IUPAC - NIST Solubility Data Series 66. Ammonium Phosphates

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The solubility of ammonium phosphate is reviewed. Many ammonium phosphates can be described in terms of the ternary system: $NH_3-PO_5-H_2O$. However, this system differs from systems like the sulfates and halates in that it has a marked tendency to form condensed oligophosphate ions. The literature survey covers the period up to 1988.

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1. Preface

Phosphates, in general, have some properties that complicate a study of these compounds. This behavior is discussed elsewhere.[1] Ammonium phosphates also have these characteristics. The current volume presents and evaluates data for the solubility of ammonium phosphates. The amount of published material dealing with this subject is rather large, probably because of interest in, and use of ammonium phosphates as fertilizers. So far as we are aware, all the relevant articles published before 1988 have been reviewed. However, because of page limitations, all this material has not been covered in this volume.

1.1. General Description of Ammonium Phosphate Systems

Many ammonium phosphates can be described in terms of the $NH_3-P_2O_5-H_2O$ system, Table I and Figure 1. However, this system differs from other systems such as sulfates and halates in that it has a marked tendency to form condensed oligophosphate anions. Thus, e.g., along the line representing the ratio of $NH_3/P_2O_5=2$ in Figure 1, the compounds $NH_4H_2PO_4$ {5}, $(NH_4)_2H_2P_2O_7${12}, $(NH_4)_3H_2P_3O_{10}$ {13} and $(NH_4)_4H_2P_4O_{13}$ {15} may be found.

Figure 1 serves as a guide for arranging and organizing the material contained in this volume. The following five paragraphs give a further explanation of Figure 1.

1. The line depicting the ratio $NH_3:P_2O_5=6$ (line r=6) marks the limit of neutralization. Basic systems containing excess NH_3 lie to the right of this line. No additional solid phases exist in this region. Completely or partially neutralized phosphates lie to the left of the line.

2. All the solid phosphates mentioned in this volume may be classified into series depending on the degree of condensation of the anion: orthophosphates, diphosphates, triphosphates and tetraphosphates. However, all members of these series cannot be individually depicted on Figure 1 because points referring to individual partially neutralized phosphates must also indicate the water of hydration content. Thus, ammonium dihydrogenphosphate, $NH_4H_2PO_4$ {5}, and diammonium dihydrogendiphosphate monohydrate, $(NH_4)H_2P_2O_7 \cdot H_2O$, appear at the same location (point {5} on Figure 1).

3. Systems consisting of ammonia, the respective acid and water are ternary. For congruently soluble phosphates (both completely and partially neutralized) the respective binary systems (phosphate-water) can be understood as a binary section of the basic ternary system.

4. Each system consisting of two phosphates belonging to the same series, e.g., $NH_4HPO_4-(NH_4)_2HPO_4-H_2O$, is also a ternary system. However, such ternary systems can also be considered as subsystems of the primary ternary system ($NH_3-H_3PO_4-H_2O$ in this instance) and will be discussed in terms of this latter system. However, quaternary systems and systems of a higher order formed by adding another component to the above-mentioned ternary system will be evaluated separately. It should be noted that a system consisting of two phosphates belonging to a different series is ternary (pseudoternary) only in special cases determined by pH, stability constants of the species involved and solubility of possible solid phases. Most of the possible systems consisting of two partially neutralized phosphates of different series behave as unstable diagonals of quaternary systems, i.e., the respective pair of salts cannot coexist in a truly saturated solution.

5. Hydrolytic equilibria must be considered when evaluating systems containing condensed oligophosphates. In many

papers the rates of hydrolysis of condensed phosphates are discussed, e.g., by Chulanova et al.[2] As a general rule the solubilities of the polyphosphates decrease as the chain length increases. Furthermore, the rates of decomposition of the condensed oligophosphates depend on pH, temperature and the nature of the cation in a rather complex way. As a result, it is difficult to attain equilibrium in mixtures of phosphates of different families. This is especially true when heterogeneous equilibria are involved. The time required to establish equilibrium is very long if it can even be attained.

1.2. Procedure Used for Evaluating Binary Systems

All the data were examined and evaluated using the method of others.[2–4] Only experimentally determined data were evaluated. Data obtained from smoothing equations or by extrapolation were excluded from consideration. The treatment differs somewhat when anhydrous solid phases or hydrates are evaluated.

1.2.1. Anhydrous Solid Phases ($NH_4H_2PO_4$ and $(NH_4)_2HPO_4$)

The data were fitted to Eq. (1)

$$\ln(x/x_o) = A(1/T - 1/T_o) + B\ln(T/T_o) + C(T - T_o). \tag{1}$$

A, B and C are adjustable parameters. x_o is a reference mole fraction at temperature T_o. For the selection of these reference constants, the following criteria were used:

a. x_o was chosen as the mean value of the experimental data of more than one study. Furthermore, the standard deviation did not exceed the experimental uncertainty in obtaining the data.

b. T_o was chosen near the middle of the temperature range in which the hydrate exists rather than at or near a transition point of one hydrate into another.

x_o and T_o are pairs of constants and are not chosen independently of each other. The choice of the reference constants x_o and T_o as well as the entire computational procedure, including weights given to individual data, was also followed for discussing the solubilities of alkali metal phosphates.[22] The experimental uncertainty of solubility data for ammonium phosphates was also estimated to be between 1 and 2% and the selection conditions were defined by Eq. (2):

$$[x_j - x(T_j)]/x(T_j) \leq 0.015 \tag{2}$$

x_j and T_j are coordinates of the experimental point j, $x(T_j)$ is the calculated mole fraction.

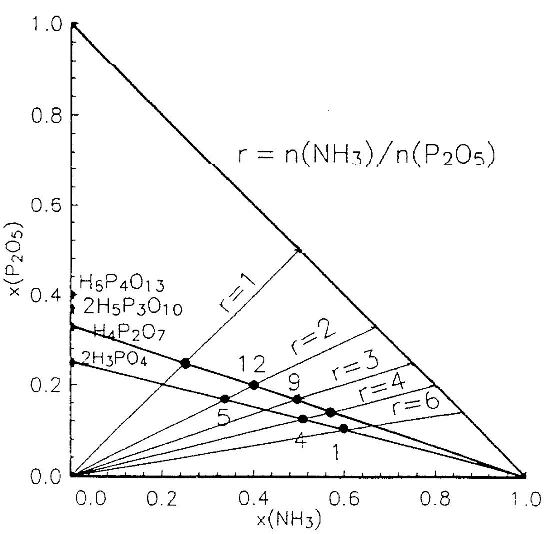

FIG. 1. Ammonium phosphates in the $NH_3-P_2O_5-H_2O$ system.

Table I. Solid phases in the $NH_3-P_2O_5-H_2O$ system

No[a]	Formula	No[a]	Formula
	A. Orthophosphate series (based on H_3PO_4)		C. Diphosphate series (based on $H_4P_2O_7$)
1	$(NH_4)_3PO_4$	9	$(NH_4)_4P_2O_7$
2	$(NH_4)_3PO_4\cdot 2H_2O$	10	$(NH_4)_4P_2O_7\cdot H_2O$
3	$(NH_4)_3PO_4\cdot 3H_2O$	11	$(NH_4)_3HP_2O_7\cdot H_2O$
4	$(NH_4)_2HPO_4$	12	$(NH_4)_2H_2P_2O_7$
5	$NH_4H_2PO_4$		
	B. Acidic orthophosphate double salts		D. Triphosphate series (based on $H_5P_3O_{10}$)
		13	$(NH_4)_3H_2P_3O_{10}$
6	$NH_4H_2PO_4\cdot H_3PO_4$	14	$(NH_4)_5P_3O_{10}$
7	$NH_4H_2PO_4\cdot H_3PO_4\cdot H_2O$		
8	$3NH_4H_2PO_4\cdot H_3PO_4$		E. Tetraphosphate series (based on $H_6P_4O_{13}$)
		15	$(NH_4)_4H_2P_2O_{13}$
		16	$(NH_4)_6P_4O_{13}$

[a]These numbers indicate the location of the corresponding compound on Figure 1. Only some of these compounds are located on Figure 1.

1.2.2. $(NH_4)_2HPO_4\cdot 2H_2O$

For hydrated equilibrium solid phases, the (metastable or stable) melting point of the pure solid phase is the optimum reference point. The solubility of the hydrate can be represented by Eq. (3)

$$Y = A/T + B\ln(T/T_f) + CT + D \tag{3}$$

In Eq. (3), Y is the natural logarithm of the solubility product of the solid in equilibrium with the solution. For $(NH_4)_2HPO_4\cdot 2H_2O$ most of the data were found as molalities; therefore the molality form of Y

$$Y = \ln(m/m_o) - (m/m_o - 1) \tag{4}$$

was used. Here, $m_o = 1/rM_w$ is the molality of the metastable melting point of the hydrate $(NH_4)_2HPO_4\cdot 2H_2O$ (r = 2, M_w is the molar mass of water).

1.3. Choice of Material for This Volume and its Organization

Chemical Abstracts was used to locate material containing solubility data published in the period 1920–1988. The following three sources were used to locate information published before 1920.

1. The 1928 edition of Gmelin's Handbuch der Anorganischen Chemie.[6]

2. The 1953 edition of Seidell's compilation.[7]

3. References cited in the publications that have been reviewed for this volume.

Some articles were excluded from consideration in this volume because of the guidelines mentioned in the numbered paragraphs above, especially paragraphs 4 and 5. A few of these articles[6-8] reported solubility data in systems consisting of ortho- and diphosphates which cannot coexist in a truly saturated solution. It is probable that the solid phases were not identified correctly in the work reported in those articles.

A research group at the Tennessee Valley Authority in the USA made a detailed study of what were called multicomponent systems consisting of ortho-, di-, tri- and tetraphosphoric acid, their ammonium salts and mixtures of these components.[11-21] In one case potassium salts were also added. The solid phases were identified by petrographic microscopy, and persistence of phases identified in that way was taken as an indication of equilibrium. For example, Farr and Willard[16] examined the system which they called $NH_3-H_3PO_4-H_4P_2O_7-H_5P_3O_{10}-H_2O$ at 0 °C, and claimed the existence of equilibria with four solid phases. The Phase Rule permits a maximum of only two solid phases and a solution phase in a three-component system, so either their system was not at equilibrium or identification of the solid phase was incorrect. The information they reported may be useful for fertilizer production but, because there is doubt that real equilibrium was established, these articles are neither compiled nor critically evaluated in this volume.

The material that is compiled and evaluated in this volume is organized as follows. The $NH_3-P_2O_5-H_2O$ ternary system is discussed first and then the materials are treated in the following order:

I. The $NH_3-H_4P_2O_7-H_2O$, $NH_3-H_5P_3O_{10}-H_2O$ and $NH_3-H_6P_4O_{13}-H_2O$ systems.

II. Systems in which the formation and solubility of ammonium orthophosphates are treated. In this section the individual ammonium phosphates existing in the $NH_3-H_3PO_4-H_2O$ system are listed. First, the binary phosphate-water systems are discussed, if sufficient data are available. After that, the crystallization field of each ammonium phosphate is treated.

III. Quaternary and multicomponent systems formed by the addition of one or more compounds to the $NH_3-P_2O_5-H_2O$ system.

IV. Quaternary and multicomponent systems formed by adding one or more compounds to the $NH_4H_2PO_4-(NH_4)_2HPO_4-H_2O$ system. This system may also be considered to be a ternary section of the parent $NH_3-P_2O_5-H_2O$ ternary system.

V. Ternary and multicomponent systems formed by adding one or more components to the $NH_4H_2PO_4-H_2O$, $(NH_4)_2HPO_4-H_2O$ and $(NH_4)_3PO_4-H_2O$ binary systems.

Where the matters listed in paragraphs III, IV and V above are discussed the systems are listed according to the position in the Periodic Table of the electronegative part of the added component; when the anions are identical, the position of the positive part of the added component is the controlling factor.

The editors wish to acknowledge with thanks the help of members of the IUPAC commission V.8. Prof. Dr. Christo Balarew of the Bulgarian Academy of Sciences provided us with copies of several of the articles reviewed in this volume. Drs. Kurt Loening and Byron Bossenbroek of the Chemical Abstract Services generously provided CAS registration numbers for some of the less well-known chemical compounds. We are especially grateful to Prof. J. W. Lorimer. He guided us with respect to the details in the preparation of this volume, he supplied a computer program for treating the data of binary systems and gave us generously of his time helping with the organization of the materials covered in this volume.

1.4. References for the Preface

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2. Introduction to the Solubility Data Series Solubility of Solids in Liquid

2.1. The Nature of the Project

The Solubility Data project (SDP) has as its aim a comprehensive review of published data for solubilities of gases, liquids and solids in liquids or solids. Data of suitable precision are compiled for each publication on data sheets in a uniform format. The data for each system are evaluated and, where data from independent sources agree sufficiently, recommended values are proposed. The evaluation sheets, recommended values, and compiled data sheets are published on consecutive pages.

Compilations and Evaluations

The formats for the compilations and critical evaluations have been standardized for all volumes. A description of these formats follows.

Compilations

The format used for the compilations is, for the most part, self-explanatory. Normally, a compilation sheet is divided into boxes, with detailed contents described below.

Components: Each component is listed according to IUPAC name, formula, and Chemical Abstracts (CA) Registry Number. The Chemical Abstracts name is also included if this differs from the IUPAC name, as are trivial names if appropriate. IUPAC and common names are cross-referenced to Chemical Abstracts names in the System Index.

The formula is given either in terms of the IUPAC or Hill (1) system and the choice of formula is governed by what is usual for most current users: i.e., IUPAC for inorganic compounds, and Hill system for organic compounds. Components are ordered on a given compilation sheet according to:

(a) saturating components:

(b) non-saturating components;

(c) solvents.

In each of (a), (b) or (c), the components are arranged in order according to the IUPAC 18column periodic table with two additional rows:

Columns 1 and 2: H, alkali elements, ammonium, alkaline earth elements

Columns 3 to 12: transition elements

Columns 13 to 17: boron, carbon, nitrogen groups; chalcogenides, halogens

Column 18: noble gases

Row 1: Ce to Lu

Row 2: Th to the end of the known elements, in order of atomic number.

The same order is followed in arranging the compilation sheets within a given volume.

Original Measurements:

References are abbreviated in the forms given by Chemical Abstracts Service Source Index (CASSI). Names originally in other than Roman alphabets are given as transliterated by Chemical Abstracts. In the case of multiple entries (for example, translations) an asterisk indicates the publication used for compilation of the data.

Variables:

Ranges of temperature, pressure, etc. are indicated here.

Prepared by:

The names of all compilers are given here.

Experimental Values:

Components are described as (1), (2), etc., as defined in the "Components" box. Data are reported in the units used in the original publication, with the exception that modern names for units and quantities are used; e.g., mass per cent for weight per cent; mol dm^{-3} for molar; etc. Usually, only one type of value (e.g., mass per cent) is found in the original paper, and the compiler has added the other type of value (e.g., mole per cent) from computer calculations based on 1989 atomic weights (2). Temperatures are expressed as t/°C, t/°F or T/K as in the original; if necessary, conversions to T/K are made, sometimes in the compilations and always in the critical evaluation. However, the author's units are expressed according to IUPAC recommendations (3) as far as possible.

Errors in calculations, fitting equations, etc. are noted, and where possible corrected. Material inserted by the compiler is identified by the word "compiler" or by the compiler's name in parentheses or in a footnote. In addition, compiler-calculated values of mole or mass fractions are included if the original data do not use these units. If densities are reported in the original paper, conversions from concentrations to mole fractions are included, but otherwise this is done in the evaluation, with the values and sources of the densities being quoted and referenced.

Details of smoothing equations (with limits) are included if they are present in the original publication and if the temperature or pressure ranges are wide enough to justify this procedure and if the compiler finds that the equations are consistent with the data.

The precision of the original data is preserved when derived quantities are calculated, if necessary by the inclusion of one additional significant figure. In some cases, compilers note that numerical data have been obtained from published graphs using digitizing techniques. In these cases, the precision of the data can be determined by the quality of the original graph and the limitations of the digitizing technique. In some cases graphs have been included, either to illustrate data more clearly, or if this is the only information in the original. Full grids are not usually inserted as it is not intended that users should read data from the graphs.

Method:

The apparatus and procedure are mentioned briefly. Abbreviations used in Chemical Abstracts are often used here to save space, reference being made to sources of further detail if these are cited in the original paper.

Source and Purity of Materials:

For each component, referred to as (1), (2), etc., the following information (in this order and in abbreviated form) is provided if available in the original paper: source and specified method of preparation; properties; degree of purity.

Estimated Error:

If estimated errors were omitted by the original authors, and if relevant information is available, the compilers have attempted to estimate errors (identified by ''compiler'' or the compiler's name in parentheses or in a footnote) from the internal consistency of data and type of apparatus used. Methods used by the compilers for estimating and reporting errors are based on Ku and Eisenhart (4).

Comments and/or Additional Data:

Many compilations include this section which provides short comments relevant to the general nature of the work or additional experimental and thermodynamic data which are judged by the compiler to be of value to the reader.

References:

The format for these follows the format for the Original Measurements box, except that final page numbers are omitted. References (usually cited in the original paper) are given where relevant to interpretation of the compiled data, or where cross-reference can be made to other compilations.

Evaluations

The evaluator's task is to assess the reliability and quality of the data, to estimate errors where necessary, and to recommend ''best'' values. The evaluation takes the form of a summary in which all the data supplied by the compiler have been critically reviewed. There are only three boxes on a typical evaluation sheet, and these are described below.

Components:

The format is the same as on the Compilation sheets.

Evaluator: The name and affiliation of the evaluator(s) and date up to which the literature was checked.

Critical Evaluation:

(a) Critical text. The evaluator checks that the compiled data are correct, assesses their reliability and quality, estimates errors where necessary, and recommends numerical values based on all the published data (including theses, patents and reports) for each given system. Thus, the evaluator reviews the merits or shortcomings of the various data. Only published data are considered. Documented rejection of some published data may occur at this stage, and the corresponding compilations may be removed.

The solubility of comparatively few systems is known with sufficient accuracy to enable a set of recommended values to be presented. Although many systems have been studied by at least two workers, the range of temperatures is often sufficiently different to make meaningful comparison impossible.

Occasionally, it is not clear why two groups of workers obtained very different but internally consistent sets of results at the same temperature, although both sets of results were obtained by reliable methods. In such cases, a definitive assessment may not be possible. In some cases, two or more sets of data have been classified as tentative even though the sets are mutually inconsistent.

(b) Fitting equations. If the use of a smoothing equation is justifiable the evaluator may provide an equation representing the solubility as a function of the variables reported on all the compilation sheets, stating the limits within which it should be used.

(c) Graphical summary. In addition to (b) above, graphical summaries are often given.

(d) Recommended values. Data are recommended if the results of at least two independent groups are available and they are in good agreement, and if the evaluator has no doubt as to the adequacy and reliability of the applied experimental and computational procedures. Data are reported as tentative if only one set of measurements is available, or if the evaluator considers some aspect of the computational or experimental method as mildly undesirable but estimates that it should cause only minor errors. Data are considered as doubtful if the evaluator considers some aspect of the computational or experimental method as undesirable but still considers the data to have some value where the order of magnitude of the solubility is needed. Data determined by an inadequate method or under ill-defined conditions are rejected. However, references to these data are included in the evaluation together with a comment by the evaluator as to the reason for their rejection.

(e) References. All pertinent references are given here, including all those publications appearing in the accompanying compilation sheets and those which, by virtue of their poor precision, have been rejected and not compiled.

(f) Units. While the original data may be reported in the units used by the investigators, the final recommended values are reported in SI units (3) when the data can be accurately converted.

2.2. Quantities and Units Used in Compilation and Evaluation of Solubility Data

Mixtures, Solutions and Solubilities

A *mixture* (5) describes a gaseous, liquid or solid phase containing more than one substance, where the substances are all treated in the same way.

A *solution* (5) describes a liquid or solid phase containing more than one substance, when for convenience one of the substances, which is called the *solvent*, and may itself be a mixture, is treated differently than the other substances, which are called *solutes*. If the sum of the mole fractions of the solutes is small compared to unity, the solution is called a *dilute solution*.

The *solubility* of a solute 1 (solid, liquid or gas) is the analytical composition of a saturated solution, expressed in terms of the proportion of the designated solute in a designated solvent (6).

"Saturated" implies equilibrium with respect to the processes of dissolution and precipitation; the equilibrium may be stable or metastable. The solubility of a substance in metastable equilibrium is usually greater than that of the same substance in stable equilibrium. (Strictly speaking, it is the activity of the substance in metastable equilibrium that is greater.) Care must be taken to distinguish true metastability from supersaturation, where equilibrium does not exist.

Either point of view, mixture or solution, may be taken in describing solubility. The two points of view find their expression in the reference states used for definition of activities, activity coefficients and osmotic coefficients.

Note that the composition of a saturated mixture (or solution) can be described in terms of any suitable set of thermodynamic components. Thus, the solubility of a salt hydrate in water is usually given as the relative proportions of anhydrous salt in solution, rather then the relative proportions of hydrated salt and water.

Physicochemical Quantities and Units

Solubilities of solids have been the subject of research for a long time, and have been expressed in a great many ways, as described below. In each case, specification of the temperature and either partial or total pressure of the saturating gaseous component is necessary. The nomenclature and units follow, where possible, Ref. (3). A few quantities follow the ISO standards (7) or the German standard (8); see a review by Cvitaš (9) for details.

A Note on Nomenclature

The nomenclature of the IUPAC *Green Book* (3) calls the solute component B and the solvent component A. In compilations and evaluations, the first-named component (component 1) is the solute, and the second (component 2 for a two-component system) is the solvent. The reader should bear these distinctions in nomenclature in mind when comparing equations given here with those in the *Green Book.*

1. *Mole fraction* of substance 1, x_1 or $x(1)$ (condensed phaes), y_1 (gases):

$$x_1 = n_1 \Big/ \sum_{s=1}^{c} n_s \qquad (1)$$

where n_s is the amount of substance of s, and c is the number of distinct substances present (often the number of thermodynamic components in the system). *Mole per cent* of substance 1 is 100 x_1.

2. *Ionic mole fractions* of salt i, x_{i+}, x_{i-}: For a mixture of s binary salts i, each of which ionizes completely into ν_{i+} cations and ν_{i-} anions, with $\nu_i = \nu_{i-} + \nu_{i-}$ and a mixture of p non-electrolytes k, of which some may be considered as solvent components, a generalization of the definition in (10) gives:

$$x_{+i} = \frac{v_{+i}x_{+i}}{1+\Sigma_{j=1}^{s}(v_j-1)x_j}, \quad x_{-i} = \frac{v_i x_{+i}}{v_{+i}} \quad i=1\ldots s \qquad (2)$$

$$x_{ok} = \frac{x_j}{1+\Sigma_{j=1}^{s}(v_j-1)x_j}, \quad k=(s+1)\ldots c \qquad (3)$$

The sum of these mole fractions is unity, so that, with $c=s+p$,

$$\sum_{i=1}^{s}(x_{+i}+x_{-i}) + \sum_{i=s+1}^{c} x_{oi} = 1 \qquad (4)$$

General conversions to other units in multicomponent systems are complicated. For a three-component system containing non-electrolyte 1, electrolyte 2 and solvent 3,

$$x_1 = \frac{v_{+2}x_{o1}}{v_{+2}-(v_2-1)x_{+2}} \qquad x_2 = \frac{x_{+2}}{v_{+2}-(v_2-1)x_{+2}} \qquad (5)$$

These relations are used in solubility equations for salts, and for tabulation of salt effects on solubilities of gases.

3. *Mass fraction* of substance 1, w_1 or $w(1)$:

$$w_1 = g_1 \Big/ \sum_{s=1}^{c} g_s \qquad (6)$$

where g_s is the mass of substance s. *Mass per cent* of substance 1 is 100 w_1. The equivalent terms *weight fraction, weight per cent* and *g (1)/100 g solution* are no longer used.

4. *Solute mole fraction* of substance 1, xv,1 :

$$x_{s,1} = m_1 \Big/ \sum_{s=1}^{c} m_s = x_1 \Big/ \sum_{s=1}^{c} x_s \qquad (7)$$

where c' is the number of solutes in the mixture. These quantities are sometimes called Jänecke mole (mass) fractions (11, 12). *Solute mass fraction* of substance 1, $w_{s,1}$, is defined analogously.

5. *Solvent mole fraction* of substance 1, $x_{v,1}$:

$$x_{v,1} = x_1 \Big/ \sum_{s=1}^{p} x_s \qquad (8)$$

Here, p is the number of solvent components in the mixture. *Solvent mass fraction* of substance 1, $w_{v,1}$, is defined analogously.

6. *Molality* of solute 1 in a solvent 2, m_1:

$$m_1 = n_1 / n_2 M_2 \qquad (9)$$

SI base units: mol kg^{-1}. Here, M_2 is the molar mass of the solvent.

7. *Aquamolality, Solvomolality* of substance 1 in a mixed solvent with components 2, 3 (13), $m_1^{(3)}$:

$$m_1^{(3)} = m_1 \bar{M} / M_3 \qquad (10)$$

SI base units: mol kg^{-1}. Here, the average molar mass of the solvent is

$$\bar{M} = x_{v,2}M_2 + (1-x_{v,2})M_3 \qquad (11)$$

and $x_{v,2}$ is the solvent mole fraction of component 2. This term is used most frequently in discussing comparative solubilities in water (component 2) and heavy water (component 3) and in their mixtures.

8. *Amount concentration* of solute 1 in a solution of volume V, c_1:

$$c_1=[\text{formula of solute}]=n_1/V \quad (12)$$

SI base units: mol m^{-3}. The symbol c_1 is preferred to [formula of solute], but both are used. The old terms *molarity*, *molar* and *moles per unit volume* are no longer used.

9. *Mass concentration* of solute 1 in a solution of volume V, ρ_1:

$$\rho_1=g_1/V=c_1M_1/V \quad (13)$$

SI base units: kg m^{-3}.

10. *Mole ratio*, $r_{A,B}$ (dimensionless) (9):

$$r_{n,12}=n_1/n_2 \quad (14)$$

Mass ratio, symbol $\zeta_{A,B}$, may be defined analogously (9).

11. *Ionic strength*, I_m (molality basis), or I_c (concentration basis):

$$I_m=\frac{1}{2}\sum_i m_iz_i^2 \quad I_c=\frac{1}{2}\sum_i c_iz_i^2 \quad (15)$$

where z_i is the charge number of ion i. While these quantities are not used generally to express solubilities, they are used to express the compositions of non-saturating components. For a single salt i with ions of charge numbers z_+ and z_-,

$$I_m=|z_+z_-|\upsilon m_i, \quad I_c=|z_+z_-|\upsilon c_i \quad (16)$$

Mole and mass fractions and mole ratios are appropriate to either the mixture or the solution point of view. The other quantities are appropriate to the solution point of view only. Conversions between pairs of these quantities can be carried out using the equations given in Table 1 at the end of this Introduction. Other useful quantities will be defined in the prefaces to individual volumes or on specific data sheets.

Salt hydrates are generally not considered to be saturating components since most solubilities are expressed in terms of the anhydrous salt. The existence of hydrates or solvates is noted carefully in the critical evaluation.

Mineralogical names are also quoted, along with their CA Registry Numbers, again usually in the text and CA Registry Numbers (where available) are given usually in the critical evaluation.

In addition to the quantities defined above, the following are useful in conversions between concentrations and other quantities.

12. *Density*, ρ:

$$\rho=g/V=\sum_{s=1}^{c}\rho_s \quad (17)$$

SI base units: kg m^{-3}. Here g is the total mass of the system.

13. *Relative density*, $d=\rho/\rho°$: the ratio of the density of a mixture at temperature t, pressure p to the density of a reference substance at temperature t', pressure p'. For liquid solutions, the reference substance is often water at 4°C, 1 bar. (In some cases 1 atm is used instead of 1 bar.) The term *specific gravity* is no longer used.

Thermodynamics of Solubility

Thermodynamic analysis of solubility phenomena provides a rational basis for the construction of functions to represent solubility data, and thus aids in evaluation, and sometimes enables thermodynamic quantities to be extracted. Both these aims are often difficult to achieve because of a lack of experimental or theoretical activity coefficients. Where thermodynamic quantities can be found, they are not evaluated critically, since this task would involve examination of a large body of data that is not directly relevant to solubility. Where possible, procedures for evaluation are based on established thermodynamic methods. Specific procedures used in a particular volume will be described in the Preface to that volume.

References

[1] E.A. Hill, J. Am. Chem. Soc. **22**, 478 (1900).

[2] IUPAC Commission on Atomic Weights and Isotopic Abundances. I., *Quantities, Units and Symbols in Physical Chemistry* (The Green Book) (Blackwell Scientific Publications, Oxford, UK, 1993).

[3] I. Mills et al., eds., *Quantities, Units and Symbols in Physical Chemistry* (The Green Book) (Blackwell Scientific Publications, Oxford, UK, 1993).

[4] H.H. Ku, p. 73; C. Eisenhart, p. 69; in H.H. Ku, ed., Precision Measurement and Calibration, *NBS Special Publication 300*, Vol. 1 (Washington, 1969).

[5] V. Gold et al., eds., *Compendium of Analytical Nomenclature* (The Gold Book) (Blackwell Scientific Publications, Oxford, UK, 1987).

[6] H. Freiser and G.H. Nancollas, eds., *Compendium of Analytical Nomenclature* (The Orange Book) (Blackwell Scientific Publications, Oxford, UK, 1987), Sect. 9.1.8.

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[9] T. Cvitaš, Chem. International **17**, No. 4, 123 (1995).

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[11] E. Jänecke, Z. Anorg. Chem. **51**, 132 (1906).

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[13] J.W. Lorimer, R. Cohen-Adad, and J.W. Lorimer, in *Alkali Metal and Ammonium Chlorides in Water and Heavy Water (Binary Systems)*, IUPAC Solubility Data Series, Vol. 47 (Pergamon, Oxford, UK, 1991), p. 495.

Components:	Evaluator
(1) Ammonia; NH_3; [7664-41-7] (2) Diphosphorus pentoxide; P_2O_5; [1314-56-3] (3) Water; H_2O; [7732-18-5]	J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

3. Oligophosphate Systems

Chulanova, et al.,[1,2] published solubility data for the following three systems:

1. $NH_4H_2PO_4-(NH_4)_4P_2O_7-H_2O$;
2. $NH_4H_2PO_4-(NH_4)_2H_2P_2O_7-H_2O$;
3. $(NH_4)_2HPO_4-(NH_4)_2H_2P_2O_7-H_2O$.

The compounds chosen as components in the first system cannot coexist in a saturated solution. Perhaps there was an error in identifying the solid phases at equilibrium. In the third system, the authors observed a crystallization field for $(NH_4)_3HP_2O_7\cdot H_2O$ as a product of reaction between the compounds chosen as components. Therefore, the solubility data in Ref. 1 are rejected.

The data in Ref. 2 can be compared with the 0 °C isotherm of the $NH_4HPO_4-(NH_4)_2H_2P_2O_7-H_2O$ system reported by others,[3] see Fig. 2. The data points for 50 and 70 °C on Fig. 2 were found by extrapolation from the solubility isotherms.[2] The variation of composition with temperature shown in Fig. 2 appears to be reasonable. Consequently, the data can be accepted tentatively.

A research group at the Tennessee Valley Authority in the USA studied the following systems:[4-6]

$NH_3-H_2P_2O_7-H_2O$;

$NH_3-H_5P_3O_{10}-H_2O$;

$NH_3-H_6P_4O_{13}-H_2O$.

The solubility data presented for these systems cannot be critically evaluated because of the absence of other, similar experimental work. The same research group also made a detailed study of multicomponent systems consisting of di-, tri- and tetra- phosphoric acid, the corresponding ammonium salts (and, in one case also, with potassium salts).[7-14] They used a petrographic examination of the solid phases as the main criterion of equilibrium. In these works they report more solid phases than are allowed by the Phase Rule. The solubility information presented in these articles may be useful for fertilizer production. However, there is real doubt that true equilibrium was established in the experimental work and, therefore, these articles are neither compiled nor critically evaluated in this volume.

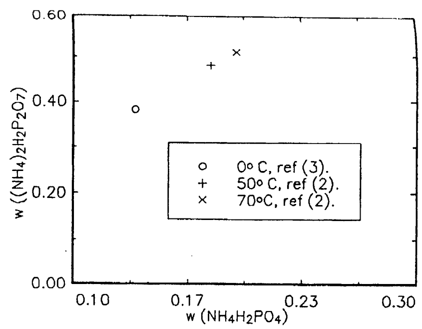

FIG. 2. Composition of solutions saturated with both $NH_4H_2PO_4$ and $(NH_4)_2H_2P_2O_7$.

References:

[1]G. A. Chulanova, R. I. Shipyatskaya, and L. S. Mukhina, Zh. Prikl. Khim. (Leningrad) **47**, 1637 (1974).
[2]G. A. Chulanova, L. S. Mukhina, R. I. Shipyatskaya, and A. I. Taran, Zh. Prikl. Khim. (Leningrad) **49**, 1933 (1976).
[3]A. G. Kuznetsova and T. L. Il'ina, Zh. Prikl. Khim. (Leningrad) **55**, 1153 (1982).
[4]T. D. Farr and J. D. Fleming, J. Chem. Eng. Data **10**, 20 (1965).
[5]T. D. Farr, J. D. Fleming, and J. D. Hatfield, J. Chem. Eng. Data **12**, 141 (1967).
[6]T. D. Farr, J. W. Willard, and J. D. Hatfield, J. Chem. Eng. Data **17**, 313 (1972).
[7]A. V. Slack, J. D. Hatfield, H. B. Shaffer, and J. C. Driskell, J. Agr. Food Chem. **7**, 404 (1959).
[8]A. V. Slack, J. M. Potts, and H. B. Shaffer, J. Agr. Food Chem. **12**, 154 (1964).
[9]A. V. Slack, J. M. Potts, and H. B. Shaffer, Jr., J. Agr. Food Chem. **13**, 165 (1965).
[10]T. D. Farr and J. W. Willard, J. Chem. Eng. Data **14**, 367 (1969).
[11]T. D. Farr and J. W. Willard, J. Chem. Eng. Data **16**, 67 (1971).
[12]T. D. Farr and J. W. Willard, J. Chem. Eng. Data **17**, 317 (1972).
[13]A. W. Frazier, E. F. Dillard, R. D. Thrasher, and K. R. Waerstad, J. Agr. Food Chem. **21**, 700 (1973).
[14]J. W. Willard and E. F. Dillard, J. Chem. Eng. Data **20**, 436 (1975).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium dihydrogendiphosphate; $(NH_4)_2H_2P_2O_7$; [13597-86-9]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

G. A. Chulanova, L. S. Mukhina, R. I. Shipyatskaya, A. I. Taran, Zh. Prikl. Khim. (Leningrad) **49**, 1933-5 (1976).

Variables:

Composition at 50 and 70 °C

Prepared By:

J. Eysseltová

Experimental Data

Solubility values for the $(NH_4)_2H_2P_2O_7-NH_4H_2PO_4-H_2O$ system

$(NH_4)_2H_2P_2O_7$ 100 w_i	m_i/mol kg^{-1} [a]	$NH_4H_2PO_4$ 100 w_i	m_1/mol kg^{-1} [a]	H_2O[a] 100 w_i	pyro-P_2O_5 m_i/mol kg^{-1}	ortho-P_2O_5 m_i/mol kg^{-1}	Solid phase[b]
			temp = 50 °C				
0.0	0.0	40.5	5.92	59.5	0.0	2.96	A
6.3	0.53	37.7	5.85	56.0	0.53	2.93	A
9.1	0.79	36.4	5.81	54.5	0.79	2.90	A
16.3	1.51	32.7	5.57	51.0	1.51	2.78	A
26.7	2.70	26.7	4.98	46.6	2.72	2.50	A
34.8	3.91	23.2	4.80	42.0	3.91	2.40	A
40.0	4.72	20.0	4.35	40.0	4.72	2.17	A
48.0	6.29	16.0	3.86	36.0	6.29	1.53[c]	B
51.0	6.61	12.8	3.07	36.2	6.65	1.53	B
53.6	6.74	8.9	2.1	37.5	6.74	1.03	B
61.0	7.38	0.0	0.0	39.0	7.38	0.00	B

[a]These values were calculated by the compiler.
[b]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2H_2P_2O_7$.
[c]This is an obvious error. The compiler thinks this value should be 1.93.

Solubility values for the $(NH_4)_2H_2P_2O_7-NH_4H_2PO_4-H_2O$ system

$(NH_4)_2H_2P_2O_7$ 100w_i	m_i/mol kg^{-1} [a]	$NH_4H_2PO_4$ 100w_i	m_i/mol kg^{-1} [a]	H_2O[a] 100w_i	pyro-P_2O_5 m_i/mol kg^{-1}	ortho-P_2O_5 m_i/mol kg^{-1}	Solid phase[b]
			temp = 70 °C				
0.0	0.0	49.5	8.52	50.5	0.0	4.26	A
7.5	0.74	45.0	8.24	47.5	0.74	4.12	A
10.8	1.10	43.0	8.09	46.2	1.10	4.04	A
19.0	2.08	38.0	7.68	43.0	2.08	3.84	A
31.1	3.88	31.1	7.15	37.8	3.88	3.57	A
39.0	5.25	26.0	6.46	35.0	5.26	3.23	A
44.9	6.47	22.4	5.95	32.7	6.48	3.00	A
52.5	8.25	17.5	5.07	30.0	8.25	2.53	B
55.5	8.55	13.9	3.95	30.6	8.56	1.97	B
59.5	9.17	9.9	2.8	30.6	9.17	1.40	B
67.0	9.57	0.0	0.0	33.0	10.02	0.00	B

[a]These values were calculated by the compiler.
[b]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2H_2P_2O_7$.

Auxiliary Information

Method / Apparatus / Procedure:
The visual polythermic method was used. All experimental details are described in Ref 1.

Source and Purity of Materials:
The only information given is that $(NH_4)_2H_2P_2O_7$ was prepared by heating $(NH_4)_2P_2O_7$ to 125 °C.

Estimated Error:
No information is given.

References:
[1]G. A. Chulanova, R. I. Shipyatskaya, L. S. Mukhina, Zh. Prikl. Khim. (Leningrad) **47**, 1637 (1974).

Components:

(1) Ammonium dihydrogenphosphate: $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium dihydrogendiphosphate; $(NH_4)_2H_2P_2O_7$; [13597-86-9]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A. G. Kuznetsova, T. L. Il'ina, Zh. Prikl. Khim. (Leningrad) **55**, 1153-4 (1982).

Variables:

Composition at 0 °C.

Prepared By:

J. Eysseltová

Experimental Data

The solubility isotherm for the $NH_4H_2PO_4-(NH_4)_2H_2P_2O_7-H_2O$ system at 0 °C is given in graphical form and described verbally as follows:

Solubility of $NH_4H_2PO_4$ is virtually constant in the concentration range of 0–19.5 mass % of $(NH_4)_2H_2P_2O_7$, then decreases slightly.

Solubility of $(NH_4)_2H_2P_2O_7$ increases in the concentration range of 0–6.3 mass % of $NH_4H_2PO_4$, but decreases in the concentration range of 6.3–13.6 mass % $NH_4H_2PO_4$.

The composition of the eutonic point is 13.6 mass % $NH_4H_2PO_4$ (2.5 mol/kg–compiler), 38.2 mass % $(NH_4)_2H_2P_2O_7$ (3.7 mol/kg–compiler), 48.2 mass % H_2O.

The total plant food ($N+P_2O_5$) in the system under consideration is in the range of 13.7–40.6 mass %, the ratio N/P_2O_5 being constant at 1:5.

The authors linearized the dependence of total plant food on total P_2O_5 content in the form $y=0.05+1.195x$ where y is the total plant food ($N+P_2O_5$) and x is the total P_2O_5 content.

Auxiliary Information

Method / Apparatus / Procedure:
The isothermal method was used. The system was equilibrated for 4 hrs. Liquid phases and wet residue were analyzed for total P_2O_5 and P_2O_5 in ortho form spectrophotometrically.[1]

Source and Purity of Materials:
Chemically pure $NH_4H_2PO_4$ was used. $(NH_4)_2H_2P_2O_7$ was prepared by heating $(NH_4)_4P_2O_7$ at 110°C for 46 hours. The product contained 91.9% $(NH_4)_2H_2P_2O_7$ and 4.4% $NH_4H_2PO_4$. Paper chromatography[2] showed the absence of any more condensed polyphosphates.

Estimated Error:
No information is given.

References:
[1]*Metody Analiza Fosfatnogo Syrya, Fosfornykh i Kompleksnykh Udobreniy, Kormevykh Fosfatov*, Moscow 1975.
[2]L. A. Ionova, N. N. Postnikov, Khim. Prom. 3, 198 (1969).

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Diphosphoric acid; $H_4P_2O_7$; [2466-09-3]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
T. D. Farr, J. D. Fleming, J. Chem. Eng. Data **10**, 20-1 (1965).

Variables:
Composition at 273 and 298 K.

Prepared By:
J. Eysseltová

Experimental Data
Solubility in the NH_3–$H_4P_2O_7$–H_2O system at 273 K

N	P_2O_5		NH_3[a]		$H_4P_2O_7$[a]		H_2O[a]	
100 w_i	100 w_i	pH	100 w_i	m_i/mol kg^{-1}	100 w_i	m_i/mol kg^{-1}	100 w_i	Solid phases[b]
4.83	22.59		5.87	5.24	28.32	2.42	65.80	A
7.66	30.74	4.80	9.31	10.49	38.54	4.15	52.14	A
8.23	32.24	4.97	10.00	11.85	40.42	4.58	49.57	A
8.96	34.18	5.09	10.89	13.82	42.83	5.20	46.28	A+B
9.05	31.02	5.81	11.00	12.89	38.89	4.36	50.10	B
9.24	30.88	-	11.23	13.18	38.72	4.35	50.05	B
10.04	31.42		12.21	14.81	39.40	4.57	48.40	B
10.33	32.03	6.50	12.56	15.60	40.16	4.77	47.28	B
9.26	27.36	6.88	11.26	12.14	34.30	3.54	54.44	B+D
7.75	20.65	7.80	9.44	8.57	25.89	2.25	64.67	D
6.11	28.85	3.51	7.43	7.73	36.17	3.60	56.40	A
8.33	35.34	4.66	10.13	13.05	44.31	5.46	45.56	A
9.52	38.89	4.66	11.58	17.13	48.76	6.91	39.66	A
11.05	42.39	4.84	13.44	23.61	53.15	8.94	33.41	B
10.69	40.27	5.05	13.00	20.90	50.49	7.77	36.51	B
10.49	38.52	5.30	12.75	19.23	48.30	6.97	38.95	B
10.42	37.21	5.75	12.67	18.29	46.65	6.44	40.68	B
10.61	36.22	5.91	12.90	18.17	45.41	6.12	41.69	B
10.61	35.81	6.05	12.90	17.95	44.90	5.98	42.20	B
11.29	35.99	-	13.73	19.59	45.13	6.16	41.15	B
11.55	36.60	6.26	14.04	20.58	45.89	6.44	40.07	B+C
11.34	34.93	6.40	13.54	18.64	43.80	5.77	42.66	C
11.13	35.10	6.43	13.53	18.71	44.01	5.82	42.46	C
11.12	35.12	6.42	13.52	18.70	44.03	5.83	42.45	C
11.05	34.62	6.42	13.44	18.28	43.41	5.65	43.15	C
10.86	33.45	-	13.20	17.28	41.94	5.25	44.86	C+D
10.52	31.82	6.79	12.79	15.87	39.90	4.74	47.31	D
9.79	28.63	7.02	11.90	13.39	35.90	3.86	52.20	D
9.00	24.86	7.35	10.94	11.10	31.17	3.03	57.89	D
8.53	22.67	7.95	10.37	9.95	28.42	2.61	61.20	D
8.26	21.27	8.20	10.04	9.32	26.67	2.37	63.29	D

[a]These values were calculated by the compiler.
[b]The solid phases are: A=$(NH_4)_2H_2P_2O_7$; B=$(NH_4)_3H_2P_2O_7\cdot H_2O$; C=$(NH_4)_4P_2O_7$; D=$(NH_4)_4P_2O_7\cdot H_2O$.

Auxiliary Information

Method / Apparatus / Procedure:
The complexes, in capped glass tubes, were equilibrated in a cold room or in a water bath. The approach to equilibrium was followed by periodic petrographic and X-ray examination of the solid phases and by analyses of the liquid phase. Phosphorus was determined gravimetrically as quinolinium molybdophosphate[1] and nitrogen by distillation of ammonia with NaOH. pH was measured with a glass electrode. One-dimensional paper chromatography[2] was used to check the hydrolysis.

Source and Purity of Materials:
The ammonium pyrophosphates and their solutions were prepared by ammoniation and vacuum evaporation of 0.3 N $H_4P_2O_7$ that had been prepared by ion exchange from solutions of recrystallized tetrasodium pyrophosphate. All operations were carried out at temperatures below 10 °C. No significant hydrolysis of the pyrophosphate was observed.

Estimated Errors:
The only information given is that the temperature was kept constant as follows: ±0.5 °C; 25±0.02 °C.

References:
[1]C. H. Perrin, J. Assoc. Offic. Agr. Chemists **41**, 758 (1958).
[2]E. Karl-Kroupa, Anal. Chem. **28**, 1091 (1956).

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Triphosphoric acid; $H_5P_3O_{10}$; [10380-08-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
T. D. Farr, J. D. Fleming, J. D. Hatfield, J. Chem. Eng. Data **12**, 141-2 (1967).

Variables:
Composition at 273 and 298.3 K.

Prepared By:
J. Eysseltová

Experimental Data
Solubility in the NH_3–$H_5P_3O_{10}$–H_2O system at 273 K

N	P_2O_5		NH_3[a]		$H_5P_3O_{10}$[a]		H_2O[a]	Solid
100 w_i	100 w_i	pH	100 w_i	m_i/mol kg^{-1}	100 w_i	m_i/mol kg^{-1}	100 w_i	phases[b]
8.36	25.33	8.30	10.16	10.09	30.69	2.02	59.15	A
9.04	30.52	5.90	10.99	12.40	36.98	2.76	52.03	A
9.42	33.68	5.53	11.45	14.09	40.81	3.32	47.74	A
9.83	35.69	5.35	11.95	15.66	43.24	3.74	44.81	A+C
9.75	36.66	5.19	11.85	15.92	44.42	3.94	43.73	C
9.86	37.69	4.95	11.99	16.62	45.67	4.18	42.34	C
9.75	38.09	4.93	11.85	16.57	46.15	4.26	42.00	D
9.61	40.16	4.41	11.68	17.30	48.66	4.76	39.66	D
9.68	43.41	4.00	11.77	19.39	52.60	5.72	35.63	D
9.73	44.35	3.72	11.83	20.17	53.73	6.04	34.44	D+E
8.80	42.66	3.13	10.70	16.70	51.69	5.32	37.61	E
8.38	42.36	2.51	10.19	15.54	51.32	5.16	38.49	E
9.30	26.30	8.72	11.31	11.68	31.87	2.18	56.82	A
9.39	28.49	7.88	11.42	12.40	34.52	2.48	54.06	A
9.39	28.45	7.80	11.42	12.39	34.47	2.46	54.11	A
9.65	31.15	6.38	11.73	13.63	37.74	2.90	50.53	A+B
9.69	32.01	6.25	11.78	13.99	38.78	3.04	49.43	B
9.72	32.43	6.02	11.82	14.19	39.29	3.12	48.89	B
10.00	35.39	5.58	12.16	15.88	42.88	3.70	44.96	B
10.30	36.56	5.57	12.52	17.03	44.30	3.98	43.18	B
10.30	36.52	5.54	12.52	17.01	44.25	3.96	43.23	B
10.40	39.79	5.12	12.65	18.97	48.21	4.78	39.14	C

[a]These values were calculated by the compiler.
[b]The solid phases are: A=$(NH_4)_5P_3O_{10}\cdot 2H_2O$, D=$(NH_4)_5P_3O_{10}\cdot H_2O$, C=$(NH_4)_9H(P_3O_{10})_2\cdot 2H_2O$; D=$(NH_4)_4H_2P_3O_{10}$; E=$(NH_4)_3H_2P_3O_{10}$.

Auxiliary Information

Method / Apparatus / Procedure:
The complexes, in capped plastic bottles, were equilibrated isothermally in a cold room or in a water bath. The approach to equilibrium was followed by periodic petrographic and X-ray examination of the solid phases and by determination of composition and pH of the liquid phase. Phosphorus was determined gravimetrically as quinolinium molybdophosphate,[1] and nitrogen was determined by distillation of ammonia with NaOH.

Source and Purity of Materials:
The ammonium tripolyphosphates and their solutions were prepared by ammoniation and vacuum evaporation of 0.3 N tripolyphosphoric acid that had been prepared by ion exchange from solutions of recrystallized $Na_5P_3O_{10}$. All operations were carried out at temperatures below 10 °C. Techniques similar to those used in preparing crystalline ammonium pyrophosphates[2] were used to prepare ammonium tripolyphosphates.

Estimated Error:
The only information given is that the temperature control was as follows: 273 ± 0.5 K and 298.30 ± 0.05 K

References:
[1]C. H. Perrin, J. Assoc. Offic. Agr. Chemists **41**, 758 (1958).
[2]T. D. Farr, J. D. Fleming, J. Chem. Eng. Data **10**, 20 (1965).

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Tetraphosphoric acid; $H_6P_4O_{13}$; [13813-62-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
T. D. Farr, J. W. Williard, J. D. Hatfield, J. Chem. Eng. Data 17, 313-7 (1972).

Variables:
Composition at 273 K.

Prepared By:
J. Eysseltová

Experimental Data

Solubility values in the $NH_3-H_6P_4O_{13}-H_2O$ system at 273 K

N	P_2O_5		NH_3[a]		$H_6P_4O_{13}$[a]		H_2O[a]	Solid
$100w_i$	$100\,w_i$	pH	$100\,w_i$	m_i/mol kg^{-1}	$100\,w_i$	m_i/mol kg^{-1}	$100\,w_i$	phase[b]
8.94	46.00	2.25	10.87	18.57	54.76	4.71	34.37	A
9.24	46.06	2.81	11.23	19.44	54.83	4.78	33.93	A
9.65	46.67	3.56	11.73	21.06	55.56	5.03	32.71	A
9.81	46.67	3.66	11.93	21.54	55.56	5.06	32.51	A
10.56	48.32	4.07	12.84	25.44	57.52	5.74	29.64	A
10.77	48.64	4.02	13.09	26.51	57.90	5.91	29.01	A+B
10.72	47.76	4.25	13.03	25.42	56.86	5.59	30.11	B
10.83	45.83	4.74	13.17	23.96	54.56	5.00	32.27	B
10.95	45.52	4.83	13.31	24.05	54.19	4.93	32.50	B
11.03	45.58	4.85	13.41	24.36	54.26	4.97	32.33	C
10.70	43.15	5.47	13.01	21.44	51.37	4.27	35.62	C
10.37	38.84	5.76	12.61	17.99	46.24	3.32	41.15	C
10.38	38.64	5.76	12.62	17.91	46.00	3.29	41.38	C
10.31	36.07	6.28	12.54	16.53	42.94	2.85	44.52	C
11.00[c]	45.50[c]		13.37	24.19	54.17	4.94	32.46	B+C

[a]These values were calculated by the compiler.
[b]The solid phases are: A = $(NH_4)_4H_6P_4O_{13}$; B = $(NH_4)_5HP_4O_{13}\cdot H_2O$; C = $(NH_4)_6P_4O_{13}\cdot 2H_2O$.
[c]The composition of this invariant point was estimated graphically from plots of pH vs N or P_2O_5.

Auxiliary Information

Method / Apparatus / Procedure:
A stock solution was prepared by saturating conductivity water with $(NH_4)_6P_4O_{13}\cdot 2H_2O$. Portions of this solution were adjusted with either anhydrous ammonia or the H-form of Amberlite IR-120 resin to a selected pH value and evaporated under vacuum at about 298 K to crystallization. The mixture was then equilibrated in a cold room for 15–48 days. Phosphorus was determined gravimetrically as quinolinium molybdophosphate (1), and nitrogen was determined by distillation of ammonia with NaOH. The pH was measured, after warming to 298 K, with a conventional meter and a glass electrode.

Source and Purity of Materials:
$(NH_4)_6P_4O_{13}\cdot 2H_2O$ of sufficient purity was prepared by a modification of 2 published procedures.[2,3] Conductivity water was used.

Estimated Errors:
The only information given is that the temperature was kept constant to within % 0.5 K.

References:
[1]C. H. Perrin, J. Assoc. Offic. Agr. Chem. **41**, 758 (1958).
[2]G. J. Griffith, J. Inorg. Nucl. Chem. **26**, 1381 (1964).
[3]R. K. Osterheld and R. P. Langguth, J. Phys. Chem. **59**, 76 (1955).

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Evaluator:
J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

4. Ammonium Orthophosphates

Twenty-one publications contain solubility data for ammonium orthophosphates.[1–21] The following solid phases have been reported as being in equilibrium with saturated solutions in the $NH_3-H_3PO_4-H_2O$ system.

$(NH_4)_3PO_4\cdot 3H_2O$	[25447-33-0]
$(NH_4)_3PO_4\cdot 2H_2O$	no registry number available
$(NH_4)_3PO_4$	[10361-65-5]
$(NH_4)_7H_2(PO_4)_3$	no registry number available
$(NH_4)HPO_4\cdot 2H_2O_2$	[51457-70-8]
$(NH_4)_2HPO_4$	[7783-28-0]
$NH_4H_2PO_4$	[7722-76-1]
$(NH_4)_3H_9(PO_4)_4$	[54285-90-4]
$NH_4H_5(PO_4)_2\cdot H_2O$	[28037-74-3]
$NH_4H_5(PO_4)_2$	[28537-48-6]

There are sufficient published data to enable a critical evaluation to be made of the binary system, ammonium phosphate-water, for only two of these ammonium phosphates: $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$. A variety of experimental methods has been used to determine the temperature dependence of the solubility of these phosphates. Some of these methods are: isothermal method;[23,24,27,30,49,75] graphical measurement from a plot of density vs composition;[29] Toepler's method;[47] visual polythermic method;[39,53,63,66] and measurement of the temperature at which the last crystal disappears.[22] Ross et al.[26] do not describe their experimental method, but the solubility data reported by them are reasonable. The temperature dependence of the solubility of these compounds has been reported in many articles.[23,27,29,30,39,47,49,53,63,66,75] Solubility data have also been presented as a limiting condition in the study of multicomponent systems.[27,28,31–38,40–46,48,50–52,54 56, 57–62,64,65,67–69,71–74,76,78,80,82,83] Thus, there are ample data available for a critical evaluation to be made.

There is only one report for the solubility of $(NH_4)_3PO_4$.[26] This may be due to the fact that this salt is strongly hydrolyzed in aqueous solution and even has a significant partial pressure of ammonia at room temperature.[26] There is also only a single report for the temperature dependence of the solubility of $NH_4H_5(PO_4)$.[22] These two solubility branches in the $NH_3-H_3PO_4-H_2O$ system will be discussed on pp. 1313,1314. Solubility branches of the other orthophosphates will also be discussed later.

4.1. Binary Systems: Phosphate–Water

Solubility of NH_4HPO_4

Some articles contain obviously incorrect data.[27,34,36,41,82] These data were excluded before critical evaluation was made. Furthermore, the data in one reference[25] are the same as in another.[24] These data were considered only once. One article[53] reported the existence of a transition point at 308.5 K for the $NH_4H_2PO_4-H_2O$ system. a-$NH_4H_2PO_4$ and b-$NH_4H_2PO_4$ were said to be equilibrium solid phases at this temperature. However, no other sources confirmed this observation. The solubility curve does not have a break at this temperature. Therefore, all the available data were treated together. The solubility results are summarized in Table I. During the iteration process the data in Refs. 66, 75, 80, 72, 57, 38, 54, 82, 32, 64, 45, 83, 55, 58, 56 were eliminated. A summary of the values for the parameters in Eq. (1) is given in Table II. Table III contains some solubility values obtained by using Eq. (1) (see the Preface) and the parameters given in Table II. The values in Table III are recommended values

Table I. Solubility values of $NH_4H_2PO_4$ in water

T/K	$100w_1$	Ref.	Weight init./final
268.5	18	55	1/0
268.6	17.4	34	1/0
268.6	18.0	83	1/0
268.7	16.9	69	1/0
268.7	16.9	46	1/0
268.8	18.0	75	1/0
269	16.8	60	1/0
271.4	19	55	1/0
273	18.4	34,42,35,55	4/4
273	18.50	41	1/1
273	18.53	32,36	1/1
273	18.6	28	1/1
273	18.8	39	1/0
273	19.0	56	1/0
273	19.2	78	1/0
273	19.6	23	1/0
275.5	20	55	1/0
277.8	20.3	24	1/1
277.8	20.5	24	1/1
282.5	22.5	55	1/0
283	21.3	34	1/0
283	21.4	55	1/0
283	21.8	42,35	2/0
283	22.10	41	1/0
283	22.2	39	1/0
283	22.4	56	1/1
283	22.55	32,36	1/1
288	32,36	1/1	
291.3	25.9	24	1/0
291.3	26.0	24	1/0
293	25.5	34,55,70	3/0
293	25.9	42,35	2/0
293	26.0	39,56	2/0
293	26.30	41	1/0
293	26.8	32,36	1/1
293	27.2	85	1/0
293	75	1/0	
295.5	27.5	55	1/0
296	28.3	30	1/1
298	28.40	78	1/0
298	28.8	23	1/0
298	28.85	43	1/1
298	28.9	37	1/1
298	29.0	49,32,36	2/2
298	29.05	46	1/1
298	29.2	23,29	2/2
298	29.23	38	1/1
298	29.30	76	1/1
298	29.31	50,52	1/1
298	29.42	79	1/1
298	29.45	33	1/1
298	29.62	23	1/1
298	29.7	78	1/0
298	29.77	67	1/0
298	30.4	23	1/0
302.5	30.87	44	1/1
303	29.6	56	1/0
303	30.2	55,34,42,35	4/0
303	30.6	39	1/0
303	31.18	32,36	1/1
303	31.2	49	1/1
303	31.4	24	1/1
303	31.7	24	1/1
305.5	32.5	55	1/1
308	33.51	32,36	1/1
308.5	34	55	1/1
312	35	55	1/0
313	35.5	47	1/0
313	35.8	49,32,36	2/2
313	36.1	24,37	2/2
313	36.2	70	1/1
313	36.3	24	1/1
314.5	37.5	55	1/0
323	39.88	33	1/0
323	40.5	49	1/1
323	40.6	78	1/1
323	40.7	24	1/1
323	40.8	24	1/1
323	41.0	23	1/1
323	41.05	23	1/1
323	41.6	60	1/0
333	43.8	42	1/0
333	45.2	86	1/0
333	45.3	49	1/1
342	49.7	24	1/1
342	49.8	24	1/1
343	48.3	23	1/0
343	50.0	23	1/0
343	50.2	37	1/1
343	51.0	53	1/0
348	55.66	67	1/0
353	53.6	42	1/0
353	54.8	53	1/1
356	56.5	23	1/1
356	56.7	23	1/0
363	58.8	24	1/0
363	59.3	24	1/1
363	59.6	53	1/1
363	61.85	67	1/0
373	63.4	66	1/0
373	63.5	53	1/0
373	63.9	37	1/1
375	63.2	24	1/0
382	70.95	57	1/0
382.4	71.08	61	1/0
382.4	71.84	58	1/0
383	67.3	42	1/0
383	67.8	66	1/1
383	68.3	53	1/0
383.5	67.3	24	1/0
383.5	68.30	68	1/1
393	72.0	66	1/1
403	75.7	66	1/1
413	79.0	66	1/1
423	82.2	66	1/0
433	85.2	66	1/0
443	88.3	66	1/0
453	91.6	66	1/1
463	94.7	66	1/1

Table II. Values of the parameters in Eq. (1) for $NH_4H_2PO_4$

Parameter	Value	Standard deviation
A	5.368×10^{3}	290
B	−23.30	1.7
C	3.84×10^{-2}	2.5×10^{-3}
x_0	0.060487	
T_0	298	

Table III. Solubility of $NH_4H_2PO_4$ calculated by Eq. (1)

T/K	Mole fraction	m_i/mol kg^{-1}	$100w_i$
268	0.03016	1.727	16.57
273	0.03428	1.972	18.48
278	0.03876	2.240	20.48
283	0.04360	2.533	22.55
288	0.04883	2.852	24.69
293	0.05445	3.199	26.89
298	0.06049	3.577	29.14
303	0.06695	3.986	31.43
308	0.07386	4.431	33.75
313	0.08124	4.912	36.09
318	0.08910	5.434	38.45
323	0.09747	6.000	40.82
328	0.1064	6.613	43.19
333	0.1158	7.278	45.56
338	0.1259	8.001	47.91
343	0.1365	8.786	50.25
348	0.1479	9.640	52.57
353	0.1599	10.57	54.86
358	0.1726	11.59	57.13
363	0.1861	12.70	59.36
368	0.2004	13.93	61.56
373	0.2156	15.27	63.72
378	0.2318	16.76	65.83
383	0.2489	18.40	67.91
388	0.2670	20.24	69.94
393	0.2863	22.28	71.92
398	0.3067	24.58	73.86
403	0.3284	27.17	75.75
408	0.3515	30.11	77.59
413	0.3760	33.48	79.38
418	0.4021	37.36	81.12
423	0.4299	41.89	83.01
428	0.4594	47.21	84.55
433	0.4908	53.55	86.03
438	0.5243	61.22	87.56
443	0.5599	70.69	89.04
448	0.5980	82.63	90.48
453	0.6385	98.13	91.86
458	0.6818	119.0	93.19
463	0.7280	148.7	94.47

The $(NH_4)_2HPO_4-H_2O$ system.

The existence of the hydrate $(NH_4)_2HPO_4\cdot2H_2O$ has been reported and the transition temperature between it and the anhydrous salt has been reported to be 288.2 K.[59] Before making the critical evaluation some obviously incorrect data points[60,71,75,78] as well as data for reportedly metastable systems[39,46] were eliminated from consideration. Also, the same data were reported in two articles[24,25] and these data were counted only once. The experimental data are summarized in Table IV. The data for the solubility of the hydrate $(NH_4)_2HPO_4\cdot2H_2O$ are relatively few and rather scattered. The only equation that gave reasonable results was the three-parameter form of the smoothing equation (3)

$$y = A/T + B\ \ln(T/T_f) + C. \qquad (5)$$

The values of the parameters for the smoothing equations are given in Tables V and VI. Table VII lists solubility data for $(NH_4)_2HPO_4\cdot2H_2O$ using the values of the parameters given in Table V. These data may be accepted as tentative. Table VIII contains solubility data for $(NH_4)_2HPO_4$ calculated by using the parameters listed in Table VI. The data in Table VIII are recommended values.

Table IV. Solubility of $(NH_4)_2HPO_4$ in water

T/K	$100w_i$	Ref.	Weight init./final
	$(NH_4)_2HPO_4\cdot2H_2O$		
266.3	29.60	48	1/1
266.5	29.6	40	1/1
267.5	28.0	62	1/1
273	29.7	24	1/1
273	30.3	24	1/1
273	30.4	40	1/1
277	32.0	40	1/1
281.4	34.0	40	1/1
283	35.0	81	1/1
283	38.3	24	1/1
283	38.4	24	1/1
283.6	35.2	40	1/1
285.2	36.0	40	1/1
288.2	39.5	62	1/1
	$(NH_4)_2HPO_4$		
288.2	39.5	62	1/1
288.8	38.4	40	1/0
289.5	39.0	40	1/0
293	40.7	24	1/0
293	40.8	24,86,6	3/0
296	41.1	30	1/1
298	41.1	65	1/0
298	41.4	77	1/1
298	41.5	72	1/1
298	41.6	78	1/1
298	42.7	29,38	2/0
303	40.8	86,71	2/0
303	42.2	24	1/0
303	42.8	24	1/1
308	43.2	65	1/0
313	44.4	24	1/0
313	45.6	24	1/0
323	46.50	54	1/0
323	47.0	24,78	2/2
323	47.05	45	1/1
323	47.2	24	1/0
333	48.8	24,86	2/2
333	49.9	24	1/0
343	51.0	24	1/1
343	51.8	24	1/0
390	62.2	31	1/1
395	64.9	31	1/0
432	73.0	31	1/0
453	82.0	31	1/0

Table V. Values of the parameters in Eq. (5) for $(NH_4)_2HPO_4 \cdot 2H_2O$

Parameter	Value	Standard error
A	700	350
B	2.8×10^4	1.4×10^4
C	106	52

standard error of estimate $= 5.0\times10^{-2}$
congruent m.p. of hydrate, T_t = 309.6 K

Table VI. Values of the parameters in Eq. (1) for $(NH_4)_2HPO_4$

Parameter	Value	Standard error
A	1.42×10^4	4.0×10^3
B	85	24
C	0.134	0.036
x_o	0.108145	
T_o	323	

Table VII. Solubility of $(NH_4)_2HPO_4 \cdot 2H_2O$ calculated by Eq. (5)

T/K	$100x_i$	m_i/mol kg^{-1}	$100w_i$
266.3	5.749	3.385	30.90
268	5.816	3.427	31.16
270	5.925	3.495	31.58
272	6.078	3.591	32.17
274	6.268	3.711	32.89
276	6.499	3.857	33.75
278	6.779	4.035	34.77
280	7.117	4.252	35.96
282	7.508	4.505	37.30
284	7.964	4.802	38.81
286	8.495	5.152	40.49
288.3	9.197	5.621	42.61

Table VIII. Solubility of $(NH_4)_2HPO_4$ calculated by Eq. (1)

T/K	Mole fraction	m_i/mol kg^{-1}	$100w_i$
288	0.08180	4.950	39.51
293	0.08580	5.214	40.76
298	0.08968	5.473	41.93
303	0.09346	5.727	43.05
308	0.09717	5.979	44.10
313	0.1008	6.230	45.12
318	0.1045	6.482	46.10
323	0.1081	6.737	47.06
328	0.1119	6.997	48.01
333	0.1157	7.266	48.95
338	0.1196	7.546	49.90
343	0.1237	7.840	50.85
348	0.1280	8.152	51.82
353	0.1325	8.484	52.82
358	0.1373	8.841	53.85
363	0.1424	9.227	54.91
368	0.1479	9.647	56.01
373	0.1539	10.11	57.15
378	0.1604	10.61	58.34
383	0.1674	11.17	59.58
388	0.1750	11.79	60.87
393	0.1834	12.48	62.22
398	0.1926	13.25	63.62
403	0.2026	14.12	65.07
408	0.2136	15.09	66.50
413	0.2258	16.20	68.14
418	0.2393	17.47	69.75
423	0.2541	18.93	71.41
428	0.2706	20.61	73.12
433	0.2888	22.56	74.86
438	0.3091	24.86	76.64
443	0.3317	27.58	78.44
448	0.3569	30.83	80.27
453	0.3850	34.78	82.11

Vogel's equation

Vogel et al.[51] measured the temperature dependence of the water solubility of $NH_4H_2PO_4$, $(NH_4)_2HPO_4$ and KH_2PO_4. Starting with Schroeder's equation (77) they derived an equation which is identical to the three-parameter form of Eq. (3), and given here as Eq. (5). In order to test the validity and usefulness of this equation, the evaluator used the iterative procedure described earlier to determine the values of the coefficients in this equation. She used all the data collected for $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$. The values obtained are given in Table IX.

Table IX. Values of the parameters in Eq. (5)

	$NH_4H_2PO_4$		$(NH_4)_2HPO_4$	
Parameter	Value	Standard error	Value	Standard error
A_1	−22.63 36.422[a]	0.89	−52.9 −31.639[a]	3.4
B_1	−633 −3370.284[a]	43	1690 697.129[a]	170
C_1	385 −4.901[a]	0.13	7.87 4.718[a]	0.50

[a]These values have been reported by Vogel et al.[15]

Figures 3 and 4 present graphical comparisons of the recommended values of Tables III and VIII, respectively, with the values obtained by the use of Eq. (5) with the values of the parameters given in Table IX. It is obvious from these Figures that Vogel's values for the coefficients may be considered satisfactory only in the temperature range 283–338 K. The reason is probably the limited number of data treated by Vogel's group.

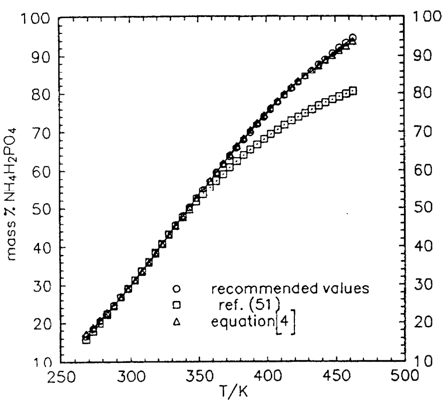

FIG. 3. Solubility data for $NH_4H_2PO_4$.

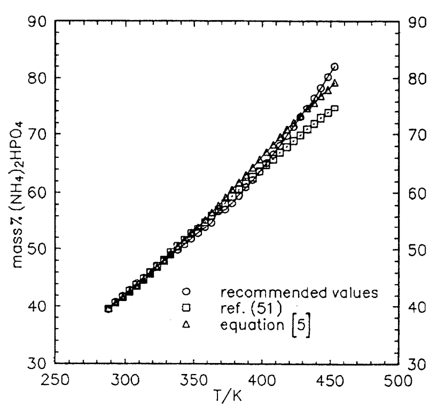

FIG. 4. Solubility data for $(NH_4)_2HPO_4$.

References:

[1]J. D'Ans and G. Schreiner, Z. Phys. Chem. **75**, 95 (1911).
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[84]J. Eysseltova and T. P. Dirkse, *Alkali Metal Orthophosphates* (Vol. 31 of the Solubility Data Series) (Pergamon Press, 1988).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]

(2) Phosphoric acid; H_3PO_4; [7664-38-2]

(3) Water; H_2O; [7732-18-5]

Original Measurements:

N. Paravano, A. Mieli, Gazz. Chim. Ital. **38**, 535-44 (1908).

Variables:

Composition and temperature with a $NH_4H_2PO_4/H_3PO_4$ ratio equal to 1.

Prepared By:

J. Eysseltová

Experimental Data

Saturation temperatures of solutions of $NH_4H_2PO_4 \cdot H_3PO_4$ in water

	$NH_4H_2PO_4 \cdot H_3PO_4$			H_2O[a]
t/°C	$100w_i$	$100\,x_i$	m_i/mol kg^{-1}[a]	$100w_i$
48.5	64.10	13.11	8.380	35.90
66.2	74.07	19.47	13.41	25.93
92.5	84.48	31.53	25.55	15.52
97.0	86.38	34.91	29.77	13.62
109.8	92.58	51.34	58.58	7.42
112.8	95.80	65.87	107.1	4.20
118	100	100	—	0.00

[a]These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

Saturation temperatures were determined visually as the temperature at which the last crystal disappeared.

Source and Purity of Materials:

$NH_4H_2PO_4 \cdot H_3PO_4$ was prepared from an equimolar mixture of concentrated solutions of $NH_4H_2PO_4$ and H_3PO_4 by slow crystallization. The analysis was:

	found	calculated
P_2O_5	66.27%	66.65%
$(NH_4)_2O$	12.15%	12.25%

Estimated Error:

No information is given.

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Water; H_2O; [7732-18-5]

Original Measurements:
O. Apfel, Dissertation, Technical University, Darmstadt (1911).

Variables:
Composition and temperature

Prepared By:
J. Eysseltová

Experimental Data

Composition of the saturated liquid phase

	PO_4^{3-}	NH_4^+	$NH_4H_2PO_4$[a]		$NH_4H_2PO_4$[b]	
t/°C	comp[c]	comp[c]	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}
0	1.73	1.70	19.9	2.16	19.6	2.11
25	2.575	2.64	29.62	3.659	30.4	3.79
25	2.50	2.54	28.8	3.51	29.2	3.59
50	3.569	3.56	41.05	6.055	41.0	6.03
70	4.35	4.20	50.0	8.71	48.3	8.13
83	4.93	4.91	56.7	11.4	56.5	11.3

[a]These values were calculated by the compiler, taking the phosphate ion content as the starting point.
[b]These values were calculated by the compiler, taking the ammonium ion content as the starting point.
[c]The composition unit is: mol/1000 g of solution.

Auxiliary Information

Method / Apparatus / Procedure:
The isothermal method was used. Ammonia was determined by the distillation method. The phosphate ion content was determined gravimetrically as $Mg_2P_2O_7$.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given. The author indicates his results are imprecise because of hydrolysis of the ammonium salt.

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Water; H_2O; [7732-18-5]

Original Measurements:
G. H. Buchanan, G. B. Winner, Ind. Eng. Chem. **12**, 448-51 (1920).

Variables:
Composition and temperature.

Prepared By:
J. Eysseltová

Experimental Data

Solubility in the $NH_4H_2PO_4-H_2O$ system

t/°C	w_1[a]	w[b]	w[c]	w_3[d]	g/100 g H_2O	m_i/mol kg^{-1}[e]
4.8	20.5	20.3	20.4	20.2	25.3	2.23
18.3	25.9	26.6	26.3	26.3	35.7	3.10
30.0	31.4	31.7	31.6	31.7	46.4	4.02
40.0	36.1	36.3	36.2	36.2	56.7	4.93
50.0	40.8	40.8	40.8	40.8	69.1	5.99
69.0	49.7	49.8	49.8	49.4	97.9	8.62
90.0	59.3	58.8	59.1	58.9	143	12.6
102.0	63.2	—	63.2	64.4	181	14.9
110.5	67.3	—	67.3	68.3	215	17.9

[a]Solubility as mass % in the bottle where equilibrium was reached by heating.
[b]Solubility as mass % in the bottle where equilibrium was reached by cooling.
[c]The mean of w_1 and w.
[d]The value of w_3 was calculated by the following formula derived by the authors: $w_3 = 18 + 0.455\ t$/°C.
[e]The molalities were calculated by the compiler using the w value as the starting point.

Auxiliary Information

Method / Apparatus / Procedure:
The samples were placed in 2 glass bottles of about 250 cm^3 capacity. In one of them, the equilibrium was approached from below, in the other from above. Samples of the satd soln were withdrawn by a special weighing pipet and analyzed for NH_3 using the distillation method (no other details are given). The temperature of the thermostatic bath was controlled by the introduction of steam or ice water. For the higher temperatures, calcium chloride brine was used in the bath.

Source and Purity of Materials:
The salt was prepared by recrystallization of commercial mono-salt ("Amo-Pros").

Analyses:	experimental	calculated
NH_3	14.80	14.80
P_2O_5	61.57	61.72

Estimated Error:
The temperature was kept constant to within 0.5 K. The compiler estimates the reproducibility of the solubility values to be approximately 1%.

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Water; H_2O; [7732-18-5

Original Measurements:

G. H. Buchanan, G. B. Winner,
Ind. Eng. Chem. **12**, 448-51 (1920).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Table I. Analyses for NH_3 and P_2O_5 with special attention given to possible loss of ammonia due to hydrolysis of $(NH_4)_2HPO_4$

	Mass % NH_3			Mass % P_2O_5				
t/°C	up[a]	down[a]	mean	up[a]	down[a]	mean	P/N ratio	% di-salt
0	7.69	7.62	7.66	16.28	16.28	16.28	0.470	96
10	9.89	9.85	9.87	20.70	20.61	20.66	0.478	99
20	10.54	10.46	10.50	21.94	21.89	21.92	0.480	100
30	10.87	10.89	10.88	23.00	23.00	23.00	0.473	97
40	11.45	11.46	11.46	24.47	24.55	24.51	0.467	95
50	12.06	12.20	12.13	25.41	25.34	25.38	0.478	99
60	12.58	12.55	12.57	26.80	26.90	26.85	0.468	95
70	13.07	13.22	13.15	27.58	28.01	27.80	0.473	97

[a]The way of equilibration.

Table II. Solubility in the $(NH_4)_2HPO_4$–H_2O system derived on the basis of the data in Table I

t/°C	w_1[a]	w_2[b]	w[c]	w_3[d]	g/100 g H_2O	m_1/mol kg^{-1} [e]
0	29.7	30.3	30.0	—	—	3.25
10	38.3	38.4	38.4	38.6	62.8	4.72
20	40.7	40.8	40.8	40.8	69.0	5.22
30	42.2	42.8	42.5	42.9	75.2	5.60
40	44.4	45.6	45.0	45.0	81.8	6.20
50	47.0	47.2	47.1	47.2	89.2	6.74
60	48.8	49.9	49.4	49.3	97.3	7.39
70	51.0	51.8	51.4	51.4	106.0	8.01

[a]Solubility as mass % calculated on the basis of the analysis for NH_3.
[b]Solubility as mass % calculated on the basis of the analysis for P_2O_5.
[c]The mean of w_1 and w.
[d]The value of w_3 was calculated from the formula: $w_3 = 36.5 + 0.213\ t/°C$.
[e]The molalities were calculated by the compiler, using the value of w as the starting point.

Auxiliary Information

Method / Apparatus / Procedure:

The samples were placed in 2 glass bottles of about 250 cm^3 capacity. In one of them, the equilibrium was approached from below, in the other from above. Samples of the satd soln were withdrawn by a special weighing pipet and analyzed. NH_3 was determined by the distillation method and P_2O_5 was determined by precipitation as "double magnesium salt" (NH_4MgPO_4–compiler). The temperature of the thermostatic bath was controlled by the introduction of steam or ice water. At higher temperatures an electric hot plate was used. For the highest temperatures, calcium chloride brine was used in the bath.

Source and Purity of Materials:

The salt was prepared by ammoniating a nearly satd soln of mono-salt at a temperature above 80 °C, cooling the mixture and filtering the crystals, and air drying them.

Analyses:	experimental	calculated
NH_3	25.8	25.8
P_2O_5	53.9	53.8

Estimated Error:

The temperature was kept constant to within 0.5 K. The compiler estimates the reproducibility of the solubility values to be approximately 1%.

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1] or
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0] or
(1) Triammonium phosphate; $(NH_4)_3PO_4$; [10361-65-6]
(2) Water; H_2O; [7732-18-5]

Original Measurements:
W.H. Ross, A.R. Herz, K.D. Jacob, Ind. Eng. Chem. **21**, 286-9 (1929).

Variables:
Composition at 25 °C.

Prepared By:
J. Eysseltová

Experimental Data

Solubility of ammonium phosphates in water at 23 °C

Compound	comp[a]	Solubility conc. $100w_i$[b]	m_i/mol kg^{-1}[b]	H_2O $100w_i$[b]
$NH_4H_2PO_4$	40.0	28.6	3.48	71.4
$(NH_4)_2HPO_4$	69.5	41.0	5.26	59.0
$(NH_4)_3PO_4$	17.7	15.0	1.25	85.0

[a]The composition unit is: g/100 g H_2O.
[b]These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:
No information is given.

Source and Purity of Material:
No information is given.

Estimated Error:
No information is given.

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Water; H_2O; [7732-18-5]

Original Measurements:
P. Askenasy, F. Nessler, Z. Anorg. Chem. **189**, 305-28 (1930).

Variables:
Composition and temperature.

Prepared By:
J. Eysseltová

Experimental Data

Solubility of ammonium dihydrogenphosphate in water

t/°C	$NH_4H_2PO_4$ c/mol l^{-1}	t/°C	$NH_4H_2PO_4$ c/mol l^{-1}
0	1.98	60	7.16
25	3.60	70	8.35
50	5.90	80	10.28

These values were obtained by interpolation.

Auxiliary Information

Method / Apparatus / Procedure:
The isothermal method was used. The mixtures were agitated in a thermostat for 2 to 4 days. The solid phase was separated from the liquid phase by centrifuging. The analytical procedures are not described.

Source and Purity of Materials:
No information is given.

Estimated Error:
The temperature was controlled to within 0.1 K. No other information is given.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1] or
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Water; H_2O; [7732-18-5]

Original Measurements:

K. Chomyakov, A. Yaworovskaya, P. Z. Shirokikh, Phys. Chem. A **167**, 36-9 (1933).

Variables:

Composition at 23 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility of ammonium phosphates in water at 23 °C

	Solubility		H_2O
Compound	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$ [a]
$NH_4H_2PO_4$	28.3	3.43	71.7
$(NH_4)_2HPO_4$	41.1	5.28	58.9

[a] These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

The solubility was found graphically from the plot of density vs composition.

Source and Purity of Materials:

All materials were from de Haen or Kahlbaum and were purified twice, pulverized, and dried in vacuum before being used.

Estimated Error:

No information is given.

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Water; H_2O; [7732-18-5]

Original Measurements:

E. Jänecke, Z. Phys. Chem. **177**, 7-16 (1936).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

The temperatures at which the last crystals disappeared in the $(NH_4)_2HPO_4-H_2O$ system

NH_3	H_2O			$(NH_4)_2HPO_4$ [a]	
$100w_i$	$100w_i$	t/°C [b]	t/°C [b]	$100w_i$	m_i/mol kg^{-1}
21.4	16.9	193	191	83.1	37.3
21.1	19.4	184	180	82.0	34.4
18.8	25.2	163	159	73.0	20.5
16.7	34.1	130	122	64.9	14.0
16.0	37.0	123	117	62.2	12.4

[a] These values were calculated by the compiler. The NH_3 content was taken as the starting point in these calculations.
[b] These are the results of repeated observations.

Auxiliary Information

Method / Apparatus / Procedure:

The only information given is that a self-constructed rotating furnace was used.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given. The compiler estimates the reproducibility of the temperature measurement to be ±3 °C.

Components:
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Water; H_2O; [7732-18-5]

Original Measurements:
K. S. Chernova, Izv. Sektora Fiz. Khim. Analiza, Inst. Obshch. Neorg. Khim. Akad. Nauk SSSR **15**, 112-7 (1947).

Variables:
Composition and temperature.

Prepared By:
J. Eysseltová

Experimental Data

Solubility of $(NH_4)_2HPO_4$ in water

	$(NH_4)_2HPO_4$		H_2O	
t/°C	$100w_i$	m_i/mol kg^{-1a}	$100w_i$[a]	Solid phase[b]
0.6	3	0.2	97	A
1.2	6	0.5	94	A
1.6	9	0.7	91	A
2.2	12	1.0	88	A
-2.8	15	1.3	85	A
3.6	19	1.8	81	A
-4.2	21.6	2.09	78.4	A
-4.8	24	2.4	76	A
6.1	28	2.9	72	A
6.5	29.6	3.18	70.4	A+B
7.0	30.4	3.31	69.6	A[c]
-7.8	32.0	3.56	68.0	A[c]
-8.2	33.0	3.73	67.0	A[c]
-9.0	34.4	3.97	65.6	A[c]
9.5	35.0	4.08	65.0	A+C[c]
0.0	36.4	4.33	63.6	C[c]
0.0	30.4	3.31	69.6	B
4.0	32.0	3.56	68.0	B
8.4	34.0	3.90	66.0	B
10.6	35.2	4.11	64.8	B
12.2	36.0	4.26	64.0	B
15.8	38.4	4.72	61.6	B
16.5	39.0	4.84	61.0	B
26.0	40.4	5.13	59.6	B

[a]These values were calculated by the compiler.
[b]The solid phases are: A = ice; B=$(NH_4)_2HPO_4\cdot 2H_2O$; C=$(NH_4)_2HPO_4$.
[c]This is a metastable equilibrium.

Auxiliary Information

Method/Apparatus/Procedure:
A polythermic method was used. The cooling agent was a mixture of ice and NaCl. Because of supersaturation, the temperature of dissolution of the last crystal was measured.

Source and Purity of Materials:
Anhydrous $(NH_4)_2HPO_4$ was recrystallized from a solution containing a small excess of ammonia. No other information is given.

Estimated Error:
The only information given is that the precision of the eutectic temperatures is -6.5 ± 0.30 °C and -9.5 ± 0.20 °C.

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Water; H_2O; [7732-18-5]

Original Measurements:
J. Myl, Z. Solc, J. Kvapil, E. Schierova, Sb. Ved. Praci VSChT Pardubice (Trans. of the High School of Chemical Technology at Pardubice) **2**, 63-76 (1961).

Variables:
Composition and temperature.

Prepared By:
J. Eysseltová

Experimental Data

Composition of saturated solutions of $NH_4H_2PO_4$ in water

	$NH_4H_2PO_4$			H_2O
t/°C	comp[a]	$100w_i$[b]	m_i/mol kg^{-1b}	$100m_i$[b]
25	40.8	29.0	3.55	71.0
30	45.3	31.2	3.94	68.8
40	55.8	35.8	4.85	64.2
50	68.2	40.5	5.93	59.5
60	82.8	45.3	7.20	54.7

[a]The composition units are: g/100 g H_2O.
[b]These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:
A modification of Toepler's method[1] was used.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given.

References:
[1]J. Myl, J. Kvapil, Colln. Czechoslov. Chem. Commun. **25**, 194 (1960).

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Water; H_2O; [7732-18-5]

Original Measurements:
A. G. Bergman, R. Tashtemirov, Ukr. Khim. Zh. **33**, 565-8 (1967)

Variables:
Temperature and composition

Prepared By:
J. Eysseltová

Experimental Data

Solubility in the $NH_4H_2PO_4-H_2O$ system

t/°C	$100w_1$	m_1/mol kg^{-1a}	Solid phase[b]
2	10	0.966	A
4	17	1.78	A
4.5	18	1.91	A+B
1.6	19	2.04	B
+2.5	20	2.17	B
+9.5	22.5	2.52	B
+22.5	27.5	3.30	B
+32.5	32.5	4.19	B
+35.5	34	4.48	B+C
+39	35	4.68	C
+46.5	37.5	5.22	C
+51.5	40	5.80	C

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = ice; B = α-$NH_4H_2PO_4$; C = β-$NH_4H_2PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:
A visual polythermic method was used. A mixture of solid carbon dioxide and acetone was used as the cooling agent.

Source and Purity of Materials:
Reagent grade $NH_4H_2PO_4$ was used. It had a melting point of 200 °C.

Estimated Error:
No information is given.

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Water; H_2O; [7732-18-5]

Original Measurements:
S. D. Fridman, N. N. Polyakov, L. S. Skum, R. Ya. Kirindasova, Khim. Prom. (Moscow) **47**, 588-9 (1971).

Variables:
Temperature and composition.

Prepared By:
J. Eysseltová

Experimental Data

Solubility of $NH_4H_2PO_4$ in water

t/°C	$NH_4H_2PO_4$ $100w_1$	m_1/mol kg^{-1a}	H_2O $100w_2$[a]
100	63.4	15.1	36.60
110	67.8	18.3	32.20
120	72.0	22.4	28.00
130	75.7	27.1	24.30
140	79.0	32.7	21.00
150	82.2	40.1	17.80
160	85.2	50.0	14.80
170	88.3	65.6	11.70
180	91.6	94.8	8.40
190	94.7	155.3	5.30

[a]These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:
A visual polythermic method was used.

Source and Purity of Materials:
No information is given.

Estimated Error:
The precision of the temperature of disappearance of the last crystal was ±0.5 K.

Components:	**Original Measurements:**
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1] (2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0] (3) Water; H_2O; [7732-18-5]	T. Akiyama, H. Kanzaki, S. Minagawa, Nippon Dojo Hiryogaku Zasshi **49**, 243-6 (1978).
Variables:	**Prepared By:**
Composition at 273, 298 and 323 K.	Hiroshi Miyamoto

Experimental Data

Solubility of $NH_4H_2PO_4$ in water

t/°C	$100w_i$	m_i/mol kg^{-1}[a]
0	19.2	2.07
25	29.7	3.67
50	40.6	5.94

Solubility of $(NH_4)_2HPO_4$ in water

t/°C	$100w_i$	m_i/mol kg^{-1}[a]
0	36.3	4.32
25	41.6	5.39
50	47.0	6.72

[a]These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

The $NH_4H_2PO_4$ or $(NH_4)_2HPO_4$ was added to water in a glass-stoppered bottle and heated on a water bath at 90 °C. The mixture was then allowed to settle at a given temperature for 7 days. Total nitrogen content in the saturated solutions was determined by chemical analysis. The phosphate content was determined as P_2O_5.

Source and Purity of Materials:

Chemically pure ammonium salts were used.

Estimated Error:

Nothing is specified.

Components:	**Original Measurements:**
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1] (2) Water; H_2O; [7732-18-5]	A. N. Sarbaev, E. V. Polyakov, M. F. Tyunina, Z. A. Polyakova, A. Kh. Ruchkova, Khim. Prom. (Moscow) **49**, 121-2 (1973).
Variables:	**Prepared By:**
Composition and temperature of cryohydric point.	J. Eysseltová

Experimental Data

The T-p-d data are given only in graphical form.

The cryohydric temperature is −4.3 °C.

The composition of the eutectic point is 16.9 mass % $NH_4H_2PO_4$ (1.77 mol/kg-compiler) and 83.1 mass % water.

Auxiliary Information

Method / Apparatus / Procedure:

No information is given. The compiler assumes that some polythermic method was used.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components:
(1) Ammonium dihydrogenphosphate: $NH_4H_2PO_4$; [7722-76-1] or
(1) Diammonium hydrogenphosphate: $(NH_4)_2HPO_4$; [7783-28-0] or
(1) Potassium dihydrogenphosphate: KH_2PO_4; [7778-77-0]
(2) Water, H_2O; [7732-18-5]

Original Measurements:
L. Vogel, G. Figurski, P. Vohland, Z. Chem. **23**, 331-2 (1983).

Variables:
Composition and temperature.

Prepared By:
J. Eysseltová

Experimental Data

The solubilities are presented in graphical form only. The data can be represented by the following equation:

$$\ln x = A + B/T + C \ln T$$

where x is the mol fraction of the salt in the saturated solution. The values of the constants are given below:

Salt component	A	B/K	C	Median error of smoothing (x)
$NH_4H_2PO_4$	36.422	−3370.284	4.901	0.156
$(NH_4)_2HPO_4$	31.639	697.129	4.718	0.072
KH_2PO_4	−4.810	−1510.549	1.128	0.094

Auxiliary Information

Method / Apparatus / Procedure:
The method and apparatus have been described previously.[1] However, plastic stoppers with glass caps were used instead of sealing the vessels.

Source and Purity of Materials:
No information is given.

Estimated Error:
The precision of the weights was ±0.0001 g. The temperature was accurate to within ±0.05 K.

References:
[1]H. Schuberth, Abhandlung der Deutschen Akademie der Wissenschaften zu Berlin, Klasse fur Chemie, Geologie U. Biologie, Jg. **3**, 40 (1960).

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Evaluator:
J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

4.2. Crystallization Fields of Individual Ammonium Phosphates

Ammonium Orthophosphates in the $NH_3-H_3PO_4-H_2O$ system

A. Solubility branches on isotherms. The coordinates used for all the Figures in this Critical Evaluation are: $(NH_4)_3PO_4-H_3PO_4-H_2O$. These are the coordinates also used for the discussion of alkali metal orthophosphates in our earlier volume.[22]

1. $(NH_4)_3PO_4$ and its hydrates.

Most of the articles report the trihydrate $(NH_4)_3PO_4\cdot 3H_2O$ as the solid phase in equilibrium with solutions in the region having the highest concentration of NH_3. Anhydrous $(NH_4)_3PO_4$ is reported as the stable solid phase at 25 °C by Parker[2] and Flatt et al.[16] The latter authors also designated $(NH_4)_3PO_4$ as the equilibrium solid phase at 0 °C in solutions in the region having the highest NH_3 concentration. The solubility curve reported by Flatt et al.[16] is in good agreement with that reported by other authors and it is possible that Flatt and his co-workers neglected to determine the extent of hydration of the stable equilibrium solid phase. In all likelihood they used materials identical to those used by others. On the other hand, Jänecke's study at higher temperatures[5] reports that $(NH_4)_3PO_4\cdot 2H_2O$ is the stable solid phase at temperatures above 100 °C.

Reports of the solubility of $(NH_4)_3PO_4$ in solutions of NH_3 and H_3PO_4 at 273 K (Fig. 5) and at 298 K (Fig. 6) can be evaluated. The solubility data at 273 K reported by Jänecke,[3] Muromtsev[6,7] and Flatt et al.[16] agree fairly well with each other and may tentatively be accepted as correct. A comparison of the data at 298 K indicates that the data of Parker[2] and the more recent results of Vol'fkovich et al.[10] are in error and should be rejected.

2. $(NH_4)_7H_2(PO_4)_3$.

$(NH_4)_7H_2(PO_4)_3$ is reported as a stable solid phase at 333 and 348 K by Brosheer and Anderson,[11] and at 323 K by Fleet et al.[16] However, Muromtsev[6,7] did not find it at 323 K, nor does Jänecke,[5] mention it in his study at 373 K. Obviously, additional work is necessary before a recommendation can be made about the existence of this compound.

3. $(NH_4)_2HPO_4$.

The isotherms at 273 K are shown in Fig. 7 and those at 298 K in Fig. 8. These Figures represent the solubility field of $(NH_4)_2HPO_4$ in the $NH_3-H_3PO_4-H_2O$ system. From Fig. 7 it is evident that the solubility results reported at 273 K by different authors differ substantially. The evaluator's opinion is that, at 273 K, the phase diagram is markedly influenced by the possibility that the dihydrate $(NH_4)_2HPO_4\cdot 2H_2O$ is formed. According to Kaganskiy and Babenko,[19] the triple point for the simultaneous crystallization of $NH_4H_2PO_4$, $(NH_4)_2HPO_4$ and $(NH_4)_2HPO_4\cdot 2H_2O$ is at 3.4 °C. However, Balabanovich et al.[17] point out that measurements in this region are complicated by supersaturation. Therefore, the nature of the equilibrium solid phase may depend on the experimental conditions.

At 298 K, the solubility results of Parker[2] have a systematic error and must be rejected. This also appears to be true for the data presented by Flatt, Brunisholz and Dagon[16] for solutions from which $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ precipitate simultaneously in spite of the fact that their complete isotherms are in agreement with those of other authors. Vol'fkovich[9,10] presents two isotherms for this region. In one, the composition unit is g/100 g H_2O; in the other it is $100w_i$. The results of the two isotherms are not identical. The former appear to be in error and are rejected. The rest of the data[1,9,10,13] agree with each other and are recommended tentatively.

4. $NH_4H_2PO_4$.

$NH_4H_2PO_4$ crystallizes congruently in a well developed crystallization field. The data can be evaluated at 273, 298 and 323 K, Figs. 9–11. These Figures show that the data of the different investigators are in good agreement with each other, except for the eutonic points reported by Flatt, Brunisholz and Dagon.[16]

5. $NH_4H_5(PO_4)_2\cdot H_2O$.

Both Muromtsev[6,7] and Flatt[15] report that this compound has a definite crystallization field in the most acid region ($100w_i$ $H_3PO_4>61$) at 273 K. The data do have some scatter, probably due to analytical difficulties. Additional data are needed before a recommendation can be made. A similar situation exists at 298 K where Muromtsev's data[6,7] differ appreciably from those of Flatt and co-workers. The latter found crystallization fields for $NH_4H_5(PO_4)_2$ and $(NH_4)_3H_9(PO_4)_4$ in their detailed study of the region with excess H_3PO_4.[15]

6. The tentative data for the solubility isotherms of $(NH_4)_3PO_4\cdot 3H_2O$, $(NH_4)_2HPO_4$, and $NH_4H_2PO_4$ can be expressed by the following equations:

$$w_{salt}=a_0+a_1\cdot w_{acid}+a_2\cdot w_{acid}^2+a_3\cdot w_{acid}^3 \quad (6)$$

or

$$m_{salt}=b_o+b_1\cdot m_{acid}+b_2\cdot m_{acid}^2+b_3\cdot m_{acid}^3 \quad (7)$$

where salt = $(NH_4)_3PO_4$, acid = H_3PO_4, $w=100w_i$, m = mol/kg H_2O, and a and b are coefficients whose values are given in Table 1.

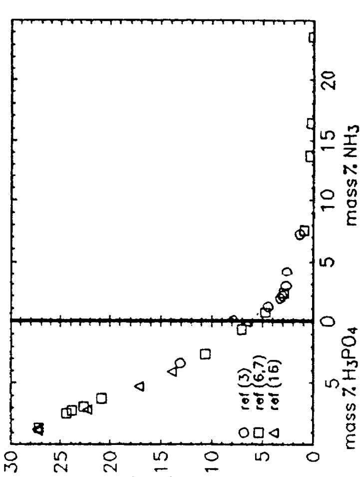

FIG. 5. Solubility of $(NH_4)_3PO_4$ in the NH_3–H_3PO_4–H_2O system at 273 K.

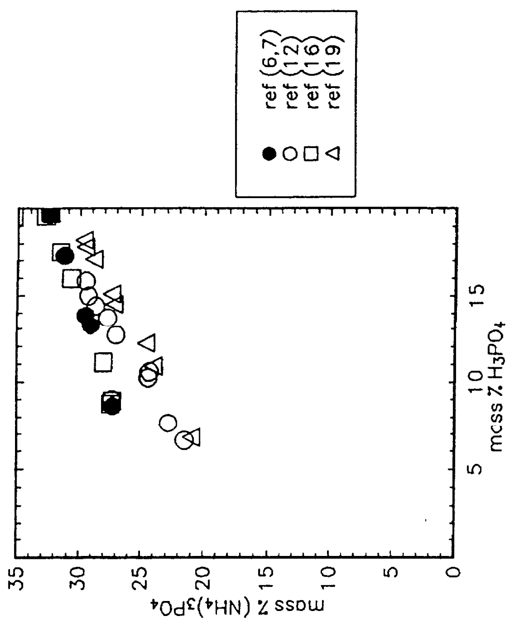

FIG. 7. Solubility branch of $(NH_4)_2HPO_4$ in the NH_3–H_3PO_4–H_2O system at 273 K.

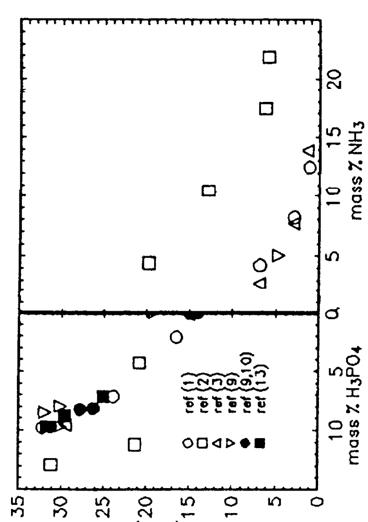

FIG. 6. Solubility of $(NH_4)_3PO_4$ in the NH_3–H_3PO_4–H_2O system at 298 K.

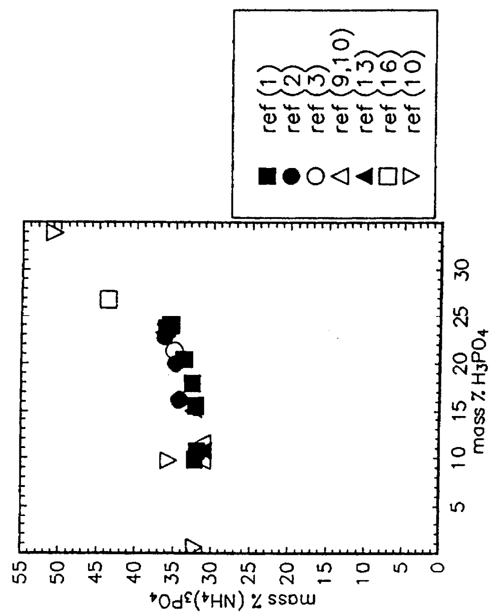

FIG. 8. Solubility branch of $(NH_4)_2HPO_4$ in the NH_3–H_3PO_4–H_2O system at 298 K.

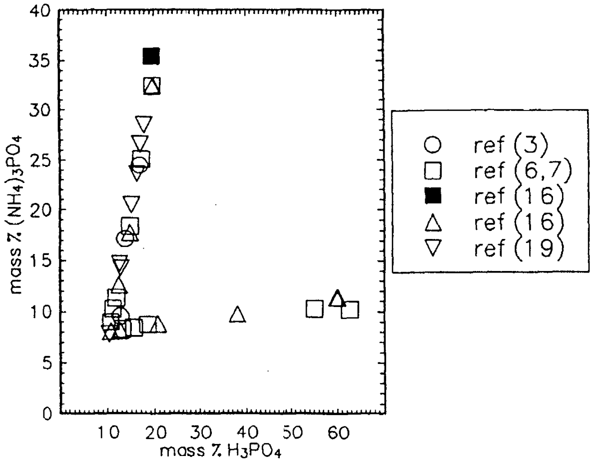

FIG. 9. Solubility branch of $NH_4H_2PO_4$ in the $NH_3-H_3PO_4-H_2O$ system at 273 K.

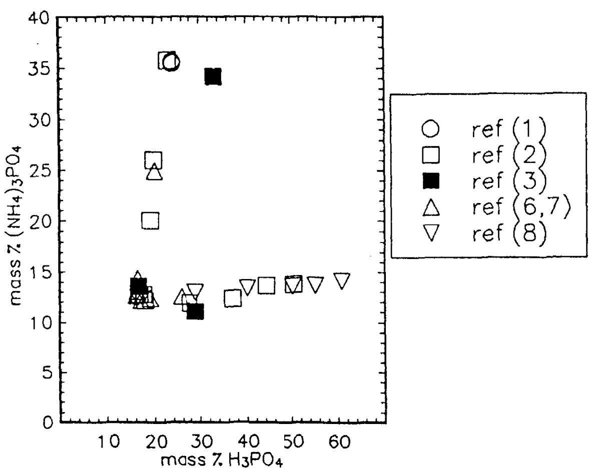

FIG. 10. Solubility branch of $NH_4H_2PO_4$ in the $NH_3-H_3PO_4-H_2O$ system at 298 K.

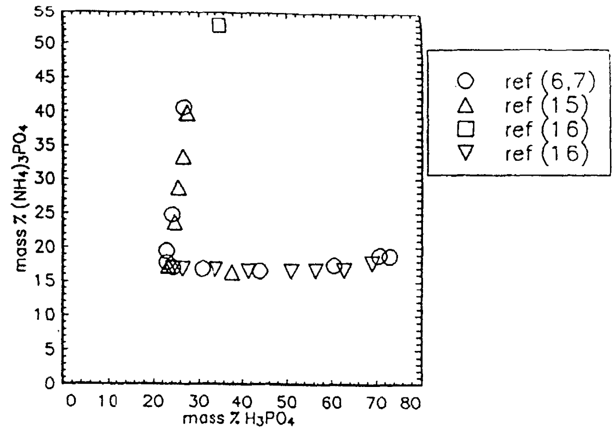

FIG. 11. Solubility branch of $NH_4H_2PO_4$ in the $NH_3-H_3PO_4-H_2O$ system at 323 K.

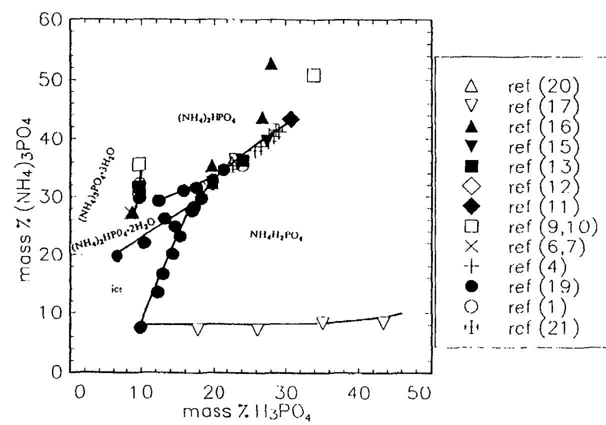

FIG. 12. Curves of simultaneous crystallization of two solid phases in the $NH_3-H_3PO_4-H_2O$ system.

Table 1a. The parameters a and b for the smoothing equations

No	T/K	Solid phase	a_0	a_1	a_2	a3
1	273	$(NH_4)_3PO_4 \cdot 3H_2O$	6.587	0.6166	0.4105	-0.02405
2	298	$(NH_4)_3PO_4 \cdot 3H_2O$	14.66	0.7367	0.06145	0.004111
3	298	$(NH_4)_2HPO_4$	32.32	0.1263	0.0	0.0004983
4[b]	273	$NH_4H_2PO_4$	16.46	2.196	0.0148	0.0
5[a]	273	$NH_4H_2PO_4$	13.21	4.145	0.2584	0.005298
6[b]	298	$NH_4H_2PO_4$	76.07	6.155	0.0	-0.002572
7[a]	298	$NH_4H_2PO_4$	3.138	1.224	0.0510	0.0006692
			b_0	b_1	b_2	b_3
8	273	$(NH_4)_3PO_4 \cdot 3H_2O$	0.4701	0.7083	1.591	-0.6248
9	298	$(NH_4)_3PO_4 \cdot 3H_2O$	1.150	0.7173	0.4319	0.0
10	298	$(NH_4)_2HPO_4$	3.700	0.3480	0.1985	0.01286
11[b]	273	$NH_4H_2PO_4$	0.05600	0.06804	0.5227	-0.06021
12[a]	273	$NH_4H_2PO_4$	0.8363	2.074	-0.8966	0.1307
13[b]	298	$NH_4H_2PO_4$	2.609	1.666	0.0	0.006842
14[a]	298	$NH_4H_2PO_4$	1.120	0.0	0.009931	0.0

[a] This is the branch of the isotherm where $m_{acid}/m_{salt} < 2$, i.e., the solubility of $NH_4H_2PO_4$ in the $NH_4H_2PO_4-(NH_4)_2HPO_4-H_2O$ system.
[b] This is the branch of the isotherm where $m_{acid}/m_{salt} > 2$, i.e., the solubility of $NH_4H_2PO_4$ in the $NH_4H_2PO_4-H_3PO_4-H_2O$ system.

Table 1b. Characteristics of the regression and the smoothing equations

No	Interval w_{acid}/m_{acid}	Mean relative error	Regression sum of squares	Residual std deviation
1	w 0 8.9	1.69	716.5	0.460
2	w 0 9.80	2.13	711.0	0.7443
3	w 9.7 24.1	1.18	58.84	0.4969
4	w 10.7 19.7	3.08	1054.09	0.7891
5	w 10.7 22	2.99	0.9506	0.5149
6	w 16.4 33.2	4.91	1417.1	1.7421
7	w 16.4 29	2.74	1.3390	0.5459
8	m 0 1.42	1.92	9.737	0.0433
9	m 0 1.72	2.30	14.76	0.0774
10	m 1.68 6.2	1.54	16.31	0.0051
11	m 1.34 4.20	2.69	28.32	0.0721
12	m 1.34 5.00	4.10	0.04209	0.0495
13	m 2.36 10.4	3.50	69.73	0.1505
14	m 2.36 5.00	3.19	0.5710	0.0632

References:

[1] J. D'Ans and G. Schreiner, Z. Phys. Chem. **75**, 95 (1911).
[2] E. G. Parker, J. Phys. Chem. **18**, 653 (1914).
[3] E. Jänecke, Z. Phys. Chem. **127**, 71 (1927).
[4] M. Voogd, Over de Bereiding von Mono- en Diammoniumphosphaat. (Technical University Delft-in honor of P.E.C. Scheffer) quoted in *Gmelins Handbuch der anorganischen Chemie*, 8th ed., 1936, Springer 1974, p. 419.
[5] E. Jänecke, Z. Phys. Chem. **177**, 7 (1936).
[6] B. A. Muromtsev, Kaliy **1**, 36 (1937).
[7] B. A. Muromtsev and L. A. Nazarova, Izv. Akad. Nauk SSSR, otd. Estestv. i Mat. Nauk 177 (1938).
[8] S. Uno, Kogyo Kagaku Zasshi **43**, 399 (1940). J. Soc. Chem. Ind. Japan, Suppl. Binding **43**, 168B (1940).
[9] S. I. Vol'fkovich, L. E. Berlin, and B. M. Mantsev, Zh. Prikl. Khim. (Leningrad) **5**, 1 (1932).
[10] S. I. Vol'fkovich, L. E. Berlin, and B. M. Mantsev, Tr. NIUIFa 228 (1940).
[11] J. C. Brosheer and J. F. Anderson, Jr., J. Am. Chem. Soc. **68**, 902 (1946).
[12] K. S. Chernova. Izv. Sektora Fiz.-Khim. Analiza, Inst. Obshch. Neorg. Khim. Akad. Nauk SSSR **15**, 112 (1947).
[13] R. Flatt, G. Brunisholz, and S. Chapuis-Gottreux, Helv. Chim. Acta **34**, 683 (1951).
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Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
J. D'Ans, O.Z. Schreiner, Z. Phys. Chem. **75**, 95-102 (1911).

Variables:
Composition at 25 °C.

Prepared By:
J. Eysseltová

Experimental Data

Solubility in the $(NH_4)_3PO_4$–NH_3–H_3PO_4–H_2O system at 25 °C

NH_3 comp[a]	H_3PO_4 comp[a]	NH_3[b] 100w_1	NH_3[b] m_1/mol kg^{-1}	H_3PO_4[b] 100w_2	H_3PO_4[b] m_2/mol kg^{-1}	H_2O[b] 100w_3	Solid phase[c]
7.42	0.084	12.6	8.57	0.82	0.097	86.5	A[d]
5.02	0.20	8.55	5.61	2.0	0.22	89.5	A[d]
2.95	0.46	5.04	3.26	4.5	0.51	90.5	A[d]
3.04	1.02	5.18	3.58	10.0	1.20	84.8	A[d]
3.32	1.32	5.65	4.08	12.9	1.62	81.4	A[d]
4.78	2.32	8.14	6.92	22.7	3.36	69.1	A[d]
6.48	3.16	11.0	11.2	31.1	5.45	58.0	A+B
6.42	3.23	10.9	11.2	31.7	5.63	57.4	B
6.46	3.74	11.0	12.3	36.7	7.15	52.3	B
6.56	4.01	11.2	13.2	39.3	8.10	49.5	B
6.78	4.34	11.5	14.8	42.5	9.45	45.9	B
7.26	4.83	12.4	18.0	47.3	12.0	40.3	B
7.16	4.82	12.2	17.6	47.2	11.9	40.6	B
7.14	4.83	12.2	17.6	47.3	11.9	40.5	B+C
7.18	4.83	12.2	17.8	47.3	11.9	40.4	B+C
7.14	4.83	12.2	17.6	47.3	11.9	40.5	B+C
7.14[e]	4.83[e]	12.2	17.6	47.3	11.9	40.5	
7.15[e]	5.10[e]	12.2	18.9	50.0	13.5	37.8	
6.86[e]	5.70[e]	11.7	21.1	55.9	17.6	32.5	
6.70	6.74	11.4	29.7	66.1	29.9	22.5	C[d]
6.72	4.54	11.4	15.3	44.5	10.3	44.1	C
5.62	3.88	9.57	10.7	38.0	7.40	52.4	C
4.62	3.36	7.87	7.80	32.9	5.68	59.2	C[d]
2.72	2.59	4.63	3.89	25.4	3.70	70.0	C
2.50	2.54	4.26	3.53	24.9	3.59	70.9	C
2.58	4.29	4.39	4.82	42.0	8.01	53.6	C
2.76	6.21	4.70	8.01	60.9	18.0	34.4	C
3.06	7.70	5.21	15.8	75.5	39.8	19.3	C
3.10	7.86	5.28	17.5	77.0	44.4	17.7	C[d]

[a]These compositions are expressed as mol/kg of solution.
[b]These values were calculated by the compiler.
[c]The solid phases are: A = $(NH_4)_3PO_4 \cdot 3H_2O$; B = $(NH_4)_2HPO_4$; C = $NH_4H_2PO_4$.
[d]These solid phases were analyzed.
[e]Metastable solutions.

Auxiliary Information

Method / Apparatus / Procedure:
The isothermal method was used. H_3PO_4 was precipitated as $NH_4MgPO_4 \cdot 6H_2O$ and weighed as $Mg_2P_2O_7$. Ammonia was distilled into an acid solution and determined volumetrically.

Source and Purity of Materials:
Commercial materials, pure.

Estimated Error:
The temperature was controlled to within 0.05 K. No other details are given. The compiler assumes the reproducibility of the analyses to be about ±0.5%.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
E. G. Parker, J. Phys. Chem. **18**, 653-61 (1914).

Variables:
Composition at 25 °C.

Prepared By:
J. Eysseltová

Experimental Data

Solubility in the NH_3–H_3PO_4–H_2O system at 25 °C

NH_3 comp[b]	H_3PO_4 comp[b]	NH_3[a] 100w_1	NH_3[a] m_1/mol kg^{-1}	H_3PO_4[a] 100w_2	H_3PO_4[a] m_2/mol kg^{-1}	H_2O[a] 100w_3	Solid phase[c]
2.77	6.09	4.72	8.22	61.57	18.63	33.72	A
2.75	5.44	4.68	6.82	55.00	13.92	40.32	A
2.50	4.61	4.26	5.09	46.60	9.68	49.14	A
2.40	3.62	4.09	4.05	36.60	6.30	59.32	A
2.45	2.64	4.17	3.54	26.69	3.94	69.14	A
2.58	2.57	4.39	3.71	25.98	3.81	69.62	A
2.58	2.67	4.39	3.76	26.99	4.01	68.61	A
4.04	3.30	6.88	6.76	33.36	5.70	59.76	A
5.23	3.77	8.91	9.87	38.11	7.34	52.98	A
7.21	4.75	12.28	18.16	48.02	12.34	39.70	A
7.30	4.76	12.43	18.51	48.12	12.45	39.45	B
7.01	4.38	11.94	16.01	44.28	10.32	43.78	B
6.90	3.95	11.75	14.28	39.93	8.43	48.32	B
6.27	3.41	10.68	11.43	34.47	6.41	54.85	C
4.28	2.57	7.29	6.41	25.98	3.97	66.73	C
4.19	1.83	7.14	5.63	18.50	2.54	74.36	C
6.59	1.33	11.22	8.75	13.45	1.82	75.33	C
8.75	0.87	14.90	11.47	8.80	1.18	76.30	C
11.48	0.43	19.55	15.08	4.35	0.58	76.10	C
14.08	0.41	23.98	19.59	4.14	0.59	71.88	C

[a]All these values were calculated by the compiler.
[b]The composition unit is: mol/1000 g of the solution.
[c]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2HPO_4$; C = $(NH_4)_3PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:
Bottles containing mixtures of ammonia and orthophosphoric acid and in contact with a solid phase were allowed to rotate in a thermostat until equilibrium was established. Ammonia and phosphorus were determined by methods described elsewhere.[1]

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given.

References:
[1]F. P. Treadwell, W. T. Hall, Analytical Chemistry, Vol II, **59**, 434 (1913).

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
E. Jänecke, Z. Phys. Chem. **127**, 71–92 (1927)

Variables:
Composition at 273 and 298 K.

Prepared By:
J. Eysseltová

Experimental Data
Solubility in the NH_3-H_3PO_4-H_2O system

NH_3 comp[a]	P_2O_5 comp[a]	H_2O comp[a]	NH_3[b] $100w_i$	NH_3[b] m_i/mol kg^{-1}	H_3PO_4[b] $100w_i$	H_3PO_4[b] m_i/mol kg^{-1}	H_2O[b] $100w_i$
			temp = 0 °C				
24.0	76.0	326	5.63	4.74	24.6	3.60	69.7
65.0[c]	34.5[c]	2110	2.94	1.82	2.16	0.232	94.9
68.0	32.0	2075	3.13	1.94	2.03	0.219	94.8
42.0	58.0	1440	2.73	1.74	5.20	0.576	92.1
86.1	19.9	1480	5.43	3.43	1.73	0.190	92.8
75.0	25.0	1870	3.81	2.37	1.75	0.189	94.4
92.2	7.80	1090	7.75	4.98	0.905	0.101	91.3
55.7	44.3	1990	2.67	1.66	2.93	0.316	94.4
34.0	66.0	659	4.48	3.15	12.0	1.47	83.5
31.0	69.0	257	8.68	7.89	26.7	4.21	64.6
26.0	74.0	210	8.39	8.40	33.0	5.73	58.7
19.2	80.8	486	3.28	2.48	19.0	2.50	77.7
24.5	75.5	315	5.90	5.03	25.1	3.72	69.0
6.00	94.0	65.8	3.62	11.7	78.3	44.1	18.1
			temp = 25 °C				
95.3	4.70	563	14.4	9.97	0.979	0.118	84.6
85.8	14.2	881	8.75	5.75	2.00	0.228	89.3
60.7	39.3	1090	5.10	3.32	4.56	0.515	90.3
41.5	58.5	705	5.16	3.57	10.0	1.21	84.8
32.5	67.5	222	10.1	9.72	28.9	4.84	61.0
27.2	72.8	127	12.0	16.1	44.3	10.3	43.7
22.5	77.5	92.2	11.7	21.1	55.7	17.4	32.6
20.1	79.9	333	4.64	3.90	25.5	3.72	69.9
12.6	87.4	232	3.80	3.72	36.3	6.20	59.9
8.60	91.4	63.7	5.25	17.5	77.1	44.6	17.7

[a]The composition unit is: g/100 g (NH_3 + P_2O_5).
[b]These values were calculated by the compiler.
[c]This is the only solution for which the total amount of (NH_3 + P_2O_5) is not equal to 100. At least one of these values is likely to be in error.

Auxiliary Information

Method / Apparatus / Procedure:
No information is given.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
M. Voogd, Over de Bereiding van Mono- en Diamoniumphosphaat (Technical University of Delft, in honor of P.E.O. Scheffer) 5 (1934) [quoted in Ref. (1)].

Variables:
Temperature and composition.

Prepared By:
J. Eysseltová

Experimental Data
Solubility in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–H_2O system

t/°C	NH_4^+ comp[a]	PO43− comp[a]	NH_3[b] $100w_i$	NH_3[b] m_i/mol kg^{-1}	H_3PO_4[b] $100w_i$	H_3PO_4[b] m_i/mol kg^{-1}	H_2O[b] $100w_i$	Solid phases[c]
60	8.29	5.72	14.1	27.8	56.1	19.2	29.8	A+B
55	8.13	5.60	13.8	26.0	54.9	17.9	31.3	A+B
50	7.97	5.47	13.6	24.3	53.6	16.7	32.8	A+B
45	7.78	5.31	13.3	22.4	52.0	15.3	34.7	A+B
40	7.64	5.18	13.0	21.1	50.8	14.3	36.2	A+B
60	7.39	5.22	12.6	20.4	51.2	14.4	36.3	A
55	5.73	4.53	9.76	12.5	44.4	9.88	45.8	A
60	8.20	5.54	14.0	25.8	54.3	17.4	31.7	B
55	7.49	4.65	12.8	18.0	45.6	11.2	41.7	B

[a]The composition units are: mol/1000 g solution.
[b]All these data were calculated by the compiler.
[c]The solid phases are: A=$NH_4H_2PO_4$; B=$(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:
No information is given.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given.

References:
[1]Gmelins Handbuch der anorganischen Chemie, 8th ed., Springer, 1974, p. 419 (1934).

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
E. Jänecke, Z. Phys. Chem. **177**, 7-16 (1936).

Variables:
Composition and temperature.

Prepared By:
J. Eysseltová

Experimental Data

Part I. The temperature at which the last crystal disappeared in the NH_3–H_3PO_4–H_2O system

NH_3 100w_i	H_2O 100w_i	t_1/°C[a]	t_2/°C[a]	NH_3[b] m_i/mol kg^{-1}	H_3PO_4[b] 100w_i	H_3PO_4[b] m_i/mol kg^{-1}	Solid phase
6.50	35.0	90	-	10.9	58.5	17.1	$NH_4H_5(PO_4)_2$
5.90	3.0	50	48	115	91.1	310	$NH_4H_5(PO_4)_2$
11.3	2.2	185	184	302	86.5	401	$NH_4H_2PO_4$
8.50	30.0	126	--	16.6	61.5	20.9	$NH_4H_2PO_4$
6.50	30.0	88		12.7	63.5	21.6	$NH_4H_2PO_4$
11.0	35.0	93	--	18.5	54.0	15.7	$NH_4H_2PO_4$
8.50	35.0	65	-	14.3	56.5	16.5	$NH_4H_2PO_4$
10.0	40.0	88	--	14.7	50.0	12.8	$NH_4H_2PO_4$
17.0	30.7			32.5	52.3	17.4	$(NH_4)_2HPO_4$
18.5	22.6	164		48.1	58.9	26.6	$(NH_4)_2HPO_4$
16.4	18.4	~180		52.3	65.2	36.2	$(NH_4)_2HPO_4$
15.0	30.0	110		29.4	55.0	18.7	$(NH_4)_2HPO_4$
12.5	30.0	100?		24.5	57.5	19.6	$(NH_4)_2HPO_4$
13.5	35.0	72		22.6	51.5	15.0	$(NH_4)_2HPO_4$
13.2	41.8	58		18.5	45.0	11.0	$(NH_4)_2HPO_4$
12.5	40.0	53		18.3	47.5	12.1	$(NH_4)_2HPO_4$
22.6	19.2	185?	—	69.1	58.2	30.9	$(NH_4)_3PO_4 \cdot 2H_2O$
21.5	22.3	189	185	56.6	56.2	25.7	$(NH_4)_3PO_4 \cdot 2H_2O$
18.5	32.6	147	144	33.3	48.9	15.3	$(NH_4)_3PO_4 \cdot 2H_2O$
18.7	36.6	148	148	30.2	45.0	12.6	$(NH_4)_3PO_4 \cdot 2H_2O$
19.1	41.1	149	—	27.3	39.8	9.88	$(NH_4)_3PO_4 \cdot 2H_2O$
16.7	40.9	124	--	24.0	42.4	10.6	$(NH_4)_3PO_4 \cdot 2H_2O$
19.3	58.9	115	114	19.2	21.8	3.78	$(NH_4)_3PO_4 \cdot 2H_2O$
18.6	57.0	138	—	19.2	24.4	4.37	$(NH_4)_3PO_4 \cdot 2H_2O$
27.0	17.1	121	121	92.7	55.9	33.4	$(NH_4)_3PO_4 \cdot 2H_2O$
16.6	57.3	117	116	17.0	26.1	4.65	$(NH_4)_3PO_4 \cdot 2H_2O$
16.5	51.4	125?	—	18.8	32.1	6.37	$(NH_4)_3PO_4 \cdot 2H_2O$
15.3	52.5	114	113	17.1	32.2	6.26	$(NH_4)_3PO_4 \cdot 2H_2O$
13.9	53.9	95	—	15.1	32.2	6.10	$(NH_4)_3PO_4 \cdot 2H_2O$
17.8	69.6	101	100	15.0	12.6	1.85	$(NH_4)_3PO_4 \cdot 2H_2O$

[a]The meaning of t_1 and t_2 is not defined. The compiler's opinion is that these are the results of repeated measurements.
[b]These values were calculated by the compiler.

Part II. The characterization of the miscibility gap in the above systems

NH_3 100w_i	H_2O 100w_i	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] 100w_i	H_3PO_4[a] m_i/mol kg^{-1}	t_1/°C[b]	t_2/°C[b]	t_3/°C[b]	t_4/°C[b]	R[b]
24.9	18.5	79.0	56.6	31.2	—	179	194	—	
27.2	36.9	43.3	35.9	9.93	146	175	180	—	—
27.2	27.2	58.7	45.6	17.1	—	—	195; 195	155	3:2
24.4	28.3	50.6	47.3	17.1	138	158	183; 180	—	3:1
27.0	38.4	41.3	34.6	9.19	160	171	explosion	—	3:1
25.6	38.1	39.5	36.3	9.72	125	160	170; 170	148	5:2
24.0	36.4	38.7	39.6	11.1	138	165	175	157	3:1
22.3	31.0	42.2	46.7	15.4	95	142; 140	170; 167	152	3:1
22.0	31.9	40.5	46.1	14.7	122	142	164	—	1:3
21.8	32.6	39.3	45.6	14.3	115	155	160	125	3:1
22.8	41.3	32.4	35.9	8.87	140	147	162	110	5:2
23.5	45.5	30.3	31.0	6.95	—	158	164; 162	148	4:1
20.2	51.2	23.2	28.6	5.70	151	145	155; 152	—	2:1
21.9	47.0	27.4	31.1	6.75	130	149	162	—	—
20.9	54.5	22.5	24.6	4.61	80	141	144; 144	105	—
20.5	60.3	20.0	19.2	3.25	—	144	147; 147	138	1:1

[a]These data were calculated by the compiler.
[b]The meaning of the terms is as follows:
t_1..the temperature at which one liquid phase was observed during heating.
t_2..the temperature at which the other liquid phase appeared.
t_3..the temperature at which the last crystal disappeared.
t_4..the temperature at which the first crystal appeared during cooling.
R..approximate ratio of the amount of upper layer to that of the lower layer.

Auxiliary Information

Method / Apparatus / Procedure:
The only information given is that a self-constructed apparatus was used.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given. The compiler estimates the reproducibility of the temperature measurement to be about 2 °C.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
1. B.A. Muromtsev, Kaliy 1937, **1**, 36-9. 2. B.A. Muromtsev, L.A. Nazarova, Izv. Akad. Nauk SSSR, Otd. Estestv. i. Mat. Nauk 177-84 (1938).

Variables:
Composition at 273, 298 and 323 K

Prepared By:
L.V. Chernykh and J. Eysseltová

Experimental Data

Table I. Solubility in the $NH_3-H_3PO_4-H_2O$ system at 0 °C

NH_3[a] $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$	$(NH_4)_2O$ $100w_i$	P_2O_5 $100w_i$	$(NH_4)_2O$ $100x_i$	P_2O_5 $100x_i$	Solid phase[b]
				temp = 0 °C[c]					
23.71	18.27	0.070	0.009	76.22	36.25	0.05	16.45	0.009	A
16.48	11.61	0.150	0.018	83.37	25.18	0.11	10.44	0.017	A
13.88	9.49	0.230	0.027	85.89	21.21	0.17	8.53	0.025	A
7.85	5.04	0.620	0.069	91.53	12.00	0.45	4.53	0.062	A
3.22	1.99	1.88	0.202	94.90	4.92	1.36	1.78	0.18	A
2.26	1.40	3.10	0.334	94.64	3.46	2.24	1.25	0.30	A
2.41	1.53	5.24	0.579	92.35	3.68	3.79	1.35	0.51	A
3.65	2.47	9.65	1.14	86.70	5.58	6.99	2.14	0.98	A
7.14	5.75	19.92	2.79	72.94	10.90	14.42	4.70	2.28	A
7.78	6.49	21.81	3.16	70.41	11.89	15.80	5.25	2.56	A
8.18	6.97	22.92	3.39	68.90	12.50	16.60	5.59	2.72	A
8.35	7.19	23.50	3.52	68.15	12.76	17.02	5.75	2.81	A
9.34	8.56	26.56	4.23	64.10	14.28	19.22	6.68	3.30	A+B
9.97	10.15	32.35	5.72	57.68	15.23	23.43	7.57	4.27	B
10.12	10.50	33.26	5.99	56.62	15.49	24.07	7.78	4.43	B
10.71	12.22	37.84	7.50	51.45	16.39	27.40	8.68	5.32	B
11.14	13.68	41.06	8.77	47.80	17.04	29.75	9.37	6.00	B+C
8.60	8.76	33.76	5.98	57.64	13.14	24.45	6.49	4.43	C
6.32	5.57	27.02	4.14	66.66	9.67	19.59	4.36	3.24	C
3.89	2.98	19.37	2.58	76.74	5.95	14.03	2.45	2.12	C
3.52	2.63	17.98	2.34	78.50	5.38	13.02	2.19	1.94	C
3.07	2.25	16.65	2.12	80.28	4.69	12.03	1.88	1.76	C
2.85	2.13	18.69	2.43	78.46	4.35	13.52	1.76	2.01	C
2.90	2.24	21.19	2.85	75.91	4.43	15.34	1.83	2.32	C
3.00	2.42	24.25	3.40	72.75	4.59	17.57	1.94	2.73	C
3.52	5.99	61.96	18.32	34.52	5.38	44.90	3.24	9.94	C
3.50	7.60	69.46	26.21	27.04	5.35	50.27	3.32	12.10	C+D
3.54	8.19	71.09	28.59	25.37	5.41	51.50	3.64	12.69	D
3.25	7.65	71.80	29.36	24.95	4.97	52.00	3.35	12.85	D
2.70	6.97	74.54	33.42	22.76	4.13	54.00	2.85	13.62	D
2.96	8.67	77.00	39.21	20.04	4.52	55.80	3.24	14.65	D
2.82	9.22	79.22	45.01	17.96	4.31	57.35	3.17	15.44	D
3.40	15.76	83.93	67.59	12.67	5.20	60.75	4.14	17.68	D
3.52	17.33	84.55	72.32	11.93	5.38	61.25	4.33	18.06	E
2.92	15.99	86.36	82.20	10.72	4.46	62.50	3.63	18.65	F
1.71	6.54	82.93	55.09	15.36	2.61	60.06	1.97	16.59	F
				temp = 25 °C[c]					
4.31	4.11	34.09	5.65	61.60	6.59	24.69	3.08	4.22	C
4.25	3.64	27.20	4.05	68.55	6.50	19.70	2.86	3.18	C
4.18	3.47	25.09	3.62	70.73	6.59	18.18	2.77	2.89	C
4.34	3.58	24.46	3.51	71.20	6.64	17.72	2.87	2.80	C
4.48	3.73	24.92	3.60	70.60	6.85	18.05	2.95	2.87	C
2.93	2.42	25.94	3.72	71.13	7.54	18.79	3.32	3.03	C
8.55	9.14	36.50	6.78	54.95	13.05	26.44	6.62	4.91	C
5.22	22.91	81.40	62.08	13.38	7.98	58.96	6.38	17.27	C+E
3.27	20.67	87.44	96.04	9.29	5.00	63.33	4.17	19.40	E
2.90	20.84	88.93	111.1	8.17	4.43	64.41	3.74	20.11	E
				temp = 50 °C					
12.26	8.50	3.01	0.362	84.73	18.76	2.18	7.56	0.32	A
9.35	6.71	8.80	1.10	81.85	14.31	6.38	5.82	0.95	A
8.97	6.85	14.10	1.87	76.93	13.72	10.21	5.78	1.58	A
9.33	7.54	18.05	2.54	72.62	14.27	13.08	6.23	2.09	A
11.18	10.98	29.02	4.95	59.80	17.11	21.02	8.40	3.79	A
11.49	11.72	30.96	5.49	57.55	17.58	22.43	8.83	4.13	A+B
12.20	13.34	34.10	6.48	53.70	28.67	24.70	9.75	4.73	B
12.03	13.26	34.71	6.65	53.26	18.41	25.14	9.65	4.83	B
12.00	13.25	34.81	6.68	53.19	18.36	25.22	9.61	4.85	B
12.03	13.47	35.52	6.91	52.45	18.41	25.73	9.73	4.98	B
12.07	13.67	36.07	7.10	51.86	18.47	26.13	9.82	5.09	B
12.28	14.70	38.67	8.04	49.05	18.79	28.01	10.41	5.70	B
12.64	16.49	42.35	9.60	45.01	19.34	30.68	11.05	6.43	B
13.88	24.76	53.20	16.49	32.92	21.24	38.54	14.01	9.32	B+C
8.50	9.77	40.42	8.07	51.08	13.00	29.28	6.81	5.63	C
6.68	6.80	35.63	6.30	57.69	10.22	25.81	4.99	4.63	C
6.10	6.04	34.58	5.95	59.32	9.33	25.05	4.48	4.41	C
5.84	5.85	35.51	6.18	58.65	8.94	25.78	4.31	4.55	C
5.77	6.47	41.88	8.16	52.35	8.82	30.34	4.50	5.68	C
5.68	8.43	54.77	14.13	39.55	8.68	39.68	5.03	8.43	C
5.97	15.86	71.92	33.19	22.11	9.13	52.09	6.50	13.62	C
6.48	36.27	83.03	80.77	10.49	9.91	60.14	8.36	18.60	C
6.44	45.95	85.33	105.8	8.23	9.85	61.80	8.60	19.80	C
5.88	56.98	88.06	148.3	6.06	8.99	63.78	8.09	21.07	B+C
13.81	24.71	53.37	16.59	32.82					E

[a]These values were calculated by the compilers.
[b]The solid phases are: A = $(NH_4)_3PO_4\cdot 3H_2O$; B = $(NH_4)_2HPO_4$; C = $NH_4H_2PO_4$; D = $NH_4H_5(PO_4)_2\cdot H_2O$; E = $NH_4H_5(PO_4)_2$; F = $2H_3PO_4\cdot H_2O$.
[c]These data appear only in source paper 2.

ADDITIONAL DATA: In source paper 1 the composition of the solution saturated simultaneously with $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ at 323 K is reported as 13.81 mass % NH_3 (24.72 mol kg^{-1} –compilers) and 53.37 mass % H_3PO_4 (8.36 mol kg^{-1}–compilers).

Auxiliary Information

Method / Apparatus / Procedure: The isothermal method was used. The composition of the solid phases was determined microscopically and with the use of the Schreinemakers method.

Source and Purity of Materials: Chemically pure ammonia and analytical reagent grade H_3PO_4 were used. The materials were purified by repeated freezing.

Estimated Error:
The temperature was kept constant within 0.05 K.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

1. S.I Vol'fkovich, L.E. Berlin, B.M. Mantsev, Zh. Prikl. Khim. (Leningrad) **5**, 1 (1932). 2. S.I Vol'fkovich, L.E. Berlin, B.M. Mantsev, Tr. NIUIFa 228-42 (1940).

Variables:

Composition at 25 °C.

Prepared By:

L.V. Chernykh and J. Eysseltová

Experimental Data

Table I. Solubility in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–H_2O system at 25 °C.

$NH_4H_2PO_4$ g/100g H_2O	$(NH_4)_2HPO_4$ g/100g H_2O	NH_3[a] $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$	Solid phase[b]
41.3	0.0	4.33	3.59	24.9	3.59	70.8	A
43.7	4.00	5.08	4.40	27.2	4.10	67.7	A
53.7	27.2	8.27	8.79	36.4	6.73	55.3	A
60.1	43.2	9.86	11.8	41.0	8.50	49.2	A
59.2	71.6	11.8	16.0	44.9	10.6	43.3	A
66.9	80.8	12.4	18.1	47.2	11.9	40.4	A+B
0.0	74.5	11.0	11.3	31.7	5.64	57.3	B

Table II. Solubility in the $(NH_4)_2HPO_4$–$(NH_4)_3PO_4$–H_2O system at 25 °C.[c]

$(NH_4)_2HPO_4$ g/100g H_2O	$(NH_4)_3PO_4$ g/100g H_2O	NH_3[a] $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$	Solid phase[b]
74.5	0.0	11.0	11.3	31.7	5.64	57.3	B
64.3	6.59	11.0	11.1	30.5	5.31	58.5	B+C
52.4	6.45	9.90	9.23	27.1	4.40	63.0	C
47.5	6.24	9.36	8.45	25.6	4.02	65.0	C
0.0	23.4	6.50	4.71	12.5	1.57	81.0	C

Table III. Solubility in the NH_3–H_3PO_4–H_2O system at 25 °C.

NH_3 $100w_i$	P_2O_5 $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$	Solid phase[b]
4.23	18.1	3.51	25.0	3.60	70.8	A
5.08	19.7	4.40	27.2	4.10	67.7	A
6.53	22.8	6.19	31.5	5.18	62.0	A
8.26	26.4	8.77	36.5	6.73	55.3	A
9.84	29.7	11.8	41.0	8.51	49.2	A
11.8	32.6	16.0	45.0	10.6	43.2	A
12.5	34.2	18.2	47.2	12.0	40.3	A+B
10.7	23.2	11.0	32.0	5.71	57.3	B
10.7	21.9	10.6	30.2	5.22	59.1	B+C
9.52	19.2	8.74	26.5	4.23	64.0	C
8.98	18.4	8.04	25.4	3.95	65.6	C
4.79	6.66	3.27	9.20	1.09	86.0	C
6.70	2.29	4.36	3.16	0.358	90.1	C

[a] These values were calculated by the compilers.
[b] The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2HPO_4$; C = $(NH_4)_3PO_4 \cdot 3H_2O$.
[c] These data appear in source paper 2 only. The rest of the data are in both source papers.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. Equilibration required 4 to 5 days. The composition of the solid phases was determined by the Schreinemakers method.

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was kept constant within 0.05 K.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

S. Uno, Kogyo Kagaku Zasshi **43**, 399-402 (1940); J. Soc. Chem. Ind., Japan, Suppl. Binding **43**, 168B-70B (1940).

Variables:

Composition at 25 and 70 °C.

Prepared By:

J. Eysseltová and Hiroshi Miyamoto

Experimental Data

Composition of the saturated solutions[a]

$NH_4H_2PO_4$ g/100g H_2O	H_3PO_4 g/100g H_2O	NH_3[b] $100w_i$	NH_3[b] m_i/mol kg^{-1}	H_3PO_4[b] $100w_i$	H_3PO_4[b] m_i/mol kg^{-1}	H_2O[b] $100w_i$
			temp = 25 °C			
40.7	0	4.28	3.54	24.6	3.54	71.1
51.9	20.5	4.46	4.51	37.5	6.60	58.0
66.6	48.9	4.58	5.79	49.0	10.8	46.4
87.3	90.6	4.65	7.59	59.4	16.8	36.0
102.2	119.3	4.706	8.884	64.19	21.06	31.10
130.7	169.3	4.837	11.36	70.16	28.64	25.00
239.0	336.5	5.238	20.78	79.96	55.11	14.80
			temp = 70 °C			
100.7	0	7.428	8.753	42.74	8.753	49.83
105.7	14.10	7.119	9.188	47.38	10.63	45.50
110.7	23.80	6.988	9.623	50.36	12.05	42.64
136.1	61.60	6.768	11.83	59.64	18.12	33.59
157.1	96.50	6.577	13.66	65.14	23.50	28.28
249.9	206.5	6.649	21.72	75.37	42.79	17.97

[a] The nature of the solid phase was not reported.
[b] These values were calculated by the compilers.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. Ammonium dihydrogenphosphate, phosphoric acid and water were placed in ampules. The mixtures were shaken in a thermostat at 25 and 70 °C. After equilibrium was etablished, the mixtures were allowed to settle. A pipet was used in sampling aliquots of the saturated solution for analysis.

Source and Purity of Materials:

Chemically pure reagents were used. Ammonium dihydrogenphosphate was recrystallized.

Estimated Error:

Solubility: nothing specified. Temperature: precision ±0.05 K at 298 K and ±0.5 K at 343 K.

Components:
(1) Ammonia, NH_3; [7664-41-7]
(2) Phosphoric acid, H_3PO_4; [7664-38-2]
(3) Water, H_2O; [7732-18-5]

Original Measurements:
J.C. Brosheer, J.F. Anderson, Jr., J. Am. Chem. Soc. **68**, 902-4 (1946).

Variables:
Composition at 60 and 75 °C

Prepared By:
J. Eysseltová

Experimental Data

Table I. Solubility in the NH_3–H_3PO_4–H_2O system at 75 °C. The solid phase was determined by microscopic examination

NH_3		H_3PO_4		H_2O[a]	
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$ [a]	Solid phases[b]
6.75	13.49	63.86	22.17	29.39	A
6.87	11.52	58.11	16.93	35.02	A
6.98	10.73	54.81	14.64	38.21	A
7.02	10.76	54.67	14.56	38.31	A
7.25	9.91	49.79	11.83	42.96	A
7.23	9.47	47.96	10.92	44.81	A
7.48	9.29	45.25	9.77	47.27	A
7.71	9.46	44.42	9.47	47.87	A
7.81	9.62	44.54	9.54	47.65	A
7.80	9.68	44.86	9.67	47.34	A
8.11	10.14	44.91	9.75	46.98	A
8.20	10.31	45.11	9.86	46.69	A
8.53	10.85	45.31	10.02	46.16	A
9.22	12.37	47.02	10.96	43.76	A
9.27	12.50	47.17	11.05	43.56	A
9.60	13.27	47.93	11.52	42.47	A
9.82	13.69	48.05	11.64	42.13	A
9.90	13.85	48.13	11.70	41.97	A
10.54	15.58	49.73	12.77	39.73	A
11.09	17.20	51.06	13.77	37.85	A
11.34	17.97	51.61	14.21	37.05	A
11.52	18.54	52.00	14.55	36.48	A
12.07	20.44	53.25	15.67	34.68	A
12.50	21.96	54.07	16.50	33.43	A
13.04	24.00	55.05	17.60	31.91	A
13.14	24.83	55.79	18.32	31.07	A
14.10	29.34	57.68	20.86	28.22	A
14.34	30.65	58.19	21.62	27.47	A
14.39	31.07	58.41	21.91	27.20	A
14.61	31.96	58.55	22.26	26.84	A
17.89	25.91	59.23	26.42	25.88	A+B
14.70	30.34	56.85	20.39	28.45	B
14.47	26.15	53.04	16.66	32.49	B
14.24	23.34	49.93	14.22	35.83	B
13.82[c]	20.44	46.48[c]	11.95	39.70	B
13.58	17.76	41.53	9.44	44.89	B
13.42	16.61	39.13	8.41	47.45	B
13.38	16.39	38.69	8.24	47.93	B

[a]These values were calculated by the compiler.
[b]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2HPO_4$.
[c]This is the average of five determinations.

Table II. Solubility in the NH_3–H_3PO_4–H_2O system at 75 °C. The solid phase was determined by the Schreinemakers' method

NH_3		H_3PO_4		H_2O	
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$ [a]	Solid phases[b]
6.85	31.42	80.35	64.05	12.80	A
6.72	21.87	75.24	42.56	18.04	A
13.55[c]	16.24[c]	37.46	7.80	48.99	B+C
12.88	14.68	35.61	7.05	51.51	C
12.47	13.43	33.02	6.18	54.51	C
12.08	12.16	29.57	5.17	58.35	C
11.91	11.48	27.16	4.55	60.93	C
11.98	11.30	25.74	4.22	62.28	C
11.83	10.59	22.60	3.52	65.57	C
11.94	10.43	20.86	3.17	67.20	C
12.15	9.79	14.96	2.09	72.89	C
13.47	10.18	8.86	1.16	77.67	C
15.40	11.41	5.36	0.690	79.24	C
20.47	15.49	1.92	0.252	77.61	C
23.73	18.53	1.09	0.148	75.18	C

Table III. Solubility in the NH_3–H_3PO_4–H_2O system at 60 °C. The solid phase was determined by the Schreinemakers' method

NH_3		H_3PO_4		H_2O	
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$ [a]	Solid phases[b]
12.74	16.26	41.24	9.14	46.02	B
12.36	14.61	37.96	7.80	49.68	B
12.45	14.39	36.76	7.39	50.79	B
12.54	14.28	35.90	7.10	51.56	B
12.62	14.34	35.69	7.05	51.69	B+C
12.64	14.34	35.61	7.02	51.75	B+C
11.72	12.04	31.13	5.56	57.15	C
11.04	10.29	25.98	4.21	62.98	C

[a]These values were calculated by the compiler.
[b]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2HPO_4$; C = $(NH_4)_7H_2(PO_4)_3$ or $(NH_4)_3PO_4 \cdot 2(NH_4)_2HPO_4$.
[c]This is the average of four determinations.

Auxiliary Information

Method / Apparatus / Procedure:

Mixtures were placed in 300 ml glass-stoppered bottles which were rotated end-over-end in a constant temperature bath for at least 3 days. Mixtures in which the vapor pressure of NH_3 prevented accurate sampling from open flasks were placed in special flasks for use under pressure. Aliquots of HCl solns of the samples were analyzed for NH_3 by addition of alkali and distillation into standard acid. Other aliquots were analyzed for H_3PO_4 by double precipitation as $NH_4MgPO_4 \cdot 6H_2O$ and ignition to $Mg_2P_2O_7$.

Source and Purity of Materials:

Reagent grade H_3PO_4, monoammonium phosphate, diammonium phosphate and aqueous ammonia were used. Recrystallization did not alter the solubility of the salts.

Estimated Error:

The temperature was kept constant to within ±0.05 K. Duplicate results were accepted only when they agreed within 0.5%.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

K.S. Chernova, Izv. Sektora Fiz. Khim. Analiza, Inst. Obshch. Neorg. Khim. Akad. Nauk SSSR **15**, 112-7 (1947).

Variables:

Composition at 0 °C in the region where $(NH_4)_2HPO_4 \cdot 2H_2O$ and $(NH_4)_2HPO_4$ are the solid equilibrium phases.

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the crystallization field of $(NH_4)_2HPO_4 \cdot 2H_2O$ in the $(NH_4)_3PO_4-H_3PO_4-H_2O$ system at 0 °C

NH_3		H_3PO_4		H_2O	
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$ [a]	Solid phase[b]
9.35	8.62	26.95	4.32	63.70	A
7.80	6.58	22.60	3.31	69.60	B
7.38	6.03	20.79	2.95	71.83	B
8.38	7.53	26.31	4.11	65.31	B
8.31	7.49	26.52	4.15	65.17	B
9.25	9.00	30.40	5.14	60.35	B
9.50	9.52	31.93	5.56	58.57	B
		32.20[c]			B
9.85	10.17	33.30	5.98	56.85	D
10.04	10.58	34.24	6.27	55.72	B
10.12	10.88	35.26	6.59	54.62	B
10.71	12.22	37.84	7.50	51.45	A
11.14	13.68	41.06	8.77	47.80	A+C

[a] These values were calculated by the compiler.
[b] The solid phasaes are: A = $(NH_4)_2HPO_4$; B = $(NH_4)_2HPO_4 \cdot 2H_2O$; C = $NH_4H_2PO_4$.
[c] The meaning of this point is not clear. The compiler assumes it is a parallel analysis of H_3PO_4 in the solution above.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used with mechanical stirring and an ice-water mixture as the bath. The equilibrium was ascertained by repeated analyses of the liquid phase (no details are given). Equilibrium was reached within 24 hrs.

Source and Purity of Materials:

Anhydrous $(NH_4)_2HPO_4$ was recrystallized from a solution containing a small excess of ammonia. No other information is given.

Estimated Error:

No information is given.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, S. Chapuis-Gottreux, Helv. Chim. Acta **34**, 683-91 (1951).

Variables:

Composition at 25 °C.

Prepared By:

J. Eysseltová

Experimental Data

Composition of saturated solutions of the $NH_4^+-H^+-PO_4^{3-}-H_2O$ system at 25 °C

NH_4^+	H^+	H_2O	NH_3 [b]		H_3PO_4 [b]		H_2O [b]	
ion %	ion %	comp[a]	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	Solid phases[c]
8.96	91.04	5.30	4.34	93.82	92.94	349.0	2.72	A
9.31	90.69	14.00	4.31	36.90	88.83	132.1	6.86	A
10.56	89.44	21.60	4.69	27.13	85.16	85.64	10.15	A
10.83	89.17	21.80	4.80	27.57	84.98	84.85	10.22	A
11.11	88.89	24.10	4.86	25.58	83.97	76.76	11.16	B+C
12.72	87.28	27.80	5.44	25.39	81.99	66.54	12.57	C
12.95	87.05	36.50	5.32	19.69	78.81	50.68	15.87	C
13.10	86.90	37.00	5.37	19.65	78.59	49.99	16.04	C
14.01	85.99	91.00	4.64	8.54	63.49	20.33	31.87	C
14.24	85.76	94.00	4.66	8.41	62.78	19.68	32.56	C
17.08	82.92	163.0	4.48	5.81	50.30	11.35	45.22	C
20.76	79.24	246.0	4.39	4.68	40.56	7.52	55.05	C
25.07	74.93	349.0	4.28	3.99	32.72	5.30	63.00	C
30.33	69.67	473.0	4.20	3.56	26.54	3.91	69.26	C
32.60	67.40	512.0	4.25	3.53	25.04	3.61	70.71	C
34.97	65.03	487.0	4.71	3.98	25.85	3.80	69.44	C
37.30	62.70	421.0	5.53	4.92	28.43	4.39	66.04	C
40.70	59.30	345.0	6.81	6.55	32.10	5.36	61.09	C
47.38[d]	50.62[d]	210.0	10.27	12.52	41.57	8.81	48.16	C
49.80	50.20	150.0	12.44	18.42	47.91	12.33	39.65	C+D
58.63	41.37	262.0	11:11	12.42	36.35	7.06	52.54	D
65.57	34.43	340.0	10.62	10.70	31.08	5.44	58.29	D
68.23	31.77	348.0	10.86	10.88	30.53	5.32	58.61	D+E
68.01	31.99	353.0	10.74	10.69	30.29	5.24	58.98	E
68.95	31.05	396.0	10.14	9.66	28.22	4.67	61.64	E
69.81	30.19	521.0	8.59	7.44	23.60	3.55	67.82	E
100.0	0.00	1610	5.01	3.45	9.61	1.15	85.38	E

[a] The composition unit is: mol/100 mol solute.
[b] These values were calculated by the compiler.
[c] The solid phases are: A = $(NH_4)H_5(PO_4)_2$(?); B = $(NH_4)_3H_9(PO_4)_4$; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$; E = $(NH_4)_3PO_4$.
[d] **COMPILER'S COMMENT:** The mol % data for this solution appear to be incorrect.

Auxiliary Information

Method / Apparatus / Procedure:

No information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
R. Flatt, G. Brunisholz, O. Blumer, Helv. Chim. Acta **38**, 753-69 (1955).

Variables:
Composition at 25 °C.

Prepared By:
J. Eysseltová

Experimental Data

Composition of saturated solutions of the $NH_4^+ - H^+ - PO_4^{3-} - H_2O$ system at 25 °C

NH_4^+ ion %	H^+ ion %	H_2O comp[a]	NH_3[b] 100w_1	NH_3[b] m_1/mol kg^{-1}	H_3PO_4[b] 100w_2	H_3PO_4[b] m_2/mol kg^{-1}	H_2O[b] 100w_3	Solid phases[c]
12.8	87.2	30.5	5.40	23.3	81.0	60.65	13.6	A+B
12.8	87.2	30.3	5.41	23.4	81.1	61.05	13.5	A+B
12.8	87.2	30.1	5.41	23.6	81.1	61.46	13.5	B
12.8	87.2	28.9	5.44	24.6	81.6	64.01	13.0	B
12.7	87.3	28.4	5.41	24.8	81.8	65.13	12.8	B
12.7	87.3	26.8	5.45	26.3	82.3	69.02	12.3	B+C
11.4	88.6	23.7	4.99	26.7	84.0	78.05	11.0	C
10.3	89.7	20.6	4.60	27.8	85.7	89.80	9.7	C
10.1	89.9	19.8	4.53	28.3	86.1	93.42	9.4	C
9.2	90.8	12.6	4.3	40.5	89.5	146.8	6.2	C
8.9	91.1	6.8	4.3	72.6	92.3	272.0	3.5	C
9.2	90.8	3.0	4.5	170	93.9	616.6	1.6	C
9.2	90.8	2.8	4.5	182	94.0	660.6	1.5	C
9.3	90.7	2.6	4.6	198	94.1	711.5	1.3	C
9.1	90.9	2.4	4.5	210	94.3	770.7	1.2	C
4.0	96.0	2.9	2.0	76.5	96.4	637.9	1.5	C
4.0	96.0	3.3	2.0	67.3	96.2	560.5	1.8	C
1.2	98.8	7.5	0.60	8.9	95.4	246.6	4.0	C
0.0	100.0	8.4	0.0	0.0	95.6	220.2	4.4	C

[a]The composition unit is: mol/100 mol solute.
[b]These values were calculated by the compiler.
[c]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_3H_9(PO_4)_4$; C = $NH_4H_5(PO_4)_2$; D = H_3PO_4.

Auxiliary Information

Method / Apparatus / Procedure:
No information is given.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given. The compiler estimates the reproducibility to be about 0.1%.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
R. Flatt, G. Brunisholz, A. Dénéréaz, Helv. Chim. Acta **39**, 483-91 (1956).

Variables:
Composition at 50 °C.

Prepared By:
J. Eysseltová

Experimental Data

Composition of saturated solutions in the $(NH_4)_3PO_4 - H_3PO_4 - H_2O$ system at 50 °C

NH_4^+ ion	H_2O comp[a]	NH_3[b] 100w_1	NH_3[b] m_1/mol kg^{-1}	H_3PO_4[b] 100w_2	H_3PO_4[b] m_2/mol kg^{-1}	H_2O[b] 100w_3	Solid phases[c]
22.7	171.8	5.73	7.33	48.4	10.8	45.87	A
33.4	309.6	6.04	5.99	34.7	5.97	59.26	A
33.4	312.6	6.01	5.93	34.5	5.92	59.49	A
39.4	233.2	8.24	9.38	40.1	7.93	51.63	A
43.3	187.2	10.0	12.8	44.3	9.88	45.73	A
46.0	150.5	11.1	17.0	48.3	12.3	40.11	A
49.5	111.0	13.8	24.8	53.5	16.7	32.74	A+B
49.7	111.3	13.8	24.8	53.4	16.6	32.78	A+B
53.3	154.5	13.0	19.1	47.0	12.0	40.01	B
55.5	176.6	12.8	17.4	44.2	10.5	43.04	B
59.0	217.6	12.3	15.1	39.9	8.50	47.86	B
62.8	250.0	12.1	13.9	37.0	7.40	50.95	B
65.5	274.7	12.0	13.2	35.0	6.73	53.04	B
66.2	278.3	12.0	13.2	34.7	6.65	53.30	B
66.3	274.2	12.1	13.4	35.0	6.75	52.92	B
68.1	281.7	12.2	13.4	34.4	6.57	53.42	B+C

[a]The composition unit is: mol/100 mol solute.
[b]These values were calculated by the compiler.
[c]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2HPO_4$; C = $(NH_4)_7H_2(PO_4)_3$.

Auxiliary Information

Method / Apparatus / Procedure:
No information is given.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given. The compiler estimates the reproducibility to be about 0.5%.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, R. Dagon, Helv. Chim. Acta **44**, 2173-93 (1961).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Composition of eutonic solutions in the $NH_4H_2PO_4$-$(NH_4)_2HPO_4$-H_2O system

	$NH_4H_2PO_4$			$(NH_4)_2HPO_4$			H_2O
t/°C	comp[a]	$100w_i$[b]	m_i/mol kg^{-1}[b]	comp[a]	$100w_i$[b]	m_i/mol kg^{-1}[b]	$100w_i$[b]
0	23.0	18.7	3.61	57.1	36.3	6.11	45.0
25	41.4	29.3	8.63	70.2	41.2	10.57	29.5
50	68.3	40.6	28.0	87.8	46.8	28.1	12.6

[a]The composition unit is: g/100 g H_2O.
[b]These values were calculated by the compiler.

The compiler recalculated the data in the Table above to give the following values

$(NH_4)_3PO_4$		H_3PO_4		H_2O
$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
35.4	5.28	19.6	4.44	45.0
43.7	9.93	26.8	9.28	29.5
52.8	28.1	34.6	28.0	12.6

Auxiliary Information

Method / Apparatus / Procedure:

No information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, R. Dagon, Helv. Chim. Acta **44**, 2173-93 (1961).

Variables:

Composition at 0 and 50 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Composition of saturated solutions of the NH_4^+ – H^+ – PO_4^{3-} – H_2O system

NH_4^+	H^+	H_2O	NH_3[b]		H_3PO_4[b]		H_2O[b]	
ion %	ion %	comp[a]	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	Solid phases[c]
				temp = 0 °C				
100.0	0.0	3900	2.26	1.42	4.34	0.47	93.4	A
69.1	30.9	1130	4.74	3.39	13.2	1.64	82.1	A
68.2	31.8	849	5.89	4.46	16.6	2.18	77.5	A
67.2	32.8	589	7.62	6.33	21.7	3.14	70.0	A
67.3	32.7	432	9.40	8.65	26.8	4.28	63.8	A+B
66.8	33.2	432	9.33	8.58	26.8	4.28	63.9	A+B
62.4	37.6	374	9.60	9.26	29.5	4.95	60.9	B
55.8	44.2	267	10.5	11.6	36.2	6.93	53.3	B
54.2	45.8	241	10.8	12.5	38.3	7.68	50.9	B
52.4	47.6	210	11.2	13.8	41.1	8.81	47.6	B
51.9	48.1	212	11.1	13.6	41.0	8.73	47.9	B+C
31.9	68.1	211	7.14	8.39	42.9	8.77	50.0	B+C
44.1	55.9	462	6.08	5.30	26.5	4.00	67.4	C
39.8	60.2	656	4.30	3.37	20.7	2.82	75.0	C
33.2	66.8	924	2.76	1.99	15.9	2.00	81.3	C
33.1	66.9	920	2.76	2.00	16.0	2.01	81.2	C
29.7	70.3	799	2.78	2.06	18.0	2.32	79.2	C
21.8	78.2	483	3.01	2.50	26.5	3.83	70.5	C
14.4	85.6	213	3.34	3.75	44.4	8.68	52.2	C
11.1	88.9	77.2	3.90	7.98	67.4	24.0	28.7	C+D
11.1	88.9	75.9	3.92	8.12	67.7	24.4	28.4	C+D
8.7	91.3	66.3	3.21	7.28	70.9	27.9	25.9	D
7.8	92.2	57.8	2.99	7.49	73.6	32.0	23.4	D
7.2	92.8	43.8	2.93	9.12	78.2	42.2	18.9	D
7.3	92.7	34.2	3.10	11.8	81.5	54.1	15.4	D
7.3	92.7	33.0	3.12	12.3	82.0	56.0	14.9	D
7.7	92.3	25.8	3.39	16.6	84.6	71.7	12.0	D+E
7.3	92.7	20.1	3.31	20.2	87.0	92.0	9.65	E
7.5	92.5	10.6	3.56	39.3	91.1	174	5.33	E
6.1	93.9	24.1	2.73	14.1	85.9	76.8	11.4	F
5.1	94.9	29.2	2.24	9.7	84.2	63.4	13.6	F
3.8	96.2	34.6	1.64	6.1	82.6	53.5	15.8	F
2.2	97.8	40.7	0.93	3.0	80.9	45.4	18.2	F
0.0	100.0	48.7	0.00	0.0	78.8	38.0	21.2	F
0.0	100.0	48.2	0.00	0.0	79.0	38.4	21.0	F
				temp = 50 °C				
31.5	68.5	302	5.80	5.79	35.3	6.13	58.9	C
29.6	70.4	277	5.75	5.93	37.3	6.68	57.0	C
24.4	75.6	200	5.70	6.77	44.8	9.25	49.5	C
20.8	79.2	146	5.67	7.91	52.2	12.6	42.1	C
17.6	82.4	95.9	5.66	10.2	61.7	19.3	32.6	C
16.2	83.8	73.5	5.67	12.2	67.1	25.2	27.2	C
15.1	84.9	50.1	5.81	16.7	73.8	36.9	20.4	C
14.5	85.5	29.7	6.10	27.1	80.7	62.3	13.2	C

[a]The composition unit is: mol/100 mol solute.
[b]These values were calculated by the compiler.
[c]The solid phases are : A = $(NH_4)_3PO_4$; B = $(NH_4)_2HPO_4$; C = $NH_4H_2PO_4$; D = $NH_4H_5(PO_4)_2 \cdot H_2O$; E = $NH_4H_5(PO_4)_2$; F = $H_3PO_4 \cdot 0.5\ H_2O$.

Part 2. Composition of solutions saturated simultaneously with $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.

t/°C	$NH_4H_2PO_4$ comp[a]	$(NH_4)_2HPO_4$ comp[a]	NH_3[b] $100w_i$	NH_3[b] m_i/mol kg^{-1}	H_3PO_4[b] $100w_i$	H_3PO_4[b] m_i/mol kg^{-1}	H_2O[b] $100w_i$
0	23.0	57.1	10.1	10.6	34.4	6.32	55.5
25	41.4	70.2	11.5	14.2	41.3	8.91	47.3
50	68.3	87.8	12.8	19.2	48.2	12.6	39.0

[a]The composition unit is: g/100g H_2O.
[b]These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

No information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given, but the compiler estimates the reproducibility to be about 0.5%.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

Ya. S. Shenkin, S.A. Ruchnova, A.P. Shenkina, Zh. Neorg. Khim. **14**, 1420-2 (1969).

Variables:

Temperature and composition at atmospheric pressure.

Prepared By:

J. Eysseltová

Experimental Data

Composition and boiling points in the $NH_4H_2PO_4$–H_3PO_4–H_2O system

$NH_4H_2PO_4$ $100w_i$	H_3PO_4 $100w_i$	NH_3[a] $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$	b.p./°C	$-\lg N$[b]
71.84	0.00	10.63	22.18	61.20	22.18	28.16	109.4	0.1463
67.90	1.82	10.05	19.49	59.66	20.11	30.28	110.8	0.1343
64.20	8.90	9.50	20.75	63.59	24.12	26.90	111.1	0.1568
60.01	14.12	8.88	20.16	65.24	25.73	25.87	112.0	0.1656
57.22	22.34	8.47	24.33	71.08	35.49	20.44	115.1	0.1865
59.44	23.21	8.80	29.78	73.85	43.43	17.35	119.2	0.2510
58.29	29.02	8.63	39.93	78.68	63.26	12.69	122.9	0.3633
64.53	30.98	9.55	124.9	85.95	195.3	4.49	147.0	0.6556
71.50	24.64	10.58	161.0	85.55	226.2	3.86	152.0	0.7054
76.76	19.50	11.36	178.4	84.89	231.6	3.74	155.6	0.7146
79.72	16.24	11.80	171.5	84.15	212.5	4.04	149.8	0.6840
82.82	14.71	12.26	291.5	85.26	352.2	2.47	161.0	0.8662
83.17	14.75	12.31	347.6	85.60	419.9	2.08	170.8	0.9318
86.60	12.31	12.82	690.6	86.08	805.9	1.09	170.0	1.1906
90.56	6.00	13.41	228.8	83.15	246.6	3.44	212.0	0.7375
90.56	8.19	13.41	629.8	85.34	696.6	1.25	210.5	1.1805
92.77	4.39	13.73	283.9	83.42	299.7	2.84	221.5	0.9079

[a]These values were calculated by the compiler.
[b]N is the mol fraction of water in the system.

NOTE: According to the authors, the "temperature depression" (not defined) is a nearly linear function of $-\lg N$.

Auxiliary Information

Method / Apparatus / Procedure:

The method was the same as that described earlier.[1]

Source and Purity of Materials:

Chemically pure salts were recrystallized before being used.

Estimated Error:

No information is given.

Reference:

[1]Ya.S. Shenkin, S.A. Ruchnova, A.P. Shenkina, Zh. Neorg. Khim. **13**, 256 (1968).

Components:

(1) Ammonia, NH_3; [7664-41-7]
(2) Phosphoric acid, H_3PO_4; [7664-38-2]
(3) Water, H_2O; [7732-18-5]

Original Measurements:

Ya.K. Balabanovich, I.I. Orekhov, L.Ya. Tereshchenko, Trud. Sev.-Zapad. Politekh. Inst. 69-72 (1969).

Variables:

Temperature and composition

Prepared By:

L.V. Chernykh and J. Eysseltová

Experimental Data

Part 1. Definition of the sections

Section	1	2	3	4
Mass ratio H_2O/H_3PO_4	9	4	2.3	1.5

Part 2. Eutectic points having $NH_4H_2PO_4$ and ice as the equilibrium solid phases

Sect	$NH_4H_2PO_4$ $100w_i$	H_3PO_4 $100w_i$	NH_3[a] $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$	t_s/°C[b]	t_e/°C[c]
1	16.60	8.29	2.46	1.92	22.43	3.047	75.11	−6	−12
2	16.60	16.70	2.46	2.16	30.84	4.718	66.70	−7	−17
3	19.35	24.15	2.86	2.98	40.63	7.339	56.50	−14.5	−21
4	19.35	32.35	2.86	3.48	48.83	10.32	48.30	−25.5	−28

[a]These values were calculated by the compilers.
[b]Eutectic temperature measured by heating.
[c]Eutectic temperature measured by cooling.

Part 3. Solubility of $NH_4H_2PO_4$ in aqueous solutions of H_3PO_4[a]

Sect	10 °C	20 °C	30 °C	40 °C	50 °C	60 °C	70 °C
1	20.99	26.63	29.27	31.50	35.61	40.84	44.6
2	23.57	25.92	28.69	31.54	34.07	38.11	41.31
3	22.41	24.99	30.32	32.24	35.9	38.69	41.09
4	21.09	26.26	29.21	33.12	36.28	38.86	41.19

[a]The solubility values are given as $100w_i$.

Part 4. Using the data in Part 3, the compilers have calculated the following values.

t/°C	NH_3 $100w_i$	NH_3 m_i/mol kg^{-1}	H_3PO_4 $100w_i$	H_3PO_4 m_i/mol kg^{-1}	H_2O $100w_i$
			Section 1		
10	3.11	2.57	25.78	3.70	71.11
20	3.94	3.51	30.02	4.64	66.03
30	4.33	4.00	32.01	5.13	63.66
40	4.66	4.44	33.68	5.58	61.65
50	5.27	5.34	36.78	6.48	57.94
60	6.05	6.67	40.71	7.80	53.24
70	6.60	7.78	43.53	8.91	49.86
			Section 2		
10	3.49	3.35	35.36	5.90	61.14
20	3.84	3.80	36.90	6.35	59.26
30	4.25	4.37	38.70	6.92	57.05
40	4.67	5.01	40.56	7.56	54.77
50	5.04	5.62	42.21	8.17	52.74
60	5.64	6.69	44.84	9.24	49.51
70	6.12	7.65	46.93	10.20	46.95
			Section 3		
10	3.32	3.60	42.60	8.04	54.08
20	3.70	4.16	44.02	8.59	52.28
30	4.49	5.43	46.94	9.86	48.56
40	4.77	5.93	48.00	10.37	47.23
50	5.31	6.99	50.01	11.42	44.68
60	5.73	7.87	51.54	12.31	42.73
70	6.08	8.70	52.86	13.14	41.06
			Section 4		
10	3.12	3.87	49.53	10.67	47.35
20	3.89	5.16	51.87	11.96	44.24
30	4.32	5.98	53.20	12.78	42.47
40	4.90	7.17	54.97	13.98	40.13
50	5.37	8.25	56.39	15.05	38.23
60	5.75	9.21	57.56	16.01	36.68
70	6.10	10.15	58.61	16.95	35.29

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used. Standard methods of analysis were used, but no specific details are given.

Source and Purity of Materials:

Chemically pure H_3PO_4 and recrystallized $NH_4H_2PO_4$ were used.

Estimated Error:

No information is given.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
I.M. Kaganskiy, A.M. Babenko, Zh. Prikl. Khim. (Leningrad) **44**, 315-9 (1971).

Variables:
Temperature and composition.

Prepared By:
J. Eysseltová

Experimental Data

Part 1. Solubility isotherms in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–H_2O system

$NH_4H_2PO_4$ $100w_i$	$(NH_4)_2HPO_4$ $100w_i$	NH_3[a] $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$
			temp = 0 °C			
18.2	0.0	2.7	1.9	15.5	1.9	81.8
19.0	8.1	4.9	3.9	22.2	3.1	72.9
19.5	16.1	7.0	6.4	28.6	4.5	64.4
19.9	20.0	8.1	7.9	31.8	5.4	60.1
9.8	27.0	8.4	7.8	28.4	4.6	63.2
19.5	24.1	9.1	9.5	34.5	6.2	56.4
13.2	28.5	9.3	9.4	32.4	5.7	58.3
20.1	26.3	9.8	10.7	36.6	7.0	53.6
19.1	28.3	10.1	11.3	37.3	7.2	52.6
19.9	28.0	10.2	11.5	37.7	7.4	52.1
0.0	27.8	7.2	5.8	20.6	2.9	72.2
7.2	27.6	8.2	7.4	26.6	4.2	65.2
14.3	28.2	9.4	9.6	33.1	5.9	57.5
20.0	19.9	8.1	7.9	31.8	5.4	60.1
18.0	28.0	9.9	10.7	36.1	6.8	54.0
18.3	9.2	5.1	4.3	22.2	3.1	72.7
			temp = −5 °C			
6.7	23.3	7.0	5.9	23.0	3.4	70.0
11.2	17.8	6.2	5.2	22.7	3.3	71.0
16.5	8.3	4.6	3.6	20.2	2.7	75.2
18.1	8.2	4.8	3.8	21.5	3.0	73.7
18.3	16.3	6.9	6.2	27.7	4.3	65.4
18.7	20.3	8.0	7.7	31.0	5.2	61.0
18.4	24.5	9.0	9.3	33.9	6.0	57.1
18.7	26.8	9.7	10.4	35.8	6.7	54.5
17.7	11.7	5.6	4.7	23.8	3.4	70.6
8.3	17.5	5.7	4.5	20.1	2.8	74.2
0.0	24.3	6.3	4.9	28.0	2.4	75.7
18.8	24.8	9.2	9.6	34.4	6.2	56.4
7.5	25.5	7.7	6.7	25.3	3.9	67.0
14.9	25.7	8.8	8.7	31.8	5.5	59.4
18.4	26.4	9.5	10.1	35.3	6.5	55.2
0.0	26.4	6.8	5.4	19.6	2.7	73.6
			temp = 10 °C			
20.6	0.0	3.0	2.3	17.5	2.3	79.4
21.8	7.8	5.2	4.4	24.4	3.5	70.4
22.2	15.5	7.3	6.9	30.4	5.0	62.3
22.4	19.4	8.3	8.4	33.5	5.9	58.2
21.9	23.4	9.3	10.0	36.0	6.7	54.7
22.7	25.5	9.9	11.3	38.3	7.5	51.8
22.4	27.1	10.3	12.0	39.2	7.9	50.5
17.0	33.2	11.1	13.1	39.1	8.0	49.8
21.8	31.2	11.3	14.1	41.7	9.1	47.0
0.0	33.1	8.5	7.5	24.6	3.7	66.9
6.6	33.6	9.6	9.5	30.6	5.2	59.8
13.2	33.8	10.7	11.8	36.3	7.0	53.0
22.4	10.2	5.9	5.2	26.7	4.0	67.4
16.8	32.5	10.9	12.6	38.4	7.7	50.7
22.8	24.0	9.6	10.6	37.2	7.1	53.2
20.3	32.3	11.3	14.0	41.3	8.9	47.4

Part 2. Crystallization temperatures and composition of solutions existing in equilibrium with two or three solid phases

t/°C	$NH_4H_2PO_4$ $100w_i$	$(NH_4)_2HPO_4$ $100w_i$	NH_3[a] $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$	Solid phase[b]
−4.4	17.50	0.00	2.59	1.84	14.91	1.84	82.50	A+B
−5.3	18.00	8.20	4.78	3.80	21.42	2.96	73.80	A+B
−6.4	18.00	16.40	6.89	6.17	27.50	4.28	65.60	A+B
−7.4	18.00	20.50	7.95	7.59	30.55	5.07	61.50	A+B
−5.4	17.60	12.00	5.70	4.75	23.90	3.46	70.40	A+B
−5.1	18.70	26.80	9.68	10.43	35.82	6.71	54.50	B+C
−6.3	19.80	28.00	10.15	11.42	37.64	7.36	52.20	B+C
−6.0	18.50	26.00	9.44	9.99	35.05	6.44	55.50	B+C
+6.8	21.30	31.40	11.25	13.97	41.44	8.94	47.30	B+D
+18.8	23.60	32.50	11.88	15.88	44.22	10.28	43.90	B+D
−5.4	0.00	26.30	6.78	5.40	19.52	2.70	73.70	A+C
−6.6	7.50	25.00	7.56	6.57	24.94	3.77	67.50	A+C
−8.2	15.10	24.40	8.53	8.28	30.97	5.22	60.50	A+C
+16.0	0.00	39.60	10.21	9.93	29.38	4.96	60.40	C+D
+12.0	6.48	35.20	10.04	10.11	31.64	5.54	58.32	C+D
+9.4	13.20	33.70	10.65	11.77	36.25	6.97	53.10	C+D
+8.6	16.90	32.20	10.81	12.47	38.29	7.68	50.90	C+D
−8.6	17.80	24.66	8.99	9.18	33.46	5.93	57.54	A+B+C
+3.4	21.20	31.60	11.29	14.04	41.51	8.97	47.20	B+C+D

[a]These values were calculated by the compiler.
[b]Solid phases are: A=ice; B=$NH_4H_2PO_4$; C=$(NH_4)_2HPO_4 \cdot 2H_2O$; D=$(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:
A modified polythermic method was used.[1]

Source and Purity of Materials:
Chemically pure or reagent grade salts were used. They were recrystallized twice. During the recrystallization special care was taken to obtain anhydrous $(NH_4)_2HPO_4$. The products were dried gently at 30–50 °C and analyzed for NH_3 and P_2O_5 content.

Estimated Error:
No information is given.

References:
[1]L.N. Erayzer, I.M. Kaganskiy, Zavod. Lab. 1, 119 (1967).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A.A. Volkov, O.E. Sosnina, L.S. Sedavnykh, Uch. Zap. Permsk. Gos. Univ. **289**, 9-14 (1973).

Variables:

Composition at 20 °C

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the $(NH_4)_3PO_4$–H_3PO_4–H_2O system at 20 °C

$(NH_4)_3PO_4$ $100w_i$	H_3PO_4 $100w_i$	NH_3[a] $100w_i$	NH_3[a] m_i/mol kg^{-1}	H_3PO_4[a] $100w_i$	H_3PO_4[a] m_i/mol kg^{-1}	H_2O[a] $100w_i$	Refract. index	Solid phases[b]
12.80	0.00	4.39	2.98	8.41	0.985	87.20	1.3580	A
15.20	2.00	5.21	3.69	11.99	1.48	82.80	1.3670	A
18.70	4.10	6.41	4.87	16.39	2.17	77.20	1.3370	A
21.30	5.25	7.30	5.84	19.25	2.67	73.45	1.3855	A
26.05	6.75	8.93	7.80	23.87	3.62	67.20	1.3970	A
27.15	7.25	9.30	8.33	25.10	3.90	65.60	1.4050	A
29.35	8.45	10.06	9.49	27.74	4.55	62.20	1.4090	A
30.50	9.00	10.45	10.14	29.05	4.90	60.50	1.4100	A+B
30.10	10.00	10.31	10.11	29.78	5.07	59.90	1.4100	B
31.00	11.70	10.62	10.89	32.08	5.71	57.30	1.4130	B
32.00	13.70	10.96	11.86	34.73	6.53	54.30	1.4170	B
32.30	14.70	11.07	12.26	35.93	6.92	53.00	1.4180	B
33.00	16.50	11.31	13.15	38.19	7.73	50.50	1.4210	B
33.40	17.45	11.44	13.67	39.40	8.18	49.15	1.4235	B
34.50	18.55	11.82	14.79	41.23	8.96	46.95	1.4260	B
36.00	21.15	12.34	16.90	44.81	10.67	42.85	1.4280	B
35.85	22.55	12.28	17.34	46.11	11.31	41.60	1.4300	B+C
32.60	23.00	11.17	14.77	44.43	10.21	44.40	1.4260	C
29.35	21.30	10.06	11.97	40.59	8.39	49.35	1.4180	C
26.40	20.50	9.05	10.00	37.85	7.27	53.10	1.4100	C
24.20	20.10	8.29	8.74	36.01	6.60	55.70	1.4040	C
19.80	19.35	6.78	6.55	32.36	5.43	60.85	1.3935	C
17.60	18.45	6.03	5.54	30.02	4.79	63.95	1.3860	C
14.30	16.30	4.90	4.15	25.70	3.78	69.40	1.3780	C
12.10	16.40	4.15	3.41	24.35	3.48	71.50	1.3700	C
11.75	17.00	4.03	3.32	24.72	3.54	71.25	1.3730	C
12.10	20.25	4.15	3.60	28.20	4.25	67.65	1.3770	C
11.75	22.25	4.03	3.58	29.97	4.63	66.00	1.3780	C
11.35	25.35	3.89	3.61	32.81	5.29	63.30	1.3800	C
11.75	26.90	4.03	3.85	34.62	5.76	61.35	1.3805	C
11.75	29.80	4.03	4.04	37.52	6.55	58.45	1.3880	C
11.75	34.85	4.03	4.43	42.57	8.13	53.40	1.3910	C
12.85	41.25	4.40	5.63	49.70	11.05	45.90	1.3990	C
13.20	49.20	4.52	7.06	57.88	15.71	37.60	1.4090	C
13.95	55.10	4.78	9.07	64.27	21.19	30.95	1.4225	C
14.10	58.40	4.83	10.32	67.67	25.11	27.50	1.4280	C
14.70	60.80	5.04	12.07	70.4	29.35	24.50	1.4330	C
14.85	64.60	5.09	14.54	74.6	36.92	20.55	1.4390	C
15.35	70.40	5.26	21.67	80.49	57.64	14.25	1.4420	C
15.30	71.40	5.24	23.15	81.46	62.50	13.30	1.4430	C+D
13.70	72.75	4.69	20.34	81.75	61.57	13.55	1.4435	D
13.20	75.30	4.52	23.10	83.98	74.51	11.50	1.4440	D+E
12.20	76.40	4.18	21.53	84.42	75.56	11.40	1.4460	E
11.60	78.10	3.98	22.66	85.72	84.93	10.30	1.4465	E
10.90	80.40	3.74	25.21	87.56	102.7	8.70	1.4750	E
10.95	81.50	3.75	29.18	88.70	119.9	7.55	1.4480	E

[a]These values were calculated by the compiler.
[b]The solid phases are: A = $(NH_4)_3PO_4 \cdot 3H_2O$; B = $(NH_4)_2HPO_4$; C = $NH_4H_2PO_4$; D = $3NH_4H_2PO_4 \cdot H_3PO_4$; E = $NH_4H_2PO_4 \cdot H_3PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

The method of sections[1,2] was used. The solubility diagram is derived from the linear dependence of a property of the liquid phase on the concentration.

Source and Purity of Materials:

Chemically pure H_3PO_4 and twice-distilled water were used. $(NH_4)_3PO_4 \cdot 3H_2O$ was synthesized according to directions given by others.[3]

Estimated Error:

No information is given.

References:

1. R.V. Mertslin, Izv. Biol. Nauchno-issl. In-ta pri Permsk. Un-ta **11**, 1 (1937).
2. E.F. Zhuravlev, A.D. Sheveleva, Zh. Neorg. Khim. **5**, 2630 (1960).
3. M.E. Pozin, Tekhnologiya Mineral'nykh Soley, Leningrad, Goskhimizdat, 1961.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

S.A. Mazunin, O.E. Sosnina, A.A. Volkov, T.L. Danina, Termicheskiy Analiz i Fazovye Ravnovesiya, Perm 79-88 (1985).

Variables:

Composition at 20 and 60 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–H_2O system

$NH_4H_2PO_4$	$(NH_4)_2HPO_4$	NH_3[a]		H_3PO_4[a]		H_2O[a]	Solid
$100w_i$	$100w_i$	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	phase[b]
			temp = 20 °C				
0.0	40.8	10.5	10.4	30.3	5.2	59.2	A
6.0	39.0	11.0	11.7	34.1	6.3	55.0	A
9.0	38.0	11.1	12.3	35.9	6.9	53.0	A
12.0	37.0	11.3	13.0	37.7	7.5	51.0	A
16.0	36.0	11.6	14.3	40.3	8.6	48.0	A
26.0	32.0	12.1	16.9	45.9	11.2	42.0	A+B
24.0	31.5	11.7	15.4	43.8	10.1	44.5	A+B
25.0	23.0	9.6	10.9	38.4	7.5	52.0	A+B
26.0	14.0	7.5	7.3	32.5	5.5	60.0	A+B
27.0	7.0	5.8	5.2	28.2	4.4	66.0	A+B
27.3	0.0	4.0	3.3	23.3	3.3	72.7	A+B
			temp = 60 °C				
0.0	48.8	12.6	14.4	36.2	7.2	51.2	A
6.5	45.7	12.8	15.7	39.4	8.4	47.8	A
13.1	42.7	13.0	17.2	42.8	9.9	44.2	A
20.4	40.5	13.5	20.2	47.4	12.4	39.1	A
26.7	38.3	13.8	23.2	51.2	14.9	35.0	A
35.1	35.0	14.2	27.9	55.9	19.1	29.9	A+B
35.7	31.8	13.5	24.4	54.0	17.0	32.5	B
36.4	25.2	11.9	18.2	49.7	13.2	38.4	B
39.3	17.6	10.4	14.1	46.5	11.0	43.1	B
40.8	11.2	8.9	10.9	43.1	9.2	48.0	B

[a]These values were calculated by the compilers.
[b]The solid phases are: A = $(NH_4)_2HPO_4$; B = $NH_4H_2PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

The refractometric variation of the isothermal method was used. The compilers assume that it was the method described elsewhere.[1] NH_4H_2PO4 and $(NH_4)_2HPO_4$ were determined by potentiometric titration. The composition of the solid phase was determined by the Schreinemaker's method.

Source and Purity of Materials:

No information is given, but the compilers assume that the materials were the same as those used in Ref. 2.

Estimated Error:

The precision of the analysis of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ was 0.2 and 0.6%, respectively.

References:

[1]E.F. Zhuravlev, A.D. Sheveleva, Zh. Neorg. Khim. **5**, 2630 (1960). 2. O.E. Sosnina, A.A. Volkov, Uch. Zap. Perm. Gos. Univ., Ser. Khim. **289**, 20 (1973).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Nitric acid; HNO_3; [7697-37-2]
(3) Phosphoric acid; H_3PO_4; [7664-38-2]
(4) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic
September, 1995

Critical Evaluation:

5.1. Solubilities in the NH_3–H_3PO_4–HNO_3–H_2O System

This system can be prepared by the addition of HNO_3 to the NH_3–H_3PO_4–H_2O ternary system. Flatt et al. published solubility data for the quaternary system at 25 and 50 °C.[1,2] However, these data of Flatt and co-workers cannot be critically evaluated because there are no other published solubility data with which they can be compared.

If CaO is added to the above quaternary system, the quinary system NH_3–H_3PO_4–HNO_3–CaO–H_2O is formed. Flatt, Brunisholz and co-workers published solubility data for this quinary system.[3,5] The main interest of these authors was the region where Ca $(H_2PO_4)_2 \cdot H_2O$ crystallizes. They also reported the existence of a double salt $Ca_9(NH_4)_4H_{32}(PO_4)_{18} \cdot 10H_2O$ [no registry number available]. So far as comparisons can be made, the solubility data in Refs 1–5 are fairly consistent with each other.

The system NH_3–H_3PO_4–CaO–H_2O is a quaternary subsystem of the quinary system discussed in the preceding paragraph. Flatt and co-workers published solubility data for this system at 0, 25 and 50 °C.[6,7] Orekov and Slobodkina[8] published solubility data for this system at 45, 60, 75 and 90 °C in the region where the NH_3/H_3PO_4 ratio is 0.5. The data of Flatt et al. at 50 °C can be compared with those of Orekov and Slobodkina at 45 °C. However, the two sets of data do not agree with respect to the identity of the phases and the composition of the solutions present at equilibrium. Orekov and Slobodkina[8] did not find the double salt but did find anhydrous $CaHPO_4$ as one of the equilibrium solid phases. Flatt's group[7] report the crystallization field of the double salt diminishing with increasing temperature, but still present at 50 °C, and their $CaHPO_4$ exists as a dihydrate. Obviously, more experimental work is necessary before this sytem can be evaluated.

References:

[1]R. Flatt and G. Brunisholz, Ph. Rod, Helv. Chim. Acta **38**, 769 (1955).
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[8]I.I. Orekhov and G.I. Slobodkina, Zh. Neorg. Khim. **17**, 829 (1972).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Nitric acid; HNO_3; [7697-37-2]
(3) Phosphoric acid; H_3PO_4; [7664-38-2]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, Ph. Rod, Ph. Helv. Chim. Acta **38**, 769-83 (1955).

Variables:

Composition at 25 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data

Table I. Special points in the NH_3–HNO_3–H_3PO_4–H_2O system at 25 °C

Soln no	HNO_3 eq %	H_3PO_4 eq %	NH_3 eq %	H_2O cont[a]	Solid phases[b]
1	0.0	66.4	33.6	103	A+B
2	0.0	60.0	40.0	205	B
3	0.0	59.6	40.4	206	B+C
4	0.0	59.4	40.6	242	C+D
5	0.0	50.0	50.0	803	D
6	50.0	0.0	50.0	107	E
7	43.5	8.5	48.0	98	A+B+E
8	47.3	3.3	49.4	102	B+E
9	47.1	3.1	49.8	101	B+C+E
10	47.2	2.8	50.0	101	C+E
11	47.3	2.5	50.2	101	C+E+F
12	40.7	9.3	50.0	204	C+D
13	45.7	2.7	51.6	128	C+D+F

Table II. Points of simultaneous crystallization of two solid phases and invariant points in the [illegible]

Soln no	HNO_3 eq %	H_3PO_4 eq %	NH_3 eq %	H_2O cont[a]	Solid phases[b]
14	0.0	59.6	40.4	205	B+C
15	0.0	59.5	40.5	207	B+C
16	4.4	54.3	41.3	223	B+C
17	7.5	50.6	41.9	231	B+C
18	9.9	47.5	42.6	236	B+C
19	12.6	44.3	43.1	240	B+C
20	20.3	35.1	44.6	244	B+C
21	26.2	27.9	45.9	239	B+C
22	38.7	12.9	48.4	192	B+C
23	47.1	3.1	49.8	101	B+C+E
24	0.0	59.5	40.5	212	C+D
25	0.0	59.4	40.6	212	C+D
26	24.9	29.0	46.1	262	C+D
27	32.4	19.7	47.9	248	C+D
28	43.7	5.5	50.8	169	C+D
29	45.9	2.6	51.5	125	C+D+F
30	45.5	2.8	51.7	132	C+D+F
31	45.5	2.7	51.8	128	C+D+F
32	45.7	2.6	51.7	128	C+D+F
33	45.5	2.8	51.7	130	C+D+F
34	45.8	2.7	51.5	125	C+D+F
35	47.3	2.5	50.2	101	D+E+F
36	47.3	2.5	50.2	101	D+E+F
37	46.0	2.7	51.3	122	C+F
38	45.9	2.7	51.4	122	C+F
39	47.3	1.7	51.0	103	E+F
40	47.4	0.7	51.9	98	E+F
41	47.4	0.7	51.9	98	E+F
42	46.5	0.5	53.0	95	E+F
43	44.0	0.2	55.8	85	E+F
44	39.9	0.1	60.0	67	E+F
45	37.9	0.1	62.0	57	E+F
46	45.7	1.9	52.4	127	D+F
47	45.3	1.6	53.1	125	D+F
48	44.4	1.2	54.4	123	D+F
49	44.7	1.1	54.2	122	D+F
50	42.1	0.6	57.3	114	D+F

Table III. Solutions saturated by a single solid phase

51	50.0	0.0	50.0	107	E
52	46.7	0.0	53.3	96	E
53	43.0	0.0	57.0	83	E
54	39.3	0.0	60.7	66	E
55	48.0	1.5	50.5	104	E
56	48.4	1.3	50.3	106	E
57	47.5	2.5	50.0	102	E
58	46.4	1.8	51.8	118	F
59	46.6	1.5	51.9	114	F
60	47.2	0.9	51.9	101	F
61	46.2	0.6	53.2	100	F
62	46.4	0.4	53.2	98	F
63	30.6	22.6	46.8	233	C
64	37.4	14.0	48.6	215	C
65	46.0	4.1	49.9	123	C
66	46.2	3.7	50.1	114	C
67	46.9	3.0	50.1	103	C
68	46.0	2.9	51.1	127	C
69	0.0	59.1	40.9	258	D
70	0.0	59.1	40.9	273	D
71	0.0	58.1	41.9	330	D
72	0.0	57.0	43.0	474	D
73	0.0	49.5	50.5	824	D
74	0.0	49.2	50.9	832	D
75	0.0	48.5	51.5	848	D
76	0.0	48.1	51.9	865	D
77	0.0	47.8	52.2	871	D
78	0.0	46.3	53.7	910	D
79	0.0	42.0	58.0	994	D
80	0.0	35.3	64.7	1071	D
81	0.0	25.4	74.6	1094	D
82	0.0	11.5	88.5	946	D
83	0.0	11.4	88.6	919	D
84	0.0	1.2	98.8	465	D
85	0.0	0.2	99.8	278	D
86	10.1	25.7	64.2	986	D
87	15.5	11.8	72.7	904	D
88	18.2	4.0	77.8	705	D
89	6.5	40.4	53.1	834	D
90	12.8	31.3	55.9	842	D
91	23.2	15.4	61.4	762	D
92	29.4	6.1	64.5	589	D
93	23.3	23.0	53.7	641	D
94	31.8	12.8	55.4	524	D
95	40.1	3.1	56.8	292	D
96	5.6	44.9	49.5	738	D
97	6.8	43.9	49.3	719	D
98	11.2	38.9	49.9	682	D
99	11.7	38.2	50.1	688	D
100	13.7	37.7	48.6	590	D
101	17.0	33.1	49.9	610	D
102	17.3	32.7	50.0	615	D
103	28.3	22.0	49.7	425	D
104	39.0	11.4	49.6	225	D
105	40.1	9.8	50.1	216	D
106	7.6	40.7	51.7	789	D
107	8.8	39.0	52.2	792	D
108	9.0	38.8	52.2	792	D
109	10.7	36.5	52.8	791	D
110	25.1	22.8	52.1	564	D
111	43.5	5.0	51.5	195	D
112	43.6	3.2	53.2	204	D
113	45.1	1.6	53.3	134	D
114	41.7	1.6	56.7	195	D
115	41.7	1.6	56.7	195	D
116	41.5	1.7	56.8	223	D
117	38.6	1.0	60.4	227	D
118	37.7	0.4	61.9	145	D
119	36.4	1.6	62.0	283	D
120	35.6	0.2	64.4	141	D

[a]The content is expressed as: mol/100 mol solute.

[b]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2HPO_4$; C = $(NH_4)_7H_2(PO_4)_3$; D = $(NH_4)_3PO_4$; E = NH_4NO_3; F = $3NH_4NO_3 \cdot (NH_4)_3PO_4$.

Part 2. The compiler has used the tabular data above to calculate the following values

Soln no	HNO_3 100w_i	HNO_3 m_i/mol kg^{-1}	H_3PO_4 100w_i	H_3PO_4 m_i/mol kg^{-1}	NH_3 100w_i	NH_3 m_i/mol kg^{-1}	H_2O 100w_i
1	0.0	0.0	72.8	11.9	6.4	18.1	20.7
2	0.0	0.0	57.3	5.42	6.6	10.8	36.0
3	0.0	0.0	57.0	5.36	6.7	10.9	36.2
4	0.0	0.0	53.6	4.55	6.4	9.32	40.1
5	0.0	0.0	24.2	1.15	4.2	3.46	71.5
6	53.2	26.0	0.0	0.0	14.4	26.0	32.5
7	44.5	24.7	13.5	1.61	13.3	27.2	28.7
8	49.8	25.8	5.4	0.60	14.1	26.9	30.7
9	50.0	25.9	5.1	0.57	14.3	27.4	30.6
10	50.3	26.0	4.6	0.51	14.4	27.5	30.7
11	50.5	26.0	4.2	0.46	14.5	27.6	30.8
12	32.1	11.1	11.4	0.84	10.6	13.6	45.9
13	45.5	19.8	4.2	0.39	13.9	22.4	36.4
14	0.0	0.0	57.1	5.38	6.7	11.0	36.1
15	0.0	0.0	56.9	5.32	6.7	10.9	36.4
16	2.7	1.10	51.6	4.51	6.8	10.3	38.9
17	4.6	1.80	48.1	4.06	6.9	10.1	40.4
18	6.1	2.33	45.4	3.73	7.1	10.0	41.4
19	7.8	2.92	42.6	3.42	7.2	9.98	42.4
20	13.0	4.62	34.8	2.66	7.7	10.2	44.5
21	17.4	6.09	28.9	2.16	8.3	10.7	45.4
22	30.5	11.2	15.8	1.24	10.3	14.0	43.3
23	51.8	25.9	5.3	0.57	14.8	27.4	31.7
24	0.0	0.0	56.4	5.20	6.7	10.6	36.9
25	0.0	0.0	56.4	5.19	6.7	10.6	36.9
26	15.8	5.28	28.7	2.05	7.9	9.78	47.6
27	22.1	7.26	20.9	1.47	8.8	10.7	48.2
28	38.2	14.4	7.5	0.60	12.0	16.7	42.2
29	46.1	20.4	4.1	0.39	14.0	22.9	35.9
30	44.8	19.2	4.3	0.39	13.8	21.8	37.1
31	45.4	19.8	4.2	0.39	14.0	22.5	36.5
32	45.6	19.8	4.0	0.38	13.9	22.4	36.5
33	45.1	19.4	4.3	0.40	13.8	22.1	36.8
34	46.0	20.4	4.2	0.40	14.0	22.9	35.8
35	50.5	26.0	4.2	0.46	14.5	27.6	30.8
36	50.5	26.0	4.2	0.46	14.5	27.6	30.8
37	46.5	21.0	4.2	0.41	14.0	23.4	35.2
38	46.4	20.9	4.2	0.41	14.1	23.4	35.3
39	50.8	25.5	2.8	0.31	14.8	27.5	31.6
40	52.4	26.9	1.2	0.13	15.5	29.4	30.9
41	52.4	26.9	1.2	0.13	15.5	29.4	30.9
42	52.4	27.2	0.9	0.10	16.1	31.0	30.6
43	52.6	28.8	0.4	0.04	18.0	36.5	29.0
44	52.9	33.1	0.2	0.03	21.5	49.8	25.4
45	53.3	36.9	0.2	0.03	23.6	60.4	22.9
46	46.1	20.0	3.0	0.28	14.3	22.9	36.6
47	46.3	20.1	2.5	0.24	14.7	23.6	36.5
48	46.2	20.1	1.9	0.18	15.3	24.6	36.6
49	46.6	20.4	1.8	0.17	15.3	24.7	36.3
50	46.2	20.5	1.0	0.10	17.0	27.9	35.8
51	53.2	26.0	0.0	0.0	14.4	26.0	32.5
52	52.8	27.0	0.0	0.0	16.3	30.8	31.0
53	52.4	28.8	0.0	0.0	18.8	38.2	28.9
54	52.7	33.1	0.0	0.0	22.0	51.1	25.3
55	51.2	25.6	2.5	0.27	14.6	27.0	31.7
56	51.3	25.4	2.1	0.23	14.4	26.4	32.1
57	50.5	25.9	4.1	0.45	14.4	27.2	31.0
58	47.9	21.9	2.9	0.28	14.4	24.4	34.8
59	48.8	22.7	2.4	0.24	14.7	25.3	34.1
60	51.6	26.0	1.5	0.17	15.3	28.6	31.5
61	51.3	25.7	1.0	0.11	16.0	29.6	31.7
62	51.9	26.3	0.7	0.08	16.1	30.2	31.3
63	21.1	7.30	24.2	1.80	8.7	11.2	45.9
64	28.0	9.66	16.3	1.21	9.8	12.6	45.9
65	45.5	20.8	6.3	0.62	13.4	22.5	34.8
66	47.1	22.5	5.9	0.60	13.8	24.4	33.2
67	49.6	25.3	4.9	0.54	14.3	27.0	31.1

Part 2. The compiler has used the tabular data above to calculate the following values

Soln no	HNO_3 $100w_i$	HNO_3 m_i/mol kg^{-1}	H_3PO_4 $100w_i$	H_3PO_4 m_i/mol kg^{-1}	NH_3 $100w_i$	NH_3 m_i/mol kg^{-1}	H_2O $100w_i$
68	45.7	20.1	4.5	0.42	13.7	22.4	36.1
69	0.0	0.0	52.0	4.24	6.3	8.81	41.7
70	0.0	0.0	50.8	4.01	6.1	8.32	43.1
71	0.0	0.0	46.1	3.26	5.8	7.05	48.1
72	0.0	0.0	37.6	2.23	4.9	5.04	57.4
73	0.0	0.0	23.6	1.11	4.2	3.40	72.2
74	0.0	0.0	23.3	1.10	4.2	3.40	72.5
75	0.0	0.0	22.7	1.06	4.2	3.37	73.0
76	0.0	0.0	22.3	1.03	4.2	3.33	73.6
77	0.0	0.0	22.0	1.02	4.2	3.33	73.8
78	0.0	0.0	20.8	0.94	4.2	3.28	75.0
79	0.0	0.0	17.9	0.78	4.3	3.24	77.8
80	0.0	0.0	14.5	0.61	4.6	3.36	80.9
81	0.0	0.0	10.6	0.43	5.4	3.79	84.0
82	0.0	0.0	5.7	0.23	7.7	5.20	86.6
83	0.0	0.0	5.8	0.23	7.9	5.36	86.3
84	0.0	0.0	1.2	0.05	16.5	11.8	82.3
85	0.0	0.0	0.3	0.01	25.3	19.9	74.4
86	2.9	0.57	11.4	0.48	5.0	3.62	80.7
87	5.0	0.95	5.9	0.24	6.3	4.47	82.8
88	7.4	1.43	2.5	0.11	8.5	6.13	81.6
89	2.0	0.43	19.5	0.90	4.5	3.54	74.0
90	4.0	0.84	15.4	0.69	4.8	3.69	75.8
91	8.2	1.69	8.5	0.37	5.9	4.48	77.3
92	13.1	2.77	4.2	0.19	7.8	6.08	74.9
93	9.1	2.02	13.9	0.66	5.7	4.65	71.3
94	14.7	3.37	9.2	0.45	6.9	5.87	69.2
95	27.9	7.63	3.4	0.20	10.7	10.8	58.0
96	1.9	0.42	23.3	1.13	4.5	3.73	70.4
97	2.3	0.53	23.2	1.13	4.5	3.81	69.9
98	4.0	0.91	21.6	1.06	4.8	4.06	69.6
99	4.2	0.94	21.1	1.03	4.8	4.05	69.9
100	5.4	1.29	23.1	1.18	5.2	4.58	66.3
101	6.6	1.55	20.1	1.00	5.3	4.54	68.0
102	6.7	1.56	19.8	0.98	5.3	4.52	68.3
103	14.3	3.70	17.3	0.96	6.8	6.50	61.5
104	29.0	9.63	13.2	0.94	10.0	12.3	47.8
105	30.7	10.31	11.7	0.84	10.4	12.9	47.2
106	2.4	0.54	20.4	0.96	4.5	3.64	72.6
107	2.8	0.62	19.6	0.91	4.6	3.66	73.0
108	2.9	0.63	19.5	0.91	4.6	3.66	73.0
109	3.5	0.75	18.4	0.85	4.6	3.71	73.4
110	10.6	2.47	15.0	0.75	6.0	5.13	68.3
111	36.0	12.4	6.4	0.47	11.5	14.7	46.1
112	36.0	11.9	4.1	0.29	11.9	14.5	48.1
113	45.0	18.7	2.5	0.22	14.4	22.1	38.2
114	36.2	11.9	2.2	0.15	13.3	16.2	48.3
115	36.2	11.9	2.2	0.15	13.3	16.2	48.3
116	33.7	10.3	2.1	0.14	12.5	14.2	51.7
117	31.8	9.45	1.3	0.08	13.5	14.8	53.4
118	39.1	14.4	0.6	0.05	17.3	23.7	42.9
119	26.7	7.15	1.8	0.10	12.3	12.2	59.2
120	38.0	14.0	0.3	0.03	18.0	25.4	43.0

Auxiliary Information

Method / Apparatus / Procedure:

No information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given. The compiler estimates the reproducibility to be about 1%.

References:

[1]O. Blumer, Helv. Chim. Acta **38**, 753 (1953).
[2]S. Chapuis-Gottreux, Helv. Chim. Acta **34**, 689 (1951).
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Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Nitric acid; HNO_3; [7697-37-2]
(3) Phosphoric acid; H_3PO_4; [7664-38-2]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, A. Dénéréra, Helv. Chim. Acta **39**, 483-91 (1956).

Variables:

Composition at 50 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data

Tables I. Points of simultaneous crystallization of two or three solid phases in the $NH_3-HNO_3-H_3PO_4-H_2O$ system at 50 °C

Soln no	NO_3^- eq %	PO_4^{3-} eq %	NH_4^+ eq %	H_2O cont[a]	Solid phases
1	17.5	82.5	27.1	21.6	$NH_4NO_3+NH_4H_2HPO_4$
2	28.0	72.0	36.0	45.2	$NH_4NO_3+NH_4H_2HPO_4$
3	38.7	61.3	44.6	61.4	$NH_4NO_3+NH_4H_2HPO_4$
4	56.7	43.3	61.0	81.3	$NH_4NO_3+NH_4H_2HPO_4$
5	75.5	24.5	78.2	105.2	$NH_4NO_3+NH_4H_2HPO_4$
6	96.4	3.6	97.5	130.9	$NH_4NO_3+NH_4H_2HPO_4$
7	96.6	3.4	97.6	129.2	$NH_4NO_3+NH_4H_2HPO_4$
8	0.0	100.0	49.6	111.2	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
9	10.0	90.0	54.2	123.1	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
10	19.9	80.1	59.4	134.8	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
11	29.7	70.3	64.5	144.9	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
12	33.2	66.8	66.2	148.6	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
13	51.8	48.2	76.0	161.9	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
14	60.9	39.1	80.9	164.2	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
15	69.5	30.5	84.9	158.7	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
16	78.6	21.4	89.4	142.4	$NH_4H_2HPO_4+(NH_4)_2HPO_4$
17	86.8	13.2	93.5	114.6	$NH_4NO_3+NH_4H_2HPO_4+(NH_4)_2HPO_4$
18	94.2	5.8	97.7	125.1	$NH_4NO_3+(NH_4)_2HPO_4$
19	94.6	5.4	98.2	123.0	$NH_4NO_3+(NH_4)_2HPO_4$
20	95.3	4.7	98.5	121.1	$NH_4NO_3+(NH_4)_2HPO_4$

Table II. Solutions saturated by a single solid phase in the NH_3–HNO_3–H_3PO_4–H_2O system at 50 °C

Soln no	NO_3^- eq %	PO_4^{3-} eq %	NH_4^+ eq %	H_2O cont[a]	Solid phases
21	20.4	79.6	72.1	334.0	$(NH_4)_2HPO_4$
22	39.3	60.7	78.9	356.6	$(NH_4)_2HPO_4$
23	58.7	41.3	85.7	348.8	$(NH_4)_2HPO_4$
24	69.3	30.7	89.1	316.8	$(NH_4)_2HPO_4$
25	80.6	19.4	92.7	263.0	$(NH_4)_2HPO_4$
26	91.5	8.5	96.6	155.4	$(NH_4)_2HPO_4$
27	91.8	8.2	96.8	159.7	$(NH_4)_2HPO_4$
28	22.0	78.0	67.5	263.8	$(NH_4)_2HPO_4$
29	44.4	55.6	76.1	261.6	$(NH_4)_2HPO_4$
30	0.0	100.0	33.4	311.1	$NH_4H_2PO_4$
31	10.6	89.4	40.2	365.8	$NH_4H_2PO_4$
32	19.6	80.4	46.2	399.7	$NH_4H_2PO_4$
33	27.0	73.0	51.0	421.0	$NH_4H_2PO_4$
34	35.2	64.8	56.9	433.7	$NH_4H_2PO_4$
35	41.1	58.9	61.1	439.2	$NH_4H_2PO_4$
36	49.5	50.5	66.4	441.9	$NH_4H_2PO_4$
37	62.2	37.8	74.8	420.4	$NH_4H_2PO_4$
38	76.0	24.0	84.1	368.5	$NH_4H_2PO_4$
39	84.6	15.4	89.7	307.4	$NH_4H_2PO_4$
40	92.1	7.9	94.7	218.2	$NH_4H_2PO_4$
41	31.1	68.9	45.4	242.8	$NH_4H_2PO_4$
42	58.8	41.2	69.5	369.5	$NH_4H_2PO_4$
43	15.4	84.6	53.9	190.2	$NH_4H_2PO_4$
44	15.8	84.2	54.1	202.8	$NH_4H_2PO_4$
45	24.1	75.9	59.7	188.7	$NH_4H_2PO_4$
46	25.1	74.9	61.1	170.5	$NH_4H_2PO_4$
47	27.1	72.9	56.6	303.9	$NH_4H_2PO_4$
48	32.4	67.6	65.7	159.3	$NH_4H_2PO_4$
49	37.7	62.3	68.2	174.9	$NH_4H_2PO_4$
50	40.8	59.2	70.3	158.5	$NH_4H_2PO_4$
51	48.1	51.8	70.2	293.3	$NH_4H_2PO_4$

[a]The content is expressed as: mol/100 mol solute.

Part 2. The compiler has recalculated the above data to give the following values

Soln no	HNO_3 $100w_i$	HNO_3 m_i/mol kg^{-1}	H_3PO_4 $100w_i$	H_3PO_4 m_i/mol kg^{-1}	NH_3 $100w_i$	NH_3 m_i/mol kg^{-1}	H_2O $100w_i$
1	11.0	45.0	80.5	70.7	4.6	69.7	3.9
2	17.2	34.4	68.8	29.5	6.0	44.2	7.9
3	23.6	35.0	58.3	18.5	7.4	40.4	10.7
4	34.6	38.7	41.1	9.9	10.1	41.7	14.2
5	45.8	39.9	23.1	4.3	12.8	41.3	18.2
6	58.2	40.9	3.4	0.5	15.9	41.4	22.6
7	58.5	41.5	3.2	0.5	16.0	42.0	22.3
8	0.0	0.0	77.5	16.7	6.7	24.8	15.8
9	5.0	4.5	70.0	13.5	7.3	24.5	17.6
10	10.0	8.2	62.6	11.0	8.1	24.5	19.3
11	15.0	11.4	55.2	9.0	8.8	24.7	20.9
12	16.8	12.4	52.6	8.3	9.1	24.7	21.5
13	26.8	17.8	38.7	5.5	10.6	26.1	23.9
14	32.0	20.6	31.9	4.4	11.5	27.4	24.6
15	37.5	24.3	25.6	3.6	12.4	29.7	24.5
16	44.5	30.7	18.8	2.8	13.7	34.9	23.0
17	52.5	42.1	12.4	2.1	15.3	45.3	19.8
18	57.0	41.8	5.5	0.9	16.0	43.4	21.6
19	57.4	42.7	5.1	0.8	16.1	44.4	21.3
20	58.2	43.7	4.5	0.7	16.2	45.2	21.1
21	7.9	3.4	47.8	4.4	7.5	12.0	36.8
22	15.3	6.1	36.7	3.2	8.3	12.3	39.6
23	23.9	9.3	26.1	2.2	9.4	13.6	40.5
24	29.9	12.2	20.6	1.8	10.4	15.6	39.1
25	38.2	17.0	14.3	1.4	11.9	19.6	35.6
26	52.2	32.7	7.5	1.0	14.9	34.5	25.3
27	52.1	31.9	7.2	1.0	14.8	33.7	25.9
28	9.3	4.6	51.2	5.5	7.7	14.2	31.8
29	19.6	9.4	38.2	3.9	9.1	16.2	33.0
30	0.0	0.0	61.4	6.0	3.6	6.0	35.1
31	4.0	1.6	52.5	4.5	4.1	6.1	39.4
32	7.2	2.7	46.1	3.7	4.6	6.4	42.1
33	9.8	3.6	41.3	3.2	5.0	6.7	43.8
34	12.8	4.5	36.6	2.8	5.6	7.3	45.0
35	15.0	5.2	33.3	2.5	6.0	7.7	45.7
36	18.2	6.2	28.8	2.1	6.6	8.3	46.4
37	23.8	8.2	22.5	1.7	7.7	9.9	46.0
38	31.5	11.5	15.5	1.2	9.4	12.7	43.6
39	38.4	15.3	10.9	0.9	11.0	16.2	39.8
40	47.9	23.4	6.4	0.7	13.3	24.1	32.4
41	14.1	7.1	48.7	5.3	5.6	10.4	31.5
42	26.9	12.1	29.3	2.8	8.0	14.3	35.2
43	7.1	4.5	60.9	8.2	6.7	15.7	25.2
44	7.2	4.3	59.7	7.7	6.7	14.8	26.4
45	11.4	7.1	55.6	7.4	7.6	17.6	25.4
46	12.1	8.2	56.3	8.1	8.0	19.9	23.5
47	11.2	5.0	46.7	4.4	6.3	10.3	35.8
48	16.1	11.3	52.3	7.9	8.8	22.9	22.7
49	18.6	12.0	47.7	6.6	9.1	21.7	24.6
50	20.7	14.3	46.7	6.9	9.6	24.6	23.0
51	20.8	9.1	34.8	3.3	8.2	13.3	36.2

Auxiliary Information

Method / Apparatus / Procedure:
No information is given.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Calcium oxide; CaO; [1305-78-8]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, S. Chapuis-Gottreux, Helv. Chim. Acta **34**, 884-98 (1951).

Variables:

Composition at 25 °C

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data

Table I. Invariant points in the $(NH_4)_3PO_4$–$Ca_3(PO_4)_2$–H_3PO_4–H_2O system at 25 °C

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	H_2O cont[a]	Solid phases[b]
1	traces	12.70	87.30	25	A+B+C
2[c]	5.64	13.83	80.53	138	B+C+D
3[d]	15.62	7.00	77.39	271	C+D+E
4	14.62	7.50	77.88	263	C+D+E
5[d]	7.02	19.29	72.79	291	B+D+E
6	8.00	17.70	74.30	245	B+D+E

[a]The content is expressed as: mol/100 mol solute.
[b]The solid phases are: A=$(NH_4)_3H_9(PO_4)_4$; B=$NH_4H_2PO_4$; C=$Ca(H_2PO_4)_2\cdot H_2O$; D=$Ca_9(NH_4)_4H_{32}(PO_4)_{18}\cdot 10H_2O$; E=$CaHPO_4\cdot 2H_2O$.
[c]These values were obtained by direct determination and by extrapolation.
[d]These values were obtained by direct determination in solutions supersaturated with $CaHPO_4\cdot 2H_2O$. All other data were obtained by interpolation.

Table II. Solutions coexisting with two solid phases in the $(NH_4)_3PO_4$–$Ca_3(PO_4)_2$–H_3PO_4–H_2O system at 25 °C

Soln no	Ca^{2+} eq %	NH_4^+ eq	H^+ eq %	H_2O cont[a]	Solid phases[b]
7	traces	8.85	91.15	6.46	A+B
8	traces	10.03	89.97	20.0	A+B
9	0.14	12.74	87.12	32.4	A+C
10	0.66	12.90	86.44	56.6	A+C
11	1.14	13.01	85.85	86.7	A+C
12	2.30	13.30	84.40	91.7	A+C
13	3.92	13.58	82.50	118	A+C
14	5.36	13.87	80.77	137.5	A+C
15	5.26	13.92	80.82	135.5	A+C
16	6.62	13.38	80.00	159	A+D
17	7.36	12.87	79.77	170	A+D
18	7.90	12.48	79.62	178	A+D
19	10.79	9.93	79.25	210	A+D
20	10.35	10.50	79.15	211	A+D
21	11.49	9.50	79.01	222	A+D
22	12.07	9.25	78.68	233	A+D
23	14.43	7.50	78.07	260	A+D
24	6.01	14.30	79.69	153	C+D
25	6.09	14.41	79.50	152	C+D
26	6.41	14.77	78.87	161	C+D
27	6.58	15.11	78.31	171	C+D
28	6.93	15.38	77.69	181	C+D
29	7.40	16.01	76.59	197	C+D
30	7.88	17.07	75.05	226	C+D
31	8.10	18.65	73.25	260	C+D
32	17.15	4.04	78.81	298	A+E
33[c]	18.85	3.19	77.96	298	A+E
34	17.90	2.70	79.40	342	A+E
35	11.55	12.05	76.40	260	D+E
36[c]	11.62	14.74	73.64	314	D+E
37[c]	10.31	16.69	73.00	314	D+E
38	7.01	19.58	73.41	274	C+E
39	6.13	20.73	74.14	294	C+E
40	4.70	23.80	71.50	349	C+E
41	4.58	23.91	71.51	364	C+E
42[c]	3.95	26.44	69.61	409	C+E
43[c]	2.15	30.02	67.83	452	C+E
44[c]	2.01	30.90	67.09	504	C+E
45	0.81	32.32	66.87	494	C+E
46	0.38	39.32	60.30	353	C+E

Table III. Solutions in equilibrium with one solid phase in the $(NH_4)_3PO_4-Ca_3(PO_4)_2-H_3PO_4-H_2O$ system at 25 °C

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	H_2O cont[a]	Solid phases[b]
47	2.12	8.08	89.80	89	A
48	6.43	5.50	88.07	161	A
49	6.61	8.76	84.63	162	A
50	2.50	13.20	84.30	96	A
51	11.41	4.49	84.10	231	A
52	8.42	11.47	80.11	184	A
53	2.73	20.72	76.55	277	C
54	17.43	2.91	79.66	349	E
55	18.35	2.94	78.71	403	E
56	16.21	5.62	78.17	326	E
57	8.09	17.41	74.50	352	E
58	8.48	17.42	74.10	396	E
59	0.98	31.84	67.18	488	E
60	0.80	32.20	67.00	532	E
61	0.96	32.54	66.50	571	E
62	6.99	14.13	78.88	168	D
63	7.91	13.20	78.89	190	D
64	11.81	9.31	78.88	229	D
65	8.70	13.10	78.20	203	D
66	7.28	14.85	77.87	183	D
67	8.75	13.60	77.65	208	D
68	12.02	10.60	77.38	241	D
69	8.53	14.59	76.88	214	D
70	12.15	10.97	76.88	257	D
71	8.30	15.70	76.00	222	D
72	7.59	16.58	75.83	212	D
73	8.03	18.02	73.95	248	D

[a]The content is expressed as: mol/100 mol solute.

[b]The solid phases are: $A=Ca(H_2PO_4)_2\cdot H_2O$; $B=NH_4H_5(PO_4)_2$; $C=NH_4H_2PO_4$; $D=Ca_9(NH_4)_4H_{32}(PO_4)_{18}\cdot 10H_2O$; $E=CaHPO_4\cdot 2H_2O$.

[c]These solutions were supersaturated with $CaHPO_4\cdot 2H_2O$.

Components:

(1) Triammonium phosphate; $(NH_4)_3PO_4$; [10361-65-6]
(2) Tricalcium bis(phosphate); $Ca_3(PO_4)_2$; [10103-46-5]
(3) Phosphoric acid; H_3PO_4; [7664-38-2]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, S. Chapuis-Gottreux, Helv. Chim. Acta **34**, 884-98 (1951).

Experimental Data (continued . . .)

Part 2. The compiler has used the above data to calculate the following values

Soln no	CaO mass %	CaO mol/kg	NH_3 mass %	NH_3 mol/kg	H_3PO_4 mass %	H_3PO_4 mol/kg	H_2O mass %
1	trace	trace	5.509	28.97	83.30	76.03	11.18
2	2.60	1.16	3.868	5.710	53.71	13.76	39.82
3	5.114	1.648	1.39	1.48	38.17	7.039	55.33
4	4.878	1.589	1.52	1.63	38.87	7.247	54.73
5	2.20	0.680	3.666	3.738	36.49	6.460	57.64
6	2.76	0.925	3.709	4.093	40.25	7.707	53.28
7	trace	trace	4.27	81.7	92.66	307.9	3.07
8	trace	trace	4.504	28.57	86.23	94.96	9.27
9	0.0097	0.12	5.341	22.33	80.51	58.44	14.06
10	0.41	0.33	4.870	12.88	72.49	33.28	22.23
11	0.632	0.370	4.374	8.451	64.57	21.65	30.43
12	1.25	0.710	4.371	8.216	63.11	20.59	31.27
13	1.93	0.943	4.063	6.536	57.46	16.04	36.55
14	2.48	1.11	3.888	5.742	53.83	13.80	39.81
15	2.45	1.10	3.926	5.847	54.16	14.00	39.47
16	2.87	1.19	3.517	4.792	50.47	11.94	43.14
17	3.09	1.23	3.279	4.313	48.93	11.17	44.70
18	3.25	1.26	3.111	3.995	47.87	10.67	45.78
19	4.081	1.472	2.28	2.70	44.05	9.066	49.59
20	3.903	1.399	2.403	2.839	43.94	9.013	49.75
21	4.301	1.478	0.216	0.244	43.60	8.575	51.88
22	4.315	1.479	2.01	2.27	41.65	8.169	52.03
23	4.848	1.587	1.53	1.65	39.14	7.330	54.48
24	2.65	1.12	3.820	5.319	51.31	12.40	42.23
25	2.69	1.14	3.859	5.397	51.32	12.49	42.03
26	2.75	1.13	3.837	5.204	50.06	11.78	43.35
27	2.75	1.09	3.827	5.025	48.65	11.09	44.78
28	2.81	1.09	3.788	4.831	47.30	10.47	46.10
29	2.88	1.07	3.775	4.618	45.28	9.614	48.06
30	2.85	0.989	3.741	4.284	42.08	8.366	51.33
31	2.70	0.882	3.774	4.060	38.87	7.257	54.65
32	5.327	1.646	0.761	0.775	36.19	6.397	57.73
33	5.843	1.814	0.600	0.614	36.11	6.415	57.45
34	5.115	1.492	0.468	0.450	33.29	5.557	61.13
35	3.872	1.264	2.451	2.637	39.06	7.296	54.62
36	3.473	1.046	2.673	2.661	34.82	6.019	59.03
37	3.079	0.9291	3.024	3.008	34.80	6.008	59.10
38	2.27	0.722	3.850	4.034	37.76	6.867	56.112
39	1.91	0.587	3.912	3.969	36.24	6.383	57.94
40	1.31	0.378	4.038	3.825	32.58	5.357	62.06
41	1.25	0.353	3.951	3.682	31.73	5.134	63.07
42	0.995	0.270	4.039	3.618	29.34	4.562	65.63
43	0.505	0.133	4.280	3.709	27.38	4.118	67.84

44	0.438	0.111	4.081	3.421	25.36	3.691	70.12
45	0.18	0.046	4.329	3.648	25.72	3.762	69.77
46	0.10	0.030	6.517	6.224	31.83	5.276	61.55
47	1.18	0.672	2.73	5.12	64.81	21.14	31.29
48	2.83	1.13	1.47	1.94	51.21	11.75	44.49
49	2.87	1.16	2.31	3.07	50.63	11.69	44.19
50	1.33	0.738	4.272	7.790	62.15	19.67	32.24
51	4.145	1.407	0.990	1.11	42.32	8.220	52.54
52	3.14	1.30	2.817	3.333	47.16	10.33	46.61
53	0.886	0.276	4.079	4.189	37.80	6.740	57.23
54	4.920	1.422	0.498	0.475	32.89	5.439	61.70
55	4.710	1.294	0.458	0.414	29.90	4.699	64.93
56	4.765	1.416	1.00	0.982	34.24	5.825	59.99
57	2.26	0.647	2.949	2.785	32.53	5.332	62.26
58	2.19	0.602	2.733	2.474	30.13	4.734	64.94
59	0.22	0.0056	4.303	3.638	25.95	3.809	69.53
60	0.17	0.042	4.093	3.373	24.41	3.492	71.33
61	0.19	0.047	3.927	3.176	23.18	3.253	72.70
62	2.95	1.18	3.613	4.789	49.10	11.30	44.34
63	3.15	1.18	3.184	3.953	46.32	9.982	47.35
64	4.264	1.472	2.04	2.32	42.06	8.311	51.64
65	3.34	1.22	3.053	3.673	44.75	9.346	48.86
66	2.94	1.13	3.639	4.616	47.07	10.36	46.35
67	3.32	1.20	3.127	3.720	44.15	9.118	49.41
68	4.209	1.423	2.252	2.510	40.79	7.892	52.75
69	3.18	1.13	3.301	3.673	43.45	8.854	50.07
70	4.102	1.347	2.247	2.432	39.34	7.390	54.31
71	3.03	1.06	3.479	4.016	42.56	8.526	50.93
72	2.84	1.02	3.762	4.439	43.58	8.924	49.82
73	2.75	0.917	3.749	4.116	39.95	7.613	53.55

Auxiliary Information

Method / Apparatus / Procedure:

No information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given. The compiler estimates the reproducibility to be about 1%.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Calcium oxide; CaO; [1305-78-8]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, R. Dagon, Helv. Chim. Acta **44**, 2173-93 (1961).

Variables:

Composition at 0 and 50 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data

Table I. Invariant solutions in the $(NH_4)_3PO_4-Ca_3(PO_4)_2-H_3PO_4-H_2O$ system

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	H_2O cont[a]	Solid phases[b]
			temp = 0 °C		
1	9.1	11.1	79.8	214	A+B+C
2	9.1	11.1	79.8	215	A+B+C
3	21.8	3.6	74.6	389	A+C+D
4	21.9	3.5	74.6	391	A+C+D
5	12.4	16.4	71.2	436	B+C+D
			temp = 50 °C		
6[c]	4.1	16.1	79.8	92.6	A+B+C
7	4.0	16.0	80.0	93.0	A+B+C
8	7.5	12.9	79.6	141	A+C+D
9	4.8	17.1	78.1	114	B+C+D
10	4.9	17.1	78.0	115	B+C+D

Table II. Solutions coexisting with two solid phases in the $(NH_4)_3PO_4-Ca_3(PO_4)_2-H_3PO_4-H_2O$ system

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	H_2O cont[a]	Solid phases[b]
		temp = 0 °C			
11	2.2	10.8	87.0	114	A+B
12	2.4	10.8	86.8	118	A+B
13	5.6	10.9	83.5	170	A+B
14	8.1	10.9	81.0	200	A+B
15	8.8	11.0	80.2	211	A+B
16	11.5	9.4	79.1	249	A+C
17	15.1	7.1	77.8	304	A+C
18	21.3	3.8	74.9	381	A+C
19	24.1	1.2	74.7	427	A+D
20	9.6	11.1	79.3	225	B+C
21	10.6	11.8	77.6	255	B+C
22	11.7	12.8	75.5	305	B+C
23	11.9	13.4	74.7	323	B+C
24	12.3	14.3	73.4	362	B+C
25	12.4	15.8	71.8	416	B+C
26	12.4	16.0	71.6	426	B+C
27	3.0	29.6	67.4	825	B+D
28	7.0	24.1	68.9	666	B+D
29	9.6	20.6	70.0	555	B+D
30	14.8	13.0	72.2	435	C+D
31	17.2	10.1	72.7	433	C+D
32	17.5	9.6	72.9	443	C+D
33	19.2	7.4	73.4	434	C+D
34	19.9	6.0	74.1	408	C+D
35	20.0	5.9	74.1	403	C+D
		temp = 50 °C			
36	0.9	14.4	84.7	37.7	A+B
37	1.5	14.8	83.7	53.3	A+B
38	2.4	15.2	82.3	69.5	A+B
39	3.4	15.6	81.0	82.8	A+B
40	4.1	15.9	80.0	92.9	A+B
41	3.9	15.9	80.2	90.2	A+B
42	4.7	15.3	80.0	101	A+C
43	5.7	13.7	80.6	132	A+C
44	6.1	14.2	79.7	121	A+C
45	6.8	13.5	79.7	131	A+C
46	7.3	13.1	79.6	139	A+C
47	7.7	12.9	79.4	142	A+C
48	8.1	11.5	80.4	160	A+D
49	8.8	10.3	80.9	160	A+D
50	10.3	8.4	81.3	178	A+D
51	11.3	6.9	81.8	196	A+D
52	12.1	5.6	82.3	205	A+D
53	13.0	4.4	82.6	214	A+D
54	14.7	2.2	83.1	234	A+D
55	16.5	0.0	83.5	253	A+D
56	4.2	16.1	79.7	96.8	B+C
57	4.2	16.1	79.7	97.0	B+C
58	4.5	16.4	79.1	103	B+C
59	4.8	16.9	78.3	111	B+C
60	5.1	17.4	77.5	120	B+C
61	5.2	17.7	77.1	125	B+C
62	5.6	18.6	75.8	141	B+C
63	0.5	32.4	67.1	302	B+D
64	1.1	30.2	68.7	284	B+D
65	2.0	27.1	70.9	246	B+D
66	2.9	24.1	73.0	206	B+D
67	3.8	21.1	75.1	169	B+D
68	3.9	20.7	75.4	165	B+D
69	4.3	18.7	77.0	136	B+D
70	5.4	15.8	78.8	121	C+D
71	6.0	15.0	79.0	122	C+D

Table III. Saturated solutions in equilibrium with one solid phase in the $(NH_4)_3PO_4-Ca_3(PO_4)_2-H_3PO_4-H_2O$ system

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	H_2O cont[a]	Solid phases[b]
		temp = 0 °C			
72	1.3	4.9	93.8	99	A
73	3.9	4.8	91.3	149	A
74	6.1	5.5	88.4	181	A
75	7.4	4.8	87.8	200	A
76	10.8	4.6	84.6	242	A
77	11.0	2.4	86.6	243	A
78	12.7	5.9	81.4	266	A
79	12.7	2.2	85.1	269	A
80	15.0	6.9	78.1	296	A
81	15.4	6.6	78.0	305	A
82	16.0	5.5	78.5	309	A
83	16.7	5.5	77.8	321	A
84	17.5	2.6	79.9	328	A
85	18.9	0.2	80.9	350	A
86	1.4	28.5	70.1	777	B
87	1.8	23.9	74.3	598	B
88	2.7	26.0	71.3	689	B
89	5.7	23.1	71.2	618	B
90	6.1	14.6	79.3	304	B
91	7.2	16.9	75.9	408	B
92	8.2	12.7	79.1	262	B
93	14.0	10.2	75.8	330	C
94	15.8	12.1	72.1	453	D
		temp = 50 °C			
95	1.0	4.0	95.0	51.8	A
96	1.1	9.9	89.0	52.5	A
97	3.6	5.1	91.3	102	A
98	3.6	10.0	86.4	102	A
99	4.7	14.9	80.4	109	A
100	7.2	4.8	88.0	150	A
101	7.3	9.7	83.0	148	A
102	8.0	12.5	79.5	145	A
103	9.2	9.7	81.1	163	A
104	11.1	4.9	84.0	194	A
105	15.2	1.0	83.8	238	A
106	0.9	17.2	81.9	97	B
107	0.9	20.8	78.2	152	B
108	1.5	24.1	74.4	202	B
109	2.8	17.3	79.7	111	B
110	3.2	19.6	77.2	146	B
111	6.4	13.9	79.7	128	C
112	5.6	16.1	78.3	145	D

Table IV. Summary of the invariant points in the $(NH_4)_3PO_4 - Ca_3(PO_4)_2 - H_2O$ system

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	H_2O cont[a]	Solid phases[b]
		temp = 0 °C			
113	—	—	100.0	48.4	E
114	—	7.3	92.7	18.0	E+F
115		7.7	92.3	25.8	F+G
116	—	11.1	88.9	76.5	B+G
117	—	33.3	66.7	925	B
118	25.1	—	74.9	452	A+D
119	0.2	—	99.8	48.4	A+E
120	traces	7.3	92.7	18	A+E+F
121	traces	7.7	92.3	26	A+F+G
122	1.0	10.8	88.2	70	A+B+G
123	9.1	11.1	79.8	215	A+B+C
124	21.9	3.5	74.6	390	A+C+D
125	12.4	16.4	71.2	436	A+B+D
		temp = 50 °C			
126	—	33.3	66.7	313	B
127	16.5	—	83.5	253	A+D
128	4.0	16.0	80.0	92.8	A+B+C
129	7.5	12.9	79.6	141	A+C+D
130	4.8	17.1	78.1	115	B+C+D

[a]The content is expressed as: mol/100 mol solute.
[b]The solid phases are: A = $Ca(H_2PO_4)_2 \cdot H_2O$; B = $NH_4H_2PO_4$; C = $Ca_9(NH_4)_4H_{32}(PO_4)_{18} \cdot 10H_2O$; D = $CaHPO_4 \cdot 2H_2O$; E = $2H_3PO_4 \cdot H_2O$; F = $NH_4H_5(PO_4)_2$; G = $NH_4H_5(PO_4)_2 \cdot H_2O$.
[c]These data are from Ref. 1.

Part 2. The compiler has recalculated the above data to give the following values

Soln no	CaO $100w_i$	CaO m_i/mol kg^{-1}	NH_3 $100w_i$	NH_3 m_i/mol kg^{-1}	H_3PO_4 $100w_i$	H_3PO_4 m_i/mol kg^{-1}	H_2O $100w_i$
1	3.4	1.2	2.53	2.95	43.7	8.86	50.4
2	3.4	1.2	2.52	2.94	43.6	8.82	50.5
3	5.68	1.60	0.57	0.53	30.4	4.90	63.3
4	5.69	1.60	0.55	0.51	30.3	4.87	63.5
5	2.99	0.802	2.40	2.12	28.1	4.31	66.5
6	2.2	1.3	5.20	9.96	62.0	20.6	30.6
7	2.1	1.2	5.16	9.85	61.9	20.5	30.8
8	3.4	1.5	3.56	5.24	53.1	13.5	40.0
9	2.4	1.2	5.12	8.58	57.4	16.7	35.1
10	2.4	1.2	5.10	8.50	57.2	16.6	35.2
11	1.1	0.54	3.32	5.34	59.0	16.5	36.0
12	1.2	0.57	3.27	5.16	58.2	15.9	37.3
13	2.4	0.93	2.80	3.63	49.4	11.1	45.4
14	3.2	1.2	2.58	3.10	45.4	9.47	48.9
15	3.3	1.2	2.52	2.97	44.1	8.98	50.1
16	3.97	1.31	2.0	2.1	40.2	7.62	53.8
17	4.63	1.42	1.3	1.3	35.7	6.25	58.3
18	5.64	1.60	0.61	0.57	30.8	5.00	62.9
19	5.91	1.61	0.18	0.16	28.6	4.46	65.3
20	3.5	1.2	2.46	2.81	42.5	8.42	51.5
21	3.60	1.18	2.43	2.63	39.6	7.43	54.4
22	3.57	1.09	2.37	2.38	35.5	6.20	58.5
23	3.50	1.04	2.39	2.35	34.3	5.85	59.8
24	3.42	0.977	2.37	2.24	31.8	5.21	62.4
25	3.09	0.841	2.39	2.14	29.0	4.52	65.5
26	3.04	0.821	2.38	2.12	28.6	4.42	66.0
27	0.45	0.10	2.70	2.00	17.5	2.25	79.3
28	1.2	0.29	2.60	2.02	20.7	2.80	75.5
29	1.9	0.48	2.54	2.08	23.7	3.37	71.8
30	3.58	0.962	1.91	1.69	28.2	4.33	66.3
31	4.17	1.13	1.49	1.32	28.3	4.36	66.1
32	4.18	1.12	1.4	1.2	27.8	4.27	66.6
33	4.65	1.26	1.1	0.97	28.2	4.36	66.0
34	5.03	1.39	0.92	0.84	29.4	4.65	64.6
35	5.10	1.41	0.91	0.83	29.7	4.71	64.3
36	0.6	0.7	5.84	21.9	77.9	50.7	15.7
37	0.91	0.78	5.60	15.9	72.7	35.7	20.8
38	1.4	0.99	5.38	12.5	67.9	27.4	25.3
39	1.9	1.2	5.23	10.8	64.4	23.0	28.5
40	2.2	1.3	5.13	9.81	61.9	20.6	30.7
41	2.1	1.2	5.18	10.1	62.6	21.2	30.1
42	2.4	1.3	4.80	8.68	60.3	18.9	32.5
43	2.7	1.2	3.90	5.92	54.7	14.4	38.7
44	3.0	1.4	4.17	6.73	56.4	15.8	36.5
45	3.2	1.5	3.84	5.91	54.7	14.6	38.3
46	3.3	1.5	3.64	5.40	53.4	13.7	39.6
47	3.5	1.6	3.55	5.21	52.9	13.5	40.1
48	3.5	1.4	3.01	4.11	50.3	11.9	43.1
49	3.8	1.6	2.70	3.69	50.4	11.9	43.1
50	4.24	1.66	2.1	2.7	48.0	10.7	45.7
51	4.45	1.65	1.6	2.0	45.9	9.74	48.0
52	4.66	1.69	1.3	1.6	44.9	9.31	49.2

Part 2. The compiler has recalculated the above data to give the following values

Soln no	CaO 100w_i	CaO m_i/mol kg^{-1}	NH$_3$ 100w_i	NH$_3$ m_i/mol kg^{-1}	H$_3$PO$_4$ 100w_i	H$_3$PO$_4$ m_i/mol kg^{-1}	H$_2$O 100w_i
53	4.90	1.74	1.0	1.2	43.9	8.93	50.2
54	5.29	1.80	0.48	0.54	41.9	8.17	52.3
55	5.68	1.87	0.0	0.0	40.1	7.56	54.2
56	2.2	1.2	5.12	9.52	61.1	19.7	31.6
57	2.2	1.2	5.12	9.50	61.0	19.7	31.7
58	2.3	1.3	5.10	9.11	59.7	18.5	32.9
59	2.4	1.2	5.11	8.71	58.0	17.2	34.5
60	2.5	1.2	5.10	8.29	56.3	15.9	36.2
61	2.5	1.2	5.10	8.09	55.4	15.2	37.1
62	2.5	1.1	5.09	7.52	52.6	13.5	39.8
63	0.15	0.05	5.97	6.00	35.4	6.17	58.5
64	0.35	0.11	5.78	5.95	36.8	6.57	57.1
65	0.69	0.23	5.64	6.18	40.0	7.60	53.7
66	1.1	0.40	5.53	6.58	44.0	9.10	49.3
67	1.6	0.64	5.34	7.06	48.6	11.1	44.5
68	1.6	0.67	5.30	7.10	49.2	11.4	43.9
69	2.0	0.90	5.22	7.81	53.6	13.9	39.2
70	2.6	1.3	4.63	7.47	56.3	15.8	36.5
71	2.9	1.4	4.38	7.04	56.1	15.7	36.6
72	0.71	0.37	1.6	2.8	63.4	18.9	34.3
73	1.8	0.74	1.3	1.8	53.5	12.6	43.3
74	2.5	0.95	1.4	1.7	48.5	10.4	47.5
75	2.9	1.0	1.2	1.4	46.1	9.44	49.8
76	3.83	1.27	0.99	1.1	41.3	7.83	53.9
77	3.91	1.29	0.52	0.56	41.4	7.79	54.2
78	4.24	1.36	1.2	1.3	38.9	7.13	55.7
79	4.24	1.34	0.45	0.47	38.9	7.05	56.4
80	4.68	1.44	1.3	1.3	36.3	6.42	57.7
81	4.71	1.44	1.2	1.2	35.7	6.23	58.4
82	4.86	1.48	1.0	1.0	35.4	6.15	58.7
83	4.95	1.48	0.99	0.98	34.5	5.92	59.5
84	5.15	1.52	0.46	0.45	34.2	5.80	60.2
85	5.33	1.54	0.03	0.03	32.9	5.43	61.8
86	0.22	0.050	2.73	2.04	18.4	2.39	78.6
87	0.35	0.084	2.81	2.23	22.6	3.11	74.2
88	0.47	0.11	2.74	2.10	20.2	2.70	76.6
89	1.1	0.26	2.64	2.09	22.0	3.01	74.3
90	1.9	0.56	2.73	2.70	35.9	6.16	59.5
91	1.8	0.50	2.61	2.32	29.6	4.59	65.9
92	1.9	0.50	1.81	1.54	27.3	4.05	68.9
93	4.07	1.20	1.80	1.76	33.9	5.74	60.2
94	3.72	0.99	1.73	1.51	27.4	4.16	67.2
95	0.65	0.54	1.6	4.3	76.3	36.2	21.5
96	0.70	0.59	3.8	11	74.4	36.0	21.1
97	1.9	1.0	1.6	2.8	62.2	18.5	34.3
98	1.9	1.0	3.22	5.57	61.2	18.6	33.7
99	2.4	1.2	4.56	7.81	58.8	17.5	34.3
100	3.3	1.4	1.3	1.8	52.8	12.7	42.6
101	3.3	1.4	2.6	3.7	52.5	12.9	41.6
102	3.6	1.6	3.41	4.94	52.4	13.2	40.6
103	3.9	1.6	2.5	3.4	50.0	11.7	43.5
104	4.41	1.64	1.2	1.4	46.3	9.83	48.1

Part 2. The compiler has recalculated the above data to give the following values

Soln no	CaO 100w_i	CaO m_i/mol kg^{-1}	NH$_3$ 100w_i	NH$_3$ m_i/mol kg^{-1}	H$_3$PO$_4$ 100w_i	H$_3$PO$_4$ m_i/mol kg^{-1}	H$_2$O 100w_i
105	5.42	1.83	0.22	0.24	41.6	8.03	52.8
106	0.5	0.3	5.51	9.98	61.5	19.3	32.5
107	0.4	0.2	5.57	7.68	51.4	12.3	42.6
108	0.57	0.21	5.60	6.69	44.6	9.25	49.2
109	1.4	0.62	5.32	7.59	52.1	12.9	41.2
110	1.4	0.72	5.32	8.04	58.3	17.0	35.0
111	3.0	1.4	4.00	6.22	55.2	14.9	37.8
112	2.5	1.1	4.39	6.32	52.3	13.1	40.8
113	0	0	0	0	78.92	38.19	21.08
114	0	0	3.3	23	88.1	105	8.6
115	0	0	3.4	17	84.7	72.8	11.9
116	0	0	3.91	8.11	67.7	24.4	28.4
117	0	0	2.77	2.00	16.0	2.00	81.3
118	6.11	1.66	0	0	28.3	4.41	65.6
119	0.1	0.1	0	0	78.8	38.3	21.0
120	traces		3.3	23	88.1	105	8.6
121	traces		3.4	17	84.6	72.2	12.0
122	0.58	0.37	3.80	8.00	67.7	24.7	28.0
123	3.4	1.2	2.52	2.94	43.6	8.82	50.5
124	5.70	1.60	0.55	0.51	30.3	4.88	63.4
125	2.99	0.802	2.40	2.12	28.1	4.31	66.5
126	0	0	6.00	5.94	34.6	5.95	59.4
127	5.7	1.9	0	0	40.1	7.56	54.2
128	2.1	1.2	5.16	9.87	62.0	20.6	30.7
129	3.4	1.5	3.56	5.24	53.1	13.5	40.0
130	2.4	1.2	5.10	8.50	57.3	16.6	35.3

Auxiliary Information

Method / Apparatus / Procedure:
No information is given.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given. The compiler estimates the reproducibility to be about 1%.

References:

[1]R. Flatt, G. Brunisholz, E. Lauber, Helv. Chim. Acta 36, 1971 (1953).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Calcium oxide; CaO; [1305-78-8]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

I.I. Orekhov, G.L. Slobodkina, Zh. Neorg. Khim. **17**, 829-32 (1972).

Variables:

Temperature and composition at a NH_3:H_3PO_4 ratio = 0.5.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Solubility isotherms in the $(NH_4)_3PO_4 - H_3PO_4 - Ca_3(PO_4)_2 - H_2O$ system with the ratio NH_3/H_3PO_4 = 0.5

Soln no	CaO $100w_i$	NH_3 $100w_i$	P_2O_5 $100w_i$	H_2O $100w_i$	H_3PO_4[a] $100w_i$	H_2O[b] $100w_i$	Solid phases[c]
			temp = 45 °C				
1	1.33	1.24	9.88	87.55	13.6	83.79	A
2	1.62	1.80	14.77	81.81	20.40	76.18	A
3	1.84	2.41	19.64	76.11	27.12	68.63	A
4	2.10	3.01	24.56	70.33	33.91	60.98	A
5	2.32	3.68	29.35	64.65	40.53	53.47	A+B
6	2.49	4.21	34.13	59.17	47.13	46.17	A+B+C
7	2.44	4.79	39.06	53.71	53.94	38.83	B+C
8	1.91	5.47	44.22	48.40	61.06	31.56	B+C
9	1.17	6.06	49.35	43.42	68.15	24.62	B+C
10	0.50	6.73	54.72	38.05	75.56	17.21	B+C
			temp = 60 °C				
11	0.89	1.26	9.91	87.96	13.7	84.19	A
12	1.26	1.82	14.81	82.11	20.45	76.47	A
13	1.57	2.41	19.69	76.33	27.19	68.83	A
14	1.75	3.03	24.56	70.66	33.91	61.31	A
15	2.07	3.62	29.38	64.93	40.57	53.74	A+B
16	2.30	4.21	34.20	59.29	47.23	46.26	A+B
17	2.52	4.79	37.04	55.65	51.15	41.54	A+B
18	2.39	5.45	43.92	48.24	60.65	31.51	A+B+C
19	1.61	6.05	49.19	43.15	67.92	24.42	B+C
20	0.83	6.71	54.54	37.92	75.31	17.15	B+C
			temp = 75 °C				
21	0.68	1.24	9.93	88.15	13.7	84.37	A+B
22	0.99	1.82	14.86	82.33	20.52	76.67	A+B
23	1.24	2.41	19.75	76.60	27.27	69.08	A+B
24	1.38	3.03	24.69	70.90	34.09	61.50	A+B
25	1.81	3.53	29.45	65.21	40.67	53.99	A+B
26	2.01	4.22	34.30	59.47	47.36	46.41	A+B
27	2.07	4.92	39.17	53.84	54.09	38.92	A+B
28	2.43	5.44	43.87	48.26	60.58	31.55	A+B
29	2.09	6.02	49.68	42.21	68.60	23.29	B+C
30	1.36	6.67	54.25	37.72	74.91	17.06	B+C
			temp = 90 °C				
31	0.55	1.24	9.94	88.27	13.7	84.48	A+B
32	0.80	1.83	14.88	82.49	20.55	76.82	A+B
33	1.04	2.42	19.77	76.77	27.30	69.24	A+B
34	1.26	3.04	24.69	71.01	34.09	61.61	A+B
35	1.45	3.65	29.56	65.34	40.82	54.08	A+B
36	1.75	4.23	34.39	59.63	47.49	46.53	A+B
37	1.87	4.83	39.17	54.13	54.09	39.21	A+B
38	2.22	5.46	44.00	48.32	60.76	31.56	A+B
39	2.40	6.00	48.83	42.77	67.43	24.17	A+B
40	1.51	6.67	54.17	37.65	74.80	17.02	B+C

[a]These values were calculated by the compiler.
[b]This is the water content of the $CaO-NH_3-H_3PO_4-H_2O$ system.
[c]The solid phases are: A = $CaHPO_4$; B = $NH_4H_2PO_4$; C = $Ca(H_2PO_4)_2 \cdot H_2O$.

Part 2. The compiler has used the data in Part 1 to calculate the following molalities

Soln no	CaO m_i/mol kg^{-1}	NH_3 m_i/mol kg^{-1}	H_3PO_4 m_i/mol kg^{-1}
1	0.283	0.870	1.66
2	0.379	1.39	2.732
3	0.478	2.06	4.032
4	0.614	2.90	5.675
5	0.774	4.05	7.745
6	0.962	5.36	10.42
7	1.12	7.25	11.47
8	1.08	10.2	19.74
9	0.847	14.5	28.24
10	0.52	23.0	44.80
11	0.19	0.66	1.66
12	0.294	1.40	2.729
13	0.407	2.06	4.031
14	0.509	2.91	5.645
15	0.687	3.96	7.703
16	0.886	5.35	10.42
17	1.08	6.78	12.56
18	1.35	10.2	19.64
19	1.18	14.6	28.39
20	0.86	23.0	44.82
21	0.14	0.864	1.66
22	0.23	1.40	2.731
23	0.322	2.05	4.029
24	0.401	2.90	5.657
25	0.598	3.84	7.685
26	0.772	5.35	10.41
27	0.948	7.43	14.18
28	1.37	10.1	19.59
29	1.60	15.2	30.06
30	1.42	23.0	44.81
31	0.12	0.863	1.66
32	0.19	1.40	2.730
33	0.268	2.05	4.023
34	0.365	2.90	5.647
35	0.478	3.97	7.702
36	0.671	5.34	10.41
37	0.850	7.24	14.08
38	1.25	10.2	19.64
39	1.77	14.6	28.46
40	1.58	23.0	44.85

Auxiliary Information

Method / Apparatus / Procedure:

An isothermal method[1] was used. Phosphoric acid neutralized by NH_3 to the chosen ratio was placed in round 350 ml vessels and stirred. CaO was then added in small amounts until a steady turbidity appeared. Equilibrium was ascertained by repeated analysis of the liquid phase for Ca. This was done complexometrically using fluorexon as indicator.[2] Equilibrium was reached in 4–6 hrs. The composition of the solid phase was determined petrographically and by chemical analysis.

Source and Purity of Materials:

Chemically pure H_3PO_4 and aqueous ammonia and reagent grade CaO were used. The CaO was powdered and sifted through a 0.16 mm mesh sieve.

Estimated Error:

No information is given.

References:

[1]A.G. Bergman, N.P. Luzhnaya, Fizikokhimicheskiye Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow, IAN SSSR, 1951.
[2]I.B. Moyzhes, V.A. Ershova, Eds.; Metody Analiza pri Kontrole Proizvodstva Fosfora I Fosfornoy Kisloty, Leningrad, 1968.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Nitric acid; HNO_3; [7697-37-2]
(3) Phosphoric acid; H_3PO_4; [7664-38-2]
(4) Calcium oxide; CaO; [1305 78 8]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, P. Clerc, Helv. Chim. Acta **35**, 336-40 (1952).

Variables:

Composition at 25 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data

Table I. Solutions coexisting with $Ca(H_2PO_4)_2 \cdot H_2O$ and $NH_4H_2PO_4$

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	NO_3 eq %	PO_4^{3} eq %	H_2O cont[a]
1	19.3	44.0	36.7	55.4	44.6	173.2
2	18.5	41.2	40.3	49.9	50.1	206.2
3	8.5	32.9	58.6	33.2	66.8	106.0
4	13.0	28.8	58.2	29.1	70.9	160.0
5	5.1	27.0	67.9	23.0	77.0	57.8
6	7.8	26.4	65.8	23.5	76.5	96.5

Table II. Solutions coexisting with $Ca(H_2PO_4)_2 \cdot H_2O$, $NH_4H_2PO_4$ and NH_4NO_3.

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	NO_3^- eq %	PO_4^{3-} eq %	H_2O cont[a]	Solid phases[b]
7	1.5	20.5	78.0	11.9	88.1	19.4	A+B+C+D
8	2.2	22.2	75.6	14.4	85.6	33.4	A+B+C
9	3.3	24.1	72.6	17.8	82.2	45.0	A+B+C
10	4.9	26.8	68.3	22.7	77.3	55.4	A+B+C
11	8.4	32.9	58.7	33.1	66.9	77.0	A+B+C
12	11.2	37.7	51.1	42.0	58.0	91.4	A+B+C
13	14.6	44.2	41.2	52.4	47.6	111.7	A+B+C
14	17.4	48.4	34.2	59.5	40.5	118.3	A+B+C
15	20.9	55.7	23.4	72.2	27.8	144.1	A+B+C
16	21.6	56.5	21.9	73.8	26.2	143.3	A+B+C+E
17[c]	22.0	57.9	20.1	75.5	24.5	148.0	A+B+C
18[c]	21.9	59.0	19.1	77.2	22.9	148.1	A+B+C

[a]The content is expressed as: mol/100 mol solute.
[b]The solid phases are: A = $Ca(H_2PO_4)_2 \cdot H_2O$; B = $NH_4H_2PO_4$; C = NH_4NO_3; D = $(NH_4)_3H_9(PO_4)_4$; E = $Ca_9(NH_4)_4H_{32}(PO_4)_{18} \cdot 10H_2O$.
[c]This was a metastable equilibrium.

Part 2. The compiler has used the data in Tables I and II to calculate the following $100w_i$ values

Soln no	Ca^{2+}	NH_4^+	H^+	NO_3^-	PO_4^{3-}	H_2O
1	4.2	8.1	0.4	37.9	15.5	33.9
2	3.9	7.3	0.4	32.9	16.7	38.8
3	2.5	8.1	0.8	30.2	30.9	27.5
4	3.3	6.3	0.7	23.5	29.1	37.0
5	1.8	8.2	1.2	26.0	44.1	18.6
6	2.5	7.1	1.0	23.4	38.6	27.4
7	0.7	8.0	1.8	17.1	64.4	8.0
8	0.9	8.0	1.6	19.1	57.7	12.7
9	1.3	8.0	1.4	21.9	51.5	15.8
10	1.8	8.3	1.2	25.9	44.8	18.1
11	2.6	8.8	0.9	32.6	33.4	21.7
12	3.2	9.1	0.7	37.5	26.3	23.3
13	3.7	9.5	0.5	41.7	19.2	25.4
14	4.2	9.8	0.4	44.7	15.5	25.4
15	4.4	10.1	0.2	48.3	9.4	27.5
16	4.6	10.1	0.2	49.0	8.8	27.2
17	4.6	10.2	0.2	49.3	8.1	27.6
18	4.5	10.3	0.2	50.0	7.5	27.4

The compiler has used the data in Tables I and II to calculate the following molalities as mol/kg H_2O values

Soln no	Ca^{2+}	NH_4^+	H^+	NO_3^-	PO_4^{3-}
1	3.1	14.4	11.8	17.8	4.8
2	2.5	11.1	10.9	13.4	4.5
3	2.2	17.2	30.7	17.4	11.7
4	2.3	10.0	20.2	10.1	8.2
5	2.5	26.0	65.3	22.1	24.7
6	2.2	15.2	37.9	13.5	14.7
7	2.1	58.7	223.4	34.1	84.1
8	1.8	36.9	125.7	24.0	47.5
9	2.0	29.8	89.6	22.0	33.8
10	2.5	26.9	68.5	22.8	25.8
11	3.0	23.7	42.4	23.9	16.1
12	3.4	22.9	31.1	25.5	11.8
13	3.6	22.0	20.5	26.1	7.9
14	4.1	22.7	16.1	27.9	6.3
15	4.0	21.5	9.0	27.8	3.6
16	4.2	21.9	8.5	28.6	3.4
17	4.1	21.7	7.5	28.3	3.1
18	4.1	22.1	7.2	29.0	2.9

Auxiliary Information

Method / Apparatus / Procedure:

No information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components:	**Original Measurements:**
(1) Ammonia; NH_3; [7664-41-7] (2) Nitric acid; HNO_3; [7697-37-2] (3) Phosphoric acid; H_3PO_4; [7664-38-2] (4) Calcium oxide; CaO; [1305-78-8] (5) Water; H_2O; [7732-18-5]	R. Flatt, G. Brunisholz, E. Lauber, Helv. Chim. Acta **36**, 1971-80 (1953).
Variables:	**Prepared By:**
Composition at 0, 25 and 50 °C.	J. Eysseltová

Experimental Data

Part 1. The authors' data

Composition of saturated solutions coexisting with $Ca(H_2PO_4)_2 \cdot H_2O$, $NH_4H_2PO_4$ and $Ca_9(NH_4)_4H_{32}(PO_4)_{18} \cdot 10H_2O$

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	NO_3^- eq %	PO_4^{3-} eq %	H_2O cont[a]	Solid phases[b]
			temp = 0 °C				
1	8.45	10.93	80.62	0.00	100.00	196.5	A+B+C
2	15.18	16.53	68.29	14.73	85.27	239.1	A+B+C
3	22.56	24.10	53.34	33.46	66.54	264.6	A+B+C
4	29.90	35.01	35.09	56.35	43.65	265.2	A+B+C
5	32.94	42.09	24.97	69.14	30.86	244.2	A+B+C
6	34.33	48.05	17.62	78.30	21.70	223.8	A+B+C+D
			temp = 25 °C				
7	5.64	13.83	80.53	0.00	100.00	137.8	A+B+C
8	6.37	14.88	78.75	2.22	97.78	140.8	A+B+C
9	7.45	16.76	75.79	6.09	93.91	148.4	A+B+C
10	8.60	18.47	72.93	9.60	90.40	150.6	A+B+C
11	9.98	21.12	68.90	14.57	85.43	158.6	A+B+C
12	11.18	23.35	65.47	19.35	80.65	162.5	A+B+C
13	14.86	31.60	53.54	34.39	65.61	175.4	A+B+C
14	16.80	36.18	47.02	42.96	57.04	176.3	A+B+C
15	17.56	38.81	43.63	46.90	53.10	173.8	A+B+C
16	19.82	45.58	34.60	57.92	42.08	169.6	A+B+C
17	20.59	50.39	29.02	64.00	36.00	158.8	A+B+C
18	21.15	54.06	24.79	70.57	29.43	147.5	A+B+C
19	21.55	56.54	21.91	73.78	26.22	143.3	A+B+C+D
			temp = 50 °C				
20	4.08	16.15	79.77	0.00	100.00	92.6	A+B+C
21	7.20	25.08	67.72	16.19	83.81	97.6	A+B+C
22	9.54	37.14	53.32	34.93	65.07	105.1	A+B+C
23	12.79	53.45	33.76	59.05	40.95	96.9	A+B+C

[a]The water content is expressed as mol/100 mol solute.
[b]The solid phases are: A – $Ca(H_2PO_4)_2 \cdot H_2O$; B = $NH_4H_2PO_4$; C = $Ca_9(NH_4)_4H_{32}(PO_4)_{18} \cdot 10H_2O$; D – NH_4NO_3.

Part 2. The compiler has used the data in Part 1 to calculate the following concentration values
Values expressed as $100w_i$

Soln no	Ca^{2+}	NH_4^+	H^+	NO_3^-	PO_4^{3-}	H_2O
1	2.36	2.59	1.12	0.00	44.61	49.31
2	3.53	3.27	0.79	10.78	31.67	49.96
3	4.56	4.14	0.54	21.26	21.47	48.03
4	5.47	5.44	0.32	32.42	12.75	43.59
5	5.92	6.43	0.22	39.11	8.86	39.45
6	6.15	7.32	0.16	44.13	6.21	36.03
7	1.85	3.86	1.32	0.00	52.38	40.60
8	2.04	4.05	1.26	2.23	49.96	40.47
9	2.27	4.34	1.15	5.84	45.74	40.65
10	2.55	4.65	1.08	8.94	42.74	40.05
11	2.80	5.04	0.97	12.87	38.31	40.01
12	3.02	5.36	0.88	16.45	34.82	39.46
13	3.58	6.47	0.64	26.07	25.25	37.98
14	3.87	7.08	0.54	31.10	20.97	36.45
15	3.98	7.48	0.49	33.44	19.22	35.39
16	4.29	8.38	0.37	39.43	14.55	32.98
17	4.42	9.18	0.31	43.17	12.33	30.59
18	4.50	9.78	0.26	47.24	10.00	28.20
19	4.55	10.15	0.23	49.02	8.85	27.20
20	1.54	5.19	1.50	0.00	60.34	31.43
21	2.37	7.00	1.11	16.73	43.98	28.81
22	2.71	8.97	0.76	31.21	29.53	26.83
23	3.21	11.41	0.42	46.66	16.43	21.87

The following values are expressed as m_i/mol kg^{-1}

1	1.19	3.09	22.79	0.00	9.42
2	1.70	3.84	15.87	3.42	6.60
3	2.37	5.06	11.20	7.03	4.66
4	3.13	7.33	7.35	11.80	3.05
5	3.75	9.58	5.68	15.73	2.34
6	4.26	11.93	4.37	19.44	1.80
7	1.14	5.38	32.47	0.00	13.44
8	1.26	5.87	31.07	0.88	12.86
9	1.39	6.27	28.37	2.28	11.72
10	1.59	6.81	26.90	3.54	11.12
11	1.75	7.40	24.13	5.10	9.98
12	1.91	7.98	22.38	6.62	9.19
13	2.35	10.01	16.96	10.89	6.93
14	2.65	11.40	14.82	13.54	5.99
15	2.81	12.41	13.95	14.99	5.66
16	3.25	14.93	11.33	18.97	4.59
17	3.60	17.63	10.15	22.39	4.20
18	3.98	20.36	9.34	26.58	3.69
19	4.18	21.92	8.49	28.60	3.39
20	1.22	9.69	47.86	0.00	20.00
21	2.05	14.28	38.55	9.22	15.90
22	2.52	19.63	28.18	18.46	11.47
23	3.67	30.64	19.36	33.86	7.83

Auxiliary Information

Method / Apparatus / Procedure:

The eutonic solution existing in equilibrium with 3 salts– $Ca(H_2PO_4)_2 \cdot H_2O$, $NH_4H_2PO_4$ and $Ca_9(NH_4)_4H_{32}(PO_4)_{18} \cdot 10H_2O$–was prepared and saturated with NH_4NO_3. The system was stirred in a thermostat and examined petrographically. When all the desired phases were present, the stirring was interrupted and the system was equilibrated for at least 3 weeks. The satd soln was analyzed for Ca^{2+}, NH_4^+, H^+, NO_3 and PO_4^{3-}. The analytical methods are not described.

Source and Purity of Materials:

No information is given.

Estimated Error:

The only information given is that the temperature 273 K was kept constant within ±0.1 K.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Nitric acid; HNO_3; [7697-37-2]
(3) Phosphoric acid; H_3PO_4; [7664-38-2]
(4) Calcium oxide; CaO; [1305-78-8]
(5) Water; H_2O; [7732-18-5]

Original Measurements:
R. Flatt, G. Brunisholz, E. Lauber, Helv. Chim. Acta **36**, 1980-3 (1953).

Variables:
Composition at 25 °C.

Prepared By:
J. Eysseltová

Experimental Data

Part 1. The authors' data

Composition of saturated solutions coexisting with $Ca(H_2PO_4)_2 \cdot H_2O$ and $NH_4H_2PO_4$ at 25 °C

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	NO_3^- eq %	PO_4^{3-} eq %	H_2O comp[a]
1	3.30	15.58	81.12	4.43	95.57	90.4
2	7.98	18.89	73.13	10.39	89.61	146.6
3	8.61	18.88	72.51	10.56	89.44	148.8
4	9.51	21.52	68.97	15.77	84.23	148.9
5	9.31	26.97	63.72	25.22	74.78	116.4
6	13.14	27.87	58.99	27.51	72.49	169.0
7	14.01	35.61	50.38	39.95	60.05	141.3
8	18.13	41.49	40.38	51.24	48.76	170.1
9	17.74	45.01	37.25	55.39	44.61	149.5

[a]The composition units are: mol/100 mol solute.

Part 2. The compiler has used the data in Part 1 to calculate the following values

Composition of saturated solutions coexisting with $Ca(H_2PO_4)_2 \cdot H_2O$ and $NH_4H_2PO_4$ at 25 °C

Soln no	Ca^{2+}	NH_4^+	H^+	NO_3^-	PO_4^{3-}	H_2O
			Values as $100w_i$			
1	1.23	4.93	1.51	5.19	56.87	30.26
2	2.38	4.79	1.09	9.75	42.70	39.29
3	2.55	4.75	1.07	9.83	42.26	39.55
4	2.72	5.24	0.99	14.21	38.53	38.31
5	2.75	6.77	0.94	23.42	35.26	30.87
6	3.34	6.01	0.75	21.97	29.39	38.54
7	3.54	7.66	0.64	31.79	24.26	32.11
8	4.05	7.88	0.45	36.03	17.41	34.17
9	4.05	8.74	0.42	39.81	16.28	30.69
			Molalities as mol/kg H_2O			
1	1.01	9.57	49.85	2.72	19.58	
2	1.51	7.16	27.71	3.94	11.32	
3	1.61	7.05	27.07	3.94	11.13	
4	1.77	8.03	25.73	5.88	10.48	
5	2.22	12.87	30.41	12.04	11.90	
6	2.16	9.16	19.39	9.04	7.94	
7	2.75	14.00	19.81	15.71	7.87	
8	2.96	13.55	13.19	16.74	5.31	
9	3.30	16.73	13.84	20.58	5.53	

Auxiliary Information

Method / Apparatus / Procedure:
Nothing is stated but it is probably the same as described earlier.[1]

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given.

References:
[1]R. Flatt, G. Brunisholz, E. Lauber, Helv. Chim. Acta **36**, 1971 (1956).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Nitric acid; HNO_3; [7697-37-2]
(3) Phosphoric acid, H_3PO_4; [7664-38-2]
(4) Calcium oxide, CaO; [1305-78-8]
(5) Water, H_2O; [7732-18-5]

Original Measurements:

R. Flatt, G. Brunisholz, M. Fell, Helv. Chim. Acta. **39**, 1130-44 (1956).

Variables:

Composition at 25 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data

Table I. Composition of solutions saturated simultaneously with $Ca(H_2PO_4)_2 \cdot H_2O$, $CaHPO_4 \cdot 2H_2O$, $Ca_9(NH_4)_4H_{32}(PO_4)_{18} \cdot 10H_2O$ and NH_4NO_3

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	NO_3^- eq %	PO_4^{3-} eq %	H_2O cont[a]
1	29.60	57.50	12.90	84.40	15.60	148.6
2	27.70	56.70	15.60	81.30	18.70	142.8
3	25.70	58.90	15.40	81.60	18.40	151.7
4[b]	27.70	57.70	14.60	82.40	17.60	147.7

Table II. Composition of solutions saturated simultaneously with $Ca(H_2PO_4)_2 \cdot H_2O$, $CaHPO_4 \cdot H_2O$ and $Ca_9(NH_4)_4H_{32}(PO_4)_{18} \cdot 10H_2O$

Soln no	Ca^{2+} eq %	NH_4^+ eq %	H^+ eq %	NO_3^- eq %	PO_4^{3-} eq %	H_2O cont[a]
5	30.80	51.30	17.90	78.20	21.80	190.7
6	32.50	45.50	22.00	73.20	26.80	221.7
7	34.70	37.30	28.00	65.60	34.40	267.0
8	36.20	34.60	29.20	63.10	36.90	312.9
9	35.40	30.70	33.90	57.20	42.80	319.1
10	33.80	26.10	40.10	49.20	50.80	333.8
11	33.30	23.80	42.90	45.70	54.30	330.2
12	31.80	20.30	47.90	39.40	60.60	330.1
13	27.50	17.40	55.10	30.10	69.90	322.7
14	25.80	15.80	58.40	26.10	73.90	317.7
15	25.10	25.50	59.40	24.60	75.40	314.7
16	23.30	14.30	62.40	21.10	78.90	305.1
17	22.00	13.90	64.10	28.80	81.20	298.0
18	21.00	13.20	65.80	17.00	83.00	294.0
19	19.90	12.40	67.70	14.70	85.30	287.6

[a] The water content is expressed as mol/100 mol solute.
[b] This is the average of soln nos. 1-3.

Part 2. The compiler has used the data in Part 1 to calculate the following concentration values

Soln no	Ca^{2+}	NH_4^+	H^+	NO_3^-	PO_4^{3-}	H_2O
			Values expressed as $100w_i$			
1	5.89	9.72	0.13	52.78	4.85	26.54
2	5.65	9.82	0.16	52.13	6.09	26.15
3	5.15	10.04	0.15	51.45	5.89	27.32
4	5.57	9.86	0.15	52.10	5.65	26.67
5	5.84	8.27	0.17	46.64	6.60	32.48
6	5.97	7.10	0.20	42.29	7.86	36.58
7	6.10	5.57	0.25	36.27	9.66	42.16
8	5.98	4.86	0.24	32.77	9.73	46.42
9	5.92	4.36	0.28	30.08	11.43	47.93
10	5.69	3.74	0.34	26.06	13.66	50.51
11	5.72	3.47	0.37	24.66	14.88	50.90
12	5.59	3.03	0.42	21.79	17.02	52.14
13	5.08	2.73	0.51	17.49	20.63	53.56
14	4.89	2.54	0.55	15.56	22.37	54.09
15	4.81	2.52	0.57	14.83	23.08	54.19
16	4.61	2.41	0.62	13.14	24.95	54.27
17	4.46	2.39	0.65	11.98	26.28	54.24
18	4.32	2.31	0.68	11.01	27.29	54.38
19	4.19	2.22	0.71	9.74	28.70	54.43
			Values are expressed as m_i / mol kg^{-1} H_2O			
1	5.53	21.50	4.82	31.55	1.94	
2	5.39	22.06	6.07	31.63	2.43	
3	4.71	21.57	5.64	29.88	2.25	
4	5.21	21.70	5.49	30.99	2.21	
5	4.49	14.94	5.21	22.78	2.12	
6	4.07	11.40	5.51	18.34	2.24	
7	3.61	7.76	5.83	13.65	2.39	
8	3.21	6.14	5.18	11.20	2.18	
9	3.08	5.34	5.90	9.96	2.48	
10	2.81	4.34	6.67	8.19	2.82	
11	2.80	4.00	7.22	7.69	3.05	
12	2.68	3.42	8.06	6.63	3.40	
13	2.37	3.00	9.49	5.18	4.01	
14	2.26	2.76	10.21	4.56	4.31	
15	2.22	2.74	10.49	4.34	4.44	
16	2.12	2.60	11.36	3.84	4.79	
17	2.05	2.59	11.95	3.50	5.05	
18	1.98	2.49	12.43	3.21	5.23	
19	1.92	2.40	13.08	2.84	5.49	

Auxiliary Information

Method / Apparatus / Procedure:

No information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given. The compiler estimates the reproducibility to be about 5 %.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Sulfuric acid; H_2SO_4; [7664-93-9]
(4) Potassium oxide; K_2O; [12136-45-7]
(5) Water; H_2O; [7732-18-5]

Evaluator:
J. Eysseltová
Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

5.2. Solubilities in the NH_3–H_3PO_4–H_2SO_4–H_2O System

The quaternary system NH_3–H_3PO_4–H_2SO_4–H_2O may be formed by the addition of H_2SO_4 to the ternary system NH_3–H_3PO_4–H_2O. There are four reports[1-4] that contain solubility data for this quaternary system. The solubility data in these four reports agree reasonably well with each other after discounting a systematic error in two of the reports.[1,2] Therefore these solubility data are considered to be reliable. Furthermore, the existence of $(NH_4)_2H_3PO_4SO_4$ [25993-60-1] is also considered to have been established as well as the fact that it is congruently soluble in water over a temperature range of 273 to 373 K.

In two reports[5,6] the system is described as $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$(NH_4)_2SO_4$–H_2O. The Evaluator believes that a comparison can be made of the solubility data for this system and that of the system described in the preceding paragraph. Such a comparison can be made at 273, 298 and 323 K. To do this, the isotherms were depicted in tetrahedral coordinates and then projected on planes perpendicular to an edge of the NH_3–H_3PO_4–H_2SO_4 triangle.[15] Such a projection gives absolute solubility values, the shape and position of individual crystallization fields, and any scatter in the reported data. Using this procedure, all the data in Refs. (1–4,6) are in satisfactory agreement with each other. The data reported by Kaganskiy and Babenko[5] and by Uno[3] agree with each other but there is significant scatter in the data near the crystallization surface.

Fokina et al.,[7] studied the $NH_4H_2PO_4$–H_3PO_4–K_2SO_4–H_2O system. Such a system can be considered as a section through the NH_3–H_3PO_4–H_2SO_4–K_2O–H_2O system where the molar ratio H_2SO_4/K_2O = 1. Solid solutions between ammonium and potassium dihydrogenphosphates exist as solid equilibrium phases in this system. The ability of these two dihydrogenphosphates to form such solid solutions (designated as β-solid solution) has been proved in studies of the $NH_4H_2PO_4$–KH_2PO_4–H_2O system.[8-14]

References:

[1] L. E. Berlin, B. M. Mantsev, Zh. Prikl. Khim. (Leningrad) **6**, 385 (1933).
[2] S. I. Vol'fkovich, L. E. Berlin, B. M. Mantsev, Tr. NIUIFa 228 (1940).
[3] S. Uno, Kogyo Kagaku Zashi, **43**, 399 (1940); J. Soc. Chim. Ind., Japan, Suppl. Binding, **43**, 168B/70B (1940).
[4] Yu. S. Mishchenko, M. L. Chepelevetskiy, Tr. NIUIFa, **208**, 30 (1965).
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[12] A. G. Bergman, A. A. Gladkovskaya, R. A. Galushkina, Zh. Neorg. Khim. **17**, 3368 (1972).
[13] Ya. S. Shenkin, S. A. Ruchnova, N. A. Radionova, Zh. Neorg. Khim. **17**, 3368 (1972).
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[15] J. Eysseltová, to be published.

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Sulfuric acid; H_2SO_4; [7664-93-9]
(4) Water; H_2O; [7732-18-5]

Original Measurements:
1. L. E. Berlin, B. M. Mantsev, Zh. Prikl. Khim. (Leningrad), **6**, 385-9 (1933). 2. S. I. Vol'fkovich, L. E. Berlin, B. M. Mantsev, Tr. NIUIFa, 228-42 (1940).

Variables:
Composition at 25 °C.

Prepared By:
L. V. Chernykh and J. Eysseltová

Experimental Data

Part 1. The authors' data

Solubility in the NH_3–P_2O_5–SO_3–H_2O system at 25 °C

Soln	NH_3		P_2O_5		SO_3		
no	comp[a]	$1000w_i$[b]	comp[a]	$1000w_i$[b]	comp[a]	$1000w_i$[b]	Solid phase[c]
1	57.4	4.23	29.9	18.1	—	—	A
2	60.7	4.27	36.3	21.3	—	—	A
3	171.1	10.7	41.4	23.2	—	—	B
4	57.4	4.9	9.55	6.66	—	—	C1
5	77.8	6.7	3.16	2.29	—	—	C3
6	185.9	11.0	—	—	94.5	26.4	D
7	185.8	9.10	45.5	18.6	88.9	20.4	E
8	246.3	12.5	81.4	34.2	—	—	A+B
9	201.5	11.3	13.1	6.08	89.6	23.6	A+D
10	215.1	10.2	44.4	17.6	98.6	22.0	A+E
11	166.8	10.7	40.4	21.7	—	—	B+C3
12	230.0	12.5	21.2	9.64	78.4	20.1	B+D
13	177.3	10.8	6.0	3.09	72.1	20.9	C3+D
14	216.1	13.3	1.14	0.59	73.0	21.1	C3+D
15[d]	235.2	11.6	—	—	156.2	36.2	D+F
16[d]	542.6	11.3	—	—	552.8	54.3	F+G
17	270.4	13.3	55.2	22.7	51.0	12.0	A+B+D
18	231.3	12.8	14.8	6.85	83.1	21.8	B+C3+D
19	216.2	10.4	39.8	16.0	101.6	22.9	D+E+F
20[d]	242.2	11.1	19.9	7.45	151.8	32.7	D+E+F
21	243.6	9.72	19.9	6.62	220.8	41.5	E+F+G

[a] The composition unit is mol/1000 mol H_2O.
[b] This is an obvious error. The compilers believe that this should be $100w_i$.
[c] The solid phases are: A=$NH_4H_2PO_4$; B=$(NH_4)_2HPO_4$; C_1=$(NH_4)_3PO_4\cdot H_2O$; C_3=$(NH_4)_3PO_4\cdot 3H_2O$; D=$(NH_4)_2SO_4$; E =$NH_4H_2PO_4\cdot NH_4HSO_4$; F=$(NH_4)_3H(SO_4)_2$; G=$NH_4HSO_4$.
[d] These data appear in source paper (2) only.

Part 2. The compilers have used the data in Part 1 to calculate the following values

Soln no	NH_3 $100w_i$	NH_3 m_i/mol kg^{-1}	H_3PO_4 $100w_i$	H_3PO_4 m_i/mol kg^{-1}	H_2SO_4 $100w_i$	H_2SO_4 m_i/mol kg^{-1}	H_2O $100w_i$
1	4.21	3.50	25.2	3.65	0	0	70.6
2	4.27	3.78	29.4	4.53	0	0	66.3
3	10.88	10.85	30.3	5.25	0	0	58.8
4	4.81	3.28	9.21	1.09	0	0	86.0
5	6.70	4.36	3.13	0.354	0	0	90.2
6	11.02	11.41	0	0	32.3	5.80	56.7
7	9.108	13.33	25.7	6.53	25.1	6.38	40.1
8	12.43	18.11	47.3	2.0	0	0	40.3
9	11.26	12.85	8.43	1.67	28.8	5.71	51.5
10	10.21	15.56	24.3	6.42	27.0	7.13	38.5
11	10.69	10.55	29.8	5.11	0	0	59.5
12	12.55	14.89	13.3	2.75	24.6	5.08	49.5
13	10.92	10.83	4.25	0.733	25.6	4.40	59.2
14	13.29	13.00	0.807	0.137	25.9	4.39	60.0
15	11.61	15.49	0	0	44.39	10.29	44.00
16	12.92	67.45	0	0	75.83	68.72	11.25
17	13.34	19.18	31.3	7.83	14.5	3.62	40.8
18	12.83	14.73	9.45	1.88	26.6	5.297	51.2
19	10.38	15.42	22.0	5.68	28.10	7.24	39.5
20	11.12	17.07	10.5	2.80	40.13	10.70	38.2
[illegible]	9.726	18.81	9.11	3.071	50.77	17.05	30.6

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. Equilibration required 4 to 5 days. The composition of the solid phases was determined by the Schreinemakers method after removing the liquid from the surface of the wet residue by a piece of filter paper.

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was kept constant within ±0.05 K. No other information is given.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Sulfuric acid; H_2SO_4; [7664-93-9]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

S. Uno, Kogyo Kagaku Zasshi, **43**, 399-402 (1940); J. Soc. Chem. Ind., Japan, Suppl. Binding, **43**, 168B-70B (1940).

Variables:

Composition at 0, 25, 40, 70 and 100 °C.

Prepared By:

Hiroshi Miyamoto and J. Eysseltová

Experimental Data

Part 1. The author's data

Composition of saturated solutions in the $(NH_4)_2SO_4-H_3PO_4-H_2O$ system

Soln no	$(NH_4)_2SO_4$ $100w_i$	H_3PO_4 $100w_i$	Solid phase[a]	Soln no	$(NH_4)_2SO_4$ $100w_i$	H_3PO_4 $100w_i$	Solid phase[a]
		temp = 25 °C				temp = 70 °C	
1	43.3	0.0	A	13	47.8	0.0	A
2	41.0	10.6	A	14	45.7	9.46	A
3	39.9	15.6	A	15	44.6	17.3	A
4	39.7	19.4	A+B	16	44.1	23.9	A
5	39.8	19.4	A+B	17	44.0	27.3	A
6	36.5	22.8	B	18	44.2	29.6	A+B
7	33.8	25.1	B	19	43.4	30.3	B
8	29.7	31.7	B	20	42.2	31.3	B
9	24.0	40.6	B	21	38.6	36.3	B
10	18.3	52.3	B	22	35.1	41.2	B
11	15.8	58.6	B	23	30.6	47.7	B
12	13.3	64.4	B	24	28.3	52.0	B
				25	24.1	59.9	B

[a]The solid phases are: $A=(NH_4)_2SO_4$; $B=(NH_4)_2H_3(PO_4)(SO_4)$.

Composition of saturated solutions in the $(NH_4)_2H_3(PO_4)(SO_4)$–$(NH_4)_2SO_4$–H_2O system

Soln no	$(NH_4)_2SO_4$ comp[a]	$(NH_4)_2H_3(PO_4)(SO_4)$ comp[a]	Solid phase[b]
		temp=0 °C	
26	70.6	0	A
27	60.8	20.1	A
28	45.2	51.9	A
29	36.1	72.6	A+B
30	27.7	80.1	B
31	10.9	93.2	D
32	0	107.9	B
		temp=25 °C	
33	76.2	0	A
34	55.1	51.4	A
35	37.2	100.3	A
36	33.0	111.7	A+B
37	33.3	111.4	A+B
38	16.1	125.2	B
39	0	143.4	B
		temp=40 °C	
40	80.8	0	A
41	60.6	51.4	A
42	43.4	104.6	A
43	27.6	150.2	A+B
44	27.7	149.3	A+B
45	13.4	163.1	B
46	0	176.0	B
		temp=70 °C	
47	91.4	0	A
48	73.5	49.6	A
49	55.8	106.4	A
50	37.0	175.4	A
51	24.9	223.3	A
52	16.4	265.8	A+B
53	9.44	270.8	B
54	0	277.5	B
		temp=100 °C	
55	103.6	0	A
56	73.2	105.3	A
57	43.2	218.1	A
58	27.4	296.9	A
59	17.6	375.6	A
60	13.4	441.0	A
61	11.2	481.6	A+B
62	12.0	480.2	A+B
63	5.27	482.4	B
64	0	490.0	B

[a]The composition unit is: g/100g H_2O.
[b]The solid phases are: A=$(NH_4)_2SO_4$; B=$(NH_4)_2H_3(PO_4)(SO_4)$.

Composition of saturated solutions in the $(NH_4)_2H_3(PO_4)(SO_4)$–$NH_4H_2PO_4$–H_3PO_4–H_2O system

Soln no	$NH_4H_2PO_4$ comp[a]	$(NH_4)_2H_3(PO_4)(SO_4)$ comp[a]	H_3PO_4 comp[a]
		temp=25 °C	
65	19.3	132.7	0
66	21.6	113.9	8.31
67	25.2	79.2	23.3
68	36.7	58.1	33.0
69	68.4	37.1	53.7
		temp=70 °C	
70	74.5	234.6	0
71	70.1	217.9	3.65
72	58.8	177.1	22.1
73	72.7	123.2	44.1

[a]The composition unit is: g/100g H_2O.

Part 2. The compilers used the data in Part 1 to calculate the following values

Soln	NH_3		H_3PO_4		H_2SO_4		H_2O
no	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
1	11.1	11.6	0.0	0.0	32.2	5.78	56.7
2	10.6	12.8	10.6	2.23	30.4	6.41	48.4
3	10.3	13.6	15.6	3.58	29.6	6.79	44.5
4	10.2	14.7	19.4	4.84	29.5	7.35	40.9
5	10.3	14.8	19.4	4.85	29.5	7.38	40.8
6	9.41	13.6	22.8	5.72	27.1	6.79	40.7
7	8.71	12.4	25.1	6.23	25.1	6.22	41.1
8	7.66	11.6	31.7	8.38	22.0	5.82	38.6
9	6.19	10.3	40.6	11.7	17.8	5.13	35.4
10	4.72	9.42	52.3	18.2	13.6	4.71	29.4
11	4.07	9.34	58.6	23.4	11.7	4.67	25.6
12	3.43	6.82	64.4	29.5	9.87	3.41	29.5
13	12.3	13.9	0.0	0.0	35.5	6.93	52.2
14	11.8	15.4	9.46	2.15	33.9	7.71	44.8
15	11.5	17.7	17.3	4.63	33.1	8.86	38.1
16	11.4	20.9	23.9	7.62	32.7	10.4	32.0
17	11.3	23.2	27.3	9.71	32.7	11.6	28.7
18	11.4	25.5	29.6	11.5	32.8	12.8	26.2
19	11.2	25.0	30.3	11.8	32.2	12.5	26.3
20	10.9	24.1	31.3	12.1	31.3	12.1	26.5
21	9.95	23.3	36.3	14.8	28.7	11.6	25.1
22	9.05	22.4	41.2	17.7	26.1	11.2	23.7
23	7.89	21.3	47.7	22.4	22.7	10.7	21.7
24	7.29	21.7	52.0	26.9	21.0	10.9	19.7
25	6.21	22.8	59.9	38.2	17.9	11.4	16.0
26	10.7	10.7	0.0	0.0	30.7	5.34	58.6
27	10.3	10.9	4.72	0.873	29.7	5.47	55.3
28	9.81	11.4	11.2	2.26	28.2	5.68	50.7
29	9.61	11.8	14.8	3.15	27.7	5.89	47.9
30	9.14	11.2	16.4	3.48	26.3	5.58	48.1
31	8.13	9.75	19.4	4.05	23.4	4.87	49.0
32	7.68	9.38	22.1	4.69	22.1	4.69	48.1
33	11.1	11.5	0.0	0.0	32.1	5.77	56.8
34	10.6	12.8	10.6	2.23	30.4	6.40	48.4
35	10.3	14.3	18.0	4.36	29.6	7.17	42.1
36	10.2	14.7	19.4	4.85	29.5	7.35	40.9
37	10.2	14.7	19.4	4.84	29.5	7.36	40.9
38	9.40	13.3	22.1	5.44	27.1	6.66	41.4
39	8.72	12.5	25.1	6.23	25.1	6.23	41.1
40	11.5	12.2	0.0	0.0	33.2	6.11	55.3
41	11.0	13.6	10.3	2.23	31.5	6.82	47.2
42	10.8	15.7	18.0	4.55	31.0	7.83	40.3
43	10.6	17.2	23.0	6.53	30.4	8.61	36.0
44	10.6	17.2	23.0	6.49	30.4	8.58	36.1
45	9.98	16.2	25.1	7.09	28.7	8.10	36.2
46	9.44	15.3	27.2	7.65	27.2	7.65	36.2
47	12.3	13.8	0.0	0.0	35.4	6.92	52.2
48	11.8	15.4	9.47	2.16	33.9	7.72	44.8
49	11.5	17.7	17.3	4.62	33.1	8.85	38.1
50	11.4	20.8	23.9	7.62	32.7	10.4	32.0
51	11.3	23.2	27.3	9.70	32.7	11.6	28.7
52	11.4	25.6	29.6	11.5	32.8	12.8	26.2

Part 2. The compilers used the data in Part 1 to calculate the following values

Soln	NH_3		H_3PO_4		H_2SO_4		H_2O
no	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
53	11.2	25.0	30.3	11.8	32.2	12.5	26.3
54	10.9	24.1	31.3	12.1	31.3	12.1	26.5
55	13.1	15.7	0.0	0.0	37.8	7.84	49.1
56	12.4	20.2	16.1	4.58	35.6	10.1	35.9
57	12.0	25.5	25.7	9.48	34.6	12.7	27.7
58	12.0	29.9	29.8	12.9	34.6	15.0	23.6
59	12.2	35.3	32.4	16.3	35.1	17.7	20.3
60	12.4	40.4	33.9	19.2	35.7	20.2	18.0
61	12.5	43.5	34.6	20.9	36.0	21.8	16.9
62	12.5	43.5	34.5	20.9	36.1	21.8	16.9
63	12.4	42.7	35.0	21.0	35.6	21.4	17.0
64	12.3	42.6	35.4	21.3	35.4	21.3	16.9
65	8.93	13.2	28.9	7.44	22.4	5.775	39.7
66	8.17	11.6	30.8	7.59	19.7	4.868	41.4
67	6.79	9.07	34.5	8.01	14.8	3.441	43.9
68	6.16	8.24	39.1	9.08	10.9	2.525	43.9
69	6.02	9.17	49.3	13.0	6.10	1.612	38.6
70	11.2	26.9	39.9	16.7	24.4	10.2	24.4
71	10.9	25.0	39.9	15.9	23.7	9.49	25.5
72	9.75	20.5	41.2	15.1	21.1	7.70	27.9
73	8.53	17.0	46.6	16.2	15.4	5.35	29.4

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. Ammonium sulfate, phosphoric acid and water were placed in ampules. The mixtures were shaken in a thermostat at 25 and 70 °C. After equilibrium was etablished, the mixtures were allowed to settle. A pipet was used to obtain aliquots of the saturated solution for analysis. The saturated solution was evaporated to dryness and the solid obtained was dried at 110-115 °C to determine total solid content. The NH_3 content was determined by the distillation method. The phosphate and sulfate contents were determined gravimetrically as $Mg(NH_4)PO_4$ and $BaSO_4$, respectively.

Source and Purity of Materials:

Chemically pure reagents were used. Ammonium sulfate was recrystallized.

Estimated Error:

Solubility: nothing specified.
Temperature: precision ±0.05 K at 298 K and ±0.5 K at 343 K.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Sulfuric acid; H_2SO_4; [7664-93-9]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

Yu. S. Mishchenko, M. L. Chepelevetskiy, Tr. NIUIFa, **208**, 30-42 (1965).

Variables:

Composition at 50 °C.

Prepared By:

L. V. Chernykh and J.Eysseltová

Experimental Data

Part 1. The authors' data

Composition of saturated solutions in the $(NH_4)_2HPO_4-(NH_4)_2SO_4-H_3PO_4-H_2O$ system at 50 °C

Soln no	NH_3 $100w_i$	P_2O_5 $100w_i$	SO_3 $100w_i$	$(NH_4)_2HPO_4$ $100w_i$	$(NH_4)_2SO_4$ $100w_i$	H_3PO_4 $100w_i$	Solid phases[a]
1	10.74	20.7	20.3	7.2	33.4	27.6	A+B+C
2	10.71	20.0	21.0	7.0	34.6	22.4	A+B
3	10.70	16.5	21.7	5.9	35.8	18.5	A+B
4	10.8	14.2	22.4	5.1	36.9	15.9	A+B
5	11.65	12.8	22.6	8.4	37.4	11.7	A+B
6	11.35	11.01	22.8	6.5	37.7	10.4	A+B
7	11.6	10.6	23.0	7.4	38.0	8.7	A+B
8	12.16	9.27	24.0	7.7	39.6	7.0	A+B
9	11.82	9.05	22.9	8.1	37.8	6.0	A+B
10	12.35	9.53	21.4	9.9	35.4	5.7	A+B
11	30.05	14.5	20.25	17.3	33.4	7.2	A+B
12	12.75	23.05	13.95	23.0	25.5	12.1	A+B
13	13.6	29.3	10.8	34.9	17.8	14.5	A+B
14	14.39	31.75	9.16	40.7	15.1	13.6	A+B+D
15	13.85	11.35	20.89	21.1	34.4	0.0	A+D
16	13.46	12.34	20.45	19.3	33.8	2.6	A+B+D[b]
17	13.65	16.20	17.20	24.7	28.3	8.9	A+B+D
18	14.02	26.1	13.25	33.7	21.9	11.0	A+B+D
19	14.00	28.7	11.74	34.9	19.4	13.6	A+B+D
20	14.08	29.7	10.15	37.9	16.7	12.8	A+B+D
21	14.39	31.75	9.16	40.7	15.1	13.6	A+B+D
22	13.5	38.5	—	54.0	0.0	13.1	B+D
23	14.01	37.7	2.27	50.6	3.8	14.5	B+D
24	14.34	34.0	6.49	45.0	10.7	13.5	B+D
25	14.42	32.2	7.34	44.0	12.1	11.8	B+D
26	14.19	31.6	8.79	40.7	14.5	13.5	B+D
27	14.39	31.75	9.16	40.7	15.1	13.6	A+B+D
28	10.74	20.7	20.3	7.2	33.4	27.6	A+B+C
29	9.93	24.6	18.8	7.5	31.0	28.5	B+C
30	9.12	25.9	16.5	8.2	27.2	29.7	B+C
31	7.32	31.0	10.7	10.8	17.6	34.8	B+C

[a]The solid phases are: A=$(NH_4)_2SO_4$; B=$NH_4H_2PO_4$; C=[$NH_4H_2PO_4 \cdot NH_4HSO_4$ (i.e., $(NH_4)_2H_3(PO_4)(SO_4)$–compilers]; D =$(NH_4)_2HPO_4$.

[b]This is an obvious error. The compilers believe that the solid phase is A+D.

Composition of saturated solutions in the $(NH_4)_2HPO_4-(NH_4)_2SO_4-H_2SO_4-H_2O$ system at 50 °C

Soln no	NH_3 $100w_i$	P_2O_5 $100w_i$	mol$_3$ $100w_i$	$(NH_4)_2HPO_4$ $100w_i$	$(NH_4)_2SO_4$ $100w_i$	H_2SO_4 $100w_i$	Solid phases[a]
32	11.73	—	41.7	0.0	45.6	17.3	A+E
33	11.6	2.36	40.5	4.4	41.0	19.2	A+E
34	11.45	3.44	40.3	6.4	38.0	21.2	A+E
35	11.3	6.15	38.2	11.4	32.6	22.5	A+E
36	11.3	10.0	35.9	18.6	26.0	24.6	A+E
37	11.3	10.6	35.6	19.6	24.2	25.4	A+C+E
38	12.23	—	57.6	0.0	49.5	33.8	E+F
39	12.57	1.83	57.6	3.3	45.6	35.4	E+F
40	12.1	4.43	55.95	8.3	38.8	39.3	E+F
41	11.8	6.24	54.45	11.6	34.2	41.2	C+E+F
42	11.3	10.6	35.6	19.6	24.2	25.4	A+C+E
43	10.59	10.11	36.2	18.8	22.3	27.8	C+E
44	10.1	7.65	41.8	14.2	24.9	33.5	C+E
45	11.8	6.24	54.15	11.6	34.2	41.2	C+E+F

Composition of saturated solutions in the $(NH_4)_2HPO_4-(NH_4)_2SO_4-H_3PO_4-H_2SO_4-H_2O$ system at 50 °C

Soln no	NH_3 $100w_i$	P_2O_5 $100w_i$	SO_3 $100w_i$	Solid phases[a]
46	10.74	20.7	20.3	A+B+C
47	11.01	17.81	25.43	A+B
48	10.9	13.1	32.1	A+B
49	11.0	11.9	33.7	A+B
50	11.3	10.6	35.6	A+B+G

[a]The solid phases are: A=$(NH_4)_2SO_4$; B=$NH_4H_2PO_4$; C=$NH_4H_2PO_4 \cdot NH_4HSO_4$, [i.e., $(NH_4)_2H_3PO_4SO_4$–compilers]; D =$(NH_4)_2HPO_4$; E=$(NH_4)H_3(SO_4)_2$; F=NH_4HSO_4; G=$(NH_4)_3H(SO_4)_2$.

Part 2. The compilers have calculated the following values from the authors' data for the NH_3, P_2O_5 and SO_3 contents

Soln no	NH_3 100w_i	NH_3 m_i/mol kg^{-1}	H_3PO_4 100w_i	H_3PO_4 m_i/mol kg^{-1}	H_2SO_4 100w_i	H_2SO_4 m_i/mol kg^{-1}	H_2O 100w_i
1	10.74	17.61	28.6	8.14	24.9	7.08	35.8
2	10.71	17.49	27.6	7.84	25.7	7.30	36.0
3	10.70	15.73	22.8	5.82	26.6	6.79	39.9
4	10.8	15.0	19.6	4.75	27.4	6.64	42.2
5	11.65	15.91	17.7	4.19	27.7	6.57	43.0
6	11.35	14.64	15.2	3.41	27.9	6.26	45.5
7	11.6	14.9	14.6	3.28	28.2	6.30	45.6
8	12.16	15.64	12.8	2.86	29.4	6.57	45.6
9	11.82	14.57	12.5	2.68	28.1	6.00	47.6
10	12.35	15.02	13.2	2.78	26.2	5.54	48.3
11	30.05	70.23	20.0	8.13	24.8	10.1	25.1
12	12.75	19.53	31.8	8.47	17.1	4.54	38.3
13	13.6	24.4	40.5	12.6	13.2	4.12	32.7
14	14.39	27.66	43.8	14.6	11.2	3.74	30.6
15	13.85	18.12	15.7	3.56	25.6	5.81	44.9
16	13.46	17.78	17.0	3.91	25.0	5.75	44.5
17	13.65	18.68	22.4	5.32	21.1	5.01	42.9
18	14.02	24.42	26.0	10.9	16.2	4.91	33.7
19	14.00	25.70	39.6	12.6	14.4	4.58	32.0
20	14.08	25.46	41.0	12.9	12.4	3.90	32.5
21	14.39	27.66	43.8	14.6	11.2	3.74	30.6
22	13.5	23.8	53.2	16.3	0.0	0.0	33.3
23	14.01	26.4	52.1	17.0	2.78	0.910	31.1
24	14.34	27.37	46.9	15.6	7.95	2.63	30.8
25	14.42	26.35	44.5	14.1	8.99	2.85	32.1
26	14.19	26.53	43.6	14.2	10.8	3.49	31.4
27	14.39	27.66	43.8	14.6	11.2	3.74	30.6
28	10.74	17.61	28.6	8.14	24.9	7.08	35.8
29	9.93	17.6	34.0	10.5	23.0	7.10	33.1
30	9.12	15.3	35.8	10.5	20.2	5.90	34.9
31	7.32	11.7	42.8	11.9	13.1	3.63	36.8
32	11.73	18.52	0.0	0.0	51.1	14.0	37.2
33	11.6	19.2	3.26	0.936	49.6	14.2	35.5
34	11.45	19.52	4.75	1.41	49.4	14.6	34.4
35	11.3	19.9	8.49	2.59	46.8	14.3	33.4
36	11.3	21.5	13.8	4.56	44.0	14.5	30.9
37	11.3	21.8	14.6	4.90	43.6	14.6	30.5
38	12.23	41.72	0.0	0.0	70.6	41.8	17.2
39	12.57	51.45	2.53	1.80	70.6	50.1	14.3
40	12.1	53.6	6.12	4.71	68.5	52.7	13.2
41	11.8	53.8	8.62	6.82	66.7	52.8	12.9
42	11.3	21.8	14.6	4.90	43.6	14.6	30.5
43	10.59	19.99	14.0	4.58	44.3	14.5	31.1
44	10.1	21.1	10.6	3.83	51.2	18.6	28.1
45	11.8	52.3	8.62	6.63	66.3	51.0	13.3
46	10.74	17.61	28.6	8.14	24.9	7.08	35.8
47	11.01	19.44	24.6	7.55	31.1	9.55	33.2
48	10.9	20.2	18.1	5.82	39.3	12.6	31.7
49	11.0	20.6	16.4	5.36	41.3	13.5	31.3
50	11.3	21.8	14.6	4.90	43.6	14.6	30.5

Auxiliary Information

Method / Apparatus / Procedure:

Nothing is stated. The compilers assume that some sort of the invariant points method was used.

Source and Purity of Materials:

No information is given

Estimated Error:

Nothing is specified.

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Sulfuric acid; H_2SO_4; [7664-93-9]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

I. M. Kaganskiy, A. M. Babenko, Zh. Prikl. Khim. (Leningrad) **48**, 1387-99 (1975).

Variables:

Concentration of $(NH_4)_2SO_4$ at 0 and −10 °C in an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data

Solubility isotherms in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$(NH_4)_2SO_4$–H_2O system

Soln no	"mixture"[a] 100w_i	$NH_4H_2PO_4$ 100w_i	$(NH_4)_2HPO_4$ 100w_i	$(NH_4)_2SO_4$ 100w_i	H_2O 100w_i	$(N+P_2O_5)$ 100w_i	ratio[a] $N:P_2O_5:S$
				temp = −10 °C			
1	14.706	6.8945	7.9152	18.3	66.94	19.23	0.73:1:0.52
2	11.6	5.44	6.24	26.52	61.88	20.6	1.14:1:0.96
3	19.481	9.1331	10.485	15.3	65.219	21.44	0.58:1:0.32
4	21.5	10.1	11.6	14.0	64.5	22.35	0.55:1:0.28
5	24.752	11.604	13.322	11.6	63.648	23.68	0.47:1:0.20
6	13.76	6.451	7.4060	31.2	55.04	24.4	1.14:1:0.97
7	19.4	9.10	10.4	22.4	58.2	24.6	0.71:1:0.48
8	31.02	14.54	16.70	6.0	62.98	25.8	0.37:1:0.081
9	15.91[b]	7.459	8.563	30.8	53.284	25.8	1.0:1:0.81
10	30.6[b]	14.3	16.5	7.2	62.176	26.0	0.38:1:0.099
11	24.42	11.45	13.14	18.6	56.98	26.6	0.58:1:0.32
				temp = 0 °C			
12	21.8	10.2	11.7	15.64	62.56	23.32	0.56:1:0.30
13	16.4	7.69	8.83	25.08	58.52	23.58	0.86:1:0.63
14	11.916	5.5865	6.4135	33.8	54.284	24.24	1.33:1:1.18
15	13.52	6.338	7.277	32.4	54.08	24.74	1.19:1:0.34
16	22.68	10.63	12.21	19.0	58.32	25.5	0.59:1:0.34
17	15.732[b]	7.3755	8.4674	31.6	52.68	26.0	1.04:1:0.85
18	24.18	11.34	13.01	19.4	56.42	26.8	0.59:1:0.33
19	29.106[b]	13.646	15.666	11.8	59.09	27.0	0.45:1:0.17
20	33.075	15.506	17.802	5.5	61.425	27.0	0.35:1:0.06
21	41.832	19.612	22.515	0.4	57.768	31.3	0.30:1:0.003

[a]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b]There is a typographical error on this line. The sum of the components does not equal 100.

Part 2. The compiler has used the authors' data (Part 1) to calculate the following values

Soln no	NH_3 $100w_i$	NH_3 m_i/mol^{-1} kg^{-1}	H_3PO_4 $100w_i$	H_3PO_4 m_i/mol^{-1} kg^{-1}	H_2SO_4 $100w_i$	H_2SO_4 m_i/mol^{-1} kg^{-1}	H_2O $100w_i$
1	7.757	6.799	11.66	1.776	13.58	2.067	67.00
2	9.233	8.761	9.200	1.517	19.68	3.243	61.88
3	7.971	7.176	15.45	2.417	11.36	1.775	65.22
4	8.053	7.331	17.05	2.698	10.39	1.642	64.50
5	8.107	7.479	19.63	3.147	8.609	1.379	63.65
6	10.89	11.61	10.91	2.023	23.16	4.289	55.04
7	9.784	9.871	16.39	2.698	16.62	2.912	58.20
8	7.960	7.421	24.60	3.986	4.453	0.721	62.98
9	11.23	12.37	12.62	2.416	22.86	4.373	53.29
10	8.182	7.724	24.27	3.981	5.344	0.876	62.20
11	9.843	10.14	19.37	3.468	13.81	2.470	56.98
12	8.538	8.013	17.29	2.820	11.61	1.892	62.56
13	9.855	9.888	13.01	2.268	18.61	3.243	58.52
14	11.18	12.09	9.451	1.770	25.09	4.711	54.29
15	11.15	12.10	10.72	2.023	24.05	4.533	54.08
16	9.586	9.651	17.99	3.147	14.10	2.465	58.32
17	11.40	12.71	12.48	2.417	23.45	4.540	52.67
18	9.999	10.41	19.18	3.468	14.40	2.602	56.42
19	9.059	9.001	23.09	3.986	8.758	1.511	59.10
20	8.256	7.891	26.23	4.358	4.082	0.678	61.43
21	8.752	8.895	33.18	5.860	0.29	0.052	57.77

Auxiliary Information

Method / Apparatus / Procedure:

An improved polythermic method was used.[1]

Source and Purity of Materials:

Chemically pure or reagent grade salts were used. They were recrystallized twice and dried at 40–50 °C. The material designated "mixture" was prepared by grinding an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ in a mortar.

Estimated Error:

No information is given.

References:

[1] I. N. Frayzer, I. M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Sulfuric acid; H_2SO_4; [7664-93-9]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

T. Akiyama, H. Kanzaki, S. Minagawa, Nippon Dojo Hiryogaku Zasshi **49**, 243-6 (1978).

Variables:

Composition at 0, 25 and 50 °C.

Prepared By:

Hiroshi Miyamoto and J. Eysseltová

Experimental Data

Part 1. The authors' data

Composition of saturated solutions in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$(NH_4)_2SO_4$–H_2O system

Soln no	N $100w_i$	P_2O_5 $100w_i$	SO_3 $100w_i$	N/PO_4	SO_4/PO_4
			temp = 0 °C		
1	8.0	20.3	1.2	1.91	0.05
2	8.9	26.8	2.4	1.53	0.08
3	10.3	16.2	13.3	1.78	0.75
4	12.2	18.5	17.9	1.61	0.86
			temp = 25 °C		
5	10.4	31.4	3.2	1.50	0.09
6	11.1	28.3	7.0	1.55	0.22
7	9.9	19.9	9.9	1.64	0.44
8	11.4	18.8	13.7	1.79	0.65
			temp = 50 °C		
9	13.8	31.8	10.6	1.59	0.31
10	11.0	24.8	12.1	1.37	0.43
11	18.1	26.1	28.2	1.79	0.96
12	14.2	18.2	27.5	1.29	1.34

Part 2. The compilers have used the data in Part 1 to calculate the following values

Soln no	NH_3 $100w_i$	NH_3 m_i/mol^{-1} kg^{-1}	H_3PO_4 $100w_i$	H_3PO_4 m_i/mol^{-1} kg^{-1}	H_2SO_4 $100w_i$	H_2SO_4 m_i/mol^{-1} kg^{-1}	H_2O $100w_i$
1	9.7	9.4	28.0	4.71	1.5	0.25	60.8
2	10.8	12.9	37.0	7.67	2.9	0.61	49.2
3	12.5	15.1	22.4	4.68	16.3	3.40	48.8
4	14.8	23.1	25.5	6.91	21.9	5.93	37.7
5	12.6	18.5	43.4	11.0	3.9	1.0	40.0
6	13.5	20.4	39.1	10.3	8.6	2.2	38.8
7	12.0	14.6	27.5	5.80	12.1	2.56	48.4
8	13.9	18.8	26.0	6.10	16.8	3.94	43.4
9	16.8	37.4	43.9	17.0	13.0	5.03	26.3
10	13.4	20.9	34.2	9.30	14.8	4.02	37.6
11	22.0	174	36.0	49.6	34.5	47.5	7.4
12	17.2	42.4	25.1	10.7	33.7	14.4	23.9

Comments and Additional Data:

The solubilities of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ in the quaternary system $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$(NH_4)_2SO_4$–H_2O in the range of N/PO_4 = 1.0–2.0 may be calculated from Eqs. (1) and (2), respectively.

$$S/(\text{g}/100\text{g soln}) = 6.76(2 - M)A/(5.76 + M) \quad (1)$$

$$S/(\text{g}/100\text{g soln}) = 7.76(1 - M)A/(5.76 + M) \quad (2)$$

A is the sum of solubilities of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ in the ternary system $NH_4H_2PO_4-(NH_4)_2HPO_4-H_2O$ for a given value of M. $M = nN_1/n_1$ where n_N is the amount of nitrogen in $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$, and n_p is the amount of the phosphate. The amount of nitrogen in $(NH_4)_2SO_4$ is not included in the ratio nN_1/n_p.

Auxiliary Information

Method / Apparatus / Procedure:

Mixtures of $NH_4H_2PO_4$, $(NH_4)_2HPO_4$, $(NH_4)_2SO_4$ and water were placed in glass stoppered bottles and heated on a water bath at 90 °C. The bottles were allowed to settle at a given temperature for 7 days. (If no crystals had formed, then seed crystals were added and the mixtures were allowed to settle for another 7 days.) Total nitrogen content in the saturated solutions was determined by chemical analysis. The phosphate and sulfate contents were determined as P_2O_5 and SO_3, respectively.

Source and Purity of Materials:

Chemically pure ammonium salts were used.

Estimated Error:

Nothing is specified

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Sulfuric acid; H_2SO_4; [7664-93-9]
(4) Potassium oxide; K_2O; [12136-45-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

Z. N. Fokina, E. N. Kornishina, P. P. Kim, Tekhnologiya Mineral'nykh Udobreniy (Leningrad) 63-8 (1977).

Variables:

Composition at 80 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Part 1. The authors' data

Solubility isotherms in the $NH_4H_2PO_4-H_3PO_4-K_2SO_4-H_2O$ system at 80 °C

Soln no	K_2O $100w_i$	NH3 $100w_i$	P_2O_5 $100w_i$	Solid phase
1	12.54	1.41	30.36	$KHSO_4\cdot KH_2PO_4$
2	11.02	2.63	32.38	$KHSO_4\cdot KH_2PO_4$
3	10.60	3.55	29.40	$KHSO_4\cdot KH_2PO_4$
4	10.20	5.20	28.60	$KHSO_4\cdot KH_2PO_4$
5	6.30	6.00	28.15	$(K,NH_4)H_2PO_4$
6	7.29	5.70	29.80	$(K,NH_4)H_2PO_4$
7	5.14	6.41	32.17	$(K,NH_4)H_2PO_4$
8	2.32	6.61	30.76	$(K,NH_4)H_2PO_4$
9	9.03	0.30	40.00	$KHSO_4\cdot KH_2PO_4$
10	8.63	0.65	38.90	$KHSO_4\cdot KH_2PO_4$
11	7.36	2.49	39.00	$KHSO_4\cdot KH_2PO_4$
12	6.51	4.33	40.61	$KHSO_4\cdot KH_2PO_4$
13	5.28	4.82	40.40	$(K,NH_4)H_2PO_4$
14	3.53	5.70	39.56	$NH_4H_2PO_4$
15	0.47	7.86	40.80	$NH_4H_2PO_4$

Part 2. The compilers have used the data in Part 1 to calculate the following values

Soln no	NH_3 m_i/mol^{-1} kg^{-1}	$100w_i$	H_3PO_4 m_i/mol^{-1} kg^{-1}	$100w_i$	H_2SO_4 m_i/mol^{-1} kg^{-1}	K_2O m_i/mol^{-1}	H_2O $100w_i$
1	2.66	41.92	13.77	13.06	4.284	4.284	31.07
2	5.12	44.71	15.12	11.47	3.878	3.878	30.17
3	6.09	40.59	12.11	11.04	3.288	3.288	34.22
4	8.85	39.49	11.68	10.62	3.140	3.140	34.49
5	8.33	38.87	9.383	6.56	1.58	1.58	42.27
6	8.75	41.15	10.97	7.59	2.02	2.02	38.27
7	9.73	44.42	11.72	5.35	1.41	1.41	38.68
8	8.40	42.47	9.384	2.42	0.533	0.533	46.18
9	0.68	55.23	21.65	9.40	3.68	3.68	26.04
10	1.36	53.71	19.56	8.99	3.27	3.27	28.02
11	5.11	53.85	19.19	7.66	2.73	2.73	28.64
12	9.66	56.07	21.75	6.78	2.63	2.63	26.31
13	9.89	55.78	19.89	5.50	1.96	1.96	28.62
14	10.3	54.62	17.17	3.68	1.15	1.15	32.47
15	13.2	56.34	16.50	0.49	0.14	0.14	34.85

Auxiliary Information

Method / Apparatus / Procedure:

No information is given. The compilers assume that the methods were the same as those given earlier.[1]

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

References:

[1]T. N. Baranova, N. T. Semkin, P. P. Kim, E. N. Kornishina, and I. S. Nikandrov, Tekhnologiya Mineral'nykh Udobreniy (Leningrad) 55 (1977).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Hydrogen chloride; HCl; [7647-01-0]
(4) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic
September, 1995

Critical Evaluation:

5.3. Solubility in the NH_3–H_3PO_4–HCl–H_2O System

There is only one report[1] that presents data about the composition of solutions on the boundaries of the crystallization fields of this system. Another article[2] describes the system as comprising $NH_4H_2PO_4$, $(NH_4)_2HPO_4$, HCl and H_2O as components at a NH_3/H_3PO_4 ratio $<$ 1.2. A visual comparison[3] of the projections of the 293 K isotherm reported in Ref. 1 and the polytherm reported in Ref. 2 shows an intersection at a position which appears to be reasonable so far as the composition of the saturated solutions and the temperature are concerned. Therefore, these data are accepted tentatively.

There is a report of solubility data for that part of the quinary system NH_3–H_3PO_4–HCl–K_2O–H_2O where $H_3PO_4/N>1$.[4] However, these data cannot be critically evaluated because of lack of other similar data. To a limited extent the data can be compared with those for the $NH_4H_2PO_4$–KCl–H_2O and $(NH_4)_2HPO_4$–KCl–H_2O systems.[5,7] It is difficult to compare these data with each other because of different experimental conditions, but they will be discussed further in connection with the $NH_4^+,K^+\|H_2PO_4^-,Cl^-$–$H_2O$ system (see pp. 1366–1369, 1376).

References:

[1]A. A. Volkov, O. E. Sosnina, Izv. Vuzov. Khim. Khim. Tekhnol. **17**, 1725 (1974).
[2]I. N. Grantscharov, Dokl. Bolg. Akad. Nauk **29**, 669 (1976).
[3]J. Eysseltová, to be published.
[4]V. A. Polosin, M. I. Shakhparonov, Zh. Fiz. Khim. **21**, 119 (1947).
[5]I. Karshev, K. Asitska, God. na VKhTI, Sofia 101 (1970).
[6]T. N. Baranova, N. T. Semkin, P. P. Kim, E. N. Kornishina, I. S. Nikandrov, Tekhnologiya Mineral'nykh Udobreniy (Leningrad) 55 (1977).
[7]Z. N. Fokina, E. N. Kornishina, P. P. Kim, Tekhnologiya Mineral'nykh Udobreniy (Leningrad) 63 (1977).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Hydrogen chloride; HCl; [7674-01-0]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

A. A. Volkov, O. E. Sosnina, Izv. Vuzov, Khim. Khim. Tekhnol. **17**, 1725-6 (1974).

Variables:

Composition at 20 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors present their data in the following form:
Solubility in the NH_4^+, H^+ ‖ PO_4^{3-}, Cl^- – H_2O system at 20 °C

Soln no	NH_4Cl 100w_i	H_3PO_4 100w_i	$(NH_4)_3PO_4$ 100w_i	H_2O 100w_i	Solid phases[a]
1		22.8	77.2	60.5	A+B
2		38.6	61.4	41.6	B+C
3		81.4	18.6	13.3	C+D
4		85.3	14.7	11.5	D+E
5[b]	5.0	87.7	...	11.5	F
6	10.5	89.5	...	11.5	F
7	3.8	79.4	16.8	—	C+D+F
8	25.3	62.5	12.2	46.0	C+F
9	45.5	45.5	9.0	59.5	C+F
10	46.4	45.1	8.5	59.0	C+F
11	65.1	27.9	7.0	67.5	C+F
12	84.8	8.6	6.6	70.5	C+F
13	48.3	20.7	31.0	58.5	C+F
14	15.1	31.5	53.4	46.0	B+C
15	27.1	27.2	45.7	50.0	B+C+F
16	44.1	18.9	37.0	61.0	B+F
17	64.1	8.8	27.1	65.0	B+F
18	77.8		22.2	68.5	A+F
19	65.6	3.5	30.9	65.2	A+B+F
20	32.9	14.1	53.0	66.0	A+B
21	18.8	18.7	62.5	63.0	A+B

[a]The solid phases are: A = $(NH_4)_3PO_4 \cdot 3H_2O$; B = $(NH_4)_2HPO_4$; C = $NH_4H_2PO_4$; D = $3NH_4H_2PO_4 \cdot H_3PO_4$; E = $NH_4H_2PO_4 \cdot H_3PO_4$; F = NH_4Cl.

[b]In this solution, 0.073 w (presumably of solute—compiler) HCl was present.

Part 2. The sum of the components in the data of Part 1 exceeds 100%. The compiler [illegible] components and phosphoric acid do not refer to the solution but to the solute. On the basis of that assumption the compiler has recalculated the data of Part 1 to give the following values

Soln no	NH_3 100 w_i	NH_3 m_i/mol^{-1} kg^{-1}	H_3PO_4 100 w_i	H_3PO_4 m_i/mol^{-1} kg^{-1}	HCl 100 w_i	HCl m_i/mol^{-1} kg^{-1}	H_2O 100 w_i
1	10.4	10.1	29.0	4.90	0	0	60.5
2	12.3	17.3	46.1	11.3	0	0	41.6
3	5.53	24.4	81.2	62.3	0	0	13.3
4	4.46	22.8	84.0	74.6	0	0	11.5
5	1.41	7.76	77.6	74.3	10.3	26.5	10.7
6	2.96	15.1	79.2	70.3	6.33	15.1	11.5
7	6.97	xxx[a]	90.4	xxx[a]	2.59	xxx[a]	0
8	6.61	8.43	38.1	8.44	9.31	5.55	46.0
9	7.11	7.02	20.8	3.57	12.6	5.79	59
10	7.25	7.22	20.8	3.59	13.0	6.03	59.0
11	7.51	6.54	10.6	1.60	14.4	5.86	67.5
12	8.63	7.19	3.82	0.552	17.1	6.63	70.5
13	10.8	10.8	17.0	2.97	13.7	6.40	58.5
14	12.5	15.9	36.0	7.98	5.56	3.31	46.0
15	12.1	14.3	28.6	5.84	9.24	5.07	50.0
16	10.4	10.0	16.9	2.82	11.7	5.27	61.0
17	10.4	9.39	9.31	1.46	15.3	6.45	65.0
18	10.2	8.74	4.60	0.685	16.7	6.69	68.5
19	11.0	9.86	8.29	1.30	15.6	6.54	65.2
20	9.73	8.66	16.6	2.57	7.63	3.17	66.0
21	10.1	9.45	22.1	3.58	4.74	2.06	63.0

[a]The molalities could not be calculated because the respective liquid phase was anhydrous.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method of sections 1, 2 was used with the aid of refractive index measurements. Seven sections were studied.

Source and Purity of Materials:

Chemically pure H_3PO_4, recrystallized ammonium phosphates, and reagent grade NH_4Cl were used. $(NH_4)_3PO_4$ was synthessized according to the method of Schottlander (no details given). Its solubility was 12.8%.

Estimated Error:

No information is given.

References:

[1]R. V. Merelin, Izv. biolog. n.-i. in-ta pri Permsk. un-te. **11**, 1 (1937).
[2]E. F. Zhuravlev, A. D. Sheveleva, Zh. Neorg. Khim. **5**, 2360 (1960).

Components:
(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Hydrogen chloride; HCl; [7647-01-0]
(4) Water; H_2O; [7732-18-5]

Original Measurements:
I. N. Grantscharov, Dokl. Bolg. Akad. Nauk **29**, 669-72 (1976).

Variables:
Composition and temperature.

Prepared By:
J. Eysseltová

Experimental Data

Part 1. The author presents his data as follows:

Monovariant points in the NH_4Cl–$NH_4H_2PO_4$–$(NH_4)_2HPO_4$–H_2O system when the ratio NH_3:H_3PO_4 = 1.2

Point no	NH_4Cl 100 w_i	$(NH_4)_{1.2}H_{1.8}PO_4$ 100 w_i	H_2O 100 w_i	t/°C	Solid phases[a]
1	19.5	0.0	80.5	−14.5	A+B
2	17.6	4.2	78.2	−15.2	A+B
3	17.1	5.3	77.6	−15.0	A+C
4	13.6	8.7	77.7	−13.5	A+C
5	12.6	10.0	77.4	−12.0	A+C
6	8.5	14.0	77.5	−11.0	A+C
7	7.6	13.9	78.5	−10.0	A+C
8	4.0	19.0	77.0	−7.5	A+C
9	3.0	19.4	77.6	−7.4	A+C
10	1.0	22.8	76.2	−6.4	A+C
11	0.0	25.0	75.0	−5.8	A+C
12	19.0	5.0	76.0	−7.5	B+C
13	20.9	5.6	73.5	0.0	B+C
14	22.7	5.8	71.5	9.5	B+C
15	24.3	6.8	68.9	19.0	B+C
16	25.2	7.5	67.3	25.6	B+C
17	25.7	8.5	65.8	30.5	B+C
18	27.0	10.0	63.0	41.0	B+C

[a]The solid phases are: A = ice; B = NH_4Cl; C = $NH_4H_2PO_4$.

The following two empirical equations are also given in the paper.

$$N + P_2O_5 = a + b(P_2O_5/N) \quad (1)$$

This is valid in all crystallization fields in this system. N and P_2O_5 are the respective concentrations in mass %. a and b are constants which depend only on temperature.

$$N + P_2O_5 = 7.29 + 0.105t + 2.615(P_2O_5/N) + 0.0459t(P_2O_5/N) \quad (2)$$

This equation is valid only in the crystallization field of $NH_4H_2PO_4$.

Part 2. The compiler has calculated the following values from the data in Part 1

Soln no	NH_3 100w_i	NH_3 m_i/mol^{-1} kg^{-1}	H_3PO_4 100w_i	H_3PO_4 m_i/mol^{-1} kg^{-1}	HCl 100w_i	HCl m_i/mol^{-1} kg^{-1}	H_2O mass %
1	6.2	4.5	0.0	0.0	13.3	4.53	80.5
2	6.3	4.8	3.5	0.46	12.0	4.21	78.2
3	6.4	4.8	4.4	0.58	11.7	4.12	77.6
4	5.8	4.4	7.3	0.95	9.3	3.3	77.7
5	5.8	4.4	8.4	1.1	8.6	3.0	77.4
6	5.2	3.9	11.7	1.54	5.8	2.0	77.5
7	4.8	3.6	11.6	1.51	5.2	1.8	78.5
8	4.6	3.5	15.9	2.10	2.7	0.97	77.0
9	4.3	3.3	16.2	2.13	2.0	0.72	77.6
10	4.3	3.3	19.1	2.55	0.7	0.2	76.2
11	4.4	3.4	20.9	2.84	0.0	0.0	75.0
12	6.9	5.4	4.2	0.56	13.0	4.67	76.0
13	7.6	6.1	4.7	0.65	14.2	5.32	73.5
14	8.2	6.8	4.8	0.69	15.5	5.93	71.5
15	8.9	7.6	5.7	0.84	16.6	6.59	68.9
16	9.3	8.1	6.3	0.95	17.2	7.00	67.3
17	9.7	8.6	7.1	1.1	17.5	7.30	65.8
18	10.3	9.64	8.4	1.4	18.4	8.01	63.0

Auxiliary Information

Method / Apparatus / Procedure:
A visual polythermic method was used. The apparatus was self-constructed.[1]

Source and Purity of Materials:
Reagent grade salts were recrystallized and dried at 30–50 °C.

Estimated Error:
No information is given.

References:
[1]I. N. Grantscharov, D. G. Ivanov, God. na VKhTI **15**, 127 (1968).

Components:

(1) Ammonia; NH_3; [7664-41-7]
(2) Phosphoric acid; H_3PO_4; [7664-38-2]
(3) Hydrogen chloride; HCl; [7647-01-0]
(4) Potassium oxide; K_2O; [12136-45-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

T. N. Baranova, N. T. Semkin, P. P. Kim, E. N. Kornishina, I. S. Nikandrov, Tekhnologiya Mineral'nykh Udobreniy (Leningrad) 55-9 (1977).

Variables:

Composition at 20 and 80 °C

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

The authors present their data in the following form. Solubility isotherms in the $NH_4H_2PO_4-H_3PO_4-KCl-H_2O$ system

Soln no	K_2O 100 w_i	NH_3 100 w_i	P_2O_5 100 w_i	Solid phase
		temp = 20 °C		
1	10.22	2.20	16.23	KH_2PO_4
2	7.40	2.30	15.94	$(K,NH_4)H_2PO_4$
3	4.59	3.14	17.26	$(K,NH_4)H_2PO_4$
4	2.06	3.64	18.61	$(K,NH_4)H_2PO_4$
5	1.95	3.51	17.17	$(K,NH_4)H_2PO_4$
6	8.00	2.04	31.44	$(K,NH_4)H_2PO_4$
7	7.46	2.45	26.76	$(K,NH_4)H_2PO_4$
8	6.32	2.50	29.83	$(K,NH_4)H_2PO_4$
9	4.61	3.64	31.26	$(K,NH_4)H_2PO_4$
10	1.77	4.15	30.50	$(K,NH_4)H_2PO_4$
11	6.80	2.04	53.80	KH_2PO_4
12	5.51	2.62	51.78	$(K,NH_4)H_2PO_4$
13	4.71	3.03	51.10	$(K,NH_4)H_2PO_4$
14	3.10	3.70	50.98	$(K,NH_4)H_2PO_4$
15	1.70	4.98	52.85	$NH_4H_2PO_4$
		temp = 80 °C		
16	12.68	0.78	26.82	KCl
17	12.42	1.50	28.72	KCl
18	11.15	2.64	29.93	KCl
19	9.15	5.04	26.90	$(NH_4,K)H_2PO_4$
20	8.49	5.59	26.09	$(NH_4,K)H_2PO_4$
21	5.53	5.90	30.29	$(NH_4,K)H_2PO_4$
22	4.18	6.31	29.70	$(NH_4,K)H_2PO_4$
23	2.83	6.28	29.76	$(NH_4,K)H_2PO_4$
24	11.08	0.84	35.60	KCl
25	10.39	4.56	34.26	KCl
26	8.98	4.80	34.08	$(NH_4,K)H_2PO_4$
27	7.75	3.62	35.00	$(NH_4,K)H_2PO_4$
28	5.83	6.07	34.62	$(NH_4,K)H_2PO_4$
29	3.15	6.61	36.42	$(NH_4,K)H_2PO_4$
30	1.92	6.68	32.40	$NH_4H_2PO_4$
31	0.74	7.10	35.75	$NH_4H_2PO_4$
32	0.35	7.22	34.65	$NH_4H_2PO_4$
33	9.53	0.87	39.45	KCl
34	9.50	1.47	37.11	KCl
35	9.17	1.54	42.10	KCl
36	8.80	2.68	42.60	KCl
37	7.64	4.36	42.15	KCl
38	5.00	5.10	40.10	$(K,NH_4)H_2PO_4$
39	4.30	6.18	39.80	$(K,NH_4)H_2PO_4$
40	1.50	6.58	38.31	$NH_4H_2PO_4$
41	0.80	7.22	42.65	$NH_4H_2PO_4$
42	0.23	7.02	41.45	$NH_4H_2PO_4$
43	9.28	0.65	44.10	KCl
44	8.30	2.80	44.90	KCl
45	7.71	5.05	44.33	KCl
46	7.68	4.60	44.48	KCl
47	4.32	6.07	43.78	$(K,NH_4)H_2PO_4$
48	0.74	7.22	44.01	$NH_4H_2PO_4$
49	0.67	7.32	45.67	$NH_4H_2PO_4$
50	0.49	7.70	45.79	$NH_4H_2PO_4$

Compiler's Remark: Recalculation of the data to other coordinates is impossible due to lack of data about the chloride content in the saturated solutions.

Auxiliary Information

Method / Apparatus / Procedure:

The only information given is that the solutions were analyzed for P_2O_5, K_2O, NH_3 and Cl^-. The composition of the solid phase was determined by chemical analysis, petrographically and with the aid of IR spectroscopy.

Source and Purity of Materials:

No information is given

Estimated Error:

No information is given.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

6.1. Solubility in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–Urea–H_2O System

Many different subsystema may be selected in the NH_3–H_3PO_4–H_2O system. One of them, the ternary system $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–H_2O, is of special importance. Many studies of multicomponent systems formed by the addition of further compounds to this system have been reported. One such system, $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–urea–H_2O, has been investigated by Ivanov and Grantscharov.[1–9] They studied the parts of the system where the NH_3/P_2O_5 ratio is 1.4, 1.5, 1.6, 1.7, 1.8 and 1.9. In their reports they also included nomograms for calculating total plant food value.[6–9] The only other work that can be compared with the work of Ivanov and Grantscharov is the work of Kaganskiy and Babenko.[10] The latter report discusses a study of the sytem where the NH_3/P_2O_5 ratio is 1.5. The plant food values reported in Ref. 10 are given in Table I. This Table also includes the plant food values calculated by using the nomograms of Ivanov and Grantscharov.[4] The agreement is fairly good which indicates some validity for the nomograms of Ivanov and Grantscharov. But further independent experimental work is needed before a more detailed evaluation can be made.

Reports of studies of other multicomponent systems formed by the addition of agrochemically important components to the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–urea–H_2O system are also available.[11,12] However, no evaluation can be made of these data because of differences in the components used and in the experimental conditions that prevailed.

Table I. The total plant food in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–urea–H_2O system at a NH_3/P_2O_5 ratio of 1.5 and temperatures of 0 and 10 °C

Plant food values/$100w_i$(N+ P_2O_5)			
temp = 0 °C		temp = 10 °C	
expt[a]	calcd[b]	expt[a]	calcd[b]
18.4	19.5	21.2	22.1
21.7	22.4	23.98	24.4
25.3	25.6	27.8	27.1
29.0	29.8	30.46	30.7
34.5	32.2	35.0	34.0
33.2	32.4	36.4	34.3
33.3	32.4	37.6	34.5
31.64	34.6	36.1	35.5
		35.3	36.5
		35.0	37.9

[a]Experimental values from Ref 10.
[b]Calculated values using the nomograms in Ref. 4.

References:

[1]D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst. Sofiya **13**, 165 (1966).
[2]D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst. Sofiya **15**, 153 (1968).
[3]I. N. Grantscharov, D. G. Ivanov, God. Vissh. Khimikotekhnol. Inst. Sofiya **15**, 127 (1970).
[4]D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst. Sofiya **15**, 159 (1970).
[5]D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst. Sofiya **15**, 227 (1970).
[6]I. N. Grantscharov, D. G. Ivanov, God. Vissh. Khimikotekhnol. Inst. Sofiya **15**, 335 (1970).
[7]D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst., Sofiya **15**, 349 (1970).
[8]I. N. Grantscharov, D. G. Ivanov, Miner. Torove. Nauch Tekh. Konf. 2nd 107 (1970).
[9]I. N. Grantscharov, D. G. Ivanov, Khimiya i Industriya **14**, 63 (1971).
[10]I. M. Kaganskiy, A. M. Babenko, Zh. Prikl. Khim. (Leningrad) **43**, 2421 (1970).
[11]A. V. Slack, J. D. Hatfield, H. B. Shaffer, J. C. Driskell, J. Agr. Food Chem. **7**, 404 (1959).
[12]I. M. Kaganskiy, A. M. Babenko, Izv. Obl. Neorg. Tekhnol. 69-73 (1972).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst., Sofiya **13**, 165-82 (1966).

Variables:

Temperature and composition in solutions with a NH_3/H_3PO_4 ratio = 1.8.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Solubility values in the $CO(NH_2)_2$–$NH_4H_2PO_4$–$(NH_4)_2HPO_4$–H_2OB system in solutions having a mol ratio NH_3/H_3PO_4 = 1.8
All compositions are expressed as 100 w_i

Soln no	S[a]	N(NH_3)	N(ur)	N(tot)	P_2O_5	N+P_2O_5	N:P_2O_5	T/K[b]	Solid phase
1	63	2.47	23.51	25.98	6.95	32.93	1:0.27	339.5	$(NH_4)_2HPO_4$
2	63	1.23	26.45	27.68	3.47	31.15	1:0.13	313.5	urea
3	63	—	29.40	29.40	—	29.40	1:0.00	314.1	urea
4	61	2.39	22.77	25.16	6.73	31.98	1:0.27	328.4	$(NH_4)_2HPO_4$
5	61	1.20	25.61	26.81	3.37	30.18	1:0.13	309.6	urea
6	61	—	28.50	28.50	—	28.50	1:0.00	310.8	urea
7	59	3.47	19.26	22.73	9.86	32.59	1:0.43	338.1	$(NH_4)_2HPO_4$
8	59	2.31	22.02	22.33	6.51	30.84	1:0.27	303.1	urea
9	59	1.15	24.77	25.92	3.25	29.17	1:0.13	305.0	urea
10	59	—	27.50	27.50	—	27.50	1:0.00	306.7	urea
11	57	4.47	15.96	20.43	12.58	33.01	1:0.62	338.8	$(NH_4)_2HPO_4$
12	57	3.35	18.62	21.97	9.44	31.41	1:0.43	325.1	$(NH_4)_2HPO_4$
13	57	2.23	21.28	23.51	6.29	29.80	1:0.27	298.6	urea
14	57	1.12	23.93	25.05	3.15	28.20	1:0.13	301.6	urea
15	57	—	26.60	26.60	—	26.60	1:0.00	302.8	urea
16	55	10.78	—	10.78	30.35	41.13	1:2.82	338.8	$(NH_4)_2HPO_4$
17	55	9.70	2.57	12.27	27.31	39.58	1:2.23	337.7	$(NH_4)_2HPO_4$
18	55	8.62	5.13	13.75	24.28	38.03	1:1.77	337.6	$(NH_4)_2HPO_4$
19	55	7.54	7.70	15.24	21.24	36.48	1:1.39	337.0	$(NH_4)_2HPO_4$
20	55	6.47	10.26	16.73	18.21	34.94	1:1.09	335.4	$(NH_4)_2HPO_4$
21	55	5.39	12.83	18.22	15.17	33.39	1:0.83	331.4	$(NH_4)_2HPO_4$
22	55	4.31	15.40	19.71	12.13	31.84	1:0.62	321.9	$(NH_4)_2HPO_4$
23	55	3.23	17.96	21.19	9.10	30.29	1:0.43	308.0	$(NH_4)_2HPO_4$
24	55	2.15	20.53	22.68	6.07	28.75	1:0.27	293.8	urea
25	55	1.08	23.09	24.17	3.03	27.30	1:0.13	296.4	urea
26	55	—	25.60	25.60	—	25.60	1:0.00	298.8	urea
27	52	10.19	—	10.19	28.69	38.88	1:2.82	325.0	$(NH_4)_2HPO_4$
28	52	9.17	2.43	11.60	25.82	37.42	1:2.23	323.9	$(NH_4)_2HPO_4$
29	52	8.15	4.85	13.00	22.95	35.95	1:1.77	322.8	$(NH_4)_2HPO_4$
30	52	7.13	7.28	14.41	20.08	34.49	1:1.39	321.5	$(NH_4)_2HPO_4$
31	52	6.11	9.70	15.81	17.21	33.02	1:1.09	318.2	$(NH_4)_2HPO_4$
32	52	5.09	12.13	17.22	14.34	31.56	1:0.83	312.8	$(NH_4)_2HPO_4$
33	52	4.08	14.55	18.63	11.47	30.10	1:0.62	303.7	$(NH_4)_2HPO_4$
34	52	3.06	16.98	20.04	8.61	28.65	1:0.43	286.7	$(NH_4)_2HPO_4$
35	52	2.04	19.41	21.45	5.74	27.19	1:0.27	289.2	urea
36	52	1.02	21.83	22.85	2.87	25.72	1:0.13	292.2	urea
37	52	—	24.30	24.30	—	24.30	1:0.00	293.3	urea
38	50	9.80	—	9.80	27.58	37.38	1:2.82	315.8	$(NH_4)_2HPO_4$

Soln no	S[a]	N(NH_3)	N(ur)	N(tot)	P_2O_5	N + P_2O_5	N:P_2O_5	T/K[b]	Solid phase
39	50	8.82	2.33	11.15	24.83	35.98	1:2.23	314.5	$(NH_4)_2HPO_4$
40	50	7.84	4.66	12.50	22.07	34.57	1:1.77	312.9	$(NH_4)_2HPO_4$
41	50	6.86	7.00	13.66	19.31	33.17	1:1.39	311.3	$(NH_4)_2HPO_4$
42	50	5.88	9.33	15.21	16.55	31.76	1:1.09	307.5	$(NH_4)_2HPO_4$
43	50	4.90	11.66	16.56	13.79	30.35	1:0.83	300.8	$(NH_4)_2HPO_4$
44	50	3.92	13.99	17.91	11.03	28.94	1:0.62	290.2	$(NH_4)_2HPO_4$
45	50	2.94	16.33	19.27	8.27	27.54	1:0.43	283.2	urea
46	50	1.96	18.66	20.62	5.52	26.14	1:0.27	285.7	urea
47	50	0.98	20.99	21.97	2.76	24.73	1:0.13	288.5	urea
48	50		23.30	23.30		23.30	1:0.00	289.8	urea
49	48	9.41		9.41	26.48	35.89	1:2.82	305.4	$(NH_4)_2HPO_4$
50	48	8.47	2.24	10.71	23.84	34.55	1:2.23	304.4	$(NH_4)_2HPO_4$
51	48	7.52	4.48	12.00	21.19	33.19	1:1.77	303.1	$(NH_4)_2HPO_4$
52	48	6.58	6.72	13.30	18.54	31.84	1:1.39	299.4	$(NH_4)_2HPO_4$
53	48	5.64	8.96	14.60	15.89	30.49	1:1.09	294.8	$(NH_4)_2HPO_4$
54	48	4.70	11.20	15.90	13.24	29.14	1:0.83	289.5	$(NH_4)_2HPO_4$
55	48	3.76	13.44	17.20	10.59	27.79	1:0.62	275.7	$(NH_4)_2HPO_4$
56	48	2.82	15.68	18.50	7.95	26.45	1:0.43	279.2	urea
57	48	1.88	17.92	19.80	5.30	25.10	1:0.27	282.0	urea
58	48	0.94	20.15	21.09	2.65	23.74	1:0.13	283.3	urea
59	48		22.40	22.40	-	22.40	1:0.00	296.1	urea
60	45	8.83		8.83	24.85	33.68	1:2.82	291.1	$(NH_4)_2HPO_4$
61	45	7.94	2.10	10.04	22.37	32.41	1:2.23	287.0	$(NH_4)_2HPO_4$
62	45	7.06	4.20	11.26	19.88	31.14	1:1.77	287.0	$(NH_4)_2HPO_4$
63	45	6.18	6.30	12.48	17.40	29.88	1:1.39	284.0	$(NH_4)_2HPO_4$
64	45	5.30	8.40	13.70	14.91	28.61	1:1.09	278.9	$(NH_4)_2HPO_4$
65	45	4.41	10.51	14.92	12.42	27.34	1:0.83	271.7	$(NH_4)_2HPO_4$
66	45	3.53	12.61	16.14	9.94	26.08	1:0.62	270.8	urea
67	45	2.65	11.71	17.36	7.45	24.81	1:0.43	273.8	urea
68	45	1.76	16.81	18.57	4.76	23.54	1:0.27	277.1	urea
69	45	0.88	18.91	19.79	2.48	22.27	1:0.13	280.2	urea
70	45		21.00	21.00	--	21.00	1:0.00	281.5	urea
71	43	8.43		8.43	23.73	32.16	1:2.82	282.5	$(NH_4)_2HPO_4$
72	43	7.58	2.01	9.59	21.35	30.94	1:2.23	281.7	$(NH_4)_2HPO_4$
73	43	6.74	4.01	10.75	18.93	29.73	1:1.77	278.0	$(NH_4)_2HPO_4$
74	43	5.90	6.52	11.92	16.61	28.53	1:1.39	274.1	$(NH_4)_2HPO_4$
75	43	1.69	16.05	17.74	4.75	22.49	1:0.27	272.8	urea
76	43	0.84	18.06	18.90	2.37	21.27	1:0.13	274.8	urea

[a]This is a number characterizing the respective section. It is close to, but not identical with the total salt content of the system.
[b]This is the temperature of crystallization.

Part 2 The compiler has recalculated the data in Part 1 to give the following concentration values

Soln no	$CO(NH_2)_2$ $100w_i$	$CO(NH_2)_2$ m_i/mol kg^{-1}	$(NH_4)_2HPO_4$ $100w_i$	$(NH_4)_2HPO_4$ m_i/mol kg^{-1}	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ m_i/mol kg^{-1}	H_2O $100w_i$
1	50.43	22.71	10.33	2.11	2.27	0.53	36.98
2	56.74	25.54	5.13	1.05	1.16	0.27	36.98
3	63.06	28.43	0.00	0.00	0.00	0.00	36.94
4	48.84	20.87	9.98	1.94	2.21	0.49	38.97
5	54.93	23.48	5.03	0.98	1.08	0.24	38.96
6	61.13	26.19	0.00	0.00	0.00	0.00	38.87
7	41.31	16.83	14.33	2.66	3.50	0.74	40.86
8	47.23	19.19	9.64	1.78	2.15	0.46	40.97
9	53.13	21.58	4.78	0.88	1.10	0.23	40.99
10	58.99	23.95	0.00	0.00	0.00	0.00	41.01
11	34.23	13.26	18.68	3.29	4.11	0.83	42.97
12	39.94	15.48	13.98	2.46	3.12	0.63	42.96
13	45.65	17.69	9.30	1.64	2.10	0.42	42.96
14	51.33	19.89	4.69	0.83	1.02	0.21	42.96
15	57.06	22.12	0.00	0.00	0.00	0.00	42.94
16	0.00	0.00	45.04	7.58	9.95	1.92	45.01
17	5.51	2.04	40.53	6.82	8.95	1.73	45.01
18	11.00	4.07	35.99	6.06	7.99	1.54	45.01
19	16.52	6.11	31.48	5.30	7.00	0.35	45.01
20	22.01	8.14	27.04	4.55	5.95	1.15	45.00
21	27.52	10.18	22.53	3.79	4.96	0.96	44.99
22	33.03	12.23	18.02	3.03	3.96	0.77	44.99
23	38.52	14.26	13.48	2.27	3.00	0.58	44.99
24	44.04	16.30	8.95	1.51	2.04	0.39	44.97
25	49.53	18.33	4.53	0.76	0.96	0.19	44.98
26	54.91	20.28	0.00	0.00	0.00	0.00	45.09
27	0.00	0.00	42.57	6.71	9.41	1.70	48.02
28	5.21	1.81	38.31	6.04	8.47	1.53	48.01
29	10.40	3.61	34.04	5.37	7.54	1.36	48.02
30	15.62	5.41	29.62	4.67	6.74	1.22	48.03
31	20.81	7.21	25.51	4.02	5.66	1.03	48.02
32	26.02	9.02	21.25	3.35	4.73	0.86	48.00
33	31.21	10.83	17.08	2.69	3.71	0.67	48.00
34	36.42	12.64	12.79	2.02	2.81	0.51	47.98
35	41.63	14.45	8.53	1.35	1.87	0.34	47.96
36	46.83	16.25	4.26	0.67	0.94	0.17	47.97
37	52.12	18.13	0.00	0.00	0.00	0.00	47.88
38	0.00	0.00	40.97	6.20	9.01	1.57	50.03
39	5.00	1.66	36.85	5.58	8.13	1.41	50.01
40	10.00	3.33	32.76	4.96	7.23	1.26	50.02
41	15.02	5.00	28.67	4.34	6.32	1.10	50.00
42	20.01	6.66	24.58	3.72	5.41	0.94	50.00
43	25.01	8.33	20.48	3.10	4.50	0.78	50.00
44	30.01	9.99	16.39	2.48	3.60	0.63	50.00
45	35.03	11.67	12.30	1.86	2.69	0.47	49.99
46	40.03	13.34	8.19	1.24	1.81	0.32	49.97
47	45.02	15.00	4.09	0.62	0.91	0.16	49.98
48	49.98	16.64	0.00	0.00	0.00	0.00	50.02
49	0.00	0.00	39.34	5.73	8.64	1.44	52.02
50	4.80	1.54	35.40	5.15	7.80	1.30	52.00
51	9.61	3.08	31.39	4.57	7.00	1.17	52.01
52	14.41	4.62	27.46	4.00	6.12	1.02	52.00
53	19.22	6.15	23.54	3.43	5.24	0.88	52.00
54	24.02	7.69	19.62	2.86	4.36	0.73	51.99
55	28.83	9.23	15.70	2.29	3.48	0.58	51.99
56	33.63	10.78	11.76	1.71	2.64	0.44	51.97
57	38.44	12.32	7.84	1.14	1.76	0.29	51.96
58	43.22	13.85	3.92	0.57	0.88	0.15	51.98
59	48.05	15.40	0.00	0.00	0.00	0.00	51.95
60	0.00	0.00	36.91	5.08	8.12	1.28	54.97
61	4.50	1.36	33.14	4.57	7.38	1.17	54.97
62	9.01	2.73	29.49	4.06	6.53	1.03	54.97
63	13.51	4.09	25.82	3.56	5.71	0.90	54.96
64	18.02	5.46	22.17	3.05	4.85	0.77	54.96
65	22.54	6.83	18.42	2.54	4.08	0.65	54.95
66	27.05	8.20	14.75	2.03	3.26	0.52	54.94
67	31.55	9.56	11.09	1.53	2.41	0.38	54.94
68	36.06	10.87	7.72	1.06	0.99	0.16	55.23
69	40.56	12.29	3.67	0.51	0.82	0.13	54.95
70	45.05	13.65	0.00	0.00	0.00	0.00	54.96
71	0.00	0.00	35.23	4.68	7.77	1.18	57.00
72	4.31	1.26	31.65	4.20	7.03	1.07	57.01
73	8.60	2.51	28.15	3.74	6.23	0.95	57.01
74	13.99	4.16	24.65	3.34	5.44	0.85	55.92
75	34.43	10.06	7.08	0.94	1.53	0.23	56.96
76	38.74	11.32	3.50	0.47	0.79	0.12	56.97

Part 3. Comments and Additional Data:

The authors presented the following equations relating total plant food to temperature and to the P_2O_5/N ratio.

$N + P_2O_5 = a + b(T - 273.16)$ P_2O_5/N is constant [1] the equilibrium solid phase is constant

$N + P_2O_5 = c + d(P_2O_5/N)$ T is constant [2] the equilibrium solid phase is constant

$N + P_2O_5 = e + f(P_2O_5/N) + g(T - 273.16)(P_2O_5/N)^h$ [3] the equilibrium solid phase is constant

The values of the constants are summarized in the Table below.

Table of constants for the equations.

Mass ratio P_2O_5/N	Values of the constants a	b	Temperature K
2.82	30.78	0.157	273.16–338.16
2.23	29.80	0.151	273.16–338.16
1.77	29.20	0.137	273.16–338.16
1.39	28.50	0.124	273.16–338.16
1.09	28.10	0.108	273.16–338.16
0.83	27.50	0.100	273.16–338.16
0.62	27.53	0.085	275.66–343.16
0.43	27.60	0.075	288.66–343.16
0.43	24.60	0.295	273.16–288.66
0.27	22.61	0.282	273.16–303.16
0.13	20.85	0.257	273.16–315.66
0.00	19.14	0.250	273.16–315.66

Temperature K	Values of constants c	d	Mass ratio P_2O_5/N
273.16	26.25	1.59	2.82-0.83
283.16	27.00	1.90	2.82-0.83
293.16	27.80	2.20	2.82-0.83
303.16	28.69	2.46	2.82-0.83
313.16	29.60	2.78	2.82-0.83
273.16	19.14	12.70	0.62-0.00
283.16	21.60	13.70	0.43-0.00

Equilibrium solid phase	Values of the constants e	f	g	h
$(NH_4)_2HPO_4$	26.27	1.6	0.108	0.392
$CO(NH_2)_2$	19.17	12.675	0.3263	0.1159

Comment: The equations describe the experimental data with a relative error of ±0.5%.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used. The apparatus consisted of 2 thermostated reaction vessels, the contents of which were stirred vigorously. The appearance/disappearance of the last crystal was observed with a stereomicroscope. The composition of the equilibrium solid phases was determined analytically. Nitrogen (total and ammoniacal) was determined by the Kjeldahl method. Phosphate ions were precipitated as $NH_4MgPO_4 \cdot 6H_2O$ and the excess Mg was titrated complexometrically using eriochrome black T as indicator.

Source and Purity of Materials:

Reagent grade urea, $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ were recrystallized before being used.

Estimated Error:

The reproducibility of the crystallization temperature was within 0.3 K. For the correlations see EXPERIMENTAL VALUES.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst., Sofiya, 13, 153-68 (1968).

Variables:

Composition at 0 °C and the ratio NH_3/H_3PO_4 = 1.7.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Solubility in the $(NH_4)_2HPO_4$–$NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system at 0 °C

Soln no	N_2P[a] $100w_i$	NP[a] $100w_i$	urea $100w_i$	H_2O $100w_i$	N $100w_i$	P_2O_5 $100w_i$	Σ $100w_i$	$w_i(N)/w_i(P_2O_5)$	Solid phase[b]
1	32.83	12.26	0.00	54.91	8.46	25.21	33.67	1/2.98	A
2	29.73	11.10	4.54	54.63	9.76	22.84	32.60	1/2.34	A
3	26.55	9.91	9.12	54.42	11.08	20.39	31.47	1/1.84	A
4	23.60	8.81	13.89	53.70	12.57	18.11	30.68	1/1.44	A
5	20.72	7.73	18.97	52.58	14.18	15.88	30.06	1/1.12	A
6	17.62	6.57	24.18	51.63	15.87	13.48	29.35	1/0.85	A
7	14.66	5.47	30.20	49.67	17.84	11.23	29.07	1/0.63	B
8	10.19	3.81	32.69	53.31	17.83	7.85	25.68	1/0.44	B
9	6.54	2.44	35.92	55.10	18.49	4.99	23.48	1/0.27	B
10	3.15	1.17	38.89	56.79	18.97	2.46	21.43	1/0.13	B

[a] $N_2P = (NH_4)_2HPO_4$; $NP = NH_4H_2PO_4$.
[b] The solid phases are: $A = (NH_4)_2HPO_4$; $B = CO(NH_2)_2$.

The compiler has used the data above to calculate the following molalities.

Soln no	$(NH_4)_2HPO_4$ m_i/mol^{-1} kg^{-1}	$NH_4H_2PO_4$ m_i/mol^{-1} kg^{-1}	$CO(NH_2)_2$ m_i/mol^{-1} kg^{-1}
1	4.526	1.941	0.00
2	4.120	1.766	1.38
3	3.693	1.58	2.79
4	3.327	1.43	4.307
5	2.983	1.28	6.087
6	2.584	1.11	7.798
7	2.234	0.957	10.12
8	1.450	0.639	10.23
9	0.899	0.385	10.85
10	0.420	10.179	11.40

Part 2. Comments and Additional Data.

The authors present isotherms for 15 and 30 °C, but only in graphical form. The authors also present the following equations to express the dependence of total plant food on both temperature and the P_2O_5/N ratio.

$$N + P_2O_5 = a + bT \quad (P_2O_5/N \text{ is constant}) \qquad [1]$$

$$N + P_2O_5 = c + d(P_2O_5/N) \quad (T \text{ is constant}) \qquad [2]$$

$$N + P_2O_5 = e + f(P_2O_5/N) + gT(P_2O_5/N)^h \qquad [3]$$

For each of the above three relationships, the equilibrium solid phase is constant. The values of the constants are summarized in the Tables below.

Mass ratio P_2O_5/N	Values of the constants a	b	Temperature °C
2.98	33.67	0.146	0–55
2.34	32.60	0.137	0–55
1.84	31.47	0.131	0–55
1.44	30.68	0.117	0–55
1.12	30.06	0.102	0–55
0.85	29.35	0.094	0–55
0.63	29.07	0.082	4–55
0.44	25.68	0.274	0–16
0.27	23.48	0.268	0–27
0.13	21.43	0.254	0–45

Temperature °C	Values of constants c	d	Mass ratio P_2O_5/N
0	27.77	2.01	0.69–2.98
10	28.47	2.29	0.63–2.98
20	29.19	2.53	0.63–2.98
30	29.94	2.83	0.63–2.98
0	19.24	14.44	0.10–0.60
10	21.93	15.00	0.10–0.52
20	24.39	15.67	0.10–0.39

Equilibrium solid phase	Values of the constants e	f	g	h
$(NH_4)_2HPO_4$	27.76	2.01	0.099	0.382
$CO(NH_2)_2$	19.43	14.48	0.292	0.072

Comment: Equations (1) and (2) describe the experimental data with a relative error of ±0.5–1.0%. For Eq. (3) the error is ±1.5%.

Auxiliary Information

Method / Apparatus / Procedure:

All experimental details have been described earlier.[1]

Source and Purity of Materials:

Reagent grade urea. $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ were recrystallized before being used.

Estimated Error:

No information is given. For correlations see EXPERIMENTAL VALUES.

References:

[1] D. G. Ivanov and I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst., Sofiya **11**, 165 (1966).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

I. N. Grantscharov, D. G. Ivanov, God. Vissh. Khimikotekhnol. Inst., Sofija **15**, 127-52 (1970).

Variables:

Composition at 273 K in a solution with a NH_3/H_3PO_4 ratio = 1.9.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data

Solubility values in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$CO(NH_2)_2$–H_2O system at 0 °C and a mol ratio NH_3/H_3PO_4 = 1.9

$NH_4H_2PO_4$ $100w_i$	$(NH_4)_2NPO_4$ $100w_i$	$CO(NH_2)_2$ $100w_i$	H_2O $100w_i$	N_{tot} $100w_i$	$N+P_2O_5$ $100w_i$	Mass ratio N/P_2O_5	Solid phase[a]
3.40	35.06	0.00	51.54	7.76	28.40	1/2.67	A
3.09	31.81	3.88	61.22	8.62	27.93	1/2.13	A
2.84	28.80	7.92	60.44	10.18	27.38	1/1.69	A
2.50	25.78	12.12	59.60	11.32	26.83	1/1.37	A
2.20	22.60	16.54	58.66	12.76	26.29	1/1.06	A
1.83	19.14	20.98	58.05	13.93	25.49	1/0.83	A
1.55	15.96	26.27	56.22	15.86	25.38	1/0.60	A
1.20	12.36	31.67	54.77	17.94	25.25	1/0.42	A+B
0.78	8.04	35.26	55.92	18.29	23.05	1/0.26	B
0.37	3.88	38.25	57.50	18.77	21.02	1/0.12	B

[a] The solid phases are: A = $(NH_4)_2HPO_4$; B = $CO(NH_2)_2$.

Part 2. The compiler has used the above data to calculate the following molalities

$NH_4H_2PO_4$ m_i/mol^{-1} kg^{-1}	$(NH_4)_2HPO_4$ m_i/mol^{-1} kg^{-1}	$CO(NH_2)_2$ m_i/mol^{-1} kg^{-1}
0.48	4.31	0.00
0.44	3.93	1.06
0.41	3.61	2.18
0.36	3.28	3.39
0.33	2.92	4.69
0.27	2.50	6.02
0.24	2.15	7.78
0.19	1.71	9.63
0.12	1.09	10.50
0.06	0.51	11.08

Comments and Additional Data:

The authors present solubility polytherm and the isotherms at 15 and 30 °C in graphical form. In addition, they report the constants for empirical equations describing the solubility in the system under consideration. These linearizations are discussed in the Critical Evaluation.

The authors present the following equations to express the dependence of total plant food on both temperature and the P2O5/N ratio.

$$N + P_2O_5 = a + bT \quad (P_2O_5/N \text{ is constant}) \qquad [1]$$

$$N + P_2O_5 = c + d(P_2O_5/N) \quad (T \text{ is constant}) \qquad [2]$$

$$N + P_2O_5 = c + f(P_2O_5/N) + gT(P_2O_5/N)h \qquad [3]$$

The equilibrium solid phase is constant in each of the above three relationships. The values of the constants are summarized in the Table below.

Mass ratio P_2O_5/N	Values of the constants a	b	Temperature °C
2.67	28.41	0.144	0–60
2.13	27.94	0.135	0–60
1.69	27.39	0.131	0–60
1.37	26.82	0.120	0–60
1.06	26.29	0.119	0–60
0.83	25.49	0.109	0–60
0.60	25.37	0.102	0–60
0.26	23.05	0.256	0–19
0.12	21.02	0.266	0–40

Temperature °C	Values of constants c	d	Mass ratio P_2O_5/N
0	24.18	1.68	0.42–2.67
10	25.18	1.85	0.50–2.67
20	26.11	2.07	0.60–2.67
30	27.19	2.19	0.60–2.67
40	28.25	2.31	0.60–2.67
0	19.33	13.60	0.10–0.40
10	21.66	15.60	0.10–0.33

Equilibrium solid phase	Values of the constants e	f	g	h
$(NH_4)_2HPO_4$	24.49	1.57	0.115	0.226

Comment: Equations (1) and (2) describe the experimental data with a relative error of ∓0.5–1.0. For Eq. (3) the error is ±1.5%.

Auxiliary Information

Method / Apparatus / Procedure:

All experimental details have been described earlier.[1]

Source and Purity of Materials:

Reagent grade urea, $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ were recrystallized before being used.

Estimated Error:

No information is given.

References:

[1]D. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst., Sofiia 13, 165 (1966).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst., Sofiya. **15**, 159-70 (1968).

Variables:

Temperature and composition in solutions with a NH_3/H_3PO_4 ratio – 1.4 and 1.5.

Prepared By:

J. Eysseltová

Experimental Data

Data for some sections through the solubility polytherms at constant total salt concentration, and isotherms at 0, 15 and 30 °C are given in graphical form. The authors also give the following equations expressing the dependence of total plant food on both temperature and the P_2O_5/N ratio.

$N+P_2O_5=a+bT$ (P_2O_5N) is constant	[1]	The equilibrium solid phase is constant
$N+P_2O_5=c+d(P_2O_5N)$ (temperature is constant)	[2]	The equilibrium solid phase is constant
$N+P_2O_5=a_1+b_1(P_2O_5N)+c_1T+d_1T(P_2O_5N)$	[3]	The equilibrium solid phase is constant
$N+P_2O_5=e+f(P_2O_5N)+gT(P_2O_5N)^h$	[4]	The equilibrium solid phase is constant

Equation (3) is used when the NH_3/P_2O_5 ratio is 1.4; Eq. (4) is used when the ratio is 1.5.

Table 1. Constants for Eqs. (1)–(4)

Mass ratio P_2O_5/N	Values of constants a	b	Temperature interval °C
	mol ratio of NH_3/H_3PO_4 = 1.4		
3.62	32.10	0.271	0–50
2.74	31.23	0.263	0–60
2.10	30.30	0.273	0–60
1.62	29.68	0.283	0–55
1.23	29.43	0.274	0–55
0.68	28.80	0.303	0–43
0.47	26.76	0.269	0–47
0.29	24.27	0.259	0–50
0.13	21.77	0.252	0–55
	mol ratio of NH_3/H_3PO_4 = 1.5		
3.37	34.73	0.325	0–40
2.58	33.59	0.310	0–40
2.00	33.06	0.277	0–40
1.55	32.46	0.254	0–40
1.19	32.29	0.199	2.5–40
0.66	28.69	0.289	0–25
0.45	26.08	0.284	0–35
0.28	23.65	0.275	0–40
0.13	21.33	0.264	0–42

Temperature °C	Values of the constants c	d	Interval of the P_2O_5/N ratio
	mol ratio of NH_3/H_3PO_4 = 1.4		
0	28.14	1.03	1.23–3.62
10	30.95	0.96	1.23–3.62
20	33.40	1.00	1.23–3.62
30	36.13	1.05	1.23–3.62
40	38.71	1.10	1.23–3.62
10	22.19	14.50	0.10–0.97
20	24.75	14.51	0.10–0.90
30	27.30	14.64	0.10–0.84
	mol ratio of NH_3/H_3PO_4 = 1.5		
0	30.85	1.11	1.18–3.37
10	32.32	1.65	0.98–3.37
20	34.17	2.12	0.80–3.37
30	35.33	2.82	0.68–3.37
0	19.53	13.76	0.10–0.90
10	22.09	14.33	0.10–0.90
20	24.52	15.51	0.10–0.77

mol ratio of NH_3/H_3PO_4 = 1.4

Equilibrium solid phase	Values of constants a_1	b_1	c_1	d_1
$NH_4H_2PO_4$	28.14	1.03	0.282	0.0044
$CO(NH_2)_2$	19.86	13.84	0.238	0.086

mol ratio of NH_3/H_3PO_4 = 1.5

Equilibrium solid phase	Values of constants e	f	g	h
$NH_4H_2PO_4$	30.82	1.121	0.190	0.450
$CO(NH_2)_2$	19.37	14.48	0.298	0.065

Auxiliary Information

Method / Apparatus / Procedure:

All experimental details have been described earlier.[1]

Source and Purity of Materials:

Reagent grade urea, $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ were recrystallized before being used.

Estimated Error:

Equations (1) and (2) describe the data with a relative error of ±0.5–2%; for Eqs. (3) and (4) the error is ±2.5% and ±3.5%, respectively.

References:

[1]D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst., Sofiya 13, 165 (1966).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

D. G. Ivanov, I. N. Grantscharov, God. Vissh. Khimikotekhnol. Inst., Sofija, 15, 227-43 (1970).

Variables:

Composition at 273 K in a solution with a NH_3/H_3PO_4 ratio = 1.6.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors' data: Solubility values in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$CO(NH_2)_2$–H_2O system at 0 °C and a mol ratio NH_3/H_3PO_4 = 1.6

$NH_4H_2PO_4$ $100w_i$	$(NH_4)_2HPO_4$ $100w_i$	$CO(NH_2)_2$ $100w_i$	H_2O $100w_i$	N_{tot} $100w_i$	$N+P_2O_5$ $100w_i$	Mass ratio N/P_2O_5	Solid phase[a]
31.18	18.11	0.00	50.71	8.82	36.76	1:3.17	A
28.19	13.36	4.95	50.50	10.27	35.53	1:2.46	A
25.29	14.69	9.99	50.03	11.80	34.48	1:1.92	A
22.34	12.97	15.13	49.56	13.36	33.39	1:1.50	A
19.49	11.32	20.54	48.65	15.07	32.55	1:1.16	A
16.22	9.37	25.64	48.77	16.51	31.04	1:0.88	B
12.40	7.21	29.42	50.97	17.29	28.36	1:0.64	B
8.89	5.16	32.80	53.15	17.79	25.78	1:0.45	B
5.68	3.30	35.94	55.08	18.33	23.47	1:0.28	B
2.73	1.58	38.83	56.86	18.88	21.35	1:0.13	B

[a]The solid phases are: A–$(NH_4)_2HPO_4$; B=$CO(NH_2)_2$.

Part 2. The compiler has used the above data to calculate the following molalities

$NH_4H_2PO_4$ m_i/mol^{-1} kg^{-1}	$(NH_4)_2HPO_4$ m_i/mol^{-1} kg^{-1}	$CO(NH_2)_2$ m_i/mol^{-1} kg^{-1}
4.66	3.10	0.00
4.23	2.82	1.63
3.83	2.55	3.32
3.41	2.27	5.08
3.03	2.02	7.03
2.52	1.67	8.75
1.84	1.23	9.61
1.27	0.84	10.28
0.78	0.52	10.86
0.36	0.24	11.37

Comments and Additional Data: The authors present the solubility isotherms at 15 and 30 °C only in graphical form. In addition, they report the constants for equations describing the solubility in the system under consideration. These linearizations are discussed in the Critical Evaluation.

The authors present the following equations to express the dependence of total plant food on both temperature and the P_2O_5/N ratio.

$N+P_2O_5=a+bT$ (P_2O_5/N is constant) (1) The equilibrium solid phase is constant.

$N+P_2O_5=c+d(P_2O_5/N)$ (T is constant) (2) The equilibrium solid phase is constant.

$N+P_2O_5=e+f(P_2O_5/N)+gT(P_2O_5/N)^h$ (3) The equilibrium solid phase is constant.

The values of the constants are summarized in the Table below.

Mass ratio P_2O_5/N	Values of the constants a	b	Temperature °C
3.17	36.76	0.154	0–45
2.46	35.53	0.145	0–45
1.92	34.48	0.131	0–45
1.50	33.39	0.118	0–45
1.16	32.55	0.099	0–45
0.64	28.36	0.292	0–14
0.45	25.78	0.291	0–25
0.28	23.47	0.276	0–35
0.13	21.33	0.262	0–45

Temperature °C	Values of constants c	d	Mass ratio P_2O_5/N
0	30.28	2.09	1.1–3.17
10	30.96	2.36	0.80–3.17
20	31.20	2.85	0.60–3.17
30	31.63	3.25	0.45–3.17
40	31.99	3.69	0.30–3.17
0	19.58	13.34	0.10–1.04
10	21.91	14.87	0.10–0.52
20	24.25	16.71	0.10–0.52
30	26.56	19.39	0.10–0.38

Equilibrium solid phase	Values of the constants e	f	g	h
$(NH_4)_2HPO_4$	30.27	2.09	0.096	0.436
$CO(NH_2)_2$	19.40	14.14	0.308	0.086

Comment: Equations (1) and (2) describe the experimental data with a relative error of ±0.5–1.0%. For Eq. (3) the error is ±2.0%.

Auxiliary Information

Method / Apparatus / Procedure:

All experimental details have been described earlier.[1]

Source and Purity of Materials:

Reagent grade urea, $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ were recrystallized before being used.

Estimated Error:

No information is given.

References:

[1] D. Ivanov, I. N. Gramtscharov, God. Vissh. Khimikotekhnol. Inst., Sofija **13**, 165 (1966).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

I. M. Kaganskiy, A. M. Babenko, Zh. Prik. Khim. (Leningrad) **43**, 2421-5 (1970).

Variables:

Temperature and concentration of urea in a mixture containing a mol ratio of $NH_4H_2PO_4/(NH_4)_2HPO_4 = 1$.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Points of simultaneous crystallization of two or three solid phases in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$CO(NH_2)_2$–H_2O- system

Mixture[a] $100w_i$	Mixture[a] m_i/mol kg^{-1}[b]	$NH_4H_2PO_4$ $100w_i$[b]	$(NH_4)_2HPO_4$ $100w_i$[b]	$CO(NH_2)_2$ $100w_i$	$CO(NH_2)_2$ m_i/mol kg^{-1}[b]	H_2O $100w_i$	t/°C	Solid phases[c]
0.0	0.0	0.0	0.0	33.3	8.31	66.7	−10.8	A+B
7.12	0.910	3.31	3.81	28.8	7.48	64.08	−12.6	A+B
15.0	2.05	7.0	8.0	25.0	6.94	60.0	−14.0	A+B
19.2	2.78	8.9	10.3	24.2	7.12	56.6	−15.0	A+B
26.8	4.05	12.5	14.3	19.0	5.84	54.2	−12.0	A+B
28.5	4.37	13.3	15.2	18.0	5.60	53.5	−17.2	A+B+C
30.6	4.51	14.2	16.4	13.8	4.13	55.6	−14.1	A+C
32.0	4.52	14.9	17.1	10.0	2.87	58.0	−10.6	A+C
34.6	4.82	16.1	18.5	6.54	1.85	58.86	−10.6	A+C
38.6	5.15	18.0	20.6	0.0	0.0	61.4	−8.6	A+C
31.5	5.21	14.7	16.8	19.0	6.39	49.5	−6.4	B+C
33.6	5.93	15.6	18.0	20.0	7.18	46.4	−2.5	B+C
35.55	6.704	16.5	19.00	21.0	8.05	43.45	+5.4	B+C
36.0	6.94	16.8	19.2	21.5	8.42	42.5	6.0	B+C+D
61.0	12.8	28.4	32.6	0.0	0.0	39.0	39.0	C+D
57.48	12.29	26.7	30.72	4.2	1.8	38.32	34.5	C+D
49.77	10.29	22.89	26.28	10.6	4.45	39.63	22.5	C+D
42.0	8.19	19.6	22.4	16.0	6.34	42.0	14.0	C+D
34.0	6.76	15.8	18.2	24.8	10.0	41.2	13.0	B+D
27.8	5.96	12.9	14.9	34.0	14.8	38.2	25.9	B+D
27.9	5.50	13.0	14.9	30.5	12.2	41.6	11.8	B+D
24.0	5.17	11.2	12.8	38.0	16.6	38.0	28.0	B+D

Part 2. Solubility isotherms in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$CO(NH_2)_2$–H_2O system

Mixture[a] 100w_i	Mixture[a] m_i/mol kg^{-1b}	$NH_4H_2PO_4$ 100w_i[b]	$(NH_4)_2HPO_4$ 100w_i[b]	$CO(NH_2)_2$ 100w_i	$CO(NH_2)_2$ m_i/mol kg^{-1b}	H_2O 100w_i	$(N+P_2O_5)$ 100m_i
			temp = −10 °C				
0.0	0.0	0.0	0.0	33.7	8.46	66.3	15.7
6.96	0.910	3.24	3.72	30.4	8.08	62.64	19.3
14.5	2.04	6.80	7.70	27.2	7.77	58.3	23.5
23.4	3.51	10.9	12.5	22.0	6.71	54.6	27.5
30.0	4.81	14.0	16.0	18.9	6.16	51.1	31.1
30.5	4.80	14.2	16.3	17.4	5.56	52.1	30.7
32.5	4.93	15.1	17.4	13.5	4.16	54.0	30.4
35.0	4.90	16.3	18.7	6.5	1.9	58.5	28.9
			temp = 0 °C				
0.0	0.0	0.0	0.0	39.6	10.9	60.4	18.4
6.36	0.910	2.96	3.40	36.4	10.5	57.24	21.7
13.4	2.05	6.2	7.2	33.0	10.3	53.6	25.3
21.6	3.51	10.1	11.5	28.0	9.25	50.4	29.0
33.2	5.94	15.5	17.7	21.0	7.63	45.8	34.5
34.4	5.73	16.0	18.4	16.4	5.55	49.2	33.2
37.0	6.02	17.2	19.8	12.6	4.16	50.4	33.3
42.6	6.08	19.8	22.8	0.0	0.0	57.4	31.64
			temp = 10 °C				
0.00	0.00	0.00	0.00	45.4	13.8	54.6	21.2
5.76	0.910	2.68	3.08	42.4	13.6	51.84	23.98
12.24	2.048	5.70	6.54	38.8	13.2	48.96	27.8
19.8	3.51	9.2	10.6	34.0	12.2	46.2	30.46
31.08	5.933	14.47	16.61	26.0	10.1	42.92	35.0
34.4	6.68	16.0	18.4	23.4	9.23	42.2	36.4
37.0	7.39	17.2	19.8	22.0	8.93	41.0	37.6
41.4	7.24	19.3	22.1	11.72	4.163	46.88	36.1
44.0	7.15	20.5	23.5	5.6	1.8	50.4	35.3
47.0	7.27	21.9	25.1	0.0	0.0	53.0	35.0

[a]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b]These values were calculated by the compiler.
[c]The solid phases are: A = ice; B = $CO(NH_2)_2$; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

An improved polythermic method was used.[1]

Source and Purity of Materials:

Reagent grade salts were recrystallized and dried before use. The monoammonium salt and the urea were dried at 50 °C, the diammonium salt was dried at 25 °C. The material designated "mixture" was prepared by mixing equimolar amounts of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ and homogenizing them by grinding in a mortar.

Estimated Error:

No information is given.

References:

[1]L. N. Erayzer, I. M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Potassium chloride; KCl; [7747-40-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

A. V. Slack, J. D. Hatfield, H. B. Shaffer, J. C. Driskell, J. Agr. Food Chem. **7**, 404-8 (1959).

Variables:

Temperature and composition

Prepared By:

J. Eysseltová

Experimental Data

Solubility isotherms at 0 °C are given only graphically as contours of constant plant nutrient content in the saturated solutions with the nutrient ratios as the variables. Numerically, the data are expressed by Eq. (1)

$$y = a + bt \quad (1)$$

where y is the percent total plant nutrient ($\%N + \%P_2O_5 + \%K_2O$) in the saturated solution at temperature t(°C), and a and b are constants for each combination of nutrient ratio and ammoniation level. These constants are given in the table below.

Nutrient ratio[a]	mol ratio NH_3/H_3PO_4 1.5	1.6 constant a	1.7	1.5	1.6 constant b	1.7
1–3–0	34.6[b]	36.9[c]	34.1[e]	0.342	0.141	0.119
1–2–0	35.8[b]	34.7[c]	32.1[c]	0.244	0.123	0.119
1–1–0	32.7[d]	31.8[e]	29.1[c]	0.241	0.082	0.119
	34.6[f]			0.065		
2–1–0	26.2[g]	26.1[h]	26.1[i]	0.283	0.281	0.262
		30.3[kj]	28.6[k]		0.071	0.070
1–3–1	31.2[b]	34.9[c]	32.1[c]	0.233	0.133	0.115
1–2–1	28.2[b]	32.5[m]	31.3[c]	0.245	0.130	0.117
1–1–1[m]	25.9	27.6	27.9	0.156	0.155	0.131
2–1–2[m]	25.2	25.2	25.2	0.118	0.121	0.118
1–3–3[m]	24.7	24.8	24.5	0.138	0.135	0.139
1–2–3[m]	22.7	22.6	22.6	0.124	0.134	0.129
1–1–3[m]	20.0	19.9	20.0	0.121	0.125	0.121
2–1–6[m]	18.3	18.5	18.5	0.121	0.117	0.117

[a]The nutrient ratio is the weight ratio $N:P_2O_5:K_2O$. Symbol solid phase
[b]$NH_4H_2PO_4$
[c]$(NH_4)_2HPO_4$
[d]$CO(NH_2)_2$ ($t < 10.8$ °C)
[e]$(NH_4)_2HPO_4$ ($t > -1.5$ °C), urea crystallized below −1.5 °C
[f]$(NH_4)_2HPO_4$ ($t > 10.8$ °C)
[g]$CO(NH_2)_2$
[h]$CO(NH_2)_2$ ($t > 20.0$ °C)
[i]$CO(NH_2)_2$ ($t < 12.9$ °C)
[j]$(NH_4)_2HPO_4$ ($t > 20.0$ °C)
[k]$(NH_4)_2HPO_4$ ($t > 12.9$ °C)
[m]KCl

Auxiliary Information

Method / Apparatus / Procedure:

The solubility was determined by a polythermal method. The solutions were cooled until crystallization occurred and then warmed (2 °C per hour) with continuous stirring until the last crystals disappeared. The crystalline phases were identified petrographically.

Source and Purity of Materials:

All the salts used were reagent grade. The water was deionized.

Estimated Error:

The standard deviation of Eq. (1) from the measured values was 0.12% in plant nutrient.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(5) Potassium chloride; KCl; [7747-40-7]
(6) Water; H_2O; [7732-18-5]

Original Measurements:

A. V. Slack, J. D. Hatfield, H. B. Shaffer, J. C. Driskell, J. Agr. Food Chem. 7, 404-8 (1959).

Variables:

Composition at 271.5 K with the mol ratio $CO(NH_2)_2/NH_4NO_3$ = 1.065

Prepared By:

J. Eysseltová

Experimental Data

Solubility (expressed as $N+P_2O_5+K_2O$) in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$CO(NH_2)_2$–NH_4NO_3–KCl–H_2O system at 271.5 K with the mol ratio $CO(NH_2)_2/NH_4NO_3$ = 1.065

Nutrient ratio[a]	mol ratio NH_3/H_3PO_4 1.5	1.6	1.7
1 3 0	33.7[b]	32.9[c]	33.9[c]
1 2 0	31.3[b]	30.5[c]	30.5[c]
1 1 0	28.0[b]	27.5[c]	36.9[c]
2 1 0	26.9[b]	25.7[c]	23.7[c]
1 3 1	32.1[b]	34.1[c]	31.9[c]
1 2 1[d]	29.1	29.5	30.1
1 1 1[d]	20.5	20.7	21.3
2 1 2[d]	16.7	16.5	16.5
1 3 3[e]	24.5	24.6	24.3
1 2 3[e]	22.7	22.3	22.3
1 1 3[e]	19.9	19.7	19.9
2 1 6[e]	18.1	18.3	18.3

[a]The nutrient ratio is the weight ratio $N:P_2O_5:K_2O$.
Below are listed the solid phases in equilibrium with the above solutions.

Symbol	solid phase
b	$NH_4H_2PO_4$
c	$(NH_4)_2HPO_4$
d	KNO_3
e	KCl

Auxiliary Information

Method / Apparatus / Procedure:

A series of solutions of each ratio, differing by small increments of water content, were cooled to −1.5 °C, and each solution (about 50 ml) was seeded with about 50 mg of crystals. The mixtures were agitated mildly for about 3 days. The disappearance or growth of crystals in the samples in this period permitted determination of the solubility.

Source and Purity of Materials:

All the salts used were reagent grade. The water was deionized.

Estimated Error:

The temperature was kept constant to within −1.5 ± 0.7 °C. The solubility was determined within 0.1 to 0.2% of the plant nutrient.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Urea; CH_4N_2O; [57-13-6]
(4) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

I. M. Kaganskiy, A. M. Babenko, Izv. Obl. Neorg. Tekhnol. 69-73 (1972).

Variables:

Composition at 0 and −10 °C and the $NH_3:H_3PO_4$ ratio = 1.4, 1.5 and 1.6.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Part 1. The authors present their data as follows:

Composition of saturated solutions in the $(NH_4)_nH_{3-n}PO_4$–$CO(NH_2)_2$–NH_4NO_3–H_2O system

		$100w_i$ N + $100w_i$ P_2O_5					
		$CO(NH_2)_2$: NH_4NO_3 mass ratios					
A[a]	B[b]	0:100	20:80	40:60	60:40	80:20	100:0
		temp = 0 °C					
	0.75	20.2	20.6	22.4	24.2	26.4	29.0
1.4	1.00	18.6	19.6	21.8	23.4	26.2	31.6
	1.25	18.6	19.0	20.7	23.5	26.1	29.3
	0.75	24.1	25.7	27.4	28.6	31.6	35.5
1.5	1.00	22.2	22.9	25.1	28.1	30.5	32.0
	1.25	21.2	23.3	24.7	27.0	30.0	29.3
	0.75	28.3	28.3	29.1	29.0	29.0	30.3
1.6	1.00	27.1	27.3	27.3	28.0	28.4	32.0
	1.25	26.1	26.7	26.0	25.7	27.7	29.4
		temp = −10 °C					
	0.75	no[c]	no[c]	no[c]	22.4	23.5	25.8
1.4	1.00	no[c]	no[c]	19.2	21.0	23.2	28.4
	1.25	16.6	16.8	18.6	21.0	23.3	26.0
	0.75	21.1	23.5	24.5	26.0	28.1	33.0
1.5	1.00	19.8	20.4	22.5	25.3	27.7	28.8
	1.25	18.9	20.8	22.2	24.1	—	26.0
	0.75	24.1	23.7	24.4	24.4	24.3	25.4
1.6	1.00	22.4	22.4	22.6	23.4	23.6	28.7
	1.25	22.9	—	22.4	21.9	23.6	25.7

[a]A is the mol ratio of $NH_3:H_3PO_4$.
[b]B is the mass ratio of $N:P_2O_5$.
[c]These systems solidified completely at −10 °C.

Part 2. The compilers have calculated the following values from the data in Part 1

$NH_4H_2PO_4$		$(NH_4)_2HPO_4$		NH_4NO_3		$CO(NH_2)_2$		H_2O
$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
				temp = 0 °C				
11.2	1.80	8.59	1.20	26.1	6.02	0	0	54.1
11.4	1.82	8.76	1.22	21.3	4.87	3.99	1.22	54.5
12.4	2.08	9.53	1.39	17.3	4.16	8.67	2.78	52.0
13.4	2.35	10.3	1.57	12.5	3.14	14.1	4.71	49.7
14.7	2.72	11.2	1.82	6.81	1.82	20.4	7.26	46.8
16.1	3.22	12.3	2.15	0	0	28.1	10.7	43.5
9.04	1.39	6.92	0.930	27.6	6.13	0	0	56.4
9.53	1.49	7.30	0.996	23.3	5.25	4.37	1.31	55.5
10.6	1.77	8.12	1.18	19.4	4.66	9.72	3.11	52.1
11.4	1.96	8.71	1.31	13.9	3.45	15.7	5.18	50.3
12.7	2.30	9.25	1.59	7.79	2.10	23.1	8.39	46.4
15.4	3.55	11.8	2.37	0	0	35.2	15.6	37.6
8.04	1.26	6.15	0.843	30.5	6.88	0	0	55.3
8.21	1.28	6.29	0.852	24.9	5.57	4.67	1.39	55.9
8.95	1.45	6.85	0.967	20.4	4.74	10.2	3.16	53.7
10.2	1.79	7.78	1.19	15.4	3.90	17.3	5.85	49.3
11.3	2.14	8.64	1.43	8.56	2.33	25.7	9.32	45.6
12.7	2.64	9.70	1.76	0	0	36.0	14.4	41.6
11.2	2.28	12.8	2.28	33.4	9.80	0	0	42.6
11.9	2.55	13.7	2.55	28.5	8.80	5.35	2.19	40.6
12.7	2.86	14.6	2.86	22.8	7.39	11.4	4.93	38.5
13.2	3.04	15.2	3.04	15.9	5.24	17.9	7.86	37.8
14.6	3.80	16.8	3.80	8.77	3.27	26.3	13.1	33.5
16.4	5.15	18.9	5.15	0	0	36.9	22.1	27.8
9.00	1.71	10.3	1.71	34.9	9.52	0	0	45.8
10.2	2.07	11.7	2.07	23.7	6.93	11.8	4.62	42.7
11.4	2.60	13.1	2.60	17.7	5.80	19.9	8.70	38.0
12.4	3.06	14.2	3.06	9.58	3.41	28.8	13.6	35.1
13.0	3.27	14.9	3.27	0	0	37.7	18.2	34.4
7.64	1.40	8.77	1.40	36.3	9.61	0	0	47.3
8.39	1.66	9.63	1.66	32.0	9.07	5.99	2.27	44.0
8.90	1.81	10.2	1.81	25.4	7.42	12.7	4.94	42.8
10.8	2.64	12.4	2.64	10.3	3.60	30.9	14.4	35.6
10.6	2.31	12.1	2.31	0	0	7.67	15.8	39.7
10.5	3.09	18.1	4.64	42.0	17.8	0	0	29.5
10.5	2.89	18.1	4.33	33.6	13.3	6.30	3.32	31.6
10.8	2.95	18.6	4.42	25.9	10.2	13.0	6.78	31.8
10.7	2.73	18.5	4.10	17.2	6.29	19.4	9.43	34.2
10.7	2.57	18.5	3.86	8.60	2.96	25.8	11.8	36.3
11.2	2.73	19.3	4.10	0	0	33.7	15.7	35.7
8.79	2.45	15.1	3.67	44.9	18.0	0	0	31.2
8.85	2.33	15.2	3.50	36.2	13.7	6.78	3.42	33.0
8.85	2.18	15.2	3.28	27.1	9.61	13.6	6.41	35.2
9.08	2.20	15.6	3.30	18.5	6.45	20.9	9.68	35.9
9.21	2.14	15.8	3.22	9.40	3.15	28.2	12.6	37.3
10.4	2.82	17.9	4.22	0	0	39.7	20.7	32.0
7.52	1.99	13.0	2.99	46.7	17.8	0	0	32.8
7.69	1.99	13.2	2.98	38.2	14.2	7.17	3.54	33.7
7.49	1.73	12.9	2.59	27.9	9.24	14.0	6.16	37.7
7.41	1.58	12.8	2.37	18.4	5.64	20.7	8.46	40.8
7.98	1.80	13.7	2.70	9.91	3.21	29.7	12.8	38.6
8.47	1.96	14.6	2.95	0	0	39.5	17.5	37.5

Part 2. The compilers have calculated the following values from the data in Part 1

$NH_4H_2PO_4$		$(NH_4)_2HPO_4$		NH_4NO_3		$CO(NH_2)_2$		H_2O
$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
				temp = -10 °C				
12.4	2.02	9.53	1.35	11.6	2.70	13.0	4.05	53.5
13.1	2.15	10.0	1.44	6.06	1.44	18.2	5.75	52.7
14.3	2.51	11.0	1.67	0	0	25.0	8.36	49.7
9.33	1.40	7.15	5.94	17.1	3.70	8.56	2.47	57.8
10.2	1.60	7.82	1.07	12.5	2.81	14.1	4.22	55.4
11.3	1.87	8.64	1.25	6.90	1.64	20.7	6.56	52.5
13.1	2.73	10.6	1.82	0	0	31.7	12.0	44.0
7.17	1.04	5.4	0.692	27.2	5.65	0	0	60.1
7.26	1.03	5.5	0.690	22.0	4.51	4.13	1.13	61.0
8.04	1.20	6.15	0.799	18.3	3.91	9.15	2.61	58.4
9.07	1.44	6.95	0.962	13.8	3.14	15.5	4.71	54.7
10.1	1.69	7.71	1.13	7.64	1.85	22.9	7.38	51.7
11.2	2.03	8.60	1.35	0	0	32.0	11.04	48.2
9.77	1.71	11.2	1.71	29.3	7.35	0	0	49.7
10.9	2.07	12.5	2.07	26.1	7.13	4.89	1.78	45.7
11.3	2.19	13.0	2.19	20.4	5.65	10.2	3.77	45.0
12.0	2.41	13.8	2.41	14.4	4.14	16.2	6.20	43.5
13.0	2.77	14.9	2.77	7.79	2.38	23.4	9.53	40.9
16.3	4.04	17.5	4.04	0	0	34.3	17.4	32.8
8.02	1.35	9.21	1.35	31.1	7.52	0	0	51.7
8.27	1.39	9.49	1.39	25.6	6.18	4.81	1.55	51.8
9.12	1.63	10.5	1.63	21.2	5.45	10.6	3.63	48.6
10.3	2.02	11.8	2.02	15.9	4.49	17.9	6.74	44.2
11.2	2.38	12.9	2.38	8.70	2.65	26.1	10.6	41.1
11.7	2.47	13.4	2.47	0	0	33.9	13.8	41.0
6.81	1.12	7.82	1.12	32.4	7.64	0	0	53.0
7.49	1.30	8.60	1.30	28.5	7.12	5.35	1.80	50.0
8.00	1.43	9.18	1.43	22.8	5.87	11.4	3.91	48.6
8.68	1.63	9.97	1.63	16.5	4.46	18.6	6.69	46.2
9.36	1.75	10.8	1.75	0	0	33.4	12.0	46.5
8.93	1.94	15.4	2.92	35.8	11.2	0	0	39.9
8.78	1.79	15.1	2.68	28.1	8.23	5.27	2.06	42.7
9.04	1.84	15.6	2.75	21.7	6.34	10.9	4.22	42.8
9.04	1.76	15.6	2.64	14.5	4.05	16.3	6.08	44.6
9.00	1.68	15.5	2.52	7.21	1.93	21.6	7.72	46.7
9.41	1.77	16.2	2.66	0	0	28.3	10.2	46.1
7.26	1.46	12.5	2.19	37.1	10.7	0	0	43.1
7.26	1.40	12.5	2.10	29.7	8.24	5.56	2.06	45.0
7.33	1.37	12.6	2.06	22.4	6.05	11.2	4.03	46.4
7.59	1.42	13.1	2.13	15.5	4.17	17.4	6.25	46.4
7.65	1.39	13.2	2.08	7.81	2.04	23.4	8.15	47.9
9.30	2.07	16.0	3.11	0	0	35.6	15.2	39.0
6.60	1.40	11.4	2.10	41.0	12.5	0	0	41.1
6.46	1.21	11.1	1.82	24.0	6.48	12.0	4.32	46.4
6.31	1.11	10.9	1.66	15.7	3.96	17.6	5.93	49.5
6.80	1.24	11.7	1.86	8.45	2.21	25.3	8.84	47.7
7.41	1.42	12.7	2.13	0	0	34.5	12.7	45.3

Auxiliary Information

Method / Apparatus / Procedure:

An improved polythermic method was used.[1]

Source and Purity of Materials.

All materials were of chemically pure grade.

Estimated Error:

No information is given.

References:

[1] L. N. Erayzer, I. M. Kaganskiy, Zavod. Lab. 1, 119 (1967).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Triethylamine hydrochloride; $C_6H_{16}ClN$; [554-68-7]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

S. A. Mazunin, O. E. Sosnina, A. A. Volkov, T. L. Danina, Termicheskiy Analiz i Fazovye Rovnovesiya, Perm 79-88 (1985).

Variables:

Composition at 20 and 60 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–$(C_2H_5)_3N.HCl$–H_2O system

$NH_4H_2PO_4$		$(NH_4)_2HPO_4$		$(C_2H_5)_3N.HCl$		H_2O	Solid
$100w_1$	m_1/mol kg^{-1} [a]	$100w_2$	m_2/mol kg^{-1} [a]	$100w_3$	m_3/mol kg^{-1} [a]	$100w_4$	phase[b]
			temp = 20 °C				
1.2	0.24	0.2	0.04	56.0	9.90	42.6	A+B+C
3.1	0.55	1.0	0.15	46.5	7.09	49.4	A+B
5.7	0.90	3.0	0.41	36.3	4.97	55.0	A+B
16.4	2.59	11.9	1.64	16.7	2.29	55.0	A[c]
9.8	1.48	6.4	0.84	26.3	3.45	57.5	A[c]
22.9	4.08	21.7	3.37	6.6	1.0	48.8	
7.0	1.1	4.0	0.53	32.2	4.27	56.8	A[c]
23.7	4.52	26.4	4.38	4.3	0.71	45.6	
5.8	0.91	3.3	0.45	35.3	4.78	55.6	A+B[c]
24.4	4.94	29.2	5.15	3.5	0.61	42.9	
6.0	0.93	3.7	0.50	34.1	4.57	56.2	B[c]
22.9	4.52	29.4	5.06	3.7	0.63	44.0	
5.8	0.84	5.8	0.74	28.7	3.62	59.7	B[c]
19.2	3.52	28.8	4.60	4.6	0.73	47.4	
5.8	0.84	6.3	0.80	28.0	3.52	59.9	B[c]
17.1	3.02	28.7	4.41	4.9	0.75	49.3	
7.0	1.0	12.4	1.54	19.8	2.45	60.8	B[c]
12.3	1.96	25.1	3.49	8.1	1.1	54.5	
9.2	1.37	21.0	2.73	11.5	1.49	58.3	B
			temp = 60 °C				
4.0	1.0	0.3	0.06	60.6	13.0	35.1	A+B+C
24.0	4.28	9.1	1.4	18.1	2.79	48.8	B
16.9	2.93	4.3	0.65	28.7	4.32	50.1	A[c]
28.6	5.55	12.3	2.08	14.3	2.40	44.8	
12.8	2.23	3.5	0.53	33.7	5.08	50.0	A[c]
31.0	7.51	20.7	4.00	6.1	1.17	39.2	
9.8	1.8	2.2	0.34	39.5	6.14	48.5	A[c]
35.4	8.72	25.0	5.36	4.3	0.92	35.3	
8.1	1.5	1.6	0.26	44.5	7.32	45.8	A[c]
34.9	9.14	28.5	6.50	3.4	0.77	33.2	
6.6	1.35	1.1	0.20	49.9	8.87	42.4	A+B[c]
34.0	9.85	33.4	8.43	2.6	0.65	30.0	
5.7	1.03	2.4	0.38	43.9	6.89	48.0	B[c]
26.0	6.86	35.3	7.81	3.7	0.82	34.1	
4.7	0.77	4.1	0.58	37.9	5.36	53.3	B[c]
19.6	4.22	36.6	6.86	3.4	0.63	40.4	
4.0	0.62	5.4	0.73	34.9	4.72	55.7	B[c]
15.7	3.27	38.6	7.01	4.0	0.72	41.7	
2.4	0.35	8.8	1.1	29.4	3.73	59.4	B[c]
7.1	1.3	37.8	5.83	6.0	0.92	49.1	
...	—	19.0	2.37	20.4	2.54	60.6	B[c]
	—	35.8	5.01	10.1	1.41	54.1	

[a] The molalities were calculated by the compilers.
[b] The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4)_2HPO_4$; C = $(C_2H_5)_3N\cdot HCl$.
[c] Two layers of immiscible solutions were formed at these experimental points. The upper and lower lines refer to the upper and lower solution layer, respectively.

Auxiliary Information

Method / Apparatus / Procedure:

The refractometric variation of the isothermal method was used. The compilers assume that it was the method described elsewhere.[1] $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ were determined by potentiometric titration. The composition of the solid phase was determined by the Schreinemaker's method.

Source and Purity of Materials:

No information is given, but the compilers assume that the materials were the same as those used in (2).

Estimated Error:

The $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ contents have a precision of ±0.2 and ±0.6%, respectively.

References:

[1] E. F. Zhuravlev, A. D. Sheveleva, Zh. Neorg. Khim. **5**, 2630 (1960).
[2] O. E. Sosnina, A. A. Volkov, Uch. Zap. Perm. Gos. Univ., Ser. Khim. **289**, 20 (1973).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

L. S. Skum, S. D. Fridman, Khim. Prom. (Moscow) **47**, 588-9 (1971).

Variables:

Composition at 140–170 °C and a N/P_2O_5 ratio = 1.

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–NH_4NO_3–H_2O system with the ratio N/P_2O_5 = 1

NH_4NO_3 100w_i	NH_4NO_3 m_i/mol kg^{-1} [a]	$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1} [a]	$(NH_4)_2HPO_4$ 100w_i	$(NH_4)_2HPO_4$ m_i/mol kg^{-1} [a]	H_2O 100w_i	Solid phase
			temp = 140 °C				
46.9	30.5	33.9	15.3	-	-	19.20	$NH_4H_2PO_4$
47.6	33.0	30.5	14.7	3.90	1.64	18.00	$NH_4H_2PO_4$
52.2	65.2	26.3	22.9	11.5	8.71	10.00	$NH_4H_2PO_4$
55.1	137.7	24.7	42.9	15.2	23.0	5.00	$NH_4H_2PO_4$
56.3	234.4	24.6	71.3	16.1	40.6	3.00	$NH_4H_2PO_4$
			temp = 150 °C				
46.9	34.1	35.9	18.1	----	-	17.20	$NH_4H_2PO_4$
52.2	65.2	28.7	24.9	9.10	6.89	10.00	$NH_4H_2PO_4$
55.1	137.7	27.7	48.2	12.2	18.5	5.00	$NH_4H_2PO_4$
56.3	234.4	27.5	79.7	13.2	33.3	3.00	$NH_4H_2PO_4$
			temp = 160 °C				
52.3	66.7	37.9	33.6	--	--	9.80	$NH_4H_2PO_4$
52.2	65.2	32.7	28.4	5.10	3.67	10.00	$NH_4H_2PO_4$
55.1	137.7	31.2	54.2	8.70	12.5	5.00	$NH_4H_2PO_4$
56.3	234.5	30.7	89.0	10.0	24.0	3.00	$NH_4H_2PO_4$
			temp = 170 °C				
55.0	134.7	39.9	68.0	--	----	5.10	$NH_4H_2PO_4$
55.1	137.7	37.1	64.5	2.80	4.24	5.00	$NH_4H_2PO_4$
56.3	234.4	35.4	102.6	5.30	13.4	3.00	$NH_4H_2PO_4$

[a] The molalities were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.[1,2]

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

References:

[1] A. G. Bergman and N. P. Luzhnaya, Fiziko-khimicheskiye Osnovy Izucheniya i Ispol'zovaiya Solyanykh Mestorozhdeniy Khlorid-sul'fatnogo Tipa, Moscow, IAN SSSR (1951).
[2] S. D. Fridman, N. N. Polyakov, L. S. Skum, and R. Ya. Kirindasova, Khim. Prom. (Moscow) **46**, 191 (1970).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(4) Potassium sulfate; K_2SO_4; [7778-80-5]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

A. M. Babenko, A. M. Andrianov, Zh. Prikl. Khim. (Leningrad) **57**, 1921-5 (1984).

Variables:

Temperature and concentration of NH_4NO_3 and K_2SO_4 in a mixture containing a mol ratio of $NH_4H_2PO_4/(NH_4)_2HPO_4$ = 1.

Prepared By:

J. Eysseltová

Experimental Data

Part. 1. Points of simultaneous crystallization of two or three solid phases in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–NH_4NO_3–K_2SO_4–H_2O system

t/°C	Mixture[a] W[b]	Mixture[a] M[b]	$NH_4H_2PO_4$ W[b]	$(NH_4)_2HPO_4$ W[b]	NH_4NO_3 W[b]	NH_4NO_3 M[b]	K_2SO_4 W[b]	K_2SO_4 M[b]	H_2O W[b]	Solid phase[c]
−7.5	8.5	0.5	4.0	4.5	9.9	1.7	8.0	0.6	73.6	A+B
−11.0	13.2	0.8	6.1	7.1	15.2	2.9	5.0	0.4	66.6	A+B
−6.0	17.7	1.3	8.2	9.5	20.3	4.4	5.0	0.5	57.0	B+C
14.0	19.2	1.5	8.9	10.3	22.1	5.4	8.0	0.9	50.7	B+C
26.5	20.7	1.9	9.6	11.1	23.8	6.7	11.0	1.4	44.5	B+C
−11.8	16.7	1.1	7.8	8.9	19.3	3.8	0.0	0.0	64.0	A+B+C
9.0	8.0	0.5	3.7	4.3	9.3	1.7	13.0	1.1	69.7	B+D
14.5	12.2	0.8	5.7	6.5	14.0	2.9	12.6	1.2	61.2	B+D
20.0	16.3	1.3	7.6	8.7	18.7	4.4	12.5	1.4	52.5	B+D
25.0	18.4	1.6	8.6	9.8	21.2	5.5	12.5	1.5	47.9	B+D
29.0	20.4	1.9	9.5	10.9	23.6	6.7	12.0	1.6	44.0	B+C+D
−1.6	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.4	93.5	A+D

[a] "Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b] W = 100w_i, M = m_i/mol kg^{-1}. Mass fractions of the ammonium phosphates and all molalities were calculated by the compiler.
[c] The solid phases are: A = ice; B = NH_4NO_3; C = $NH_4H_2PO_4$; D = K_2SO_4.

Part 2 Solubility isotherms in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–NH_4NO_3–K_2SO_4–H_2O system

S[a]	Mixture[b]		$NH_4H_2PO_4$	$(NH_4)_2HPO_4$	NH_4NO_3		K_2SO_4		H_2O
W[c]	W[c]	M[c]	W[c]	W[c]	W[c]	M[c]	W[c]	M[c]	M[c]
				temp = −5 °C					
19.0	8.5	0.5	4.0	4.5	9.8	1.7	8.6	0.7	73.1
21.5	13.1	0.8	6.1	7.0	15.1	2.9	6.0	0.5	65.8
20.4	17.9	1.2	8.3	9.6	20.6	4.2	0.0	0.0	61.5
25.8	17.6	1.3	8.2	9.4	20.3	4.5	5.2	0.5	56.9
				temp = 0 °C					
20.4	8.4	0.5	3.9	4.5	9.6	1.7	10.0	0.8	72.0
21.2	18.6	1.3	8.7	9.9	21.4	4.5	0.0	0.0	60.0
22.6	12.9	0.8	6.0	6.9	14.9	2.9	7.3	0.6	64.9
26.5	17.4	1.2	8.1	9.3	20.2	4.5	6.0	0.6	56.4
				temp = −10 °C					
25.6	12.5	0.8	5.8	6.7	14.4	2.9	10.5	1.0	62.6
23.1	20.2	1.4	9.4	10.8	23.3	5.2	0.0	0.0	56.5
29.1	16.9	1.3	7.9	9.0	19.5	4.5	9.0	0.9	54.6

[a]S is the total plant nutrient: $(N + P_2O_5 + K_2O + S)$.
[b]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[c]$W = 100w_i$; $M = m_i$/mol kg^{-1}. Mass fraction of the ammonium phosphates and all molalities were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

An improved polythermic method[1] was used.

Source and Purity of Materials:

Chemically pure or reagent grade salts were recrystallized twice and dried at 40–50 °C. The material designated "mixture" was prepared by mixing equimolar amounts of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ and homogenizing by grinding in a mortar.

Estimated Error:

Precision of temperature measurement was ± 0.4 K.

References:

[1]Erayzer, L.N. Kaganskiy, I.M. Zavod. Lab. 1, 119 (1967).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(4) Potassium chloride; KCl; [7747-40-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

A. V. Slack, J. D. Hatfield, H. B. Shaffer, J. C. Driskell, J. Agr. Food Chem. 7, 404-8 (1959).

Variables:

Composition at −1.5 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility (expressed as %N + %P_2O_5 + %K_2O) in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–NH_4NO_3–KCl–H_2O system at 271.5 K

Nutrient ratio[a]	Mol ratio NH_3/H_3PO_4 1.5	1.6	1.7
1-3-0	31.9[c]	35.9[d]	33.9[d]
1-2-0	27.6[c]	30.5[d]	29.3[d]
1-1-0	24.1[c]	27.2[d]	23.5[d]
2-1-0	21.5[c]	24.9[d]	22.9[d]
1-3-1	30.5[c]	34.3[d]	31.9[d]
1-2-1[b]	23.1	23.7	24.5
1-1-1[b]	16.1	15.7	16.1
2-1-2[b]	12.7	12.7	12.7
1-3-3[e]	24.9	24.3	24.3
1-2-3[e]	22.1	23.3	22.9
1-1-3[b]	15.1	15.3	15.5
2-1-6[b]	12.5	13.1	12.9

[a]The nutrient ratio is the weight ratio N : P_2O_5: K_2O.
Below are listed the solid phases in equilibrium with the solutions above.

Symbol	solid phase
b	KNO_3
c	$NH_4H_2PO_4$
d	$(NH_4)_2HPO_4$
e	KCl

Auxiliary Information

Method / Apparatus / Procedure:

A series of solutions of each ratio, differing by small increments of water content, were cooled to −1.5 °C, and each solution (about 50 ml) was seeded with about 50 mg of crystals. The mixtures were agitated mildly for about 3 days. The disappearance or growth of crystals in the samples during this period permitted determination of the solubility.

Source and Purity of Materials:

All the salts used were reagent grade. The water was deionized.

Estimated Error:

The temperature was kept constant to within −1.5±0.7 °C. The solubility was determined within 0.1 to 0.2 of the plant nutrient.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Potassium nitrate; KNO_3; [7757-79-1]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

A. M. Babenko, A. M. Andrianov, Zh. Neorg. Khim. **29**, 2663-7 (1984).

Variables:

Temperature and concentration of KNO_3 in a mixture containing a mol ratio of $NH_4H_2PO_4/(NH_4)_2HPO_4$ = 1.

Prepared By:

J. Eysseltova

Experimental Data

Part. 1. Points of simultaneous crystallization of two or three solid phases in the $NH_4H_2PO_4-(NH_4)_2HPO_4-KNO_3-H_2O$ system

Mixture[a]	$NH_4H_2PO_4$		$(NH_4)_2HPO_4$		KNO_3		H_2O		Solid
$100w_i$	$100w_i$	m_i[b]	$100w_i$	m_i[b]	$100w_i$	m_i[b]	$100w_i$	$t/°C$	phase[c]
0	0	0	0	0	10.0	1.10	90.0	−2.9	A+B
9.0	4.2	0.4	4.8	0.4	10.0	1.22	81.0	−4.75	A+B
18.4	8.6	1.0	9.89	1.0	8.0	1.1	73.6	−6.75	A+B
27.9	13.0	1.73	14.9	1.73	7.0	1.1	65.1	−8.5	A+B
38.0	17.7	2.70	20.3	2.70	5.0	0.87	57.0	−12	A+B
40.5	18.9	3.31	21.6	3.31	10.0	2.00	49.5	14	B+C
43.0	20.0	4.05	23.0	4.05	14.0	3.22	43.0	34.5	B+C
36.0	16.8	2.40	19.2	2.40	3.2	0.52	60.8	−9.8	A+B+C
38.6	18.0	2.54	20.6	2.54	0	0	61.4	−8.6	A+C
61.0	28.4	6.33	32.6	6.33	0	0	39.0	39.0	C+D
62.5	29.1	7.44	33.4	7.44	3.5	1.02	34.0	43.5	C+D

[a]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b]The molalities were calculated by the compiler. The units are: mol kg^{-1}
[c]The solid phases are: A = ice; B = KNO_3; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$.

Part 2. Solubility isotherms in the $NH_4H_2PO_4-(NH_4)_2HPO_4-KNO_3-H_2O$ system

Mixture[a]	$NH_4H_2PO_4$		$(NH_4)_2HPO_4$		KNO_3		H_2O	Solid
$100w_i$	$100w_i$	m_i[b]	$100w_i$	m_i[b]	$100w_i$	m_i[b]	$100w_i$	phase[c]
				temp = −5 °C				
40.4	18.8	2.74	21.6	2.74	0	0	59.6	A
37.5	17.5	2.56	20.0	2.56	3.12	0.520	59.38	A
27.66	12.88	1.734	14.78	1.734	7.8	1.2	64.54	A
18.3	8.5	1.0	9.8	1.0	8.5	1.1	73.2	A
37.6	17.5	2.70	20.1	2.70	6.0	1.1	56.4	B
				temp = 0 °C				
42.8	19.9	3.03	22.9	3.03	0	0	57.2	C
39.0	18.2	2.72	20.8	2.72	3.05	0.521	57.95	C
27.3	12.7	1.73	14.6	1.73	9.0	1.4	63.7	B
18.0	8.4	1.0	9.6	1.0	10.0	1.38	72.0	B
8.82	4.11	0.450	4.71	0.450	11.8	1.47	79.38	B
7.0	3.3	0.51	3.7	0.51	37.2	6.60	55.8	B
				temp = 10 °C				
47.4	22.1	3.65	25.3	3.65	0	0	52.6	C
41.9	19.5	3.07	22.4	3.07	2.9	0.52	55.2	C
36.0	16.8	2.70	19.2	2.70	10.0	1.83	54.0	B
26.1	12.2	1.71	13.9	1.73	13.0	2.11	60.9	B
17.1	8.0	1.0	9.1	1.0	14.5	2.10	68.4	B

[a]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b]The molalities were calculated by the compiler. The units are: mol kg^{-1}.
[c]The solid phases are: A = ice; B = KNO_3; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

An improved visual polythermic method[1] was used.

Source and Purity of Materials:

Chemically pure or reagent grade salts were recrystallized twice and dried at 30–40 °C. The material designated "mixture" was prepared by mixing equimolar amounts of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ and homogenizing by grinding in a mortar.

Estimated Error:

Precision of temperature measurement was ± 0.4 K.

References:

[1]L. N. Erayzer, I. M. Kaganskiy, I.M. Zavod. Lab. **1**, 119 (1967).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Sodium dihydrogenphosphate; NaH_2PO_4; [7558-80-7]
(4) Water, H_2O; [7732-18-5]

Original Measurements:

A. M. Babenko, T.A. Vorob'eva, Zh. Prikl. Khim.(Leningrad) **49**, 1502-6 (1976).

Variables:

Temperature and concentration of NaH_2PO_4 in a mixture containing a mol ratio of $NH_4H_2PO_4/(NH_4)_2HPO_4$ = 1.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Points of simultaneous crystallization of two or three solid phases in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–NaH_2PO_4–H_2O system

Mixture[a]		$NH_4H_2PO_4$	$(NH_4)_2HPO_4$	NaH_2PO_4			Solid
$100w_i$	m_i[c]	$100w_i$[b]	$100w_i$[b]	$100w_i$	m_i[c]	t/°C	phase[d]
38.6	2.54	17.97	20.63	0.00	0.00	−8.6	A+C
32.0	2.11	14.90	17.10	6.8	0.92	−8.4	A+C
20.4	1.29	9.50	10.90	15.92	2.08	−8.4	A+C
9.8	0.63	4.56	5.24	27.06	3.57	−9.4	A+C
21.25	1.35	9.89	11.36	15.0	1.96	−8.0	A+C
16.0	1.01	7.45	8.55	20.0	2.60	−9.0	A+C
6.8	0.45	3.16	3.63	32.0	4.36	−11.0	A+C
6.0	0.43	2.79	3.21	37.6	5.55	+0.5	A+B+C
0.0	0.0	0.0	0.0	33.5	4.20	−8.8	A+B
2.4	0.17	1.12	1.28	40.0	5.79	−12.0	A+B
8.0	0.61	3.72	4.28	41.4	6.82	19.2	B+C
8.0	0.70	3.72	4.28	46.0	8.33	25.2	B+C
9.8	0.96	4.56	5.24	48.708	9.78	35.0	B+C+D
61.0	6.33	28.40	32.60	0.0	0.0	39.0	C+D
56.0	5.72	26.07	29.93	4.4	0.92	45.6	C+D
48.0	4.67	22.34	25.65	10.4	2.08	48.3	C+D
36.0	3.25	16.76	19.24	19.2	3.57	44.6	C+D
28.0	2.62	13.04	14.96	28.8	5.55	50.3	C+D
24.0	2.27	11.17	12.83	33.2	6.46	56.0	C+D
20.0	2.02	9.31	10.69	40.0	8.33	55.0	C+D
20.0	2.20	9.31	10.69	43.2	9.78	67.0	C+D
0.0	0.0	0.0	0.0	56.0	10.60	40.2	B+E
1.8	0.17	0.84	0.96	55.0	10.61	43.5	B+E
4.75	0.45	2.21	2.54	52.5	10.23	46.0	B+E
8.0	0.82	3.72	4.28	52.44	11.04	42.0	D+E
8.0	0.88	3.72	4.28	55.2	12.50	50.5	D+E
8.9	1.01	4.14	4.76	55.5	12.99	49	D+E+F
0.0	0.0	0.0	0.0	60.8	12.92	57.2	E+F
1.6	0.17	0.74	0.86	60.0	13.02	59.8	E+F
4.2	0.45	1.96	2.24	58.0	12.78	63.5	E+F
11.25	1.35	5.24	6.01	55.0	13.58	68.4	E+F

Part 2. Solubility isotherms in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–NaH_2PO_4–H_2O system

Mixture[a]		$NH_4H_2PO_4$	$(NH_4)_2HPO_4$	NaH_2PO_4		H_2O	$(N+P_2O_5)$
$100w_i$	m_i[c]	$100w_i$[b]	$100w_i$[b]	$100w_i$	m_i[c]	$100w_i$	$100w_i$
			temp = −5 °C				
0.0	0.0	0.0	0.0	35.4	4.56	64.6	21.0
6.7	0.45	3.12	3.58	33.0	4.56	60.3	24.5
12.0	0.79	5.59	6.41	26.4	3.57	61.6	24.5
2.392	0.17	1.11	1.28	40.2	5.83	57.408	25.5
22.0	1.43	10.24	11.76	15.6	2.08	62.4	25.6
33.4	2.25	15.55	17.85	6.66	0.92	59.94	28.78
40.2	2.72	18.71	21.48	0.0	0.0	59.8	29.9
			temp = 0 °C				
0.0	0.0	0.0	0.0	37.6	5.02	62.4	22.1
14.0	0.94	6.51	7.48	25.8	3.57	60.2	25.5
6.58	0.45	3.06	3.52	34.2	4.81	59.22	26.2
2.38	0.17	1.11	1.27	41.87	6.26	55.87	26.4
24.4	1.63	11.36	13.04	15.12	2.08	60.48	27.1
33.6	2.28	15.64	17.96	6.64	0.92	59.76	28.98
42.6	3.00	19.83	22.77	0.0	0.0	57.4	31.6
			temp = 10 °C				
0.0	0.0	0.0	0.0	42.2	6.08	57.8	25.0
6.38	0.45	2.97	3.41	36.2	5.25	57.42	26.24
19.0	1.36	8.85	10.15	24.3	3.57	56.7	28.63
29.0	2.06	13.50	15.50	14.18	2.08	56.72	29.9
2.28	0.17	1.06	1.22	44.8	7.05	52.992	28.29
40.0	3.00	18.62	21.38	6.0	0.92	54.0	33.36
47.0	3.59	21.88	25.12	0.0	0.0	53.0	35.0

[a] "Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b] These values were calculated by the compiler.
[c] The molalities were calculated by the compiler. The units are: mol kg^{-1}.
[d] The solid phases are: A = ice; B = $NaH_2PO_4\cdot 2H_2O$; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$; E = $NaH_2PO_4\cdot H_2O$; F = NaH_2PO_4.

Auxiliary Information

Method / Apparatus / Procedure:

An improved polythermic method[1] was used.

Source and Purity of Materials:

Reagent grade salts were recrystallized and dried. The ammonium salts were dried at 40–50 °C. The sodium salt was dried at 105 °C. The material designated "mixture" was prepared by mixing equimolar amounts of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ and homogenizing them by grinding in a mortar.

Estimated Error:

No information is given.

References:

[1] L. N. Erayzer, I. M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Potassium sulfate; K_2SO_4; [7778-80-5]
(4) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic
September 1995

Critical Evaluation:

6.2. Solubility in the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–K_2SO_4–H_2O System

There are two reports[1,2] that give data for the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–K_2SO_4–H_2O system. One article[2] reports the composition of solutions that are saturated simultaneously with two or three solid phases, and have the molar ratio of N/P = 1.5. The temperature range of 262–318 K is covered. Isotherms at 268, 273 and 283 K are also given. The other article[1] reports the contents of N, P_2O_5 and K_2O in solutions saturated at 273 K by unspecified solid phase(s). The evaluator has found that the molar ratio of N/P in these solutions is very close to 1.3. Therefore, no direct comparison of the data in these two articles can be made. Furthermore, in each of these articles there are statements that raise questions. In the work of Tishchenko and Kuznetsova[1] the time allowed for equilibration was rather short and the attainment of equilibrium was not established experimentally. Babenko and Andrianov[2] reported the simultaneous crystallization of ammonium phosphates and potassium sulfate. This is surprising in view of the well-known ability of ammonium and potassium phosphates to form so-called β-solid solutions.[3–9] Further doubt about the composition of the solid phase is cast by the work of Fokina[10] who observed these solid solutions formed between ammonium and potassium dihydrogenphosphates in her study of the $NH_4H_2PO_4$–H_3PO_4–K_2SO_4–H_2O system.

Thus, more experimental work needs to be reported for the $NH_4H_2PO_4$–$(NH_4)_2HPO_4$–K_2SO_4–H_2O system before solubility data for this system can be considered as recommended values.

References:

[1] I. N. Tishchenko, A. G. Kuznetsova, VINITI 2594 (1981), 12 p.
[2] A. M. Babenko, A. M. Andrianov, Zh. Neorg. Khim. **29**, 2663 (1984).
[3] P. Askenasy, F. Nessler, Z. Anorg. Chem. **189**, 305 (1930).
[4] N. S. Dombrovskaya, A. Y. Zvorykin, Kaliy **2**, 24 (1937).
[5] A. Y. Zvorykin, V. G. Kuznetsov, Izv. AN SSSR, Ser. Khim. 195 (1938).
[6] D. I. Kuznetsov, A. A. Kozhukhovskiy, F. E. Borovaya, Zh. Prikl. Khim. (Leningrad) **21**, 1278 (1948).
[7] A. G. Bergman, A. A. Gladkovskaya, R. A. Galushkina, Zh. Neorg. Khim. **17**, 3368 (1972).
[8] Ya. S. Shenkin, S. A. Ruchnova, N. A. Radionova, Zh. Neorg. Khim. **17**, 3368 (1972).
[9] A. P. Solov'ev, E. F. Balashova, N. A. Verendyakina, L. F. Zyuzina, Vzaimodeistvie Khloridov Kaliya, Magniya Ammoniya s ikh Nitratami i Fosfatami 3 (1977).
[10] Z. N. Fokina, E. N. Kornishina, P. P. Kim, Tekhnologiya Mineral'nykh Udobreniy (Leningrad) 63 (1977).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Potassium sulfate; K_2SO_4; [7778-80-5]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

I. N. Tishchenko, A. G. Kuznetsova, VINITI-2594, 12 p. (1981).

Variables:

Composition at 0 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the $(NH_4)_2HPO_4$–$NH_4H_2PO_4$–K_2SO_4–H_2O system at 0 °C

Soln no	Original mixture N $100w_i$	Original mixture P_2O_5 $100w_i$	Original mixture K_2O $100w_i$	Equilibrium liquid phase N $100w_i$	Equilibrium liquid phase P_2O_5 $100w_i$	Equilibrium liquid phase K_2O $100w_i$
1	6.31	21.40	9.00	6.75	21.96	3.81
2	6.98	23.07	9.00	7.66	23.35	3.62
3	6.65	20.72	9.00	7.02	21.92	3.83
4	6.52	22.04	9.00	6.99	23.78	4.19
5	6.81	22.98	9.00	7.53	24.95	3.51
6	7.35	24.92	9.00	7.98	26.00	4.01
7	8.50	28.75	9.00	8.52	26.57	3.88
8	9.87	33.58	9.00	8.28	27.77	3.60
9	8.42	27.61	9.00	8.03	25.88	3.60
10	9.73	31.88	9.00	8.35	26.78	3.01
11	7.39	23.10	9.00	8.05	25.44	3.23
12	8.53	27.32	9.00	8.25	27.48	3.58
13	9.95	31.03	9.00	8.32	27.40	3.70
14	10.80	32.99	9.00	8.26	26.97	3.52

Auxiliary Information

Method / Apparatus / Procedure:

K_2SO_4 was added to 50 g of a soln saturated with ammonium phosphates or a suspension of proper overall composition. The equilibrium vessels were thermostated in an ice-water bath for 4 hrs. The equilibrium liquid phase was analyzed for NH_4^+, PO_4^{3-} and K^+.[1]

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

References:

[1] M. M. Vinnik, L. N. Erbanova, et al. Metody Analiza Fosfatnogo Syrya, Moscow (1975).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Potassium sulfate; K_2SO_4; [7778-80-5]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

A. M. Babenko, A. M. Andrianov, Zh. Neorg. Khim. **29**, 2663-7 (1984).

Variables:

Temperature and concentration of K_2SO_4 in a mixture containing a mol ratio of $NH_4H_2PO_4/(NH_4)_2HPO_4 = 1$.

Prepared By:

J. Eysseltová

Experimental Data

Part. 1. Points of simultaneous crystallization of two or three solid phases in the $NH_4H_2PO_4-(NH_4)_2HPO_4-K_2SO_4-H_2O$ system

Mixture[a] 100w_i	$NH_4H_2PO_4$ 100w_i	m_i[b]	$(NH_4)_2HPO_4$ 100w_i	m_i[b]	K_2SO_4 100w_i	m_i[b]	H_2O 100w_i	t/°C	Solid phase[c]
0	0	0	0	0	6.5	0.40	93.5	−1.6	A+B
9.0	4.2	0.45	4.8	0.45	10.0	0.71	81.0	−4.0	A+B
18.06	8.41	1.01	9.65	1.01	9.7	0.77	72.24	−6.0	A+B
27.3	12.7	1.73	14.6	1.73	9.0	0.81	63.7	−9.0	A+B
32.2	15.0	2.18	17.2	2.18	8.0	0.77	59.8	−10.3	A+B
41.85	19.48	3.311	22.37	3.311	7.0	0.79	51.15	11.0	B+C
46.5	21.6	4.05	24.9	4.05	7.0	0.86	46.5	18.0	B+C
38.6	18.0	2.54	20.6	2.54	0	0	61.4	8.6	A+C
36.0	16.8	2.40	19.2	2.40	3.2	0.30	60.8	−9.1	A+B+C
61.0	28.4	6.33	32.6	6.33	0	0	39.0	39.0	C+D
62.2	29.0	7.19	33.2	7.19	2.8	0.46	35.0	45.0	C+D

[a]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b]The molalities were calculated by the compiler. The units are: mol kg^{-1}.
[c]The solid phases are: A = ice; B = K_2SO_4; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$.

Part 2. Solubility isotherms in the $NH_4H_2PO_4-(NH_4)_2HPO_4-K_2SO_4-H_2O$ system

Mixture[a] 100w_i	$NH_4H_2PO_4$ 100w_i	m_i/mol kg^{-1} [b]	$(NH_4)_2HPO_4$ 100w_i	m_i/mol kg^{-1} [b]	K_2SO_4 100w_i	m_i/mol kg^{-1} [b]	H_2O 100w_i	Solid phase[c]
				temp= −5 °C				
40.4	18.8	2.74	21.6	2.74	0	0	59.6	A
37.0	17.2	2.50	19.8	2.50	3.15	0.30	59.85	A
32.02	14.91	2.179	17.11	2.179	8.5	0.82	59.48	B
27.2	12.7	1.73	14.5	1.73	9.2	0.83	63.6	B
18.06	8.41	1.01	9.65	1.01	9.7	0.77	72.24	B
				temp=0 °C				
42.8	19.9	3.03	22.9	3.03	0	0	57.2	C
38.5	17.9	2.67	20.6	2.67	3.07	0.301	58.43	C
31.85	14.83	2.179	17.02	2.179	9.0	0.87	59.15	B
27.12	12.63	1.734	14.49	1.734	9.6	0.87	63.28	B
17.96	8.361	1.011	9.599	1.011	10.2	0.815	71.84	B
8.96	4.17	0.450	4.79	0.450	10.4	0.740	80.64	B
				temp=10 °C				
47.4	22.1	3.65	25.3	3.65	0	0	52.6	C
41.5	19.3	3.02	22.2	3.02	2.925	0.3020	55.575	C
31.64	14.73	2.179	16.91	2.179	9.6	0.94	58.76	B
26.91	12.53	1.734	14.38	1.734	10.3	0.941	62.79	B
17.8	8.29	1.01	9.51	1.01	11.0	0.887	71.2	B
8.88	4.13	0.450	4.75	0.450	11.2	0.804	79.92	B

[a]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b]These values were calculated by the compiler. The unit are: mol kg^{-1}.
[c]The solid phases are: A = ice; B = K_2SO_4; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

An improved visual polythermic method[1] was used.

Source and Purity of Materials:

Chemically pure or reagent grade salts were recrystallized twice and dried at 30–40 °C. The material designated "mixture" was prepared by mixing equimolar amounts of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ and homogenizing by grinding in a mortar.

Estimated Error:

Precision of temperature measurement was ± 0.4 K.

References:

[1]L.N. Erayzer, I.M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(3) Potassium thiosulfate; $K_2S_2O_3$; [10294-66-3]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

A. M. Babenko, A. M. Andrianov, Zh. Neorg. Khim. **29**, 2663-7 (1984).

Variables:

Temperature and concentration of $K_2S_2O_3$ in a mixture containing a mol ratio of $NH_4H_2PO_4/(NH_4)_2HPO_4 = 1$.

Prepared By:

J. Eysseltová

6.3. Other Systems

Experimental Data

Part. 1. Points of simultaneous crystallization of two or three solid phases in the $NH_4H_2PO_4-(NH_4)_2HPO_4-K_2S_2O_3-H_2O$ system

Mixture[a]	$NH_4H_2PO_4$		$(NH_4)_2HPO_4$		$K_2S_2O_3$		H_2O		Solid
$100w_i$	$100w_i$	m_i[b]	$100w_i$	m_i[b]	$100w_i$	m_i[b]	$100w_i$	t/°C	phase[c]
0	0	0	0	0	52.0	5.69	48.0	−21.5	A+B
5.0	2.3	0.45	2.7	0.45	50.0	5.84	45.0	−21.6	A+B
11.2	5.2	1.04	6.0	1.0	44.0	5.16	44.8	−22.5	A+C
16.0	7.4	1.3	8.6	1.3	33.6	3.50	50.4	−27.5	A+C
19.2	8.9	1.7	10.3	1.73	36.0	4.22	44.8	−21.6	A+C
24.0	11.2	1.83	12.8	1.83	22.8	2.25	53.2	−15.4	A+C
8.0	3.7	0.69	4.3	0.69	45.0	5.03	47.0	−23.0	A+B+C
27.3	12.7	2.18	14.6	2.18	22.0	2.28	50.7	−17.0	A+C+D
38.6	22.2	3.14	26.4	3.14	0	0	61.4	−8.6	A+D
36.0	16.8	2.53	19.2	2.53	6.4	0.58	57.6	13.0	A+D
32.0	14.9	2.38	17.1	2.38	13.6	1.31	54.4	−14.2	A+D
61.0	28.4	6.33	32.6	6.33	0	0	39.0	39.0	C+D
47.0	21.9	4.05	25.1	4.05	6.0	0.67	47.0	19.0	C+D
36.12	16.82	2.931	19.30	2.931	14.0	1.47	49.88	10.0	C+D
42.55	19.81	3.447	22.74	3.447	7.5	0.79	49.95	10.0	C+D
6.6	3.1	0.64	3.5	0.64	51.37	6.422	42.03	−1.0	B+C
5.0	2.3	0.53	2.7	0.53	57.0	7.88	38.0	12.0	B+C

[a]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b]The molalities were calculated by the compiler. The units are mol kg^{-1}.
[c]The solid phases are: A = ice; B = $K_2S_2O_3$; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$.

Part 2. Solubility isotherms in the $NH_4H_2PO_4-(NH_4)_2HPO_4-K_2S_2O_3-H_2O$ system

Mixture[a]	$NH_4H_2PO_4$		$(NH_4)_2HPO_4$		$K_2S_2O_3$		H_2O	Solid
$100w_i$	$100w_i$	m_i/mol kg^{-1} [b]	$100w_i$	m_i/mol kg^{-1} [b]	$100w_i$	m_i/mol kg^{-1} [b]	$100w_i$	phase[c]
				temp = −10 °C				
28.0	13.0	1.75	15.0	1.75	7.2	0.58	64.8	A
21.0	9.8	1.3	11.2	1.34	15.8	1.31	63.2	A
15.36	7.15	1.01	8.21	1.01	23.2	1.98	61.44	A
6.9	3.2	0.45	3.7	0.45	31.0	2.62	62.1	A
25.0	11.6	1.93	13.4	1.93	22.5	2.25	52.5	C
18.96	8.83	1.73	10.13	1.734	36.8	4.37	44.24	C
11.0	5.1	1.0	5.9	1.0	44.5	5.25	44.5	C
36.4	16.9	2.57	19.5	2.57	6.36	0.584	57.24	D
32.6	15.2	2.44	17.4	2.44	13.4	1.30	54.0	D
9.0	4.2	0.80	4.8	0.80	45.5	5.25	45.5	B
0	0	0	0	0	55.0	6.42	45.0	B
				temp = 0 °C				
27.0	12.6	2.14	14.4	2.14	21.9	2.25	51.1	A
23.1	10.7	1.73	12.3	1.73	23.0	2.24	53.9	A
38.0	17.7	2.76	20.3	2.76	6.2	0.58	55.8	D
33.6	15.6	2.56	18.0	2.56	13.2	1.30	53.2	D
18.78	8.74	1.73	10.04	1.734	37.4	4.48	43.82	C
11.0	5.1	1.0	5.9	1.0	45.0	5.37	44.0	C
9.4	4.4	0.84	5.0	0.84	45.3	5.25	45.3	C
4.8	2.2	0.44	2.6	0.44	51.2	6.11	44.0	B
0	0	0	0	0	57.4	7.08	42.6	B
				temp = 10 °C				
29.4	13.7	2.41	15.7	2.41	21.18	2.25	49.42	C
18.0	8.4	1.5	9.6	1.5	32.8	3.50	49.2	C
10.96	5.10	1.01	5.86	1.01	45.2	5.42	43.84	C
4.82	2.24	0.450	2.58	0.450	51.8	6.27	43.38	B
0	0	0	0	0	60.0	7.88	40.0	B

[a]"Mixture" is an equimolar mixture of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$.
[b]These values were calculated by the compiler. The units are mol kg^{-1}.
[c]The solid phases are: A = ice; B = $K_2S_2O_3$; C = $NH_4H_2PO_4$; D = $(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

An improved visual polythermic method[1] used.

Source and Purity of Materials:

Chemically pure or reagent grade salts were recrystallized twice and dried at 30 °C. The material designated "mixture" was prepared by mixing equimolar amounts of $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$ and homogenizing by grinding in a mortar. Potassium thiosulfate (p., TU 6-09-44-70) was recrystallized twice and dried at 105 °C.

Estimated Error:

Precision of temperature measurement was ± 0.4 K.

References:

[1]I. N. Frayzer, I. M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic
September 1995

Critical Evaluation:

7.1. $NH_4H_2PO_4$–Urea–H_2O

Seven articles report solubility data in the $NH_4H_2PO_4$–urea–H_2O system.[1-7] Four of these articles[1-3,7] present data on solutions in equilibrium with several solid phases. Two of these articles[1,2] also contain sets of isotherms. The rest of the data[4-6] deal with the solubility along sections having constant N/P_2O_5 ratios. The data of Blidin[1] are scattered and the description of the solid phases at 25 °C is not convincing. In fact, a reasonable phase diagram, Figure 13, can be constructed only if based on the data of Polosin[2,3] and Polyakov, et al.[6] Then, too, α- and γ-forms of urea are reported for solutions having higher urea contents and at higher temperatures[2,3] and a β-form of $NH_4H_2PO_4$ is mentioned by others.[4] However, such polymorphs seem to be inconsistent with the boundaries of the crystallization fields in the phase diagram. Therefore, any evaluation must await further investigation of the solubility of the polymorphs. Furthermore, the solubility polytherm on sections having a constant N/P_2O_5 ratio reported by Sarbaev, et al.[7] and by Polyakov, et al.[6] differ substantially from each other. Once again, further independent data are needed before any evaluation can be made. The heavy lines in Figure 13, below, represent phase equilibria while the lighter lines represent isotherms at the temperatures indicated.

Kummel and Fahsl[8] studied the closely related $NH_4H_2PO_4$-$CO(NH_2)_2$·H_3PO_4–H_2O system.

[1] V. P. Blidin, Zh. Obshch. Khim. **11**, 887 (1941).
[2] V. A. Polosin, A. G. Treshchov, Izv. Timiryazevsk. S.-kh. Akad. **2**, 203 (1953).
[3] V. A. Polosin, A. G. Treshchov, Zh. Fiz. Khim. **27**, 57 (1953).
[4] A. G. Bergman, I. V. Opredelenkova, Zh. Prikl. Khim. (Leningrad) **40**, 1835 (1967).
[5] A. N. Sarbaev, E. V. Polyakov, M. F. Tyunina, Z. A. Polyakova, A. Kh. Ruchkova, Khim. Prom. (Moscow) **48**, 437 (1967).
[6] E. V. Polyakov, L. I. Mart'yanova, A. N. Sarbaev, Zh. Prikl. Khim (Leningrad) **47**, 1507 (1974).
[7] A. N. Sarbaev, E. V. Polyakov, Z. A. Polyakova, A. Kh. Ruchkova, M. F. Tyunina, L. I. Gushchina, L. I. Mart'yanova, Khim. Prom. (Moscow) **50**, 516 (1974).
[8] R. Kummel, R. Fahsl, Z. Anorg. Allg. Chem. **402**, 305 (1973).

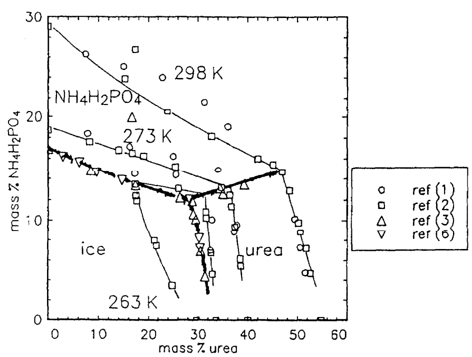

FIG. 13. Solubility in the $NH_4H_2PO_4$–urea–H_2O system.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

V. P. Blidin, Zh. Obshch. Khim. **11**, 887-90 (1941).

Variables:

Temperature and composition.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system

$NH_4H_2PO_4$		$CO(NH_2)_2$		H_2O	
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	Solid phases
			temp = −10 °C		
14.5	1.8	17.2	4.2	68.3	$NH_4H_2PO_4$
14.4	2.1	25.5	7.1	60.1	$NH_4H_2PO_4$
10.1	1.5	32.8	9.6	57.1	α-$CO(NH_2)_2$
7.0	1.0	32.5	8.9	60.5	α-$CO(NH_2)_2$
			temp = 0 °C		
17.1	2.2	16.2	4.0	66.7	$NH_4H_2PO_4$
18.4	2.2	7.8	1.8	73.8	$NH_4H_2PO_4$
16.2	2.4	25.0	7.1	58.8	$NH_4H_2PO_4$
14.9	2.5	34.0	11.1	51.1	$NH_4H_2PO_4$
9.6	1.6	37.8	12.0	52.6	α-$CO(NH_2)_2$
8.9	1.4	37.2	11.5	53.9	α-$CO(NH_2)_2$
			temp = 5 °C		
18.5	2.5	16.1	4.1	65.4	$NH_4H_2PO_4$
19.6	2.4	8.0	1.8	72.4	$NH_4H_2PO_4$
17.9	2.8	26.0	7.7	56.1	$NH_4H_2PO_4$
15.8	2.7	33.9	11.2	50.3	$NH_4H_2PO_4$
12.0	2.2	40.9	14.5	47.1	α-$CO(NH_2)_2$
6.0	1.0	40.1	12.4	53.9	α-$CO(NH_2)_2$
			temp = 15 °C		
21.2	2.9	15.8	4.2	63.0	$NH_4H_2PO_4$
22.6	2.8	7.9	1.9	69.5	$NH_4H_2PO_4$
20.1	3.1	24.0	7.1	55.9	$NH_4H_2PO_4$
16.8	3.2	37.3	13.5	45.9	$NH_4H_2PO_4$
18.1	3.2	33.0	11.2	48.9	$NH_4H_2PO_4$
5.2	0.9	45.9	15.6	48.9	α-$CO(NH_2)_2$
8.1	1.5	45.5	16.3	46.4	α-$CO(NH_2)_2$
11.2	2.2	45.1	17.2	43.7	α-$CO(NH_2)_2$
			temp = 25 °C		
25.1	3.6	15.0	4.2	59.9	$NH_4H_2PO_4$
26.3	3.4	7.4	1.9	66.3	$NH_4H_2PO_4$
24.0	3.9	22.8	7.1	53.2	$NH_4H_2PO_4$
19.1	3.7	36.0	13.3	44.9	$NH_4H_2PO_4$
21.6	4.0	31.3	11.1	47.1	$NH_4H_2PO_4$
4.8	1.0	51.6	19.7	43.6	α-$CO(NH_2)_2$+β-$CO(NH_2)_2$
7.3	1.5	50.5	19.9	42.2	α-$CO(NH_2)_2$+β-$CO(NH_2)_2$
10.2	2.2	49.5	20.5	40.3	α-$CO(NH_2)_2$+β-$CO(NH_2)_2$

[a] The molality values were calculated by the compilers.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

V. A. Polosin, A. G. Treshchov, Izv. Timiryazevsk. S.-kh. Akad. 2, 203-20 (1953).

Variables:

Composition and temperature.

Prepared By:

L.V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system

	$CO(NH_2)_2$			$NH_4H_2PO_4$		H_2O	
Comp[a]	$100w_i$	m_i/mol kg^{-1}[b]	Comp[a]	$100w_i$	m_i/mol kg^{-1}[b]	$100w_i$	Solid phase
			temp=−10 °C				
100	29.70	7.03	0.0	0.0	0.00	70.30	ice
93.19	24.82	5.76	6.81	3.48	0.42	71.70	ice
94.78	21.58	5.06	15.22	7.42	0.91	71.00	ice
83.74	21.20	4.98	16.26	7.98	0.98	70.82	ice
73.93	17.62	4.16	26.07	11.90	1.47	70.48	ice
72.92	17.40	4.13	27.08	12.39	1.53	70.21	ice
71.07	17.30	4.16	28.93	13.50	1.70	69.20	$NH_4H_2PO_4$
79.24	26.07	7.14	20.76	13.10	1.87	60.83	$NH_4H_2PO_4$
84.78	31.55	9.12	15.22	10.83	1.64	57.60	α-$CO(NH_2)_2$
85.52	31.60	9.05	14.48	10.26	1.53	58.14	α-$CO(NH_2)_2$
90.24	32.60	8.95	9.76	6.74	0.97	60.66	α-$CO(NH_2)_2$
93.19	32.89	8.76	6.81	4.61	0.64	62.50	α-$CO(NH_2)_2$
100	33.60	8.43	0.0	0.00	0.00	66.40	α-$CO(NH_2)_2$
			temp=0 °C				
—	0.00	0.00	100	18.70	2.00	81.30	$NH_4H_2PO_4$
47.29	8.24	1.85	52.71	17.60	2.06	74.16	$NH_4H_2PO_4$
61.47	13.97	3.36	38.53	16.78	2.11	69.25	$NH_4H_2PO_4$
65.98	16.70	4.16	34.02	16.50	2.15	66.80	$NH_4H_2PO_4$
69.23	19.00	4.88	30.77	16.20	2.17	64.80	$NH_4H_2PO_4$
76.23	25.44	7.14	23.77	15.20	2.23	59.36	$NH_4H_2PO_4$
83.44	34.72	11.10	16.56	13.20	2.20	52.08	$NH_4H_2PO_4$
84.78	36.38	11.85	15.22	12.52	2.13	51.10	α-$CO(NH_2)_2$
86.08	36.70	11.77	13.94	11.39	1.91	51.91	α-$CO(NH_2)_2$
88.42	37.40	11.70	11.58	9.39	1.53	53.21	α-$CO(NH_2)_2$
92.31	38.50	11.58	7.59	6.15	0.97	55.35	α-$CO(NH_2)_2$
93.19	38.60	11.48	6.81	5.40	0.84	56.00	α-$CO(NH_3)_2$
100	40.00	11.10	—	0.00	0.00	60.00	α-$CO(NH_2)_2$
			temp=25 °C				
0.0	0.00	0.00	100	29.05	3.56	70.95	$NH_4H_2PO_4$
34.37	7.32	1.85	65.63	26.80	3.54	65.88	$NH_4H_2PO_4$
55.03	15.23	4.16	44.97	23.85	3.40	60.92	$NH_4H_2PO_4$
68.91	23.82	7.14	31.09	20.60	3.22	55.58	$NH_4H_2PO_4$
77.51	32.72	11.10	22.49	18.20	3.22	49.08	$NH_4H_2PO_4$
83.42	42.00	16.65	16.58	16.00	3.31	42.00	$NH_4H_2PO_4$
84.78	45.10	19.06	15.22	15.50	3.42	39.40	$NH_4H_2PO_4$
85.95	46.92	20.35	14.05	14.70	3.33	38.38	$NH_4H_2PO_4$
87.78	48.40	20.82	12.22	12.90	2.90	38.70	β-$CO(NH_2)_2$
90.73	50.25	20.97	9.27	9.85	2.15	39.90	β-$CO(NH_2)_2$
91.61	50.60	20.80	8.39	8.89	1.91	40.51	γ-$CO(NH_2)_2$
93.19	51.75	21.01	6.81	7.23	1.53	41.02	γ-$CO(NH_2)_2$
93.21	51.80	21.05	6.79	7.23	1.53	40.97	γ-$CO(NH_2)_2$
95.50	52.60	20.53	4.50	4.74	0.97	42.66	γ-$CO(NH_2)_2$
100	54.80	20.19	0.0	0.00	0.00	45.20	γ-$CO(NH_3)_2$
			temp=40 °C				
0.0	0.00	0.00	100	35.50	4.78	64.50	$NH_4H_2PO_4$
28.47	6.75	1.85	71.53	32.50	4.65	60.75	$NH_4H_2PO_4$
49.27	14.34	4.16	50.73	28.30	4.29	57.36	$NH_4H_2PO_4$
64.68	22.83	7.14	35.32	23.90	3.90	53.27	$NH_4H_2PO_4$
74.01	31.52	11.10	25.99	21.20	3.90	47.28	$NH_4H_2PO_4$
80.28	40.50	16.65	19.72	19.00	4.08	40.50	$NH_4H_2PO_4$
83.05	45.27	20.36	16.95	17.70	4.15	37.03	$NH_4H_2PO_4$
90.81	56.30	28.60	9.19	10.92	2.90	32.78	γ-$CO(NH_2)_2$
92.92	57.80	28.51	7.08	8.44	2.17	33.76	γ-$CO(NH_2)_2$
93.82	58.80	28.98	6.18	7.42	1.91	33.78	γ-$CO(NH_2)_2$
94.60	59.40	29.00	5.40	6.50	1.66	34.10	γ-$CO(NH_2)_2$
96.70	60.50	28.34	3.30	3.95	0.97	35.55	γ-$CO(NH_2)_2$
100	62.00	27.17	0.00	0.00	0.00	38.00	γ-$CO(NH_2)_2$

[a]The composition unit is: mol/100 mol of solute.
[b]These values were calculated by the compilers.

Additional Data: the authors also give the specifics of the cryohydratic point in the $NH_4H_2PO_4$–H_2O system: 16.90 mass % $NH_4H_2PO_4$ (1.77 mol/kg H_2O–compilers) at −4.3 °C and of the eutectic point of the ternary system under consideration: 28.8 mass % $CO(NH_2)_2$ (8.09 mol/kg H_2O–compilers); 11.90 mass % $NH_4H_2PO_4$ (1.74 mol/kg H_2O–compilers); 59.30 mass % H_2O at −15.3 °C.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

V. A. Polosin, A. G. Treshchov, Zh. Fiz. Khim. **27**, 57-68 (1953).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Crystallization temperatures and composition of solutions coexisting with several solid phases in the $NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system

	$NH_4H_2PO_4$		$CO(NH_2)_2$		H_2O	Solid
t/°C	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	phases[b]
−4.3[c]	16.90	1.77	0.00	0.00	83.10	A+B
7.1	14.80	1.68	8.52	1.85	76.68	A+B
10.4	13.40	1.68	17.32	4.17	69.28	A+B
14.0	12.25	1.73	26.33	7.14	61.42	A+B
2.8	12.60	2.09	34.96	11.11	52.44	B+C
+14.1	13.90	2.81	43.05	16.66	43.05	B+D
+22.8	14.20	3.20	47.19	20.37	38.61	B+D
13.4	6.91	0.96	30.50	8.12	62.59	A+C
+3.7	5.94	1.19	50.60	19.40	43.46	C+D
+25.3	4.71	0.97	52.90	20.80	42.39	D+E
14.5	10.65	1.53	29.00	8.01	60.35[d]	A+C
+5.8	8.90	1.54	40.70	13.46	50.40	C+D
+24.8	7.25	1.54	51.70	20.99	41.05	D+E
8.1	12.22	1.91	32.10	9.01	55.68	B+F
−3.8	13.12	2.17	34.40	10.92	52.48	B+C
+7.3	11.90	2.17	40.50	14.18	47.60	C+D
+25.7	5.88	1.17	50.60	19.37	43.52	D+E
+18.1	13.80	2.90	44.80	18.03	41.40	B+D
8.5	20.00	2.74	16.65	4.38	63.35	A+B
+6.0	13.49	2.48	39.21	13.81	47.30	B+C
14.2	10.16	1.46	29.54	8.16	60.30	A+C
−5.0	5.81	0.96	41.49	13.12	52.70	C+D
12.6	4.39	0.59	31.41	8.15	64.20	A+C
−15.3	11.90	1.74	28.80	8.09	59.30	A+B+C

[a]These values were calculated by the compiler.
[b]The solid phases are: A = ice; B = $NH_4H_2PO_4$; C = α-$CO(NH_2)_2$; D = β-$CO(NH_2)_2$; E = γ-$CO(NH_2)_2$; F = $CO(NH_2)_2$ (modification not given).
[c]This is a graphical estimation, the experimental value was −4.6 °C.
[d]The value in the source paper was 560.3, an obvious error.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used. The disappearance of the last crystal and the appearance of the first crystal were observed.

Source and Purity of Materials:

Ammonium dihydrogenphosphate and urea were recrystallized three times before use and analyzed (no results given). The purity of urea was checked by melting point measurement (+132.6 °C found).

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A. G. Bergman, L.V. Opredelenkova, Zh. Prikl. Khim. (Leningrad) **40**, 1835-8 (1967).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Composition and crystallization temperature of invariant points in the $NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system

	$CO(NH_2)_2$		$NH_4H_2PO_4$		H_2O	Solid
t/°C	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	phases[b]
−17.5	30.0	8.84	13.5	2.08	56.5	A+B+C
−6.0	35.0	11.5	14.5	2.50	50.5	B+C+D
28.0	51.5	25.6	15.0	3.89	33.5	C+D+E
46.0	58.0	35.8	15.0	4.83	27.0	D+E+F

[a]The molality values were calculated by the compiler.
[b]The solid phases are: A = ice; B = α-$NH_4H_2PO_4$; C = α-$CO(NH_2)_2$; D = β-$NH_4H_2PO_4$; E = β-$CO(NH_2)_2$; F = γ-$CO(NH_2)_2$.

Additional Data:

Solubility polytherm and solubility isotherms in the temperature range −10 to +50 °C are given, but only in graphical form.

Relative areas of crystallization fields are: ice = 9.98%, α-$NH_4H_2PO_4$ = 8.01%; β-$NH_4H_2PO_4$ = 62.18%, α-$CO(NH_2)_2$ = 4.99%; β-$CO(NH_2)_2$ = 2.28%; γ-$CO(NH_2)_2$ = 12.56.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.[1] The appearance of the first crystals as well as the disappearance of the last crystals was observed, the difference between these values being kept to a minimum.

Source and Purity of Materials:

Reagent grade urea and $NH_4H_2PO_4$ were recrystallized and dried before being used. Their melting points were 132.5 and 200 °C, respectively.

Estimated Error:

No information is given.

References:

[1]A. G. Bergman, N. P. Luzhnaya, Fiziko-Khimicheskie Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow, IAN SSSR, 1951.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A. N. Sarbaev, E. V. Polyakov, M. F. Tyunina, Z. A. Polyakova, A. Kh. Ruchkova, Khim. Prom. (Moscow) **48**, 437-8 (1972).

Variables:

Composition and temperature in solutions with N/P_2O_5 ratio of 1:1.

Prepared By:

J. Eysseltová

Experimental Data

The solubility polytherm for the $NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system in a solution having a N/P_2O_5 ratio = 1:1 is given in graphical form. The eutectic point is specified as 28.4 mass % of fertilizer 1:1 and 72.6 mass % H_2O at −9.25 °C.

Compiler's Comment:

The composition values are an obvious typographical error because the sum ≈ 101%.

Auxiliary Information

Method / Apparatus / Procedure:

The method has been described earlier.[1]

Source and Purity of Materials:

$CO(NH_2)_2$ was GOST 6691-67; $NH_4H_2PO_4$ was GOST 3771-64. No other information is given.

Estimated Error:

No information is given.

References:

1. I.R. Krichevskiy, N.E. Khazanova, L.R. Liushic, Zh. Fiz. Khim. **31**, 2711 (1957).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

E. V. Polyakov, L. I. Mart'yanova, A. N. Sarbaev, Zh. Prikl. Khim. (Leningrad) **47**, 1507-9 (1974).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Composition of the relevant sections:

Sect.	$CO(NH_2)_2$	$NH_4H_2PO_4$	Ratio of $N:P_2O_5$	Comment
I	80.8%	19.2%	3.37:1	water added
II	78.7%	21.3%	3:1	water added
III	70.3%	29.7%	2:1	water added
IV	51.4%	48.6%	1:1	water added
V	39.7%	60.3%	1:1.5	water added
VI	28.6%	71.4%	1:2	water added
VII	15.2%	84.8%	1:3	water added

Part 2. The authors present their data using the total contents of salt components, the number of the relevant section and the crystallization temperatures as coordinates. The compiler has recalculated their data as follows:

$NH_4H_2PO_4$		$CO(NH_2)_2$		H_2O	
$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	t/°C
1.0	0.1	4.0	0.7	95.0	−1.5
1.9	0.2	8.1	1.5	90.0	−3.0
2.9	0.3	12.1	2.4	85.0	−4.7
3.8	0.4	16.2	3.4	80.0	−6.4
4.8	0.6	20.2	4.5	75.0	−8.3
5.8	0.7	24.2	5.8	70.0	−10.2
6.7	0.9	28.3	7.2	65.0	−12.3
7.7	1.1	32.3	9.0	60.0	−10.0
8.6	1.4	36.4	11.0	55.0	−2.4
9.6	1.7	40.4	13.5	50.0	5.5
10.6	2.0	44.4	16.4	45.0	13.8
11.5	2.5	48.5	20.2	40.0	22.8
12.5	3.1	52.5	25.0	35.0	33.0
13.4	3.9	56.6	31.4	30.0	43.8
14.4	5.0	60.6	40.4	25.0	55.8
15.4	6.7	64.6	53.8	20.0	68.3
17.3	15.0	72.7	121.1	10.0	96
18.2	31.7	76.8	255.6	5.0	100
1.1	0.1	3.9	0.7	95.0	−1.4
2.1	0.2	7.9	1.5	90.0	−2.9
3.2	0.3	11.8	2.3	85.0	−4.6
4.3	0.5	15.7	3.3	80.0	−6.4
5.3	0.6	19.7	4.4	75.0	−8.3
6.4	0.8	23.6	5.6	70.0	−10.2
7.5	1.0	27.5	7.1	65.0	−12.3
8.5	1.2	31.5	8.7	60.0	−11.4
9.6	1.5	35.4	10.7	55.0	−3.8
10.7	1.9	39.4	13.1	50.0	4.1

11.7	2.3	43.3	16.0	45.0	12.4
12.8	2.8	47.2	19.7	40.0	21.1
13.8	3.4	51.2	24.3	35.0	30.8
14.9	4.3	55.1	30.6	30.0	41.8
16.0	5.6	59.0	39.3	25.0	54.3
17.0	7.4	63.0	52.4	20.0	72.6
19.2	16.7	70.8	117.9	10.0	99
20.2	35.2	74.8	249.0	5.0	–
1.5	0.1	3.5	0.6	95.0	−1.45
3.0	0.3	7.0	1.3	90.0	−2.9
4.5	0.5	10.5	2.1	85.0	−4.6
5.9	0.6	14.1	2.9	80.0	−6.2
7.4	0.9	17.6	3.9	75.0	−8.2
8.9	1.1	21.1	5.0	70.0	−10.2
10.4	1.4	24.6	6.3	65.0	−12.5
11.9	1.7	28.1	7.8	60.0	−14.9
13.4	2.1	31.6	9.6	55.0	−3.2
14.9	2.6	35.2	11.7	50.0	9.6
16.3	3.2	38.7	14.3	45.0	23.0
17.8	3.9	42.2	17.6	40.0	37.2
19.3	4.8	45.7	21.7	35.0	50.4
20.8	6.0	49.2	27.3	30.0	63.0
22.3	7.7	52.7	35.1	25.0	75.0
23.8	10.3	56.2	46.8	20.0	86.9
26.7	23.2	63.3	105.3	10.0	110
28.2	49.1	66.8	222.4	5.0	121
2.4	0.2	2.6	0.5	95.0	−1.4
4.9	0.5	5.1	1.0	90.0	−2.8
7.3	0.7	7.7	1.5	85.0	−4.4
9.7	1.1	10.3	2.1	80.0	−6.2
12.1	1.4	12.9	2.9	75.0	−8.0
14.6	1.8	15.4	3.7	70.0	−6.9
17.0	2.3	18.0	4.6	65.0	2.4
19.4	2.8	20.6	5.7	60.0	14.4
21.9	3.5	23.1	7.0	55.0	28.7
24.3	4.2	25.7	8.6	50.0	43.0
26.7	5.2	28.3	10.5	45.0	56.0
29.2	6.3	30.8	12.8	40.0	67.1
31.6	7.8	33.4	15.9	35.0	76.1
34.0	9.9	36.0	20.0	30.0	83.8
36.4	12.7	38.6	25.7	25.0	91
38.9	16.9	41.1	34.2	20.0	97
43.7	38.0	46.3	77.0	10.0	110
46.2	80.3	48.8	162.6	5.0	115
3.0	0.3	2.0	0.3	95.0	−1.5
6.0	0.6	4.0	0.7	90.0	−2.9
9.0	0.9	6.0	1.2	85.0	−4.4
12.1	1.3	7.9	1.7	80.0	−6.1
15.1	1.7	9.9	2.2	75.0	−6.4
18.1	2.2	11.9	2.8	70.0	2.7
21.1	2.8	13.9	3.6	65.0	14.7
24.1	3.5	15.9	4.4	60.0	27.4
27.1	4.3	17.9	5.4	55.0	41.2
30.2	5.2	19.9	6.6	50.0	53.2
33.2	6.4	21.8	8.1	45.0	63.6

36.2	7.9	23.8	9.9	40.0	73.0
39.2	9.7	25.8	12.3	35.0	82.2
42.2	12.2	27.8	15.4	30.0	91
45.2	15.7	29.8	19.8	25.0	102
48.2	21.0	31.8	26.4	20.0	111
54.3	47.2	35.7	59.5	10.0	..
57.3	99.6	37.7	125.6	5.0	.
3.6	0.3	1.4	0.3	95.0	−1.4
7.1	0.7	2.9	0.5	90.0	−2.8
10.7	1.1	4.3	0.8	85.0	−4.3
14.3	1.6	5.7	1.2	80.0	−5.9
17.9	2.1	7.2	1.6	75.0	−0.2
21.4	2.7	8.6	2.0	70.0	10.7
25.0	3.3	10.0	2.6	65.0	22.8
28.6	4.1	11.4	3.2	60.0	35.8
32.1	5.1	12.9	3.9	55.0	48.2
35.7	6.2	14.3	4.8	50.0	60.0
39.3	7.6	15.7	5.8	45.0	71.1
42.8	9.3	17.2	7.1	40.0	81.6
46.4	11.5	18.6	8.8	35.0	91
50.0	14.5	20.0	11.1	30.0	99
53.6	18.6	21.5	14.3	25.0	107
57.1	24.8	22.9	19.0	20.0	113
64.3	55.9	25.7	42.9	10.0	124
67.8	117.9	27.2	90.5	5.0	129
4.2	0.4	0.8	0.1	95.0	−1.2
8.5	0.8	1.5	0.3	90.0	−2.6
12.7	1.3	2.3	0.4	85.0	−4.0
17.0	1.8	3.0	0.6	80.0	−3.4
21.2	2.5	3.8	0.8	75.0	7.4
25.4	3.2	4.6	1.1	70.0	19.2
29.7	4.0	5.3	1.4	65.0	31.1
33.9	4.9	6.1	1.7	60.0	43.0
38.2	6.0	6.8	2.1	55.0	54.4
42.4	7.4	7.6	2.5	50.0	65.1
46.6	9.0	8.4	3.1	45.0	75.0
50.9	11.1	9.1	3.8	40.0	84.8
55.1	13.7	9.9	4.7	35.0	95
59.4	17.2	10.6	5.9	30.0	104
63.6	22.1	11.4	7.6	25.0	114
67.8	29.5	12.2	10.1	20.0	124
25.4	3.2	4.6	1.1	70.0	19.2
29.7	4.0	5.3	1.4	65.0	31.1
33.9	4.9	6.1	1.7	60.0	43.0
38.2	6.0	6.8	2.1	55.0	54.4
42.4	7.4	7.6	2.5	50.0	65.1
46.6	9.0	8.4	3.1	45.0	75.0
50.9	11.1	9.1	3.8	40.0	84.8
55.1	13.7	9.9	4.7	35.0	95
59.4	17.2	10.6	5.9	30.0	104
63.6	22.1	11.4	7.6	25.0	114
67.8	29.5	12.2	10.1	20.0	124
76.3	66.3	13.7	22.8	10.0	145
80.6	140.1	14.4	48.1	5.0	–

Part 3. Invariant points in the $NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system. (The original data are presented in the form mentioned in Part 2.)

$NH_4H_2PO_4$ 100w_i	m_i/mol kg^{-1}	$CO(NH_2)_2$ 100w_i	m_i/mol kg^{-1}	H_2O 100w_i	t/°C
7.2	1.0	30.4	8.1	62.4	−13.4
8.2	1.2	30.2	8.2	61.6	−13.8
12.0	1.7	28.3	7.9	59.7	−15.0
13.8	1.7	14.6	3.4	71.6	−9.3
14.6	1.7	9.6	2.1	75.8	−7.6
15.6	1.7	6.2	1.3	78.2	−6.5
16.1	1.7	2.9	0.6	81.0	−5.2

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used with sealed glass tubes.[1] The authors state that the density of the filled tubes was 0.4–0.45 g cm^{-3} but this is not precisely defined in the article.

Source and Purity of Materials:

Chemically pure ammonium dihydrogenphosphate and urea were used. They were ground in a mortar and dried at 60–80 °C and then characterized by their melting points which were 132.5 and 200 °C, respectively.

Estimated Error:

No information is given.

References:

[1]I. F. Krichevskiy, N. E. Khazanova, L.R. Liushic, Zh. Fiz. Khim. 31, 2711 (1957).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A. N. Sarbaev, E. V. Polyakov, Z. A. Polyakova, A. Kh. Ruchkova, M. F. Tyunina, L. I. Gushchina, L. I. Mart'yanova, Khim. Prom. (Moscow) **50**, 516-21 (1974).

Variables:

Composition and temperature in solutions with N/P_2O_5 ratios of 2:1 and 3:1.

Prepared By:

J. Eysseltová

Experimental Data

The authors report the data found in Refs. 2 and 3. In addition, they report their own data at temperatures above 40 °C. These data are presented with temperature and the total content of salt components as the coordinates. The compiler has recalculated their data as follows.

Table I. Solubility data for the $NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system in solutions having a N/P_2O_5 ratio of 2:1

t/°C	Total salts 100w_i	$NH_4H_2PO_4$ 100w_i	m_i/mol kg^{-1}	$CO(NH_2)_2$ 100w_i	m_i/mol kg^{-1}	H_2O 100w_i
40	61.0	14.8	3.30	46.2	19.7	39.0
50	64.8	15.7	3.88	49.1	23.2	35.2
60	68.8	16.7	4.65	52.1	27.8	31.2
70	72.9	17.7	5.68	55.2	33.9	27.1
80	77.1	18.7	7.10	58.4	42.5	22.9
90	81.3	19.7	9.16	61.6	54.8	18.7
100	85.7	20.8	12.6	64.9	75.6	14.3
110	90.1	21.8	19.2	68.3	114.8	9.9
120	94.5	22.5	36.2	71.6	216.7	5.5
130	98.9	24.0	189.5	74.9	1134.1	1.1

Table II. Solubility data for the $NH_4H_2PO_4$–$CO(NH_2)_2$–H_2O system in solutions having a N/P_2O_5 ratio of 3:1

t/°C	Total salts 100wi	$NH_4H_2PO_4$ 100w_i	m_i/mol kg^{-1}	$CO(NH_2)_2$ 100w_i	m_i/mol kg^{-1}	H_2O 100w_i
40	69.2	11.2	3.16	58.0	31.4	30.8
50	73.3	11.8	3.84	61.5	38.3	26.7
60	77.1	12.5	4.75	64.6	47.0	22.9
70	79.3	12.8	5.38	66.5	53.5	20.7
80	82.4	13.3	6.57	69.1	65.4	17.6
90	86.3	13.9	8.82	72.4	87.9	13.7
100	90.9	14.7	14.0	76.2	139.4	9.1

Comment:

According to the authors, decomposition of urea occurs at temperatures above 70 °C.

Auxiliary Information

Method / Apparatus / Procedure:

The method has been described earlier.[1]

Source and Purity of Materials:

$CO(NH_2)_2$ was GOST 6691-67; $NH_4H_2PO_4$ was GOST 3771-64. No other information is given.

Estimated Error:

No information is given.

References:

[1]I. R. Krichevskiy, N. E. Khazanova, L. R. Liushic, Zh. Fiz. Khim. 31, 2711 (1957).
[2]V. P. Blidin, Zh. Obshch. Khim. 11, 887 (1941).
[3]E. V. Polyakov, L. I. Mart'yanova, A. N. Sarbaev, Zh. Prikl. Khim. (Leningrad) 47, 1507 (1974).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea phosphate; $CO(NH_2)_2 \cdot H_3PO_4$; [4861-19-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

R. Kümmel, R. Fahsl, Z. Anorg. Allg. Chem. **402**, 305-11 (1973).

Variables:

Composition at 20 and 40 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–$CO(NH_2)_2 \cdot H_3PO_4$–H_2O system

$CO(NH_2)_2 \cdot H_3PO_4$		$NH_4H_2PO_4$		H_2O	density	
$100w_1$	m_1/mol kg^{-1} [a]	$100w_2$	m_2/mol kg^{-1} [a]	$100w_3$	g cm^{-3}	Solid phase[b]
			temp = 20 °C			
44.35	6.03	9.08	1.69	46.57	1.2833	A
41.05	5.94	15.21	3.02	43.74	1.3062	A
38.59	6.27	22.46	5.01	38.95	1.3409	A+B
28.78	3.88	24.24	4.49	46.98	1.2877	B
16.26	1.74	24.60	3.62	59.14	1.2255	B
5.63	0.516	25.40	3.20	68.97	1.1737	B
0.000	0.000	25.50	2.98	74.50	1.1518	B
			temp = 40 °C			
58.94	10.92	6.91	1.76	34.15		A
55.05	11.01	13.31	3.66	31.64		A
44.35	10.17	28.06	8.84	27.59		A+B
35.22	6.18	28.70	6.91	36.08		B
23.39	3.22	30.67	5.80	45.94		B
11.78	1.35	33.01	5.20	55.21		B
0.000	0.000	36.20	4.93	63.80		B

[a] These values were calculated by the compiler.
[b] The solid phases are: A = $CO(NH_2)_2 \cdot H_3PO_4$; B = $NH_4H_2PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

Mixtures of the components were stirred vigorously and allowed to equilibrate for 15–25 hrs. The equilibrium was checked by repeated analysis of the liquid phase. PO_4^{3-} content was determined by precipitation titration with $La(NO_3)_3$ using Chromazurol S as indicator; NH_4^+ was determined, after removal of phosphate ions, with the aid of anion exchange resin by formol titration. Urea was determined gravimetrically as dixanthedrylurea or after enzyme decomposition as NH_3. The composition of the solid phases was determined by the method of Schreinemakers.

Source and Purity of Materials:

The ammonium phosphate was recrystallized several times before use. The urea phosphate was synthesized from urea and an equivalent amount of phosphoric acid and recrystallized several times.

Estimated Error:

The temperature was kept constant to within ± 0.05 K.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Thiourea; CH_4N_2S; [62-56-6] or (2) Methionine; $C_5H_{11}NO_2S$; [59-51-8] or (2) Triethylamine hydrochloride; $C_6H_{16}ClN$; [554-68-7] or (2) Biuret; $C_2H_5N_3O_2$; [108-19-0]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

7.2. $NH_4H_2PO_4$–Organic Compound–H_2O

The $NH_4H_2PO_4$–$CS(NH_2)_2$–H_2O system is described in two articles.[1,2] The 298 K isotherm and the complete phase diagram are given for the system. All these data are consistent with each other, but no critical evaluation can be made because there are no other data available for this system.

The same group of investigators also presented some information on the $NH_4H_2PO_4$–methionine–H_2O system.[3] The phase diagrams for the systems, Figures 14 and 15, provide an illustration of the problem involved in the so-called α- and β-$NH_4H_2PO_4$ discussed on page 1335. The authors are convinced that these two allotropes do exist and state that the transition point between them is at about 306 K. However, the evidence for these claims appears to be weak. There is no clear break where the curves for those systems in which both these solid allotropes are in equilibrium with the saturated solution join the curves for solutions in which the organic component is also an equilibrium solid phase. Furthermore, there is an insufficient number of data points for solutions in equilibrium with both the solid a-$NH_4H_2PO_4$ and b-$NH_4H_2PO_4$.

Other systems containing an organic compound that is both solid and water-soluble under ordinary room conditions and thus analogous to the systems described above are the $NH_4H_2PO_4$–$(C_2H_4)_3NKHCl$–H_2O system[4,5] and the $NH_4H_2PO_4$–$(C_4H_9)_2NHKHCl$–$(C_4H_9)_3NKHCl$–H_2O system.[6] These systems were studied by the same group of investigators, but no other data for these systems are available. Therefore, the information in these articles cannot be evaluated. This is true also for the $NH_4H_2PO_4$–Biuret–H_2O system.[7]

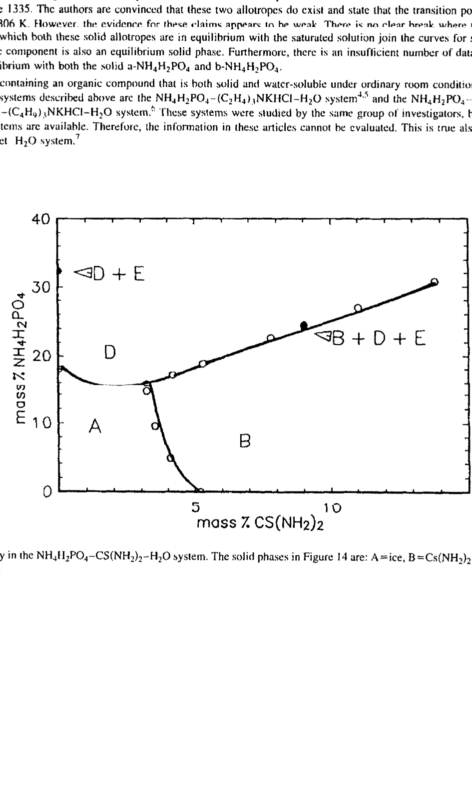

FIG. 14. Solubility in the $NH_4H_2PO_4$–$CS(NH_2)_2$–H_2O system. The solid phases in Figure 14 are: A = ice, B = $Cs(NH_2)_2$; D = α-$NH_4H_2PO_4$; E = β-$NH_4H_2PO_4$.

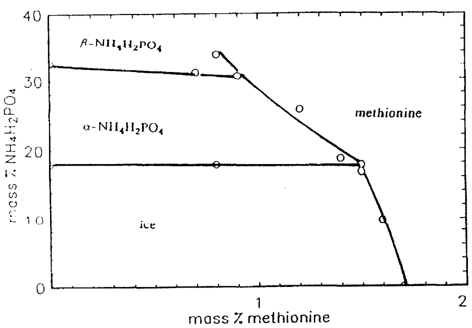

FIG. 15. Solubility in the $NH_4H_2PO_4$–methionine–H_2O system.

References:

[1] B. S. Zakirov, S. Tukhtaev, B. M. Beglov, Uzb. Khim. Zh. 19 (1974).
[2] B. S. Zakirov, S. Tukhtaev, B. M. Beglov, Dokl. Akad. Nauk Uzb. SSR 48 (1974).
[3] D. A. Anisova, B. M. Beglov, B. S. Zakirov, Kh. Kucharov, Zh. Neorg. Khim. **30**, 1342 (1985).
[4] S. A. Mazunin, O. E. Sosnina, A. A. Volkov, T. L. Danina, Termicheskiy Analiz i Fazovye Ravnovesiya, Perm 79 (1985).
[5] O. E. Sosnina, A. A. Volkov, Uch. Zap. Perm. Gos. Univ., Ser. Khim. **289**, 20 (1973).
[6] A. A. Volkov, O. E. Sosnina, Z. D. Kalinkina, N. I. Oginskaya, Termicheskiy Analiz i Fazovye Ravnovesiya, Perm 126 (1985).
[7] L. S. Bleshinskaya, K. S. Sulaymankulov, M. D. Davranov, Yu. Z. Yunusova, VINITI Nr. 120 (1983).

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Thiourea; CH_4N_2S; [62-56-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
B. S. Zakirov, S. Tukhtaev, B. M. Beglov, Uzb. Khim. Zh. 19-20 (1974).

Variables:
Composition and temperature.

Prepared By:
J. Eysseltová

Experimental Data

Points of simultaneous crystallization of two or three solid phases in the $NH_4H_2PO_4$–$CS(NH_2)_2$–H_2O system

$NH_4H_2PO_4$		$CS(NH_2)_2$		H_2O		
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	t/°C	Solid phases[b]
0	0	5.2	0.72	94.8	−0.6	A+B
4.8	0.46	4.1	0.59	91.1	−2.0	A+B
9.6	0.96	3.5	0.53	86.9	−3.1	A+B
14.5	1.53	3.2	0.51	82.3	−4.2	A+B
15.8	1.70	3.2	0.52	81.0	−4.5	A+B+C
18.0	1.91	0	0	82.0	−4.2	A+D
17.2	1.90	4.2	0.70	78.6	1.0	B+D
18.9	2.17	5.3	0.92	75.8	7.5	B+D
22.7	2.84	7.8	1.5	69.5	22.5	B+D
24.5	3.20	9.0	1.8	66.5	28.0	B+D+E
32.4	4.17	0	0	67.6	33.0	D+E
27.0	3.79	11.0	2.33	62.0	36.8	B+E
30.8	4.83	13.8	3.27	55.4	50.6	B+E

[a] These values were calculated by the compiler.
[b] The solid phases are: A = ice; B = $CS(NH_2)_2$; C = $NH_4H_2PO_4$; D = α-$NH_4H_2PO_4$; E = β-$NH_4H_2PO_4$.

Additional Data:
Solubility isotherms in the 0 to 50 °C temperature range are given, but only in graphical form.

Auxiliary Information

Method / Apparatus / Procedure:
A visual polythermic method was used.

Source and Purity of Materials:
"Chemically pure" $NH_4H_2PO_4$ was used. The thiourea was recrystallized twice.

Estimated Error:
No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Thiourea; CH_4N_2S; [62-56-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

B. S. Zakirov, B. M. Khaymov, S. Tukhtaev, B. M. Beglov, Dokl. Akad. Nauk. Uzb. SSR, 48-9 (1978).

Variables:

Composition at 25 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility in the $NH_4H_2PO_4$–$CS(NH_2)_2$–H_2O system at 25 °C

$CS(NH_2)_2$		$NH_4H_2PO_4$		H_2O	
$100w_i$	m_i/mol kg^{-1a}	$100w_i$	m_i/mol kg^{-1a}	$100w_i$	Solid phases
14.21	2.176	-	- -	85.79	$CS(NH_2)_2$
13.14	2.137	6.08	0.654	80.78	$CS(NH_2)_2$
12.38	2.129	11.24	1.279	76.38	$CS(NH_2)_2$
11.43	2.046	15.18	1.798	73.39	$CS(NH_2)_2$
10.26	1.878	17.96	2.175	71.78	$CS(NH_2)_2$
9.54	1.79	20.51	2.549	69.95	$CS(NH_2)_2$
8.47	1.63	23.31	2.970	68.22	$CS(NH_2)_2+NH_4H_2PO_4$
8.61	1.66	23.35	2.983	68.04	$CS(NH_2)_2+NH_4H_2PO_4$
5.04	0.963	26.19	3.310	68.77	$NH_4H_2PO_4$
2.59	0.487	27.54	3.426	69.87	$NH_4H_2PO_4$
		29.41	3.622	70.59	$NH_4H_2PO_4$

[a] These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used with mechanical stirring. Equilibrium was determined by repeated analysis of the liquid phase (no details are given). Equilibrium was attained in 24 hrs. The composition of the solid phases was determined by the Schreinemakers' method.

Source and Purity of Materials:

The thioureas was recrystallized twice. No other details are given.

Estimated Error:

The temperature was controlled to within ± 0.5 K. The compiler estimates that the reproducibility of the solubility values is about ± 0.5%.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Biuret; $C_2H_5N_3O_2$; [108-19-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

L. S. Bleshinskaya, K. S. Sulaymankulov, M. D. Davranov, Z. Yu. Yunusova, VINITI Nr. 120-83, 1983.

Variables:

Composition at 30 °C.

Prepared By:

J. Eysselová

Experimental Data

Solubility values in the $NH_4H_2PO_4$–biuret–H_2O system at 30 °C

$NH_4H_2PO_4$		$NH(CONH_2)_2$		H_2O	Solid
$100w_i$	m_i/mol kg^{-1a}	$100w_i$	m_i/mol kg^{-1a}	$100w_i$	phases[b]
-	—	3.08	0.306	96.92	A
3.71	0.345	2.85	0.294	93.44	A
9.42	0.928	2.37	0.259	88.21	A
23.00	2.674	2.26	0.291	74.74	A
28.32	3.526	1.89	0.261	69.79	A
29.30	3.710	2.06	0.289	68.64	A+B
29.28	3.707	2.08	0.292	68.64	A+B
29.88	3.786	1.54	0.216	68.58	B
30.44	3.855	0.94	0.13	68.62	B
31.69	4.032	—	--	68.31	B

[a] The molalities were calculated by the compiler.
[b] The solid phases are: A=$NH(CONH_2)_2$; B=$NH_4H_2PO_4$

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used with 8 to 9 hours allowed for equilibration. Equilibrium was checked by repeated analyses. Ammonia content was determined by the formaldehyde method, total nitrogen by the Kjeldahl method, and biuret by the diffrence. No other details are given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Methionine; $C_5H_{11}NO_2S$; [59-51-8]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

D. A. Amilova, B. M. Beglov, B. S. Zakirov, Kh. Kucharov, Zh. Neorg. Khim. **30**, 1342-3 (1985).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Crystallization temperatures in the $NH_4H_2PO_4$–methionine–H_2O system

$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1} [a]	methionine 100w_i	methionine m_i/mol kg^{-1} [a]	H_2O 100w_i	t/°C	Solid phases[b]
33.7	4.47	0.8	0.08	65.5	41.6	A+B
32.5	4.19	0	0	67.5	33.0	A+C
31.1	3.96	0.7	0.07	68.2	34.6	A+C
30.6	3.88	0.9	0.09	68.5	35.0	A+B+C
25.7	3.06	1.2	0.11	73.1	24.6	B+C
18.7	2.03	1.4	0.12	79.9	4.2	B+C
18.0	1.91	0	0	82.0	−4.3	C+D
17.9	1.91	0.8	0.07	81.3	−4.4	C+D
17.8	1.92	1.5	0.12	80.7	4.5	B+C+D
16.8	1.79	1.5	0.12	81.7	−4.2	B+D
9.8	0.96	1.6	0.12	88.6	−2.2	B+D
0	0	1.7	0.12	98.3	−0.1	B+D

[a]The mol/kg H_2O values were calculated by the compiler.
[b]The solid phases are: A = β-$NH_4H_2PO_4$; B = methionine; C = α-$NH_4H_2PO_4$; D = ice.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.[1]

Source and Purity of Materials:

Pure methionine and reagent grade $NH_4H_2PO_4$ were recrystallized before being used.

Estimated Error:

No information is given.

References:

[1]A. G. Bergman, N.P. Luzhnaya, Fiziko-Khimicheskiye Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow IAN SSSR (1951).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Triethylamine hydrochloride; $C_6H_{16}ClN$; [554-68-7]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

1. S. A. Mazunin, O. E. Sosnina, A. A. Volkov, T. L. Danina, Termicheskiy Analiz I. Fazovye Rovnovesiya, Perm. 79-88 (1985).
2. O. E. Sosnina, A. A. Volkov, Uch. Zap. Perm. Gos. Univ., Ser. Khim. **289**, 20-5 (1973).

Variables:

Composition at 20 and 60 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–$(C_2H_5)_3N\cdot HCl$–H_2O system

$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1} [a]	$(C_2H_5)_3N\cdot HCl$ 100w_i	$(C_2H_5)_3N\cdot HCl$ m_i/mol kg^{-1} [a]	H_2O 100w_i	Refract. index[b]	Solid phase[c]
			temp = 20 °C			
27.2[d]	3.25	—	—	72.8	1.3700	A
17.6[e]	2.19	12.4	1.33	70.0		A
15.1[d]	1.82	12.7	1.33	72.2	1.3775	A
8.8	1.2	27.4	3.24	63.8	1.3905	A
6.5	0.97	35.0	4.51	58.5	1.3995	A
2.6	0.42	43.8	6.16	53.6	1.4115	A
1.2[e]	0.24	55.2	9.54	43.6		A+B
—	—	57.2	10.1	42.8	1.4295	B
			temp = 60 °C			
—	—	64.0	13.4	36.0		B
3.3	0.80	61.0	12.9	35.7		B
4.1	1.0	60.2	12.7	35.7		A+B
5.5	1.1	52.5	9.42	42.0		A
9.8	1.7	40.7	6.19	49.5		A
13.0	2.11	33.5	4.72	53.5		A
19.0	2.95	25.1	3.38	55.9		A
30.3	4.69	13.5	1.81	56.2		A
38.4	6.07	6.6	0.90	55.09		A
45.2	7.17	—	—	54.8		A

[a]The mol/kg H_2O values were calculated by the compilers.
[b]The refractive indices are given in source paper[2] only.
[c]The solid phases are: A = $NH_4H_2PO_4$; B = $(C_2H_5)_3N\cdot HCl$.
[d]These data are given in source paper[2] only.
[e]There data are given in source paper[1] only.

Auxiliary Information

Method / Apparatus / Procedure:

The refractometric variation of the isothermal method was used. The compilers assume that it was the method described elsewhere.[1] $NH_4H_2PO_4$ was determined by potentiometric titration. The compositon of the solid phase was determined by the Schreinemaker's method.

Source and Purity of Materials:

Reagent grade $NH_4H_2PO_4$ and pure $(C_2H_5)_3N\cdot HCl$ were recrystallized before being used.

Estimated Error:

The $NH_4H_2PO_4$ content has a precision of ±0.2%.

References:

[1]E.F. Zhuravlev, A.D. Sheveleva, Zh. Neorg. Khim. **5**, 2630 (1960).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Dibutylamine hydrochloride; $C_8H_{20}ClN$; [6287-40-7]
(3) Tributylamine hydrochloride; $C_{12}H_{28}ClN$; [6309-30-4]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

A. A. Volkov, O. E. Sosnina, Z. D. Kalinkina, N. I. Oginskaya, Termicheskiy Analiz i Fazovye Rovnovesiya, Perm 126-8 (1985).

Variables:

Composition at 20 °C

Prepared By:

J. Eysseltová

Experimental Data

The isotherms are given in graphical form only.

The composition of the eutonic point in the $NH_4H_2PO_4$–$(C_4H_9)_2NH_2Cl$–H_2O system is:

12.6 mass % $NH_4H_2PO_4$ (1.62 mol/kg H_2O compiler);
19.7 mass % $(C_4H_9)_2NH_2Cl$ (1.76 mol/kg H_2O compiler);
67.7 mass % H_2O

The authors state that the crystallization field of tributylamine hydrochloride in the $NH_4H_2PO_4$–$(C_4H_9)_3NHCl$–H_2O system is too small to be depicted on the phase diagram.

Auxiliary Information

Method / Apparatus / Procedure:

The refractometric variation of the isothermal method[1] was used.

Source and Purity of Materials:

Reagent grade $NH_4H_2PO_4$ was used. Dibutyl- and tributyl-amine hydrochlorides were synthesized from the respective amines and HCl.

Estimated Error:

No information is given.

References:

[1] R. V. Merclin, Izv. ENI Perm. Un-t 11, 1 (1937).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(4) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

7.3. $NH_4H_2PO_4$–Urea–NH_4NO_3–H_2O

Solubility data for the $NH_4H_2PO_4$–urea–NH_4NO_3–H_2O system has been reported in three papers.[1–3] However, no critical evaluation can be made of these data. In Ref. 1 a supersaturation isotherm of $NH_4H_2PO_4$ in the title system is reported. In Refs. 2 and 3 different temperatures were selected and no direct comparison of the data is possible.

[1] M. E. Pozin, B. A. Kopylev, N. K. Shilling, Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol. **8**, 883 (1965).
[2] G. I. Tudorovskaya, F. G. Margolis, Khim. Prom. (Moscow) **42**, 678 (1966).
[3] I. M. Kaganskiy, A. M. Babenko, Zh. Prikl. Khim. (Leningrad) **43**, 742 (1970).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

M. E. Pozin, B. A. Kopylev, N. K. Shilling, Izv. Vissh. Ucheb. Zaved., Khim. Khim. Tekhnol. **8**, 883-8 (1965).

Variables:

Composition at 10 °C.

Prepared By:

J. Eysseltová

Experimental Data

Supersaturation in the $NH_4H_2PO_4$–NH_4NO_3–$CO(NH_2)_2$–H_2O system at 10 °C

Part 1. The authors' data:

Point No.	Total solute $100w_i$	NH_4NO_3 comp[a]	$NH_4H_2PO_4$ comp[a]	$CO(NH_2)_2$ comp[a]	Total nutrition solute	Total nutrition soln
1	40	12.8	51.2	36	59.12	23.6
2	37	15	60	25	61.12	22.6
3	30	16.1	64.4	19.5	62.29	18.7
4	40	22	33	45	52.58	20.9
5	37	27.2	40.8	32	53.9	19.9
6	35	28	42	30	54.81	19.2
7	30	30	45	25	55.38	16.6
8	40	30	30	40	51.36	20.0
9	37	32.5	32.5	35	51.79	19.15
10	35	39.5	39.5	21	52.80	18.5
11	30	41.5	41.5	17	53.13	15.95
12	40	52.7	26.3	21	47.65	19.1
13	37	60.7	30.3	9	47.85	17.7
14	35	61.3	30.7	8	47.85	16.4
15	30	63.3	31.7	5	47.94	14.1

[a]The composition unit is: mass % of solute.

Part 2. The compiler has calculated the following concentration values from the data in Part 1

Point no.	NH_4NO_3 $100w_i$	NH_4NO_3 m_i/mol kg^{-1}	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ m_i/mol kg^{-1}	$CO(NH_2)_2$ $100w_i$	$CO(NH_2)_2$ m_i/mol kg^{-1}	H_2O $100w_i$
1	5.1	1.1	20.5	2.97	14.4	4.0	60
2	5.6	1.1	22.2	3.06	9.2	2.4	63
3	4.8	0.86	19.3	2.40	5.9	1.4	70
4	8.8	1.8	13.2	1.91	18.0	5.0	60
5	10.4	2.00	15.1	2.08	11.8	3.13	63
6	9.8	1.9	14.7	1.97	10.5	2.69	65
7	9.0	1.6	13.5	1.68	7.5	1.8	70
8	12.0	2.5	12.0	1.74	16.0	4.44	60
9	11.8	2.35	12.2	1.68	13.0	3.42	63
10	13.8	2.66	13.8	1.85	7.4	1.9	65
11	12.4	2.22	12.4	1.55	5.1	1.2	70
12	21.1	4.39	10.5	1.52	8.4	2.3	60
13	22.5	4.45	11.2	1.55	3.3	0.88	63
14	21.5	4.12	10.7	1.44	2.8	0.72	65
15	19.0	3.39	9.5	1.2	1.5	0.36	70

NOTE: The authors state that the equilibrium solid phase is $NH_4H_2PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

Mixtures of dry salts and water were stirred vigorously (900–1200 rpm) and heated 1–2 °C above the temperature at which the last crystal disappeared. The solution was then cooled at the rate of 1–2 deg/hr and the temperature at which the last crystal disappeared was observed. The supersaturation isotherms were constructed graphically.

Source and Purity of Materials:

Chemically pure salts were recrystallized three times before use.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(4) Water, H_2O; [7732-18-5]

Original Measurements:

G. L. Tudorovskaya, F. G. Margolis, Khim. Prom. (Moscow) **42**, 678-80 (1966).

Variables:

Composition at 50 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Solubility in the $NH_4H_2PO_4$ - NH_4NO_3 - $CO(NH_2)_2$ - H_2O system at 50 °C

Soln no	$CO(NH_2)_2$ $100w_i$	m_i[a]	NH_4NO_3 $100w_i$	m_i[a]	$NH_4H_2PO_4$ $100w_i$	m_i[a]	H_2O $100w_i$	Solid phase[b]
1	—	—	71.77	34.32	2.11	0.702	26.12	A+B
2	13.90	11.66	64.00	40.28	2.25	0.985	19.85	A+B
3	22.05	26.49	61.89	55.78	2.20	1.38	13.86	A+B
4	32.06	47.53	54.69	60.84	2.02	1.56	11.23	A+B
5	34.63	54.04	53.25	62.34	1.45	1.18	10.67	A+B
6	46.50	XX[c]	51.66	XX[c]	1.84	XX[c]	—	A+B
7	48.92	XX[c]	48.58	XX[c]	2.51	XX[c]	—	B+C
8	51.40	56.56	30.97	25.57	2.50	1.44	15.13	B+C
9	52.62	59.89	30.00	25.62	2.75	1.63	14.63	B+C
10	52.95	38.12	16.44	8.88	7.48	2.81	23.13	B+C
11	53.30	33.91	8.25	3.94	12.28	4.08	26.17	B+C
12	51.30	30.80	—	—	20.97	6.57	27.73	B+C
13	—	—	77.05	41.94	—	—	22.95	A
14	66.52	33.08	—	—	—	—	33.48	C
15	—	—	—	—	41.60	6.19	58.40	B

[a]The compiler calculated the molalities as mol/kg H_2O values.
[b]The solid phases are: A = NH_4NO_3; B = $NH_4H_2PO_4$; C = $CO(NH_2)_2$.
[c]The molalities designated as XX cannot be calculated, because the solutions are anhydrous.

Part 2. The authors express the concentrations of the solutions in Part 1 in the following way also

Soln no	$CO(NH_2)_2$ comp[a]	NH_4NO_3 comp[a]	$NH_4H_2PO_4$ comp[a]	H_2O comp[a]
1	97.10[b]	—	2.9	35.40
2	17.40	79.79	2.81	24.75
3	25.50	71.95	2.55	16.10
4	36.12	61.69	2.19	12.65
5	38.78	59.60	1.62	11.96
6	46.50	51.66	1.84	—
7	48.92	48.58	2.51	—
8	60.50	36.55	2.95	17.85
9	61.60	35.18	3.22	17.20
10	69.60	21.40	9.00	30.13
11	77.20	11.18	16.62	35.60
12	71.03	—	25.57	38.63
13	—	100.0	—	29.78
14	100.0	—	—	50.33
15	—	—	100.0	140.60

[a]The authors state that the composition unit is g H_2O/100 g solute. The compiler's opinion is that this is a typographical error and the composition unit is g/100 g solute.
[b]This is an obvious error. The correct values are: — for urea and 97.10 for NH_4NO_3 (compiler).

Auxiliary Information

Method / Apparatus / Procedure:

An isothermal method was used. Equilibrium was checked by repeated analysis.

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was kept constant to within 0.1 K.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

I. M. Kaganskiy, A. M. Babenko, Zh. Prikl. Khim. (Leningrad) **43**, 742-9 (1970).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Six sections through the system were investigated. The sections are:

No. 1 (10% NH_4NO_3 + 90% H_2O)–urea–$NH_4H_2PO_4$
No. 2 (20% NH_4NO_3 + 80% H_2O)–urea–$NH_4H_2PO_4$
No. 3 (30% NH_4NO_3 + 70% H_2O)–urea–$NH_4H_2PO_4$
No. 4 (40% NH_4NO_3 + 60% H_2O)–urea–$NH_4H_2PO_4$
No. 5 (50% NH_4NO_3 + 50% H_2O)–urea–$NH_4H_2PO_4$
No. 6 urea–$NH_4H_2PO_4$–H_2O

Solubility data for saturated solutions in the $NH_4H_2PO_4$–NH_4NO_3–urea–H_2O system

Sect	$NH_4H_2PO_4$		NH_4NO_3		$CO(NH_2)_2$		H_2O		Solid
no	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	t/°C	phase[b]
1	10.0	1.07	9.0	1.4	—	—	81.0	−5.8	A+B
1	9.2	1.1	8.17	1.39	9.08	2.06	73.55	−9.0	A+B
1	8.2	1.1	7.34	1.39	18.36	4.625	66.1	−11.5	A+B
1	7.4	1.1	6.48	1.39	27.78	7.928	58.34	−14.5	A+B
1	8.0	1.4	5.52	1.39	36.8	12.3	49.68	−2.5	A+B
1	9.5	2.03	4.52	1.39	45.25	18.50	40.73	18.0	B+C
1	3.4	0.51	6.32	1.35	32.0	9.14	58.28	−14.4	A+C
1	—	—	6.74	1.39	32.6	8.95	60.66	−14.2	A+C
1	7.0	1.1	6.14	1.39	31.6	9.52	55.26	−15.3	A+B+C
2	5.1	0.58	18.98	3.123	—	—	75.92	−8.5	A+B
2	5.1	0.65	17.08	3.123	9.49	2.31	68.33	−12.0	A+B
2	4.7	0.67	15.24	3.121	19.06	5.202	61.0	−14.0	A+B
2	4.1	0.67	13.42	3.121	28.77	8.919	53.71	−16.5	A+B
2	5.0	0.95	11.4	3.12	38.0	13.9	45.6	−3.0	B+C
2	6.7	1.6	9.33	3.12	46.65	20.81	37.32	18.0	B+C
2	3.45	0.572	13.11	3.123	31.0	9.84	52.44	−17.6	A+C
2	—	—	13.7	3.12	31.4	9.52	54.9	−17.5	–[c]
2	4.0	0.67	13.0	3.12	31.0	9.93	52.0	−17.4	A+B+C
3	3.1	0.40	29.07	5.354	—	—	67.83	−11.5	A+B
3	3.2	0.46	26.13	5.352	9.68	2.64	60.98[d]	−14.0	A+B
3	2.6	0.41	23.37	5.352	19.48	5.946	54.54[d]	−17.0	A+B
3	2.5	0.45	20.475	5.3538	29.25	10.19	47.775	−20.2	A+B
3	3.5	0.75	17.37	5.354	38.60	15.86	40.53	−1.0	B+C
3	4.6	1.2	14.31	5.354	47.7	23.8	33.39	19.0	B+C
3	2.1	0.38	20.37	5.354	30.0	10.5	47.53	−20.3	A+C
3	—	—	20.94	5.354	30.2	10.3	48.86	−20.8	A+C
3	2.0	0.37	20.1	5.35	31.0	11.0	46.9	−20.3	A+B+C
4	1.5	0.22	39.4	8.33	—	—	59.1	−15.5	A+B
4	1.5	0.25	35.46	8.328	9.85	3.08	53.19	−18.1	A+B
4	1.5	0.28	31.52	8.328	19.7	6.94	47.28	−21.4	A+B
4	1.15	0.241	27.67	8.323	29.65	11.89	41.51[d]	−19.5	B+C
4	2.5	0.62	23.4	8.33	39.0	18.5	35.1	1.6	B+C
4	—	—	28.4	8.31	28.9	11.3	42.7	−24.5	A+C
4	1.2	0.25	28.0	8.37	29.0	11.6	41.8	−23.6	A+B+C
5	1.5	0.27	49.25	12.49	—	—	49.25	−4.0	B+D
5	1.45	0.28	44.34	12.49	9.85	3.70	44.34[d]	−9.5	B+D
5	1.2	0.26	39.52	12.49	19.76	8.325	39.52	−16.5	B+D
5	0.75	0.19	34.73	12.49	29.77	14.26	34.73[d]	−20.5	B+C
5	1.5	0.44	29.55	12.49	39.4	22.2	29.55	6.0	B+C
5	—	—	36.0[e]	12.5	28.0	13.0	36.0	−25.9	C+D
5	0.8	0.2	35.6	12.5	28.0	13.1	35.6	−22.4	B+C+D
6	16.8	1.76	—	—	—	—	83.2	−4.0	A+B
6	15.2	1.73	—	—	8.48	1.85	76.32	−6.5	A+B
6	13.0	1.62	—	—	17.4	4.16	69.6	−9.0	A+B
6	11.8	1.66	—	—	26.46	7.136	61.74	−13.0	A+B
6	13.2	2.20	—	—	34.7	11.1	52.1	−2.0	B+C
6	14.5	2.94	—	—	42.7	16.6	42.8	15.2	B+C
6	6.9	0.97	—	—	31.0	8.31	62.1	−12.8	A+C
6	—	—	—	—	33.0	8.20	67.0	−10.8	A+C
6	10.0	1.45	—	—	29.9	8.28	60.1	−13.8	A+B+C

[a]The compiler calculated the molalities as mol/kg H_2O values.
[b]The solid phases are: A = ice; B = $NH_4H_2PO_4$; C = $CO(NH_2)_2$; D = NH_4NO_3.
[c]The solid phase is not specified. The compiler thinks it is A+C.
[d]For these data the sum of the components do not equal 100%. The compiler's calculations were made on the assumption that the values for the salt contents are correct and the source of the error is the value for the water content.
[e]The authors give 26.0 for this value. The compiler thinks this is a typographical error and the correct value is the one given here.

Auxiliary Information

Method / Apparatus / Procedure:

An improved polythermic method was used.[1]

Source and Purity of Materials:

Reagent grade or chemically pure materials were recrystallized twice and dried at 60 °C.

Estimated Error:

No information is given.

References:

[1]L.N. Erayzer, I.M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

A. G. Bergman, A. A. Gladkovskaya, R. A. Galushkina, Zh. Neorg. Khim. **18**, 1978-80 (1973).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Four sections through the system were investigated. The sections are:

No. 1 (45.81% $NH_4H_2PO_4$ + 54.19% KH_2PO_4)-urea-water.
No. 2 (71.72% $NH_4H_2PO_4$ + 28.28% KH_2PO_4)-urea-water.
No. 3 (65.70% $NH_4H_2PO_4$ + 34.30% urea)-KH_2PO_4-water.
No. 4 (85.18% $NH_4H_2PO_4$ + 14.82% urea)-KH_2PO_4-water.

Solubility data for saturated solutions in the urea-$NH_4H_2PO_4$-KH_2PO_4-H_2O system

Sect no	Urea		$NH_4H_2PO_4$		KH_2PO_4		H_2O		Solid
	$100w_1$	m_1[a]	$100w_2$	m_2[a]	$100w_3$	m_3[a]	$100w_4$	t/°C	phases[b]
1	1.80	0.38	9.34	1.04	11.06	1.04	77.80	+6.4	A+B+C
1	1.50	0.30	8.06	0.86	9.54	0.86	80.90	−4.1	A+B+D
1	12.60	2.84	6.23	0.73	7.37	0.73	73.8	−8.0	B+C+D
1	40.00	13.48	4.86	0.85	5.74	0.85	49.4	+8.0	C+F+G
1	32.80	3.41	4.20	0.62	5.00	0.63	58.00	−6.0	C+E+F
1	28.40	8.50	8.98	1.40	10.62	1.40	55.60	−18.0	C+D+E
2	1.20	0.28	21.30	2.67	8.40	0.89	69.10	+19.4	A+B+C
2	1.40	0.29	14.34	1.58	5.66	0.52	78.60	−5.5	A+B+D
2	24.50	6.76	10.90	1.57	4.30	0.52	60.30	−8.8	B+C+E
2	32.00	9.68	9.32	1.47	3.68	0.49	55.00	−7.0	C+E+F
2	41.00	12.88	8.65	1.41	3.35	0.46	53.00	+9.6	C+F+G
2	24.60	6.72	10.40	1.48	4.10	0.49	60.90	−16.00	B+D+E
3	11.73	3.17	22.47	3.17	4.20	0.50	61.60	+26.5	A+B+C
3	6.52	1.45	12.48	1.45	6.50	0.64	74.50	−8.0	A+B+D
4	4.30	10.52	24.70	3.15	3.00	0.32	68.00	+17.0	A+B+C
4	2.70	5.22	15.70	1.74	3.50	0.32	78.10	−5.2	A+B+D

[a]The compiler calculated the molalities as mol/kg H_2O values.
[b]The solid phases are: A = α-$NH_4H_2PO_4$; B = (α-NH_4,K)H_2PO_4; C = (β-NH_4,K)H_2PO_4; D = ice; E = α-urea; F = β-urea; G = γ-urea.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.[1] Solid carbon dioxide was used as the cooling agent.

Source and Purity of Materials:

Chemically pure salts and bidistilled water were used.

Estimated Error:

No information is given.

References:

[1]A. G. Bergman, N.P. Luzhnaya, Fiziko-Khimicheskie Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-sul'fatnogo Tipa, Moscow, IAN SSSR, 1951.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Urea: CH_4N_2O: [57-13-6]
(3) Potassium chloride; KCl; [7747-40-7]
(4) Water; H_2O: [7732-18-5]

Original Measurements:

A. N. Sarbaev, E. V. Polyakov, A. Kh. Ruchkova, Z. A. Polyakova, M. F. Tyunina, L. I. Gushchina, Khim. Prom. (Moscow) **48**, 597-61 (1972)

Variables:

Composition, temperature and boiling points at pressures of 20–760 mm Hg of samples containing a N:P:K ratio equal to 1:1:1.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Solubility in the $NH_4H_2PO_4$–$CO(NH_2)_2$–KCl–H_2O system at the ratio N:P:K = 1:1:1

t/°C	Total salt	$CO(NH_2)_2$[a]		$NH_4H_2PO_4$[a]		KCl[a]		H_2O[a]
	$100w_i$	$100w_i$	m_i	$100w_i$	m_i	$100w_i$	m_i	$100w_i$
10	24.7	4.27	0.945	13.5	1.56	6.93	1.23	75.3
20	29.4	5.08	1.20	16.1	1.98	8.25	1.57	70.6
30	33.0	5.71	1.42	18.0	2.34	9.26	1.85	67
40	36.0	6.23	1.62	19.7	2.67	10.1	2.12	64
50	39.0	6.75	1.84	21.3	3.04	10.9	2.41	61
60	42.3	7.32	2.11	23.1	3.48	11.9	2.76	57.7
70	45.7	7.91	2.42	25.0	4.00	12.8	3.17	54.3
80	49.6	8.58	2.83	27.1	4.67	13.9	3.70	50.4
90	53.5	9.26	3.31	29.2	5.46	15.0	4.33	46.5
100	57.5	9.92	3.96	31.4	6.41	16.1	5.09	38.2
110	61.8	10.7	4.66	33.8	7.68	17.3	6.09	38.2
120	66.7	11.5	5.77	36.4	9.51	18.7	7.54	33.3
130	72.5	12.5	7.59	39.6	12.5	20.3	9.92	27.5
140	79.8	13.8	11.4	43.6	18.8	22.4	14.9	20.2

[a]These values were calculated by the compiler. The molalities are exppressed as mol/kg H_2O.

Part 2. Composition and boiling points of saturated solutions in the $NH_4H_2PO_4$–$CO(NH_2)_2$–KCl–H_2O system at the ratio N:P:K = 1:1:1

Press	Total state	$CO(NH_2)_2$[a]		$NH_4H_2PO_4$[a]		KCl[a]		H_2O[a]	b.p.
mm Hg	$100w_i$	$100w_i$	m_i	$100w_i$	m_i	$100w_i$	m_i	$100w_i$	°C
20	31.9	5.52	1.35	17.4	2.23	8.95	1.76	68.1	26.7
50	36.6	6.33	1.66	20.0	2.74	10.3	2.17	63.4	41.8
100	41.2	7.13	2.02	22.5	3.33	11.6	2.64	58.8	56.9
150	44.2	7.65	2.28	24.2	3.76	12.4	2.98	55.8	65.7
200	47.0	8.13	2.55	25.7	4.21	13.2	3.34	53.0	73.0
250	49.0	8.48	2.77	26.8	4.56	13.7	3.62	51.0	78.7
300	50.9	8.81	2.99	27.8	4.92	14.3	3.90	49.1	83.6
350	52.6	9.10	3.20	28.7	5.27	14.8	4.18	47.4	87.9
400	54.2	9.38	3.41	29.6	5.62	15.2	4.45	45.8	91.8
450	55.7	9.64	3.62	30.4	5.97	15.6	4.73	44.3	95.4
500	56.9	9.84	3.80	31.1	6.27	16.0	4.97	43.1	98.5
550	57.9	10.0	3.96	31.6	6.53	16.2	5.18	42.1	100.9
600	59.1	10.2	4.16	32.3	6.86	16.6	5.44	40.9	103.6
650	60.0	10.4	4.32	32.8	7.12	16.8	5.65	40.0	105.7
700	61.0	10.6	4.50	33.3	7.43	17.1	5.89	39.0	108.0
760	62.2	10.8	4.74	34.0	7.82	17.5	6.19	37.8	110.6

[a]These values were calculated by the compiler. The molalities are expressed as mol/kg H_2O.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used at temperatures below 50 °C. Supersaturation was prevented by seeding. Above 50 °C a synthetic method was used.[1-3] The samples were placed in glass ampules and placed in an air thermostat where they were rotated at 3 rpm. They were observed through a glass window in the thermostat. A self constructed apparatus based on the principle described elsewhere[4] was used.

Source and Purity of Materials:

Reagent grade $NH_4H_2PO_4$ (GOST 6691-67) and urea (GOST 3771-64) and chemically pure KCl (GOST 4234-69) were used.

Estimated Error:

With the visual-polythermic method the difference between the temperature of dissolution of the last crystal and appearance of the first crystal was less than + 0.5 K. Above 50 °C the temperature had a precision of 0.4 K. No other information is given.

References:

[1]V. F. Alekseev, Zh. Russ. Fiz.-Khim. Obshch. **8**, 329 (1876).
[2]E. S. Lebedeva, S. M. Khodeeva, Zh. Fiz. Khim. **35**, 2602 (1961).
[3]I. R. Krichevskiy, N. E. Khazanova, L. P. Liushits, Zh. Fiz. Khim. **31**, 2711 (1957).
[4]Ya. Goroletskiy, V. M. Olevskiy, R. P. Levitanayte, Zh. Fiz. Khim. **38**, 2874 (1964).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic
September, 1995

Critical Evaluation:

7.4. $NH_4H_2PO_4$–NH_4NO_3–H_2O

Solubility in the $NH_4H_2PO_4$–NH_4NO_3–H_2O system has been reported in nine papers.[1-9] Figure 16 shows the data of some of these papers as well as the related data of two papers in which the title system was studied as a boundary of a multicomponent system.[10,11] According to Figure 16, the data of Tudorovskaya and Margolis[10] for solutions saturated with both $NH_4H_2PO_4$ and NH_4NO_3 seem to be in error when compared with the rest of the data.

Solubility isotherms have also been reported at temperatures higher than 100 °C. Fridman *et al.*[4] presented a network of isotherms and a smoothing equation (1).

$$x = a - t/b \quad (1)$$

where x is the mass % water, t is the temperature, and a and b are constants. No temperature limits are given for the validity of this equation. The results of Fridman can be compared with those of Varlamov *et al.*[8] for the region 140–170 °C and those of Margolis and Glazova[5] at 100 and 110 °C. The agreement is not good. The values reported by Varlamov, et al.[8] and by Margolis and Glazova[5] show a slightly higher water content than do those of Fridman, et al.[4] Some investigators[4,8] report the existence of anhydrous solutions in the regions rich in NH_4NO_3. Varlamov *et al.*[8] paid special attention to the solubility values in these areas. The evaluator attempted to compare the isotherms of Bergman and Bochkarev[1-3] with values calculated using Eq. (1). The agreement was very poor. More experimental work is needed to resolve these differences.

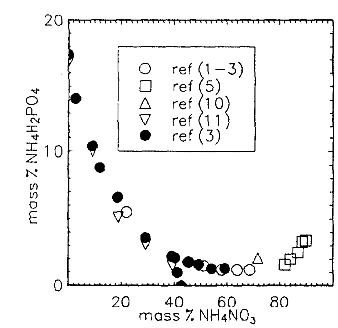

FIG. 16. Solubility in the $NH_4H_2PO_4$–NH_4NO_3–H_2O system.

References:

[1]P. F. Bochkarev, Tr. Vostoch.-Sibir. Gosud. Inst. 3 (1935).

[2]A. G. Bergman, P. F. Bochkarev, Zh. Prikl. Khim. (Leningrad) **10**, 1531 (1937).

[3]A. G. Bergman, P. F. Bochkarev, Izv. Akad. Nauk SSSR, Otd. Mater. Estestv. Nauk 237 (1938).

[4]S. D. Fridman, N. N. Polyakov, L. S. Skum, R. Ya. Kirindasova, Khim. Prom. (Moscow) **43**, 206 (1967).

[5]F. G. Margolis, T. V. Glasova, Issledovaniya po Khimii i Tekhnologii Udobreniy, Pesticidov i Soley, Moscow 82 (1966).

[6]Ya. S. Shenkin, S. A. Ruchnova, A. F. Shenkina, Zh. Neorg. Khim. **13**, 256 (1968).

[7]Ya. S. Shenkin, S. A. Ruchnova, A. F. Shenkina, Zh. Prikl. Khim. (Leningrad) **43**, 1163 (1970).

[8]M. L. Varlamov, I. M. Kaganskiy, I. A. Kashcheeva, G. A. Manakin, Zh. Prikl. Khim. (Leningrad) **46**, 2767 (1973).

[9]G. A. Sorina, L. T. Bezlyudova, E. V. Mushkina, G. M. Kozlovskaya, Yu. V. Tsekhanskaya, Zh. Prikl. Khim. (Leningrad) **57**, 947 (1987).

[10]G. L. Tudorovskaya, F. G. Margolis, Khim. Prom. (Moscow) **42**, 678 (1966).

[11]I. M. Kaganskiy, A. M. Babenko, Zh. Prikl. Khim. (Leningrad) **43**, 742 (1970).

Components	**Original Measurements:**
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1] (2) Ammonium nitrate; NH_4NO_3; [6484-52-2] (3) Water; H_2O; [7732-18-5]	1. P. F. Bochkarev, Tr. Vostoch.-Sibir. Gosud. Inst. 3-22 (1935). 2. A. G. Bergman, P. F. Bochkarev, Zh. Prikl. Khim. (Leningrad) **10**, 1531-60 (1937). 3. A. G. Bergman, P. F. Bochkarev, Izv. Akad. Nauk SSSR, Otd. Mat. Estestv. Nauk 237-66 (1938).
Variables:	**Prepared By:**
Temperature and composition	L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility in the NH_4NO_3—$NH_4H_2PO_4$–H_2O system

NH_4NO_3 comp[a]	NH_4NO_3 $100w_i$	NH_4NO_3 mol/kg[b]	$NH_4H_2PO_4$ comp[a]	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ mol/kg[b]	H_2O comp[a]	H_2O $100w_i$	Solid phase[c]
				temp = −10 °C				
100	27.2	4.7	0	0.0	0.0	1188.5	72.8	A
85.1	22.0	3.8	14.9	5.5	0.7	1245.8	72.5	A+B
91.6	28.8	5.3	8.4	3.8	0.5	951.9	67.4	B
95.9	38.9	8.3	4.1	2.4	0.4	642.6	58.7	B
97.1	45.0	10.6	2.9	2	0.3	507.2	53	B
97.3	45.6	10.8	2.7	1.8	0.3	498.3	52.6	B+C
100	47.0	11.1	0	0.0	0.0	501.2	53.0	C
				temp = 0 °C				
0	0.0	0.0	100	18.4	2.0	1830.6	81.6	B
50.5	8.8	1.4	49.5	12.4	1.4	1986.4	78.8	B
76.3	18.3	3.1	23.7	8.2	1.0	2360	73.5	B
89.5	28.6	5.4	10.5	4.8	0.6	926.6	66.6	B
94.7	38.7	8.3	5.3	3.1	0.5	633.6	58.2	B
96.4	44.9	10.6	3.6	2.4	0.4	502.6	52.7	B
97.5	49.0	12.5	2.5	1.9	0.3	433.9	49.1	B
98.0	51.2	13.5	2.0	1.5	0.3	402.0	47.3	B+C
100	53.6	14.4	0	0.0	0.0	384.5	46.4	C
				temp = 10 °C				
0.0	0.0	0.0	100	21.4	2.4	2345.7	78.6	B
43.75	8.4	1.4	56.25	15.5	1.8	1760	76.1	B
72.1	18.0	3.1	27.9	10	1.2	1280	72	B
81.4	23.5	4.3	18.6	7.7	1.0	1057.9	68.8	B
86.7	28.1	5.3	13.3	6.2	0.8	890.9	65.7	B
93.0	38.2	8.3	7.0	4.1	0.6	624.4	57.7	B
95.5	44.6	10.6	4.5	3	0.5	498.8	52.4	B
97.0	48.8	12.4	3	2.2	0.4	432.4	49	B
98.0	54.1	15.3	2.0	1.6	0.3	356.4	44.3	B
98.6	58.0	17.8	1.4	1.2	0.3	308.2	40.8	B+C
100	59.6	18.4	0	0.0	0.0	301.6	40.4	C
				temp = 20 °C				
0	0.0	0.0	100	25.5	3.0	1862.7	74.5	B
38.3	8.1	1.4	61.7	18.8	2.2	1536.7	73.1	B
67.4	17.5	3.1	32.6	12.2	1.5	1200.6	70.3	B
83.1	27.6	5.4	16.9	8.1	1.1	860.0	64.3	B
86.2	30.5	6.1	13.3	7	1.0	733.1	62.5	B
91.5	37.9	8.3	8.5	5.1	0.8	612	57	B
94.5	44.3	10.6	5.5	3.7	0.6	493.3	52	B
96.2	48.6	12.5	3.5	2.8	0.5	427.6	48.6	B
97.2	53.8	15.3	2.8	2.2	0.4	353.4	44	B
98.1	59.0	18.7	1.9	1.6	0.4	291.2	39.4	B

98.8	64.0	23.0	1.2	1.2	0.3	238.8	34.8	B+C
100	65.1	23.3	0	0.0	0.0	238.3	34.9	C
				temp=30 °C				
0	0.0	0.0	100	30.2	3.8	1478.6	69.8	B
33.0	7.8	1.4	67	22.7	2.8	1312.2	69.5	B
61.7	16.9	3.1	38.3	1.51	1.9	1103.5	68.0	B
79.1	26.9	5.4	20.9	10.3	1.4	820.2	62.8	B
89.7	37.5	8.3	10.3	6.2	1.0	598.7	56.3	B
93.4	43.9	10.6	6.6	4.5	0.8	487.9	51.6	B
95.2	48.2	13.9	4.8	8.5[d]	0.6	424.2	43.5[d]	B
96.7	53.5	15.3	3.3	2.7	0.5	351.8	43.8	B
97.7	58.8	18.7	2.3	2	0.4	289.7	39.2	B
98.8	68.7	28.5	1.2	1.2	0.3	192.5	30.1	B+C
100	69.7	28.7	0	0.0	0.0	193.1	30.3	C

[a]The composition unit is: mol/100 mol solute.
[b]The molalities were calculated by the compilers.
[c]The solid phases are: A=ice; B=$NH_4H_2PO_4$; C=NH_4NO_3.
[d]The compilers believe these are erroneous, the proper values being 3.5 and 48.3, respectively.

NOTE: These data are given in source paper (1) and repeated in source papers (2) and (3). The differences are due to typographical errors.

In addition to the above data, source paper (3) also contains the following information about the composition and crystallization temperature of solutions saturated with two or three solid phases.

	NH_4NO_3			$NH_4H_2PO_4$			H_2O		Solid
comp[a]	$100w_i$	mol/kg[b]	comp[a]	$100w_i$	mol/kg[b]	comp[a]	$100w_i$	t/°C	phase[c]
0	0	0	100	17.4	1.83	3036.4	82.6	−4.4	A+B
21.8	2.7	0.41	78.2	14.1	1.47	2960.3	83.2	−4.6	A+B
55.4	9	1	44.6	10.4	1.12	2214.9	80.6	−6.3	A+B
66.4	12	1.9	33.6	8.8	0.97	1945.1	79.2	−6.9	A+B
80.3	18.6	3.11	13.7	6.6	0.77	1436.7	74.8	−9.0	A+B
92.1	29.0	5.37	7.9	3.6	0.46	951.9	67.4	−12.9	A+B
96.3	39.1	8.42	8.7[d]	2.2	0.32	642.6	58.7	−15.9	A+B
97.2	45.2	10.7	2.8	1.8	0.30	506.4	53	−11	B+C
97.8	49.2	12.5	2.2	1.6	0.28	439.4	49.2	−3.2	B+C
98.4	54.2	15.2	1.6	1.3	0.25	359.1	44.5	5.2	B+C
98.5	59.3	18.8	1.5	1.3	0.29	290.8	39.4	11.4	B+C
100	42.7	9.31	0	0	0	596.8	57.3	−16.4	A+C
98.3	41.1	8.87	1.7	1.0	0.15	615.7	57.9	−16.3	A+C
96.5	40.3	8.74	3.5	2.1	0.32	613.6	57.6	−16.8	A+B+C

[a]The composition unit is: mol/100 mol solute.
[b]The molalities were calculated by the compilers.
[c]The solid phases are: A=ice; B=$NH_4H_2PO_4$; C=NH_4NO_3.
[d]This is an obvious error. The compilers' calculations are based on the $100w_i$ values.

Auxiliary Information

Method / Apparatus / Procedure:
A visual polythermic method was used.

Source and Purity of Materials:
Chemically pure materials were recrystallized before use.

Estimated Error:
No information is given.

Components
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
S. D. Fridman, N. N. Polyakov, L. S. Skum, R. Ya. Kirindasova, Khim. Prom. (Moscow) **43**, 206-8 (1967).

Variables:
Temperature and composition.

Prepared By:
J. Eysseltová

Experimental Data

The temperature of disappearance of the last crystal is reported as a linear function of the water content of the saturated solution, Eq. (1):

$$t=a-b(100w_3) \quad (1)$$

The values of the constants a and b depend on the $NH_4H_2PO_4/NH_4NO_3$ ratio only and are given in Table I.

Table I. Values of the constants a and b in Eq. (1)

Relation $NH_4H_2PO_4/NH_4NO_3$	a	b	Relation $NH_4H_2PO_4/NH_4NO_3$	a	b
10:90	155.0	2.08	55 : 45	182.5	2.12
20:80	170.5	2.12	70 : 30	188.5	2.33
30:70	176.0	2.12	80 : 20	191.5	2.45
42:58	180.5	2.12			

NOTE: The solubility isotherms were derived from the experimental data.

Table II. Solubility in the $NH_4H_2PO_4-NH_4NO_3-H_2O$ system

$NH_4H_2PO_4$		NH_4NO_3		H_2O
$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$
		temp=100 °C		
7.4	2.46	66.5	31.8	26.1
13.4	3.52	53.5	20.2	33.1
19.2	4.64	44.8	15.5	36.0
43.5	9.98	18.6	6.13	37.9
50.4	11.8	12.6	4.25	37.0
		temp=110 °C		
7.9	3.22	70.8	41.5	21.3
14.3	4.38	57.3	25.2	28.4
20.7	5.79	48.2	19.4	31.1
28.0	7.31	38.7	14.5	33.3
36.2	9.23	29.7	10.9	34.1
46.5	12.0	19.9	7.40	33.6
53.6	14.1	13.4	5.07	33.0
		temp=120 °C		
8.3	4.37	75.2	56.9	16.5
15.3	5.64	61.1	32.3	23.6
22.0	7.22	51.5	24.3	26.5
30.0	9.15	41.5	18.2	28.5
38.8	11.5	31.8	13.5	29.4
49.4	14.6	21.2	9.01	29.4
56.8	17.0	14.2	6.12	29.0
		temp=130 °C		
8.8	6.5	79.4	84.1	11.8
16.2	7.41	64.8	42.6	19.0
23.5	9.37	54.7	31.4	21.8

32.0	11.6	44.1	23.0	23.9
41.5	14.7	33.9	17.2	24.6
52.4	18.2	22.5	11.2	25.1
60.08	20.97	15.02	7.535	24.9
		temp = 140 °C		
9.3	11.5	83.7	149.4	7.0
17.2	10.5	68.6	60.3	14.2
24.9	12.7	58.0	42.4	17.1
33.9	15.3	46.9	30.5	19.2
44.0	19.1	36.0	22.5	20.0
55.5	23.3	23.8	14.4	20.7
63.4	26.5	15.8	9.49	20.8
		temp = 150 °C		
9.8	38.7	88.0	499.7	2.2
18.1	16.6	72.4	95.2	9.5
26.3	18.4	61.3	61.8	12.4
35.9	21.5	49.6	42.7	14.5
46.6	26.5	38.1	31.1	15.3
59.9	36.2	25.7	22.3	14.4
66.6	34.5	16.6	12.3	16.8
		temp = 160 °C		
19.0	34.4	76.2	198.3	4.8
27.7	30.9	64.5	103.3	7.8
37.9	33.6	52.3	66.7	9.8
49.1	39.9	40.2	46.9	10.7
61.5	43.8	26.3	26.9	12.2
69.8	47.4	17.4	17.0	12.8
		temp = 170 °C		
20.0	869.3	79.8	4984.5	0.2
29.1	87.2	68.0	292.9	2.9
39.9	68.0	55.0	134.7	5.1
51.1	67.3	42.3	80.1	6.6
64.4	70.0	27.6	43.1	8.0
73.0	72.9	18.3	26.3	8.7
		temp = 180 °C		
41.9	1214.1	57.8	2406.8	0.3
54.3	363.1	44.4	426.7	1.3
67.4	158.3	28.9	97.6	3.7
76.2	140.9	19.1	50.8	4.7

[a]The molalities were calculated by the compiler.

NOTE: For all these solutions, $NH_4H_2PO_4$ was the equilibrium solid phase.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.

Source and Purity of Materials:

No information is given.

Estimated Error:

The precision of the temperature of disappearance of the last crystal was ± 0.5 K.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

1. Ya. S. Shenkin, S. A. Ruchnova, A. P. Shenkina, Zh. Neorg. Khim. 13, 256-9 (1968). 2. Ya. S. Shenkin, S. A. Ruchnova, A. P. Shenkina, Zh. Prikl. Khim. (Leningrad) **43**, 1163-4 (1970).

Variables:

Temperature and composition at 0.13, 0.5 and 1 atm.

Prepared By:

J. Eysseltová

Experimental Data

NH_4NO_3 100w_i	NH_4NO_3 m_i/mol kg^{-1} [a]	$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1} [a]	H_2O 100w_i	b.p./°C	Solid phase[b]
			press. = 0.13 atm			
—	—	45.81	7.35	54.19	55.6	A
8.21	1.83	35.64	5.52	56.15	58.7	A
23.36	5.43	22.92	3.71	53.72	59.3	A
37.35	9.57	13.88	2.47	48.77	59.3	A
41.24	10.54	9.88	1.76	48.88	61.1	A
47.85	13.38	7.48	1.46	44.67	62.9	A
59.17	21.16	5.90	1.47	34.93	64.5	A
60.43	21.81	4.96	1.25	34.61	71.4	A
63.00	25.77	6.46	1.84	30.54	67.5	A
65.19	28.41	6.15	1.87	28.66	68.4	A
68.55	32.40	5.02	1.65	26.43	69.4	A
72.93	43.16	5.96	2.45	21.11	77.2	A
75.70	48.32	4.73	2.10	19.57	79.2	A
76.47	53.97	5.83	2.86	17.70	87.2	A
79.42	58.74	3.69	1.90	16.89	80.5	A
81.37	79.23	5.80	3.93	12.83	89.5	A
83.80	105.42	6.27	5.49	9.93	84.7	A
87.03	253.43	8.68	17.59	4.29	87.4	A+B
91.74	138.75	—	—	8.26	86.0	B
			press. = 0.5 atm			
—	—	59.90	12.98	40.10	85.5	A
8.35	2.53	50.35	10.60	41.30	89.4	A
16.19	5.08	44.01	9.61	39.80	89.9	A
16.83	5.36	43.98	9.76	39.19	91.6	A
25.05	7.67	34.16	7.28	40.79	91.6	A
28.89	8.87	30.40	6.49	40.71	91.5	A
33.60	10.52	26.50	5.77	39.90	92.4	A
44.19	13.95	16.23	3.56	39.58	94.0	A
46.36	16.39	18.31	4.51	35.33	95.3	A
56.68	22.76	12.21	3.41	31.11	96.0	A
52.45	18.89	12.86	3.22	34.69	97.6	A
59.94	25.86	11.11	3.34	28.95	99.7	A
66.01	33.51	9.38	3.31	24.61	101.3	A
68.12	37.27	9.05	3.45	22.83	104.0	A
71.33	46.46	9.49	4.30	19.18	109.4	A
73.30	50.79	8.67	4.18	18.03	109.5	A
76.53	61.09	7.82	4.34	15.65	115.5	A
78.04	76.22	9.17	6.23	12.79	117.4	A
78.67	94.68	10.95	9.17	10.38	125.5	A
79.65	145.04	13.49	17.09	6.86	138.4	A
78.65	152.33	14.90	20.08	6.45	139.5	A

79.30	168.47	14.82	21.91	5.88	146.0	A
78.13	176.49	16.34	25.68	5.53	131.1	A
77.02	198.38	18.13	32.49	4.85	150.0	A
41.08	189.36	56.21	180.30	2.71	171.3	A
33.40	187.95	64.38	252.09	2.22	173.4	A
28.40	186.73	69.70	318.88	1.90	183.0	A
			press. = 1 atm			
·		70.95	21.23	29.05	109.0	A
7.30	3.07	62.96	18.40	29.74	110.4	A
12.78	5.35	57.38	16.72	29.84	111.8	A
16.47	7.00	54.14	16.01	29.39	111.6	A
25.25	10.57	44.90	13.08	29.85	112.8	A
33.69	14.50	37.29	11.17	29.02	114.4	A
39.63	16.91	31.09	9.23	29.28	115.8	A
40.35	17.23	30.39	9.03	29.26	116.3	A
45.48	20.26	26.48	8.21	28.04	117.4	A
51.05	24.18	22.58	7.44	26.37	119.2	A
54.82	27.41	20.20	7.03	24.98	121.4	A
59.35	31.68	17.25	6.41	23.40	125.6	A
61.32	38.83	18.95	8.35	19.73	122.9	A
64.80	43.85	16.74	7.88	18.46	127.2	A
66.67	51.63	17.20	9.27	16.13	125.9	A
67.78	57.44	17.48	10.31	14.74	135.2	A
68.95	71.01	18.92	13.56	12.13	140.8	A
69.75	98.09	21.37	20.91	8.88	148.0	A
69.33	121.98	23.57	28.86	7.10	151.5	A
69.61	127.13	23.55	29.93	6.84	153.5	A
67.78	125.63	25.48	32.86	6.74	156.1	A
68.32	150.52	26.01	39.88	5.67	157.7	A
61.98	146.64	32.74	53.90	5.28	161.7	A
60.96	347.73	36.85	146.27	2.19	166.2	A
39.11	148.50	57.60	152.19	3.29	179.0	A

[a]These values were calculated by the compiler.
[b]The solid phases are: A = $NH_4H_2PO_4$; B = NH_4NO_3.

Compiler's Note: The data at 0.13 atm were published in source paper 2. The rest of the data were published in source paper 1.

Auxiliary Information

Method / Apparatus / Procedure:

The saturated solution and solid phase were placed in a three-necked bottle. A thermometer was placed in one neck. In another neck there was a two parallel reflux condenser connected to a differential manometer. After equilibrium the phases were sampled with a filter pipet which was placed in the third neck of the flask. Nitrogen content was determined by the Kjeldahl method, phosphorus by the pyrophosphate method (probably weighed as $Mg_2P_2O_7$–compiler) and water by the iodine-acetate method (no details given).

Source and Purity of Materials:

All materials were of chemically pure grade and were recrystallized twice from water.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

M. L. Varlamov, I. M. Kaganskiy, I. A. Kashcheeva, G. A. Manakin, Zh. Prikl. Khim. (Leningrad) **46**, 2767-9 (1973).

Variables:

Composition at 140–170 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the $NH_4H_2PO_4-NH_4NO_3-H_2O$ system

NH_4NO_3 100w_i	NH_4NO_3 m_i/mol kg^{-1} [a]	$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1} [a]	H_2O 100w_i	Solid phase[b]
		temp = 140 °C			
88.30	298.12	8.00	18.79	3.70	A
83.90	143.57	8.80	10.48	7.30	A
77.50	80.68	10.50	7.61	12.00	A
66.40	48.79	16.60	8.49	17.00	A
56.00	34.13	23.50	9.96	20.50	A
45.10	25.38	32.70	12.80	22.20	A
92.00	383.09	5.00	14.49	3.00	B
		temp = 150 °C			
88.0	XX[c]	12.0	XX[c]		B
97.02	612.12	1.00	4.39	1.98	B
89.82	5610.25	9.98	433.76	0.20	B
83.0	XX[c]	17.0	XX[c]		A
81.88	143.66	11.00	13.43	7.12	A
84.29	299.99	12.20	30.21	3.51	A
70.40	73.29	17.60	12.75	12.00	A
59.00	49.14	26.00	15.07	15.00	A
47.90	33.06	34.00	16.33	18.10	A
		temp = 160 °C			
95.4	XX[c]	4.6	XX[c]		B
80.0	XX[c]	20.0	XX[c]		A
78.40	612.12	20.00	108.66	1.60	A
75.07	299.61	21.80	60.54	3.13	A
64.00	92.97	27.40	27.70	8.60	A
50.70	50.67	36.80	25.59	12.50	A
42.00	34.98	43.00	24.92	15.00	A
		temp = 170 °C			
66.0	XX[c]	34.0	XX[c]		A
63.11	239.63	33.60	88.78	3.29	A
46.35	79.32	46.35	55.19	7.30	A
55.10	137.66	39.90	69.37	5.00	A

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = $NH_4H_2PO_4$; B = NH_4NO_3.
[c]The molalities cannot be calculated because the liquid phase is anhydrous.

Auxiliary Information

Method / Apparatus / Procedure:

A modified polythermic method[1] was used, where heat inertia of the system was eliminated. The compiler assumes that the isotherms were derived graphically from experimental results.

Source and Purity of Materials:

Chemically pure or reagent grade salts were recrystallized twice and dried at 60 °C. They were further dehydrated with absolute ethanol. They were analyzed for nitrogen (both NH_3 and NO_3^-) and P_2O_5 (no details are given). The m.p. of NH_4NO_3 was checked as 169±0.2 °C.

Estimated Error:

The difference between the temperature of appearance of the first crystal and disappearance of the last crystal was 1–3 °C.

References:

[1]L. N. Erayser, I. M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

G. A. Sorina, L. I. Bezlyudova, E. V. Mushkina, G. M. Kozlovskaya, Yu. V. Tsekhanskaya, Zh. Prikl. Khim. (Leningrad) 57, 974-7 (1984) .

Variables:

Temperature and composition at the mol ratio of N/P_2O_5 =1.

Prepared By:

J. Eysseltová

Experimental Data

Two sets of data are given.

Set 1

Solubility in the $NH_4H_2PO_4$–NH_4NO_3–H_2O system at a mol ratio N/P_2O_5=1

	Solute	NH_4NO_3[a]		$NH_4H_2PO_4$[a]		H_2O[a]
t/°C	$100w_1 + 100w_2$	$100w_1$	m_i/mol kg^{-1}	$100w_2$	m_i/mol kg^{-1}	$100w_3$
20.5	30.0	17.6	3.14	12.4	1.54	70.0
48.0	40.0	23.4	4.87	16.6	2.41	60.0
72.5	50.0	29.3	7.32	20.7	3.60	50.0
94.5	60.0	35.2	11.0	24.8	5.39	40.0
106.5	70.0	41.0	17.1	29.0	8.40	30.0

[a]These data were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used. were used.

Source and Purity of Materials:

Chemically pure salts and distilled water

Estimated Error:

Precision of temperature of disappearance of last crystal was ±0.1 K.

Set 2

Solubility in the $NH_4H_2PO_4$–NH_4NO_3–H_2O system at a mol ratio N/P_2O_5=1

Soln no.	t/°C	Solute $100w_1 + 100w_2$	Density (g/cm^3)	Viscosity (cp)
1	20.0	30.0	1.146	
2	30.0	33.6	1.159	1.280
3	40.0	37.1	1.173	1.149
4	50.0	40.9	1.189	1.090
5	60.0	44.8	1.206	1.093
6	70.0	48.9	1.224	1.135
7	80.0	53.2	1.243	1.221
8	90.0	57.5	1.264	1.320

The compiler has calculated the following data:

Soln	NH_4NO_3		$NH_4H_2PO_4$		H_2O
no.	$100w_1$	m_i/mol kg^{-1}	$100w_2$	m_i/mol kg^{-1}	$100w_3$
1	17.6	3.14	12.4	1.54	70.0
2	19.7	3.70	13.9	1.82	66.4
3	21.7	4.32	15.4	2.12	62.9
4	24.0	5.07	16.9	2.49	59.1
5	26.3	5.94	18.5	2.92	55.2
6	28.7	7.01	20.2	3.44	51.1
7	31.2	8.32	22.0	4.09	46.8
8	33.7	9.9	23.8	4.87	42.5

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used. The density was measured by the use of a self-constructed pycnometer. Viscosity was measured with a standard capillary VPZH-2 viscometer (solutions more dilute than 50%) or a viscometer according to Golubev.[1]

Source and Purity of Materials:

Chemically pure salts and distilled water were used.

Estimated Error:

Precision of temperature of disappearance of last crystal was ±0.1 K; of density was ±0.310 g/cm^3; of viscosity was ±2% (concn<50%) and ±7% (more concd solns).

References:

[1]I. F. Golubev, T. M. Potikhova, Tr. GIAP, Moscow, ONTI pp 67-80 (1971).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Urea nitrate; $CO(NH_2)_2 \cdot HNO_3$; [17687-37-5]
(4) Urea phosphate; $CO(NH_2)_2 \cdot H_3PO_4$; [4861-19-2]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

R. Kümmel, R. Fahsl, Z. Anorg. Allg. Chem. **402**, 305-11 (1973).

Variables:

Composition at 20 and 40 °C.

Prepared By:

J. Eysseltová

Experimental Data

Composition of invariant points in the $NH_4H_2PO_4$–NH_4NO_3–$CO(NH_2)_2 \cdot HNO_3$–$CO(NH_2)_2 \cdot H_3PO_4$–H_2O system at 20 and 40 °C

	$CO(NH_2)_2 \cdot HNO_3$		$CO(NH_2)_2 \cdot H_3PO_4$		$NH_4H_2PO_4$		H_2O	
t/°C	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	Solid phases[b]
20	15.26	3.245	14.92	2.469	31.59	7.183	38.23	A+B+C
40	19.53	6.255	20.73	5.168	34.36	11.77	25.38	A+B+C

	NH_4NO_3		$CO(NH_2)_2 \cdot HNO_3$		$NH_4H_2PO_4$		H_2O	
t/°C	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	Solid phases[b]
20	51.89	20.10	7.85	1.98	8.01	1.57	32.25	A+C+D
40	54.99	30.49	11.27	4.07	11.21	3.15	22.53	A+C+D

[a]The molalities were calculated by the compiler and are expressed as mol kg^{-1}.
[b]The solid phases are: A = $CO(NH_2)_2 \cdot HNO_3$; B = $CO(NH_2)_2 \cdot H_3PO_4$; C = $NH_4H_2PO_4$; D = NH_4NO_3.

Auxiliary Information

Method / Apparatus / Procedure:

Mixtures of the components were stirred vigorously and allowed to equilibrate for 15–25 hrs. The equilibrium was checked by repeated analysis of the liquid phase. PO_4^{3-} content was determined by precipitation titration with $La(NO_3)_3$ using Chromazurol S as indicator; NH_4^+ was determined, after removal of phosphate ions with the aid of anion exchange resin, by formol titration. Urea was determined gravimetrically as dixanthedrylurea or after enzyme decomposition as NH_3. Nitrate was determined gravimetrically with Nitron. The sum of NH_4^+ and urea was determined by the Kjeldahl method and the concentration of urea salts was determined by acidimetric titration with a METROHM potentiograph.

Source and Purity of Materials:

The ammonium salts were recrystallized before use. The urea salts were synthesized from urea and an equivalent amount of the respective acid and recrystallized several times.

Estimated Error:

The temperature was kept constant to within ± 0.05 K.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7783-20-2]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

7.5. $NH_4H_2PO_4$–$(NH_4)_2SO_4$–H_2O

Six articles[1–6] report solubility data for this system. In addition, Akiyama, *et al.*[7] present graphical data along with a smoothing equation (1)

$$100w_i = A/(m+B) \tag{1}$$

where $100w_i$ is the solubility of $NH_4H_2PO_4$ expressed as mass %; m is the mole ratio SO_4/PO_4 in the saturated solution; and A and B are constants having the following values:

t/°C	A	B
0	34.6	1.8
25	44.6	1.5
50	48.7	1.2

A comparison of the data at 263, 273, 293 and 298 K, as well as calculated values from Eq. (1) is given in Fig. 17. Only at 293 K are the data from different authors in agreement with each other. Therefore, data at 293 K are accepted tentatively while the data at the other temperatures can be evaluated only after the results of additional work are available. An isotherm at 293 K has been reported,[1] but when this is compared with Figure 17 its values appear to have a systematic error. Furthermore, the invariant points described in one article[4] do not correspond with results reported by others and, therefore, are rejected. The smoothing equation of Akiyama, *et al.*[7] seems to fit the experimentally determined data fairly well, especially when the concentration of $(NH_4)_2SO_4$ is less than 25 mass %.

References:

[1]S. I. Vol'fkovich, L. E. Berlin, B. M. Mantsev, Tr. NIUIFa 228 (1940).
[2]S. Uno, Kogyo Kagaku Zasshi **43**, 399 (1940); J. Soc. Chem. Ind. Japan Suppl. Binding **43**, 168B (1940).
[3]F. V. Bel'chev, A. G. Bergman, Zh. Prikl. Khim. (Leningrad) **17**, 520 (1944).
[4]A. G. Bergman, R. Tashtemirov, Ukr. Khim. Zh. **33**, 565 (1967).
[5]R. M. Bayramova, A. I. Agaev, Uch. Zap. Azerb. Gos. Univ., Ser. Khim. Nauk 8 (1968).
[6]Ya. S. Shenkin, O. I. Freyman, Zh. Neorg. Khim. **15**, 3151 (1970).
[7]T. Akiyama, H. Kanzaki, S. Minagawa, Nippon Dojo Hiryogaku Zasshi **49**, 243 (1978).

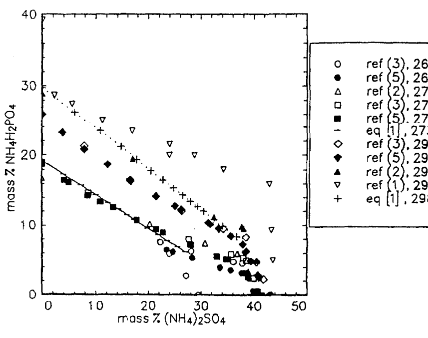

FIG. 17. Solubility of $NH_4H_2PO_4$ in the $NH_4H_2PO_4$–$(NH_4)_2SO_4$–H_2O system.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7783-20-2]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

S. I. Vol'fkovich, L. E. Berlin, B. M. Mantsev, Tr. NIUIFa 228-42 (1940).

Variables:

Composition at 25 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility in the $NH_4H_2PO_4$–$(NH_4)_2SO_4$–H_2O system at 25 °C

	$NH_4H_2PO_4$			$(NH_4)_2SO_4$		H_2O	Solid
g/100g H_2O	$100w_i$[a]	m_i/mol kg^{-1a}	g/100g H_2O	$100w_i$[a]	m_i/mol kg^{-1a}	$100w_i$[a]	phase[b]
41.30	29.23	3.59	0.00	0.00	0.00	70.77	A
40.20	28.67	3.61	2.28	2.23	0.24	69.10	A
37.80	27.43	3.56	5.89	5.56	0.63	67.01	A
33.60	25.15	3.43	12.60	11.19	1.33	63.66	A
30.70	23.49	3.43	20.40	16.94	2.15	59.57	A
27.50	21.57	3.44	21.50	23.95	3.33	54.48	A
25.00	20.00	3.10	31.50	23.95	3.23	56.05	A
25.00	20.00	3.39	40.30	28.72	4.24	51.28	A+B
22.10	18.10	3.30	52.10	34.25	5.44	47.65	B
19.10	16.04	3.40	75.20	42.92	7.91	41.04	B
10.30	9.34	1.72	76.60	43.37	6.94	47.29	B
5.29	5.02	0.85	77.20	43.57	6.41	51.41	B

[a]These values were calculated by the compilers.
[b]The solid phases are: A–$NH_4H_2PO_4$; B–$(NH_4)_2SO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

The *isothermal method* was used. Equilibration required 4 to 5 days. The composition of the solid phases was determined by the Schreinemakers method. More experimental details have been described previously.[1]

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was kept constant within ± 0.05 K. No other information is given.

References:

[1]L. E. Berlin, B. M. Mantsev, Zh. Prikl. Khim. (Leningrad) **6**, 385 (1933).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7722-76-1]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

S. Uno, Kogyo Kagaku Zasshi **43**, 399-402 (1940); J. Soc. Chem. Ind., Japan, Suppl. Binding **43**, 168B-70B (1940).

Variables:

Composition at 0, 25, 40, 70 and 100 °C.

Prepared By:

Hiroshi Miyamoto

Experimental Data

Composition of saturated solutions in the $NH_4H_2PO_4$–$(NH_4)_2SO_4$–H_2O system

	$(NH_4)_2SO_4$			$NH_4H_2PO_4$		H_2O	Solid
g/100g H_2O	$100w_i$[a]	m_i/mol kg^{-1a}	g/100g H_2O	$100w_i$[a]	m_i/mol kg^{-1a}	$100w_i$[a]	phase[b]
			temp = 0 °C				
70.6	41.4	5.34	0	0	0	58.6	A
67.4	38.9	5.10	3.67	3.39	0.310	57.71	A
64.6	36.9	4.89	10.6	6.05	0.922	57.05	A+B
64.2	36.8	4.86	10.4	5.96	0.904	57.24	A+B
49.7	30.7	3.76	12.0	7.42	1.04	61.88	B
29.1	20.3	2.20	14.6	10.2	1.27	69.5	B
0	0	0	20.2	16.8	1.76	83.2	B
			temp = 25 °C				
76.2	43.2	5.77	0	0	0	56.80	A
74.1	40.5	5.61	9.07	4.95	0.789	54.55	A
72.6	38.1	5.49	18.2	9.54	1.58	52.26	A+B
71.9	37.7	5.44	18.8	9.86	1.63	52.44	A+B
57.8	32.5	4.37	20.0	11.2	1.74	56.3	B
26.8	17.0	2.03	30.8	19.5	2.68	63.5	B
0	0	0	40.6	28.9	3.53	71.1	B
			temp = 40 °C				
80.8	44.7	6.11	0	0	0	55.3	A
77.7	39.9	5.88	16.8	8.64	1.46	51.46	A
75.9	37.7	5.74	25.3	12.6	2.20	49.7	A+B
61.6	32.3	4.66	28.9	15.2	2.51	52.5	B
39.5	22.5	2.99	35.7	20.4	3.10	57.1	B
18.8	11.5	1.42	44.4	27.2	3.86	61.3	B
0	0	0	56.4	36.1	4.90	63.9	B
			temp = 70 °C				
91.4	47.8	6.92	0	0	0	52.2	A
84.5	39.2	6.39	31.1	14.4	2.70	46.4	A
78.8	33.2	5.96	58.6	24.7	5.10	42.1	A+B
79.9	33.6	6.05	58.0	24.4	5.04	42.0	A+B
53.8	24.4	4.07	66.7	30.2	5.80	45.4	B
22.0	10.6	1.66	84.9	41.0	7.38	48.4	B
0	0	0	100.9	50.2	8.77	49.8	B
			temp = 100 °C				
103.6	50.9	7.84	0	0	0	49.1	A
97.9	42.2	7.41	34.0	14.7	2.96	43.1	A
93.1	36.4	7.05	62.4	24.4	5.42	39.2	A
86.9	30.5	6.58	98.2	34.4	8.54	35.1	A
82.9	27.0	6.27	124.4	40.5	10.8	32.5	A
81.7	26.0	6.18	132.1	42.1	11.5	31.9	A+B
78.5	25.2	5.94	133.1	42.7	11.6	32.1	B
50.5	17.1	3.82	144.7	49.0	12.6	33.9	B
20.8	7.31	1.57	163.9	57.6	14.2	35.09	B
0	0	0	176.7	63.9	15.4	36.1	B

[a]These values were calculated by the compiler.
[b]The solid phases are: A = $(NH_4)_2SO_4$; B = $NH_4H_2PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. Ammonium dihydrogenphosphate, ammonium sulfate and water were placed in ampules. The mixtures were shaken in a thermostat. After equilibrium was established, the mixtures were allowed to settle. A pipet was used to obtain aliquots of the saturated solution for analysis. The saturated solution was evaporated to dryness and the solid obtained was dried at 110–115 °C to determine total solid content. The NH_3 content was determined by the distillation method. The phosphate and sulfate contents were determined gravimetrically as $Mg(NH_4)PO_4$ and $BaSO_4$, respectively.

Source and Purity of Materials:

Chemically pure reagents were recrystallized.

Estimated Error:

Solubility: nothing specified.
Temperature: precision ± 0.05 K at 298 and 313 K, ± 0.5 K at 313 and 373 K. No information is given about 273 K.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7783-20-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

F. V. Bel'chev, A. G. Bergman, Zh. Prikl. Khim. (Leningrad) **17**, 520-6 (1944).

Variables:

Composition at −10, −5, 0, 10, 20 and 30 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–$(NH_4)_2SO_4$–H_2O system

	$NH_4H_2PO_4$			$(NH_4)_2SO_4$		H_2O		Solid
Comp[a]	$100w_i$	m_i/mol kg^{-1} [b]	Comp[a]	$100w_i$	m_i/mol kg^{-1} [b]	Comp[a]	$100w_i$	phase[c]
				temp = −10 °C				
0	0.0	0.0	100	29.4	3.2	1781	70.6	A
5.50	2.8	0.3	94.5	27.2	2.9	1879	70.0	A
12.56	6.0	0.7	87.44	24.0	2.6	1876	70.0	A
16.41	7.6	0.9	83.59	22.2	2.4	1538	70.2	B
11.25	6.3	0.8	88.74	28.1	3.2	1518	65.6	B
6.82	4.8	0.7	93.18	36.1	4.6	1139	59.1	B
6.71	4.6	0.7	93.29	37.8	5.0	1069	57.6	B+C
3.26	2.4	0.4	96.74	39.1	5.1	1065	58.5	C
0	0.0	0.0	100	40.4	5.1	1081	59.6	C
				temp = −5 °C				
0	0.0	0.0	100	16.7	1.5	3660	83.3	A
11.38	3.4	0.4	88.62	14.4	1.3	3708	82.2	A
25.42	7.0	0.7	74.58	11.6	1.1	3875	81.4	A
38.74	10.0	1.1	61.26	9.0	0.8	4050	81.0	A
56.73	13.7	1.5	43.27	6.0	0.6	4270	80.3	A+B
45.46	12.7	1.4	54.55	8.7	0.8	3606	78.6	B
23.22	9.6	1.2	76.78	18.0	1.9	2270	72.4	B
12.7	7.2	1.0	87.3	28.1	3.3	1472	64.7	B
7.77	5.4	0.8	92.23	36.1	4.7	1120	58.5	B
7.37	5.2	0.8	92.63	38.0	5.1	1010	56.8	B+C
3.0	2.4	0.4	96.76	39.6	5.2	1048	58.0	C
0	0.0	0.0	100	40.8	5.2	1066	59.2	C
				temp = 0 °C				
100	18.8	2.0	0	0.0	0.0	5620	81.2	B
49.4	14.7	1.7	51.6	8.6	0.8	3550	76.7	B
25.42	10.7	1.3	74.58	17.8	1.9	2198	71.5	B
14.05	8.0	1.1	85.95	27.6	3.2	1477	64.4	B
8.48	5.9	0.9	91.52	35.7	4.6	1098	58.4	B
7.42	5.4	0.8	92.58	38.0	5.1	1013	56.6	B+C
7.03	5.0	0.8	92.97	38.5	5.2	1002	56.5	C
3.2	2.4	0.4	96.8	40.0	5.3	1021	57.6	C
0	0.0	0.0	100	41.2	5.3	1049	58.8	C
				temp = 10 °C				
100	22.2	2.5	0	0.0	0.0	4497	77.8	B
55.08	17.4	2.0	44.92	8.2	0.8	2985	74.4	B
30.69	13.4	1.7	69.31	17.3	1.9	2035	69.3	B
17.81	10.0	1.4	82.14	27.0	3.2	1413	63.0	B
11.18	7.6	1.2	88.92	35.0	4.6	1068	57.4	B
9.12	6.9	1.1	90.88	38.2	5.3	952	54.9	B+C
6.56	4.9	0.8	93.44	39.6	5.4	962	55.5	C

3.12	2.4	0.4	96.88	41.0	5.5	981	56.6	C
0	0.0	0.0	100	42.0	5.5	1015	58.0	C
				temp=20 °C				
100	26.0	3.0	0	0.0	0.0	3507	74.0	B
60.93	21.3	2.6	39.07	7.8	0.8	2606	70.9	B
36.55	16.6	2.2	63.45	16.6	1.9	1882	66.8	B
20.72	12.1	1.7	79.28	26.3	3.2	1362	61.6	B
13.67	9.5	1.5	86.33	34.3	4.6	1040	56.2	B
12.62	8.3	1.4	87.38	38.5	5.5	887	53.2	B+C
6.43	4.8	0.8	93.57	40.5	5.6	928	54.7	C
2.79	2.3	0.4	97.21	41.9	5.7	930	55.8	C
0	0.0	0.0	100	42.9	5.7	977	57.1	C
				temp=30 °C				
100	30.6	3.8	0	0.0	0.0	2896	69.4	B
66.06	25.2	3.2	33.94	7.4	0.8	2268	67.4	B
41.83	20.1	2.7	58.17	16.1	1.9	1702	63.8	B
25.37	15.4	2.3	74.78	25.4	3.2	1268	59.2	B
17.17	12.0	1.9	82.83	33.2	4.6	1004	54.8	B
13.39	10.2	1.7	86.61	38.4	5.7	849	51.4	B+C
9.26	7.2	1.2	90.74	40.2	5.8	871	52.6	C
5.95	4.7	0.8	94.05	41.8	5.9	884	53.5	C
2.70	2.3	0.4	97.30	43.1	6.0	910	54.6	C
0	0.0	0.0	100	43.7	5.9	946	56.3	C

[a] The composition unit is: mol/100 mol of solute.
[b] The molalities were calculated by the compilers.
[c] The solid phases are: A = ice; B = $NH_4H_2PO_4$; C = $(NH_4)_2SO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used. No other details are given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7783-20-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

R. M. Bayramova, A. I. Agaev, Uch. Zap. Azer. Gos. Univ., Ser. Khim. Nauk 8-16 (1968).

Variables:

Composition and temperature.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4-(NH_4)_2SO_4-H_2O$ system

$(NH_4)_2SO_4$		$NH_4H_2PO_4$		H_2O		
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	Comp[b]	Solid phase
			temp=−10 °C			
40.4	5.1	0.0	0.0	59.6	1083.1	$(NH_4)_2SO_4$
39.8	5.1	0.6	0.1	59.6	1080.5	$(NH_4)_2SO_4$
37.7	4.8	3.2	0.5	59.1	1048.4	$(NH_4)_2SO_4$
35.6	4.4	3.6	0.5	60.8	1123.2	$NH_4H_2PO_4$
33.6	4.1	4.0	0.6	62.7	1299.1	$NH_4H_2PO_4$
28.3	3.2	5.4	0.7	66.3	1409.9	$NH_4H_2PO_4$
24.6	2.7	6.2	0.8	69.2	1605.5	$NH_4H_2PO_4$
23.4	2.5	6.5	0.8	70.1	1666.5	$NH_4H_2PO_4$
			temp=0 °C			
41.4	5.3	0.0	0.0	58.6	1065.3	$(NH_4)_2SO_4$
40.7	5.2	0.6	0.1	58.7	1049.3	$(NH_4)_2SO_4$
39.0	5.1	2.6	0.4	58.4	1028.6	$(NH_4)_2SO_4$
38.5	5.0	3.2	0.5	58.3	1026.5	$(NH_4)_2SO_4$
35.1	4.4	5.2	0.8	59.7	1082.4	$NH_4H_2PO_4$
34.8	4.4	5.2	0.8	60.0	1094.5	$NH_4H_2PO_4$
33.0	4.1	5.6	0.8	61.4	1150.4	$NH_4H_2PO_4$
28.0	3.3	7.2	1.0	64.8	1329.3	$NH_4H_2PO_4$
27.8	3.2	7.3	1.0	64.9	1324.3	$NH_4H_2PO_4$
22.8	2.5	9.0	1.1	68.2	1518.3	$NH_4H_2PO_4$
21.5	2.4	9.4	1.2	69.1	1577.5	$NH_4H_2PO_4$
17.8	1.9	10.8	1.3	71.4	1748.1	$NH_4H_2PO_4$
13.2	1.3	12.6	1.5	74.2	1974.2	$NH_4H_2PO_4$
10.8	1.1	13.4	1.5	75.8	2129.0	$NH_4H_2PO_4$
8.5	0.8	14.3	1.6	77.2	2276.6	$NH_4H_2PO_4$
5.0	0.5	16.2	1.8	78.8	2451.5	$NH_4H_2PO_4$
4.2	0.4	16.5	1.8	79.3	2528.0	$NH_4H_2PO_4$
0.0	0.0	19.0	2.0	81.0	2719.3	$NH_4H_2PO_4$
			temp=10 °C			
42.2	5.5	0.0	0.0	57.8	1013.5	$(NH_4)_2SO_4$
41.7	5.5	0.6	0.1	57.7	1011.7	$(NH_4)_2SO_4$
39.8	5.3	2.9	0.4	57.3	982.3	$(NH_4)_2SO_4$
38.4	5.1	5.0	0.8	56.6	970.2	$(NH_4)_2SO_4$
37.6	5.1	6.3	1.0	56.1	965.1	$(NH_4)_2SO_4$
37.4	5.1	6.8	1.1	55.8	959.9	$(NH_4)_2SO_4$
34.2	4.4	7.6	1.1	58.2	1001.2	$NH_4H_2PO_4$
32.2	4.1	8.1	1.2	59.7	1062.0	$NH_4H_2PO_4$
31.9	4.0	8.2	1.2	59.9	1105.9	$NH_4H_2PO_4$
27.0	3.2	9.8	1.3	63.2	1218.9	$NH_4H_2PO_4$
22.1	2.5	11.5	1.5	66.4	1386.8	$NH_4H_2PO_4$
21.4	2.4	11.8	1.5	66.8	1408.8	$NH_4H_2PO_4$
17.4	1.9	13.4	1.7	69.2	1554.8	$NH_4H_2PO_4$
15.0	1.6	14.4	1.8	70.6	1648.3	$NH_4H_2PO_4$

12.7	1.3	15.5	1.9	71.8	1731.8	$NH_4H_2PO_4$
8.2	0.8	17.4	2.0	74.4	1929.9	$NH_4H_2PO_4$
6.0	0.6	18.8	2.2	75.2	2001.2	$NH_4H_2PO_4$
4.0	0.4	19.8	2.3	76.2	2090.8	$NH_4H_2PO_4$
0.0	0.0	22.4	2.5	77.6	2158.6	$NH_4H_2PO_4$
			temp = 20 °C			
43.2	5.8	0.0	0.0	56.8	973.3	$(NH_4)_2SO_4$
41.0	5.5	2.6	0.4	56.4	948.2	$(NH_4)_2SO_4$
40.8	5.5	2.9	0.4	56.3	943.3	$(NH_4)_2SO_4$
39.4	5.4	4.9	0.8	55.7	914.3	$(NH_4)_2SO_4$
38.4	5.2	6.2	1.0	55.4	899.2	$(NH_4)_2SO_4$
38.5	5.3	6.3	1.0	55.2	892.0	$(NH_4)_2SO_4$
37.8	5.2	7.3	1.2	54.9	880.9	$(NH_4)_2SO_4$
35.6	4.8	8.5	1.3	55.9	877.6	$NH_4H_2PO_4$
33.4	4.4	9.6	1.5	57.0	947.1	$NH_4H_2PO_4$
31.8	4.1	10.2	1.5	58.0	984.0	$NH_4H_2PO_4$
31.4	4.1	10.4	1.6	58.2	990.9	$NH_4H_2PO_4$
26.2	3.2	12.3	1.7	61.5	1124.5	$NH_4H_2PO_4$
25.0	3.0	12.8	1.8	62.2	1137.8	$NH_4H_2PO_4$
21.4	2.5	14.2	1.9	64.4	1227.0	$NH_4H_2PO_4$
16.7	1.9	16.3	2.1	67.0	1387.5	$NH_4H_2PO_4$
16.6	1.9	16.5	2.1	66.9	1385.5	$NH_4H_2PO_4$
12.2	1.3	18.7	2.4	69.1	1508.7	$NH_4H_2PO_4$
7.8	0.8	20.8	2.5	71.4	1654.8	$NH_4H_2PO_4$
3.8	0.4	23.2	2.8	73.0	1759.2	$NH_4H_2PO_4$
0.0	0.0	26.0	3.1	74.0	1816.6	$NH_4H_2PO_4$
			temp = 30 °C			
44.0	5.9	0.0	0.0	56.0	941.8	$(NH_4)_2SO_4$
41.4	5.6	3.0	0.5	55.6	916.8	$(NH_4)_2SO_4$
40.1	5.5	4.8	0.8	55.1	892.5	$(NH_4)_2SO_4$
39.5	5.5	5.8	0.9	54.7	875.6	$(NH_4)_2SO_4$
39.2	5.4	6.2	1.0	54.6	871.2	$(NH_4)_2SO_4$
38.6	5.4	7.4	1.2	54.0	846.9	$(NH_4)_2SO_4$
37.4	5.3	9.4	1.5	53.2	811.8	$(NH_4)_2SO_4$
36.9	5.3	10.1	1.7	53.0	807	$NH_4H_2PO_4$
35.7	5.0	10.7	1.7	53.6	824.4	$NH_4H_2PO_4$
35.0	4.9	11.0	1.8	54.0	837	$NH_4H_2PO_4$
32.4	4.4	12.2	1.9	55.4	891	$NH_4H_2PO_4$
30.5	4.1	13.1	2.0	56.4	913	$NH_4H_2PO_4$
27.4	3.6	14.5	2.2	58.1	972.3	$NH_4H_2PO_4$
25.5	3.2	15.1	2.2	59.4	1021.8	$NH_4H_2PO_4$
20.7	2.5	17.2	2.4	62.1	1130.4	$NH_4H_2PO_4$
16.2	1.9	19.2	2.6	64.6	1242.5	$NH_4H_2PO_4$
11.8	1.3	21.4	2.8	66.8	1348.1	$NH_4H_2PO_4$
7.6	0.8	23.7	3.0	68.7	1449.0	$NH_4H_2PO_4$
3.7	0.4	26.4	3.3	69.9	1511.6	$NH_4H_2PO_4$
0.0	0.0	29.6	3.7	70.4	1521.7	$NH_4H_2PO_4$

[a]The molalities were calculated by the compilers. The unit is: mol kg^{-1}

[b]The composition unit is: mol/100 mol of solute.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used. Solid carbon dioxide was used as the cooling agent. The compilers suppose that the isotherms were obtained by interpolation.

Source and Purity of Materials:

Chemically pure reagents were used.

Estimated Error:

No details are given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]

(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7783-20-2]

(3) Water; H_2O; [7732-18-5]

Original Measurements:

Ya. S. Shenkin, O. I. Freyman, Zh. Neorg. Khim. **15**, 3151-2 (1970).

Variables:

Temperature and composition at atmospheric pressure.

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the $(NH_4)_2SO_4$–$NH_4H_2PO_4$–H_2O system at atmospheric pressure

$(NH_4)_2SO_4$		$NH_4H_2PO_4$		H_2O			
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$ [a]	t/°C [b]	$-\lg N$ [c]	Solid phase
50.75	7.80	0.00	0.00	49.25	8.95	0.063	$(NH_4)_2SO_4$
49.22	7.83	3.21	0.59	47.57	9.5	0.061	$(NH_4)_2SO_4$
47.50	7.75	6.11	1.14	46.39	9.6	0.065	$(NH_4)_2SO_4$
45.45	7.46	8.43	1.59	46.12	10.2	0.064	$(NH_4)_2SO_4$
42.50	7.00	11.58	2.19	45.92	10.2	0.067	$(NH_4)_2SO_4$
40.93	6.79	13.48	2.57	45.59	10.3	0.066	$(NH_4)_2SO_4$
38.50	6.68	17.90	3.57	43.60	10.4	0.072	$(NH_4)_2SO_4$
37.50	6.68	20.05	4.10	42.45	10.7	0.077	$(NH_4)_2SO_4$
35.50	6.40	22.50	4.66	42.00	11.1	0.080	$(NH_4)_2SO_4$
34.50	6.37	24.51	5.20	40.99	11.4	0.084	$(NH_4)_2SO_4$
33.50	6.29	26.21	5.65	40.29	11.4	0.085	$(NH_4)_2SO_4$
32.50	6.15	27.50	5.97	40.00	11.5	0.086	$(NH_4)_2SO_4$
31.10	5.98	29.56	6.53	39.34	11.9	0.091	$(NH_4)_2SO_4$
30.20	6.13	32.52	7.58	37.28	12.6	0.105	$(NH_4)_2SO_4$
27.83	5.66	34.98	8.17	37.19	12.7	0.096	$(NH_4)_2SO_4$
26.98	5.74	37.47	9.16	35.55	12.7	0.105	$(NH_4)_2SO_4$
25.50	5.51	39.50	9.81	35.00	12.9	0.106	$(NH_4)_2SO_4$
24.51	5.62	42.51	11.20	32.98	13.6	0.110	$(NH_4)_2SO_4$
23.52	5.64	44.91	12.36	31.57	14.5	0.122	$(NH_4)_2SO_4$
23.03	5.73	46.53	13.28	30.44	14.9	0.128	$(NH_4)_2SO_4$
22.50	5.70	47.62	13.85	29.88	15.1	0.130	$(NH_4)_2SO_4$
22.50	5.87	48.51	14.54	28.99	15.8	0.137	$(NH_4)_2SO_4$
22.40	6.15	50.05	15.79	27.55	16.1	0.146	$(NH_4)_2SO_4$
22.41	6.75	52.47	18.15	25.12	17.9	0.160	$(NH_4)_2SO_4$
22.40	6.86	52.89	18.60	24.71	18.3	0.164	$(NH_4)_2SO_4$
20.84	6.28	54.06	18.72	25.10	17.8	0.162 •	$NH_4H_2PO_4$
19.75	6.04	55.50	19.49	24.75	16.1	1.666[d]	$NH_4H_2PO_4$
17.97	5.33	56.51	19.24	25.52	15.4	1.660[d]	$NH_4H_2PO_4$
16.10	4.61	57.45	18.88	26.45	14.8	0.153	$NH_4H_2PO_4$
15.98	4.57	57.55	18.89	26.47	15.3	0.154	$NH_4H_2PO_4$
13.01	3.65	60.04	19.36	26.95	13.7	0.151	$NH_4H_2PO_4$
12.50	3.45	60.07	19.03	27.43	13.1	0.149	$NH_4H_2PO_4$
10.04	2.74	62.25	19.52	27.71	12.4	0.147	$NH_4H_2PO_4$
7.52	2.02	64.30	19.83	28.18	11.8	0.144	$NH_4H_2PO_4$
3.51	0.92	67.52	20.25	28.97	10.9	0.141	$NH_4H_2PO_4$
0.00	0.00	71.08	21.36	28.92	9.4	0.142	$NH_4H_2PO_4$

[a]These values were calculated by the compiler. The unit is: mol kg^{-1}.

[b]This is the difference between the boiling point of the saturated solution and the boiling point of water.

[c]N is the mol fraction of water.

[d]These are obvious typographical errors. The correct values should be 0.167 and 0.166, respectively.

Auxiliary Information

Method / Apparatus / Procedure:

The method was the same as that described earlier.[1]

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

References:

[1]Ya. S. Shenkin, S. A. Ruchnova, A. P. Shenkina, Zh. Neorg. Khim. **13**, 256 (1968).

7.6. Other Ternary Systems With the Ammonium Cation as the Common Ion

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium fluorosilicate; $(NH_4)_2$ $[SiF_6]$; [16919-10-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

E. M. Morgunova, N. D. Maslova, V. I. Golovina, Zh. Neorg. Khim. **17**, 2006-8 (1972).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Solubility isotherms in the $(NH_4)_2[SiF_6]-NH_4H_2PO_4-H_2O$ system

$(NH_4)_2[SiF_6]$		$NH_4H_2PO_4$		H_2O	Solid
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	phase[b]
		temp=25 °C			
18.70	1.29	—	—	81.30	A
18.01	1.26	1.66	0.18	80.33	A
16.59	1.16	3.38	0.37	80.03	A
15.47	1.10	5.62	0.62	78.91	A
13.50	0.98	9.33	1.05	77.17	A
12.42	0.92	11.50	1.31	76.08	A
11.59	0.87	13.48	1.56	74.93	A
10.96	0.83	15.20	1.79	73.84	A
10.11	0.78	16.93	2.02	72.96	A
9.55	0.74	18.02	2.16	72.43	A
9.26	0.73	19.48	2.38	71.26	A
8.59	0.69	21.34	2.65	70.07	A
7.97	0.64	22.42	2.80	69.61	A
7.80	0.64	23.60	2.99	68.60	A+B
7.06	0.58	24.53	3.12	68.41	B
5.45	0.45	25.87	3.27	68.68	B
3.65	0.29	26.89	3.37	69.46	B
1.84	0.15	28.11	3.49	70.05	B
—	—	29.77	3.69	70.23	B
		temp=50 °C			
25.77	1.95	—	—	74.23	A
22.13	1.76	7.17	0.88	70.70	A
17.26	1.40	13.57	1.71	69.17	A
12.77	1.09	21.54	2.85	65.69	A
9.75	0.87	27.34	3.78	62.91	A
7.80	0.72	31.72	4.56	60.48	A+B
4.07	0.38	35.13	5.02	60.80	B
—	—	43.95	6.82	56.05	B
		temp=75 °C			
32.30	2.68	—	—	67.70	A
25.16	2.14	8.88	1.17	65.96	A
20.69	1.81	15.07	2.04	64.24	A
7.17	0.80	42.35	7.29	50.48	A+B
6.30	0.72	44.33	7.81	49.37	B
3.30	0.37	46.26	7.97	50.44	B
—	—	55.66	10.91	44.34	B

		temp=90 °C			
35.82	3.13	—	—	64.18	A
33.16	2.83	1.14	0.15	65.70	A
27.08	2.40	9.71	1.34	63.21	A
22.06	2.01	16.48	2.33	61.46	A
17.72	1.71	24.27	3.64	58.01	A
18.86	1.96	27.21	4.39	53.93	A
11.17	1.25	38.52	6.66	50.31	A
9.02	1.06	43.18	7.85	47.80	A
7.13	0.87	46.95	8.89	45.92	A
6.40	0.80	48.44	9.32	45.16	A+B
4.98	0.60	48.74	9.16	46.28	B
2.82	0.34	51.17	9.67	46.01	B
1.11	0.13	51.87	9.59	47.02	B
.	...	61.85	14.09	38.15	B

[a]These values were calculated by the compiler. The unit is: mol kg^{-1}.
[b]The solid phases are: A=$(NH_4)_2[SiF_6]$; B=$NH_4H_2PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. The samples were equilibrated in polyethylene vessels at 25 and 50 °C, and in ebonite vessels at 75 and 90 °C. Equilibrium was attained in 3 weeks at 25 °C, in 7 days at 50 °C and in 2 days at 75 and 90 °C. The composition of the solid phases was determined by the Schreinemakers' method. Ammonium was determined by the distillation method. $[SiF_6]^2$ was determined by precipitation as $K_2[SiF_6]$.[1]

Source and Purity of Materials:

$(NH_4)_2[SiF_6]$ was prepared from reagent grade $H_2[SiF_6]$ (MRTU 609-4821-67) and recrystallized. $NH_4H_2PO_4$ was prepared as described by others.[2]

Estimated Error:

The temperature was controlled to within ± 0.1 K. No other information is given.

References:

[1]J. E. Ricci, J. A. Skarulis, J. Am. Chem. Soc. **73**, 3624 (1951).
[2]Yu. V. Karyakin, Chistye Khimicheskiye Reaktivi Leningrad Goskhimizdat 1947.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium fluoride; NH_4F; [12125-01-8]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

N. K. Shilling, G. S. Stetsova, Tekhnologiya Mineral'nykh Udobreniy (Leningrad) 68-71 (1977).

Variables:

Composition and temperature.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–NH_4F–H_2O system

$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1a}	NH_4F 100w_i	NH_4F m_i/mol kg^{-1a}	H_2O 100w_i	Solid phase[b]
		temp=−5 °C			
13.2	1.40	5	15	81.8	A
14.7	1.55	3	9	82.3	A
17.5	2.38	18.5	72.3	64	A
21	3.2	21	90	58	A
14	2.5	38	200	48	B
20.8	3.68	30	150	49.2	B+C
		temp=0 °C			
15.4	1.68	5	1.7	79.6	A
17.3	1.89	3	1	79.7	A
19.0	2.47	14	3.6	67	A
22	3.4	21	9.9	57	A
22.5	4.03	29	16	48.5	A
14	2.56	38.5	21.9	47.5	B
		temp=5 °C			
18.5	2.05	3	1	78.5	A
18.2	2.06	5	2	76.8	A
20	2.5	11	4.3	69	A
24	3.7	20	9.6	56	A
24	4.3	28	16	48[c]	A
22.5	4.03	29	16	48.5	A+B
18.5	3.78	39	25	42.5	B
		temp=10 °C			
21.5	2.51	4	1	74.5	A
22	2.7	6	2	72	A
26	4.9	28	16	46	A
27	4.4	20	10	53	A
13	2.5	41	24	46	B
23	4.5	33	20	44[c]	B
		temp=20 °C			
27	3.5	5	2	68	A
27	3.6	8	3	65	A
27	6.2	35	25	38	A
29	6.1	30	20	41	A
30	5.1	19	10	51	A
30	5.9	26	16	44	A
26	6.1	37	27	37	A+B
		temp=30 °C			
30	5.9	26	16	44	A
32	7.1	29	20	39	A
25	6.0	39	29	36	B

[a]The molalities were calculated by the compilers based on 100w_i of the salts.
[b]The solid phases are: A=$NH_4H_2PO_4$; B=NH_4F; C=$NH_4F \cdot H_2O$.
[c]There are obvious misprints in these data (100w_i=47 and 45, respectively) in the original article.

Auxiliary Information

Method / Apparatus / Procedure:

A polythermic method was used but no details are given. The nature of the solid phase was determined graphoanalytically (no details are given) and checked by IR spectroscopy.

Source and Purity of Materials:

Chemically pure $NH_4H_2PO_4$ and NH_4F were used.

Estimated Error:

No information is given.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

$NH_4H_2PO_4-NH_4CL-H_2O$

Figure 18 presents isotherms for the $NH_4H_2PO_4-NH_4Cl-H_2O$ system at 0 °C[1] and 20 °C.[2] The comparison appears to be reasonable and the isotherms in each of these reports can be accepted tentatively.

References:

[1] P. Askenasy, F. Nessler, Z. Anorg. Chem. **189**, 305 (1930).
[2] A. A. Volkov, O. E. Sosnina, Uch. Zap. Perm. Univ. **229**, 35 (1970).

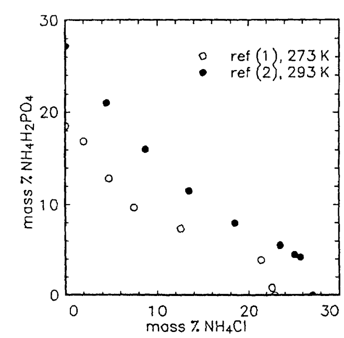

FIG. 18. Solubility isotherms in the $NH_4H_2PO_4-NH_4Cl-H_2O$ system.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

P. Askenasy, F. Nessler, Z. Anorg. Chem. **189**, 305-28 (1930).

Variables:

Composition at 0 °C.

Prepared By:

J. Eysseltová

Experimental Data

The 0 °C isotherm for the $NH_4H_2PO_4-NH_4Cl-H_2O$ system

Density	NH₄Cl			NH₄H₂PO₄			H₂O		Solid
g cm⁻³	comp[a]	$100w_i$[b]	m_i[c]	comp[a]	$100w_i$[b]	m_i[c]	comp[a]	$100w_i$[b]	phase[d]
1.0655	100.0	22.91	5.556	—	—	—	1000	77.09	A
1.0831	98.3	22.6	5.52	1.7	0.84	0.095	990	76.6	A
1.0846	92.2	21.4	5.36	7.9	3.9	0.46	995	74.6	A+B
1.0872	78.6	12.6	2.93	21.4	7.35	0.798	1490	80.05	B
1.0887	62.9	7.53	1.70	37.1	9.54	1.00	2060	82.93	B
1.0955	44.6	4.81	1.09	55.4	12.8	1.36	2270	82.35	B
1.0990	20.2	1.99	0.458	79.8	16.9	1.81	2450	81.13	B
1.1043			—	100.0	18.50	1.974	2815	81.50	B

[a] The composition unit is: mol/100 mol of solute.
[b] These values were calculated by the compiler.
[c] The molalities were calculated by the compiler and are expressed as mol kg⁻¹.
[d] The solid phases are: A = NH_4Cl; B = $NH_4H_2PO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. The mixtures were agitated in a thermostat for 2 to 4 days. The solid phase was separated from the liquid phase by centrifuging. The analytical procedures are not described.

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was controlled to within ± 0.1 K. No other information is given.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A. A. Volkov, O. E. Sosnina, Uch. Zap. Perm. Univ. **229**, 35-9 (1970).

Variables:

Composition at 20 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility in the $NH_4H_2PO_4-NH_4Cl-H_2O$ system at 20 °C

NH₄H₂PO₄		NH₄Cl		H₂O	Refractive	
$100w_i$	m_i/mol kg⁻¹ [a]	$100w_i$	m_i/mol kg⁻¹ [a]	$100w_i$	index	Solid phase
27.2	3.25	0	0	72.80	1.3700	$NH_4H_2PO_4$
21.0	2.45	4.50	1.13	74.50	1.3695	$NH_4H_2PO_4$
16.0	1.85	8.75	2.17	75.25	1.3715	$NH_4H_2PO_4$
11.50	1.333	13.50	3.364	75.00	1.3740	$NH_4H_2PO_4$
8.00	0.946	18.50	4.705	73.50	1.3790	$NH_4H_2PO_4$
5.55	0.680	23.50	6.191	70.95	1.3865	$NH_4H_2PO_4$
4.50	0.556	25.10	6.664	70.40	1.3890	$NH_4H_2PO_4+NH_4Cl$
4.25	0.528	25.75	6.876	70.00	1.3875	NH_4Cl
0	0	27.10	6.948	72.90	1.3860	NH_4Cl

[a] These values were calculated by the compilers. The unit is: mol kg⁻¹.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method of sections (1, 2) was used with the aid of refractive index measurements.

Source and Purity of Materials:

Chemically pure NH_4Cl and reagent grade $NH_4H_2PO_4$ were used.

Estimated Error:

No information is given.

References:

[1] R. V. Merclin, Izv. biolog. n.-i. in-ta pri Permsk. Un-te. **11**, 1 (1937).
[2] E. F. Zhuravlev, A. D. Sheveleva, Zh. Neorg. Khim. **5**, 2360 (1960).
[3] Yu. V. Karyakin, Chistye Khimicheskie Reaktivy, p. 58, Moscow, 1947.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Sodium dihydrogenphosphate; NaH_2PO_4; [7558-80-7]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

S. Ya. Shpunt, Zh. Prikl. Khim. (Leningrad) , **13**, 9-18 (1940).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Crystallization temperatures on sections of the $NaH_2PO_4-NH_4H_2PO_4-H_2O$ system

NaH_2PO_4		$NH_4H_2PO_4$			Solid
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	t/°C	phase[b]
		Section I			
7.7	0.70	—	—	−2.1	A
7.4	0.70	4.8	0.48	3.3	A
7.0	0.70	9.1	0.94	−4.5	A
6.8	0.71	13.0	1.41	−5.5	A
6.5	0.70	16.7	1.89	−0.6	B
6.2	0.70	20.0	2.36	−8.5	B
6.0	0.70	23.1	2.83	−17.1	B
5.8	0.71	25.9	3.30	−25.0	B
5.6	0.71	28.6	3.78	−30.8	B
		Section II			
15.4	1.52	—	—	−4.5	A
15.0	1.52	2.9	0.31	−5.0	A
14.6	1.53	5.7	0.62	5.6	A
14.2	1.53	8.3	0.93	−6.1	A
13.9	1.54	10.7	1.23	−6.7	A
13.2	1.54	15.2	1.84	1.4	B
12.8	1.52	17.3	2.15	8.9	B
12.5	1.53	19.3	2.46	13.6	B
12.2	1.53	21.3	2.78	19.8	B
12.0	1.53	23.1	3.09	24.5	B
11.7	1.54	24.8	3.39	30.1	B
		Section III			
23.1	2.50	—	—	−6.6	A
22.7	2.51	2.0	0.23	−7.1	A
22.2	2.50	3.8	0.45	−7.6	A
21.8	2.50	5.7	0.68	8.0	A
21.4	2.50	7.4	0.90	−8.5	A
21.0	2.50	9.1	1.13	−9.0	A
20.3	2.50	12.2	1.57	2.2	B
19.9	2.50	13.8	1.81	3.5	B
19.6	2.50	15.2	2.03	7.9	B
19.2	2.52	17.3	2.37	13.1	B
18.7	2.51	19.3	2.70	29.0	B
18.1	2.50	21.3	3.06	26.1	B
17.7	2.49	23.1	3.39	30.1	B
		Section IV			
34.6	4.41	—	—	2.7	C
33.9	4.41	2.0	0.27	−2.6	C
33.2	4.39	3.8	0.52	−2.5	C
32.6	4.40	5.7	0.80	−2.6	C
32.0	4.40	7.4	1.06	−2.5	C
31.5	4.42	9.1	1.33	−2.9	C
30.9	4.41	10.7	1.59	1.9	B
30.4	4.41	12.2	1.85	9.0	B
29.9	4.42	13.8	2.13	13.9	B
29.4	4.42	15.2	2.38	18.5	B
28.4	4.41	18.0	2.92	27.6	B
		Section V			
38.5	5.22	—	—	7.1	C
37.8	5.23	2.0	0.29	6.8	C
37.1	5.23	3.8	0.56	6.9	C
36.4	5.24	5.7	0.86	7.2	C
35.8	5.25	7.4	1.13	7.1	C
35.2	5.26	9.1	1.42	7.1	C
34.5	5.24	10.7	1.70	7.1	B+C
33.9	5.24	12.2	1.97	12.1	B
33.3	5.24	13.8	2.27	17.9	B
32.8	5.26	15.2	2.54	22.8	B
32.2	5.25	16.7	2.84	27.3	B
		Section VI			
42.3	6.11	—	—	14.5	C
41.4	6.09	2.0	0.31	14.4	C
39.9	6.11	5.7	0.91	14.7	C
38.4	6.09	9.1	1.51	14.6	C
37.1	6.10	12.2	2.09	14.5	C
36.4	6.09	13.8	2.41	20.9	B
35.9	6.12	15.2	2.70	26.6	B
35.2	6.10	16.7	3.02	31.1	B
		Section VII			
24.9	2.91	3.8	0.46	−8.4	A
26.6	3.18	3.7	0.46	−8.8	A
28.2	3.44	3.6	0.46	−9.7	A
31.1	3.96	3.5	0.46	−8.2	C
32.5	4.22	3.4	0.46	−5.3	C
34.1	4.54	3.3	0.46	−1.2	C
36.5	5.04	3.2	0.46	3.4	C
38.5	5.49	3.1	0.46	7.8	C
41.9	6.32	2.9	0.46	15.6	C
44.8	7.12	2.8	0.46	20.8	C
46.1	7.50	2.7	0.46	24.3	C
		Section VIII			
19.9	2.30	8.0	0.96	−7.9	A
22.0	2.61	7.8	0.96	−8.7	A
23.8	2.89	7.6	0.96	−9.3	A
25.6	3.18	7.4	0.96	−9.9	A
27.3	3.47	7.2	0.96	−10.7	A+C
28.8	3.74	7.1	0.96	−8.0	C
31.7	4.29	6.8	0.96	−3.3	C
34.1	4.79	6.6	0.97	1.5	C
36.5	5.33	6.4	0.97	6.5	C
38.5	5.80	6.2	0.97	10.7	C
40.2	6.22	6.0	0.97	14.7	C
41.9	6.68	5.8	0.96	18.3	C
44.8	7.52	5.6	0.98	23.5	C
47.3	8.31	5.3	0.97	28.2	C

Part 2. Solutions coexisting with two solid phases

t/°C	NaH_2PO_4 100w_i	NaH_2PO_4 m_i/mol kg^{-1} [a]	$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1} [a]	H_2O 100w_i	Solid phases[b]
−4.3	—	—	16.7	1.74	83.3	A+B
−9.9	32.4	3.99	—	—	67.6	A+C
6.0	6.6	0.70	14.7	1.62	78.7	A+B
−7.1	13.6	1.53	12.4	1.46	74.0	A+B
−9.1	21.0	2.53	9.8	1.23	69.2	A+B
2.8	31.3	4.39	9.3	1.36	59.4	B+C
7.1	34.4	5.22	10.7	1.69	54.9	B+C
14.7	37.3	6.09	11.7	1.99	51.0	B+C
−10.2	30.0	3.75	3.4	0.44	66.6	A+C
10.7	27.4	3.49	7.2	0.96	65.4	A+C

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A=ice; B=$NH_4H_2PO_4$; C=$NaH_2PO_4 \cdot 2H_2O$.

Part 3. Solubility isotherms

$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ comp[c]	$NH_4H_2PO_4$ m_i/mol kg^{-1} [a]	NaH_2PO_4 100w_i	NaH_2PO_4 comp[c]	NaH_2PO_4 m_i/mol kg^{-1} [a]	H_2O 100w_i	H_2O comp[c]	Solid phase[b]
				temp= −9.9 °C				
—		—	32.4	100.0	3.99	67.6	1391	A+C
3.6	11.7	0.46	28.6	88.3	3.51	67.8	1400	A
7.5	24.0	0.96	24.6	76.0	3.02	67.9	1398	A
9.2	29.6	1.18	22.8	70.4	2.79	68.0	1402	A+B
8.5	23.8	1.17	28.4	76.2	3.75	63.1	1129	B+C
3.4	10.4	0.45	30.4	89.6	3.83	66.2	1302	C
				temp= −7 °C				
—		—	24.2	100.0	2.66	75.8	2092	A
4.0	16.5	0.46	21.0	83.5	2.33	75.0	1988	A
8.4	33.5	0.98	17.4	66.5	1.95	74.2	1893	A
12.3	48.1	1.45	13.8	51.9	1.56	73.9	1851	A+B
10.6	34.6	1.34	20.8	65.4	2.53	68.6	1436	B
8.8	23.7	1.24	29.4	76.3	3.96	61.8	1068	B+C
7.0	19.8	0.96	29.7	80.2	3.91	63.3	1140	C
3.4	10.0	0.45	31.5	90.0	4.03	65.1	1239	C
—	—	—	33.6	100.0	4.22	66.4	1261	C
				temp= −4.3 °C				
—	—	—	15.1	100.0	1.48	84.9	3745	A
8.8	56.8	0.91	7.0	43.2	0.69	84.2	3484	A
16.8	100.0	1.76	—	—	—	83.2	3184	A+B
15.3	70.9	1.70	6.6	29.1	0.70	78.1	2309	B
13.3	50.8	1.58	13.5	49.2	1.54	73.2	1782	B
11.4	36.4	1.46	20.6	63.6	2.52	68.0	1396	B
9.1	23.8	1.30	30.3	76.2	4.16	60.6	1015	B+C
6.9	18.9	0.96	31.0	81.1	4.16	62.1	1084	C
3.3	9.5	0.45	32.8	90.5	4.28	63.9	1175	C
—	—	—	34.6	100.0	4.41	65.4	—[d]	C
				temp=0 °C				
18.4	100.0	1.96	—	—	—	81.6	2833	B
16.9	73.4	1.92	6.4	26.6	0.70	76.7	2127	B
16.06	65.0	1.86	9.02	35.0	1.00	74.92	1941	B
14.7	54.0	1.77	13.1	46.0	1.51	72.2	1697	B
13.11	42.6	1.66	18.46	57.4	2.25	68.43	1420	B
12.9	40.1	1.67	20.0	59.9	2.48	67.1	1333	B
10.53	28.5	1.48	27.47	71.5	3.69	62.0	1077	B
10.0	25.1	1.48	31.1	74.9	4.40	58.9	944	B
9.64	24.1	1.43	31.69	75.9	4.50	58.67	937	B+C
9.8	24.3	1.46	31.7	75.7	4.51	58.5	931	B+C
6.7	17.4	0.97	33.2	82.8	4.60	60.1	999	C
5.8	15.3	0.83	33.5	84.7	4.60	60.7	1024	C
3.2	8.8	0.45	34.8	91.2	4.68	62.0	1083	C
2.62	7.3	0.36	34.84	92.7	4.64	62.54	1109	C
—	—	—	36.4	100.0	4.77	63.6	1150	C
				temp= +10 °C				
21.8	100.0	2.42	—	—	—	78.2	2288	B
20.5	77.6	2.43	6.2	22.4	0.70	73.3	1766	B
18.0	59.7	2.26	12.7	40.3	1.53	69.3	1470	B
16.1	46.4	2.16	19.4	53.6	2.51	64.5	1196	B
12.7	30.5	1.93	30.2	69.5	4.41	57.1	875	B
11.5	26.0	1.84	34.1	74.0	5.22	54.4	788	B
11.1	24.6	1.81	35.5	75.4	5.54	53.4	757	B+C
6.2	14.6	0.96	38.0	85.4	5.67	55.8	838	C
3.0	7.3	0.45	39.5	92.7	5.72	57.5	900	C
—	—	—	40.5	100.0	5.67	59.5	961	C
				temp= +20 °C				
25.9	100.0	3.04	—	—	—	74.1	1824	B
24.2	81.4	3.00	5.7	18.6	0.68	70.1	1508	B
21.4	64.9	2.80	12.1	35.1	1.52	66.5	1293	B
19.5	51.8	2.75	18.9	48.2	2.56	61.6	1048	B
15.8	36.1	2.50	29.2	63.9	4.42	55.0	806	B
14.5	31.5	2.40	32.9	68.5	5.21	52.6	730	B
13.4	27.6	2.33	36.7	72.4	6.13	49.9	658	B
12.4	24.9	2.22	39.1	75.1	6.72	48.5	621	B+C
5.7	12.2	0.96	42.9	87.8	6.95	51.4	701	C
2.8	6.2	0.45	44.2	93.8	6.95	53.0	750	C
—		—	45.3	100.0	6.90	54.7	789	C
				temp= +30 °C				
30.2	100.0	3.76	—	—	—	69.8	1477	B
28.0	84.0	3.66	5.5	16.0	0.70	66.5	1278	B
26.10	73.6	3.54	9.77	26.4	1.27	64.13	1156	B
25.2	69.5	3.46	11.5	30.5	1.51	63.3	1116	B
23.0	56.9	3.40	18.2	43.1	2.58	58.8	930	B
20.0	45.6	3.16	24.97	54.4	3.78	55.03	802	B
18.6	40.7	3.04	28.2	59.3	4.42	53.2	745	B
17.1	36.1	2.96	31.9	63.9	5.23	50.8	678	B
16.2	32.3	2.01	35.4	67.7	6.09	48.4	617	B
15.78	31.6	2.82	35.62	68.4	6.11	48.60	622	B
13.30	24.9	2.58	41.89	75.1	7.79	44.81	536	B+C
13.20	24.9	2.54	41.60	75.1	7.67	45.20	544	B+C
9.55	18.5	1.78	43.75	81.5	7.80	46.70	580	C
6.26	12.3	1.15	46.50	87.7	8.20	47.24	594	C
5.2	10.2	0.96	47.8	89.8	8.47	47.0	588	C
3.42	6.8	0.62	48.55	93.2	8.42	48.03	615	C
2.5	5.0	0.45	49.0	95.0	8.42	48.5	627	C
—	—	—	51.2	100.0	8.74	48.8	628	C

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A=ice; B=$NH_4H_2PO_4$; C=$NaH_2PO_4 \cdot 2H_2O$.
[c]The composition units are: mol/100 mol of solute.
[d]The compiler calculates this missing value to be 1259.

Auxiliary Information

Method / Apparatus / Procedure:

A standard visual polythermic method and the isothermal method were used but no details are given. The P_2O_5 content was determined by a standard method described in the "NIUIF materials" but no reference is given. The ammonia content was determined by the Kjeldahl method. The sodium ion content was probably determined by difference-compiler.

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was controlled to within ± 0.2 K.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0] or
(2) Rubidium dihydrogenphosphate; RbH_2PO_4; [13774-18-5] or
(2) Cesium dihydrogenphosphate; CsH_2PO_4; [18649-05-3] or
(2) Thallium dihydrogenphosphate; TlH_2PO_4; [17735-75-0]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic
September 1995

Critical Evaluation

7.7. $NH_4H_2PO_4$–MH_2PO_4–H_2O (where M=K, Rb, Cs, Tl)

All the articles dealing with the $NH_4H_2PO_4$–KH_2PO_4–H_2O system[1–9] report a series of solid solutions as the equilibrium solid phases. Some comparisons are possible and they are shown in Figures 19 and 20. For the 273 K data, Figure 19, the values for the KH_2PO_4 content reported by Askenasy and Nessler[1] are larger than those reported by Polosin and Ozolin.[4] This is true also for the binary solubility of KH_2PO_4 in water at 273 K, where the 15.5 $100w_i$ value is larger than the 11.74 $100w_i$ value recommended by IUPAC.[10] It, therefore, seems likely that there is a systematic error in the analytical values for potassium and, consequently, the data in Ref. 1 are rejected. The values at 298 K, Figure 20, agree fairly well and may be tentatively accepted.

The $NH_4H_2PO_4$–MH_2PO_4–H_2O [M=Rb,[11] Cs,[12] Tl[13]] systems are characterized by the formation of solid solutions. Earlier[10] it was noted that the results in Refs. 11,12 were affected by unreliable analytical procedures and are, therefore, rejected. No independent solubililty data have, as yet, been reported for these systems.

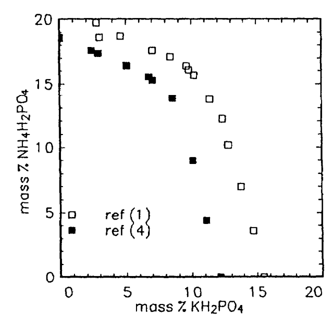

FIG. 19. Solubility in the $NH_4H_2PO_4$–KH_2PO_4–H_2O system at 273 K.

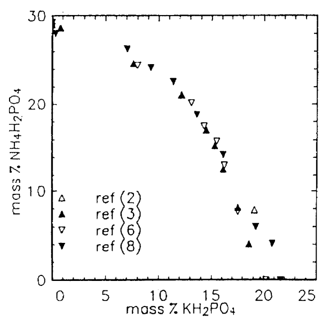

FIG. 20. Solubility in the $NH_4H_2PO_4$–KH_2PO_4–H_2O system at 298 K.

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Components:	**Original Measurements:**
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1] (2) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0] (3) Water; H_2O; [7732-18-5]	1. N. S. Dombrovskaya, A. J. Zvorykin, Kaliy **2**, 24-8 (1937). 2. A. J. Zvorykin, V. G. Kuznetsov, Izv. AN SSSR, Ser. Khim. 195-201 (1938).
Variables:	**Prepared By:**
Composition and temperature.	J. Eysseltová

Experimental Data

The solubility in the $NH_4H_2PO_4$–KH_2PO_4–H_2O system has been reported by Zvorykin and co-workers in two publications. Source paper[1] reports the solubility isotherms at 25 °C and 50 °C. Source paper[2] repeats only the data at 50 °C. The solubility data are:

t/°C	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ m_i[a]	KH_2PO_4 $100w_i$	KH_2PO_4 m_i[a]	t/°C	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ m_i[a]	KH_2PO_4 $100w_i$	KH_2PO_4 m_i[a]
25	—	—	20.42	1.88	25	25.42	3.31	7.98	0.88
25	7.87	0.93	19.12	1.92	25	29.45	3.62	—	—
25	8.04	0.95	18.52	1.85	50	—	—	28.09	2.87
25	9.98	1.20	18.14	1.85	50	9.49	1.26	25.23	2.83
25	10.44	1.26	17.66	1.80	50	25.91	4.08	18.97	2.52
25	10.52	1.27	17.94	1.84	50	29.12	4.60	15.92	2.12
25	13.09	1.62	16.78	1.75	50	30.96	4.92	14.38	1.93
25	17.47	2.24	14.80	1.60	50	33.22	5.25	11.79	1.57
25	20.82	2.72	12.74	1.40	50	35.19	5.35	7.69	0.98
25	23.16	3.01	10.17	1.12	50	38.42	5.74	3.45	0.43
25	22.93	2.97	10.02	1.09	50	39.88	5.76	—	—

[a]The molalities were calculated by the compiler and are expressed as mol kg^{-1}

NOTE: The authors also express the composition of the saturated solutions in units other than mass % and mol/kg. These are given below.

t/°C	$NH_4H_2PO_4$ mol %	$NH_4H_2PO_4$ comp[a]	$NH_4H_2PO_4$ comp[b]	KH_2PO_4 mol %	KH_2PO_4 comp[a]	KH_2PO_4 comp[b]	H_2O $100w_i$	H_2O mol %	H_2O comp[b]
25	—	—	—	3.28	33.91	100	79.58	96.72	2949
25	1.61	16.87	32.8	3.22	34.64	67.2	73.01	95.17	1941
25	1.63	17.14	33.93	3.17	33.37	66.07	73.44	95.20	1980
25	2.06	21.74	39.46	3.16	33.34	60.54	71.88	94.78	1816
25	2.15	22.73	41.16	3.08	32.50	58.84	71.90	94.77	1810
25	2.18	23.03	40.96	3.14	33.19	59.04	71.54	94.68	1779
25	2.75	29.22	47.98	2.98	31.66	52.02	70.13	94.27	1643
25	3.78	40.39	58.28	2.70	28.92	41.72	67.73	93.52	1443
25	4.56	49.05	65.91	2.36	25.37	34.09	66.44	93.08	1344
25	5.06	54.38	72.93	1.88	20.18	27.07	66.67	93.06	1344
25	4.98	53.45	73.12	1.83	19.63	26.88	67.05	93.19	1368
25	5.55	59.74	79.01	1.47	15.85	20.99	66.60	92.98	1325
25	6.13	65.36	100	—	—	—	70.55	93.87	1530
50	—	—	—	4.91	51.69	100	71.91	95.09	1935
50	2.12	22.76	30.77	4.76	51.15	69.23	65.28	93.12	1354
50	6.58	73.69	67.77	4.07	45.56	38.22	55.12	89.35	839
50	7.40	82.97	68.38	3.41	38.33	31.62	54.96	89.19	825
50	7.89	95.01	72.29	3.10	34.81	27.71	54.66	89.01	810
50	8.42	94.52	77.26	2.52	28.35	23.18	54.99	89.10	817.4
50	8.66	96.45	84.37	1.60	17.82	15.58	57.12	89.74	874.7
50	9.31	103.5	92.95	0.71	7.86	7.05	58.13	89.98	898
50	9.41	102.7	100	—	—	—	60.12	91.59	974

[a]The composition unit is: mol/1000 mol H_2O.
[b]The composition unit is: mol/100 mol solute.

The authors also give the composition of the solution that is in equilibrium with a solid phase of the same composition: at 25 °C it is 30.41 mol KH_2PO_4/100 mol solute and 69.59 mol $NH_4H_2PO_4$/100 mol solute; at 50 °C it is 26.19 mol KH_2PO_4/100 mol solute and 73.81 mol $NH_4H_2PO_4$/100 mol solute.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. The mixtures were agitated continuously in a thermostat for 2–5 days. Equilibrium was checked by repeated analysis. Potassium was determined as $KClO_4$, nitrogen by the Kjeldahl method, and phosphorus as $Mg_2P_2O_7$.

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was controlled to within ± 0.1 K.

Components

(1) Ammonium dihydrogenphosphate, $NH_4H_2PO_4$; [7722-76-1]
(2) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

1. V. A. Polosin, R. K. Ozolin, Kally, **10**, 31-4 (1937). 2. V. A. Polosin, R. K. Ozolin, Trudy TSKhA, Yubileynyi Sbornik, 29-50 (1940).

Variables:

Composition and temperature.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$–KH_2PO_4–H_2O system

comp[a]	$NH_4H_2PO_4$ 100w_i	m_i/mol kg^{-1}[b]	comp[a]	KH_2PO_4 100w_i	m_i/mol kg^{-1}[b]	H_2O 100w_i	Solid phase[c]
			temp=0 °C				
35.57	18.53	1.977	—	—	—	81.47	A
34.4	17.58	1.909	3.94	2.38	0.218	80.04	B
34.04	17.35	1.891	4.81	2.90	0.267	79.75	B
32.75	16.42	1.818	8.53	5.07	0.474	78.51	B
31.26	15.55	1.739	11.44	6.73	0.636	77.72	B
30.73	15.28	1.709	11.90	7.00	0.662	77.72	B
27.82	13.82	1.547	14.48	8.50	0.804	77.68	B
27.71	13.75	1.538	14.56	8.55	0.809	77.70	B
17.4	9.00	0.967	16.51	10.10	0.917	80.90	B
8.18	4.40	0.453	17.36	11.10	0.965	84.50	B
—	—	—	18.29	12.15	1.050	87.15	C
			temp=10 °C				
45.58	22.55	2.531	—	—	—	77.45	A
43.81	21.1	2.43	8.19	3.55	0.346	75.35	B
43.60	20.93	2.422	9.08	3.93	0.384	75.14	B
42.25	20.10	2.344	9.42	5.35	0.528	74.55	B
41.53	19.70	2.307	10.78	6.06	0.600	74.24	B
39.15	18.4	2.174	14.41	8.02	0.801	73.58	B
38.97	18.3	2.167	14.96	8.3	0.83	73.40	B
35.26	16.5	1.956	18.30	10.15	1.017	73.35	B
34.24	16.1	1.902	18.52	10.30	1.028	73.60	B
27.67	13.27	1.536	20.76	11.65	1.140	75.08	B
17.39	8.70	0.965	21.87	12.95	1.214	78.35	B
8.23	4.3	0.46	22.46	13.90	1.249	81.80	B
—	—	—	23.25	14.95	1.292	85.05	C
			temp=15 °C				
51.19	24.65	2.844	—	—	—	75.35	A
49.62	23.5	2.76	4.38	2.5	0.25	74.0	B
49.22	23.0	2.73	6.97	3.85	0.387	73.15	B
46.2	21.3	2.57	12.0	6.55	0.667	72.15	B
43.34	19.75	2.408	16.6	8.95	0.922	71.3	B
39.2	17.85	2.177	20.18	10.88	1.122	71.27	B
34.33	15.8	1.906	22.31	12.15	1.239	72.05	B
27.78	13.07	1.538	23.4	13.07	1.300	73.86	B
17.42	8.57	0.968	24.83	14.45	1.379	76.98	B
8.18	4.2	0.455	25.53	15.5	1.42	80.3	B
—	—	—	26.2	16.54	1.456	83.46	C
			temp=20 °C				
57.28	26.8	3.18	—	—	—	73.2	A
56.78	26.35	3.153	2.48	1.0	0.099	72.65	B
55.83	25.67	3.102	4.38	2.38	0.237	71.95	B
54.67	24.82	3.037	7.07	4.13	0.416	71.05	B
51.51	23.0	2.860	13.44	7.1	0.73	69.9	B
49.40	21.88	2.745	16.83	8.82	0.912	69.3	B
48.31	21.3	2.68	18.60	9.7	1.0	69.0	B

39.08	17.4	2.17	24.36	12.85	1.320	69.75	B
34.42	15.55	1.912	25.97	13.75	1.393	70.7	B
27.59	12.8	1.53	26.58	14.6	1.44	72.6	B
17.60	8.4	0.97	27.83	15.93	1.508	75.67	B
18.13	4.0	0.44	28.45	17.0	1.54	79.0	B
			29.29	18.13	1.586	81.87	C
			temp = 25 °C				
63.91	29.0	3.55	—	—	—	71.0	A
63.52	28.65	3.529	1.45	0.77	0.080	70.58	B
58.07	24.66	3.165	14.82	7.6	0.82	67.74	B
49.31	21.05	2.739	24.06	12.15	1.336	66.80	B
39.13	17.1	2.17	28.03	14.5	1.56	68.4	B
34.39	15.26	1.910	29.13	15.3	1.62	69.44	B
28.50	12.65	1.543	29.88	16.1	1.66	71.25	B
17.09	8.12	0.949	31.18	17.53	1.732	74.35	B
8.19	4.05	0.455	31.81	18.6	1.77	77.35	B
			32.44	19.7	1.80	80.3	C
			temp = 30 °C				
70.89	31.18	3.939		—	—	68.82	A
58.44	24.2	3.25	22.44	11.0	1.25	64.8	B
49.35	20.52	2.741	29.29	14.41	1.627	65.07	B
39.18	16.78	2.175	31.86	16.15	1.769	67.07	B
34.36	14.98	1.912	32.77	16.9	1.82	68.12	B
27.68	12.37	1.538	33.47	17.72	1.862	69.91	B
18.63	8.6	1.0	34.9	19.13	1.945	72.27	B
8.27	4.0	0.46	35.45	20.3	1.97	75.7	B
			35.85	21.32	1.991	78.68	C
			temp = 35 °C				
78.89	33.51	4.381	—	—	—	66.49	A
74.08	30.2	4.12	12.44	6	0.7	63.8	B
68.2	27.4	3.81	21.13	10	1.2	62.6	B
59.9	23.8	3.33	29.74	14	1.7	62.2	B
49.4	20.07	2.743	34.0	16.33	1.887	63.6	B
39.17	16.45	2.176	35.9	17.84	1.995	65.71	B
34.2	14.65	1.905	36.6	18.5	2.03	66.85	B
27.57	12.1	1.53	37.29	19.35	2.074	68.55	B
17.52	7.98	0.973	38.44	20.72	2.135	71.30	B
8.25	3.90	0.457	39.06	21.9	2.169	74.2	B
			39.33	22.92	2.185	77.08	C
			temp = 40 °C				
87.27	35.8	4.85	—	—	—	64.2	A
77.22	29.6	4.29	22.92	10.4	1.27	60.0	B
66.71	25.4	3.70	33.28	15.0	1.85	59.6	B
49.54	19.7	2.75	38.37	18.06	2.132	62.24	B
39.13	16.1	2.17	39.97	19.5	2.22	64.4	B
34.36	14.4	1.91	40.34	20.0	2.24	65.6	B
27.76	11.9	1.54	41.36	21.0	2.30	67.1	B
17.48	7.8	0.97	42.42	22.4	2.36	69.8	B
8.18	3.8	0.46	42.90	23.6	2.39	72.6	B
		—	42.90	24.45	2.378	75.55	C

[a]The composition unit is: mol/1000 mol water.
[b]These values were calculated by the compilers.
[c]The solid phases are: A = $NH_4H_2PO_4$; B = $(NH_4,K)H_2PO_4$; C = KH_2PO_4.

Auxiliary Information

Method / Apparatus / Procedure:

A polythermic method was used. Solid carbon dioxide was the cooling agent. No other information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

D. I. Kuznetsov, A. A. Kozhukhovskiy, F. E. Borovaya, Zh. Prikl. Khim. (Leningrad) **21**, 1278-81 (1948).

Variables:

Composition and vapor pressure at 25 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility and vapor pressure in the $NH_4H_2PO_4-KH_2PO_4-H_2O$ system at 25 °C

$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1} [a]	KH_2PO_4 100w_i	KH_2PO_4 m_i/mol kg^{-1} [a]	H_2O 100w_i	p (mm Hg)
—	—	20.21	1.86	79.79	22.66
7.65	0.89	17.53	1.72	74.82[b]	22.08
13.05	1.60	16.19	1.68	70.76	21.90
15.84	2.00	15.48	1.65	68.68[b]	21.84
17.53	2.23	14.27	1.54	68.20[b]	—
20.12	2.62	13.08	1.44	66.80	21.61
24.48	3.15	7.97	0.87	67.55	21.95
28.85	3.53	—	—	71.15	22.00

[a]The molalities were calculated by the compiler. The calculations were based on the 100w_i of the salts.
[b]There are misprints for these values in the original article (100w_i=74.62, 69.68 and 67.20, respectively). This may be due to an incorrect value for the concentration of a solute.

Auxiliary Information

Method / Apparatus / Procedure:

An isothermal method[1] was used. The mixtures were prepared from finely powdered salts. The system was equilibrated for 3 days although 2 days proved to be sufficient. The phosphorus content of the saturated solutions was determined gravimetrically as $NH_4MgPO_4 \cdot 6H_2O$. The ammonium content was determined by the distillation method and potassium as $KClO_4$ (after removal of NH_3). The vapor pressure was measured by the technique described elsewhere.[2]

Source and Purity of Materials:

Reagent grade salts were recrystallized three times and dried at approximately 100 °C.

Estimated Error:

No information is given.

References:

[1]D. I. Kuznetsov, A. A. Kozhukhovskij, Zh. Prikl. Khim. (Leningrad) **9**, 185 (1936).
[2]M. S. Vrevskiy, N. N. Zavaritskiy, L. E. Sharlova, Zh. Russ. Fiz.-Khim. Obsh. **54**, 360 (1923).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A. G. Bergman, A. A. Gladkovskaya, R. A. Galushkina, Zh. Neorg. Khim. **17**, 2055-6 (1972).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Original mixture	Component added	$100w_{add}$[a]	t/°C	Solid phases[b]
12.5% KH_2PO_4 + 87.5% H_2O	$NH_4H_2PO_4$	11.5	+6.0	A+B
15.0% KH_2PO_4 + 85.0% H_2O	$NH_4H_2PO_4$	11.6	+14.2	A+B
15.0% KH_2PO_4 + 85.0% H_2O	$NH_4H_2PO_4$	17.3	+17.6	A+B
71.72% $NH_4H_2PO_4$ + 28.28% KH_2PO_4	H_2O	20.5	−4.5	B+C
71.72% $NH_4H_2PO_4$ + 28.28% KH_2PO_4	H_2O	32.6	+25.0	A+B
45.81% $NH_4H_2PO_4$ + 54.19% KH_2PO_4	H_2O	18.2	−4.0	A+C
45.81% $NH_4H_2PO_4$ + 54.19% KH_2PO_4	H_2O	24.5	+13.6	A+B
45.81% $NH_4H_2PO_4$ + 54.19% KH_2PO_4	H_2O	25.0	+14.0	A+B
25.0% $NH_4H_2PO_4$ + 75.0% KH_2PO_4	H_2O	14.3	−3.6	A+C
10.0% $NH_4H_2PO_4$ + 90.0% H_2O	KH_2PO_4	10.3	−4.0	A+C

[a]This is the mass % of component added.
[b]The solid phases are: A = β-solid solution; B = α-$NH_4H_2PO_4$; C = ice.

Compiler's comment: It is not possible to construct a legitimate phase diagram on the basis of the data that are given. The concentration of component added has the meaning given only if the added component is a salt. When water is the added component, the relation $100w_{water} = 100 - 100w_{add}$ is valid. With this assumption the following compositions of points lying on the transition curve were calculated (next page).

$NH_4H_2PO_4$		KH_2PO_4		H_2O		
$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	t/°C	Solid phases[a]
11.50	1.29	11.21	1.06	77.28	+6.0	A+B
11.60	1.34	13.44	1.32	74.95	+14.2	A+B
17.30	2.15	12.78	1.34	69.91	+17.6	A+B
14.70	1.60	5.80	0.53	79.50	−4.5	B+C
23.38	3.01	9.22	1.00	67.40	+25.0	A+B
8.33	0.88	9.86	0.88	81.80	−4.0	A+C
11.22	1.29	13.28	1.29	75.50	+13.6	A+B
11.45	1.32	13.55	1.32	75.00	+14.0	A+B
2.58	0.24	7.72	0.63	89.70	−3.6	A+C
9.06	0.98	10.30	0.94	80.63	−4.0	A+C
		The composition of the transition point is:				
8.50	0.07	11.40	0.53	80.10	−4.5	A+B+C

[a]The solid phases are: A = β-solid solution; B = α-$NH_4H_2PO_4$; C = ice.

Auxiliary Information

Method / Apparatus / Procedure:

The only information given is that a visually polythermic method[1] was used.

Source and Purity of Materials:

Chemically pure salts were recrystallized and dried before use. Bidistilled water was used

Estimated Error:

No information is given.

References:

1. A. G. Bergman, N. P. Luzhnaya, Fiziko-Khimicheskie Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-sul'fatnogo Moscow, IAN SSSR, 1951.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

Ya. S. Shenkin, S. A. Ruchnova, N. A. Rodionova, Zh. Neorg. Khim. **17**, 3368-9 (1972).

Variables:

Composition and temperature at atmospheric pressure.

Prepared By:

J. Eysseltová

Experimental Data

Composition and boiling points of saturated solutions in the $NH_4H_2PO_4$–KH_2PO_4–H_2O system

$NH_4H_2PO_4$		KH_2PO_4		H_2O	
$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	b.p./°C
0	0	52.70	8.18	47.30	105.1
3.28	0.63	51.78	8.46	44.94	105.3
6.90	1.37	49.40	8.30	43.70	106.2
10.67	2.21	47.46	8.32	41.87	105.7
15.52	3.38	44.58	8.20	39.90	106.9
17.57	3.93	43.60	8.25	38.83	107.1
19.70	4.54	42.60	8.30	37.70	108.0
25.94	6.39	38.78	8.07	35.28	108.9
28.00	7.25	38.44	8.41	33.56	108.6
29.39	7.65	37.23	8.19	33.38	106.6
32.76	8.91	35.31	8.12	31.93	108.8
31.69	8.28	35.08	7.75	33.23	108.8
34.56	9.15	32.64	7.31	32.80	106.4
36.86	9.83	30.57	6.89	32.57	106.9
40.23	11.05	28.15	6.54	31.62	109.7
41.87	12.04	27.92	6.79	30.21	110.6
42.86	12.39	27.09	6.62	30.05	109.8
44.42	12.77	25.36	6.16	30.22	110.3
45.32	13.17	24.79	6.09	29.89	109.5
48.85	14.52	21.91	5.50	29.24	109.4
49.59	14.28	20.24	4.92	30.17	111.4
53.69	17.13	19.07	5.14	27.24	110.9
54.27	16.42	17.01	4.35	28.72	112.0
55.91	16.60	14.82	3.72	29.27	109.6
56.57	17.12	14.71	3.76	28.72	110.8
62.15	18.25	8.26	2.05	29.59	110.4
65.35	20.41	6.83	1.80	27.82	109.9
68.30	18.72	0	0	31.70	110.5

Auxiliary Information

Method / Apparatus / Procedure:

The method used to determine the solubility has been described earlier.[1]

Source and Purity of Materials:

Chemically pure KH_2PO_4 and $NH_4H_2PO_4$ were used.

Estimated Error:

No information is given.

References:

[1] Ya. S. Shenkin, S. A. Ruchnova, A. P. Shenkina, Zh. Neorg. Khim. **13**, 256 (1968).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A. P. Solov'ev, E. F. Balashova, N. A. Verendyakina, L. F. Zyuzina, Vzaymodeystvie Khloridov Kaliya, Magniya, Amoniya s ich Nitratami i Fosfatami 3-11 (1977).

Variables:

Composition at 25 °C.

Prepared By:

J. Eysseltová

Experimental Data

Composition of saturated solutions in the $NH_4H_2PO_4$–KH_2PO_4–H_2O system at 25 °C

$NH_4H_2PO_4$		KH_2PO_4		H_2O	Refractive	Solid
$100w_i$	m_i/mol kg^{-1a}	$100w_i$	m_i/mol kg^{-1a}	$100w_i$	index	phases
—	0.00	21.60	2.024	78.40	1.3550	KH_2PO_4
4.08	0.472	20.80	2.034	75.12	1.3630	Solid soln
5.98	0.695	19.24	1.890	74.78	1.3665	Solid soln
14.25	1.778	16.10	1.698	69.65	1.3720	Solid soln
18.80	2.417	13.60	1.478	67.60	1.3742	Solid soln
22.57	2.969	11.37	1.264	66.06	1.3750	Solid soln
24.20	2.877	9.24	0.995	66.56	1.3760	Solid soln
26.30	3.427	7.00	0.771	66.70	1.3770	Solid soln
28.05	3.403	0.30	0.030	71.65	1.3780	Solid soln
29.30	3.613	—	0.00	70.70	1.3780	$NH_4H_2PO_4$

[a] These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

The mixtures were equilibrated for 1–3 days in a thermostat. The ammonium ion content was determined by the Kjeldahl method. The H_2PO_4 was precipitated as NH_4MgPO_4, and the excess Mg was titrated complexometrically. The refractive index was measured with a IRF-22 refractometer.

Source and Purity of Materials:

The salts were reagent grade or chemically pure and were recrystallized before being used.

Estimated Error:

The temperature was controlled to within ± 0.1 K. No other information is given.

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Thallium dihydrogenphosphate; TlH_2PO_4; [17735-75-0]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
M. Bruzau, Bull. Soc. Chim. France 1177-80 (1948).

Variables:
Composition at 29.5 °C.

Prepared By:
J. Eysseltová

Experimental Data
Solubility in the $NH_4H_2PO_4$–TlH_2PO_4–H_2O system at 29.5 °C

$NH_4H_2PO_4$		TlH_2PO_4		H_2O	Density	
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	g cm^{-3}	Solid phase
30.87	3.882	0	0	69.13	1.174	Solid soln
30.42	3.873	1.30	0.0632	68.28	1.186	Solid soln
29.86	3.839	2.52	0.124	67.62	1.197	Solid soln
29.48	3.838	3.74	0.186	66.78	1.208	Solid soln
29.03	3.820	4.90	0.246	66.07	1.217	Solid soln
28.33	3.812	7.07	0.363	64.60	1.240	Solid soln
27.41	3.748	9.02	0.471	63.57	1.257	Solid soln
25.10	3.664	15.35	0.8553	59.55	1.321[b]	Solid soln
23.09	3.455	18.81	1.074	58.10	1.355[b]	Solid soln
22.22	3.382	20.66	1.200	57.12	1.380	Solid soln
22.10	3.377	21.00	1.225	56.90	1.381	Solid soln
21.75	3.415	22.88	1.371	55.37	1.405	Solid soln
21.66	3.456	23.85	1.452	54.49	1.4155	Solid soln
20.23	3.270	25.98	1.603	53.79	1.442	Solid soln
20.11	3.263	26.32	1.630	53.57	1.4465	Solid soln
20.04	3.277	26.79	1.672	53.17	1.453	Solid soln
19.63	3.274	28.25	1.799	52.12	1.472	Solid soln
19.17	3.179	28.41	1.798	52.42	1.470	TlH_2PO_4
20.48	3.558	29.48	1.955	50.04	1.502	TlH_2PO_4
20.53	3.484	28.24	1.829	51.23	1.482	TlH_2PO_4
16.13	2.625	30.45	1.891	53.42	1.4785	TlH_2PO_4
13.57	2.073	29.51	1.720	56.92	1.4386	TlH_2PO_4
11.92	1.814	30.97	1.799	57.11	1.448	TlH_2PO_4
5.16	0.732	33.56	1.817	61.28	1.425	TlH_2PO_4
3.61	0.489	32.20	1.665	64.19	1.383	TlH_2PO_4
0	0	33.94	1.705	66.06	1.3937	TlH_2PO_4

[a]The molalities were calculated by the compiler.
[b]For these data the temperature was 30 °C.

Auxiliary Information

Method / Apparatus / Procedure:
The isothermal method was used. The mixtures equilibrated for 48 hrs, with frequent agitation, in a Prolabo water thermostat. The solid and liquid phases were separated from each other by filtration. Excess liquid was removed by pressure. Analytical process: total salt content was determined by evaporation to dryness at 100–110 °C; TlH_2PO_4 was determined by titration with a bromate solution using helianthine as indicator; $NH_4H_2PO_4$ was determined by difference. Density was determined by weighing 5 cm^3 samples of solution dispensed by a calibrated pipet.

Source and Purity of Materials:
Reagent grade Fy Prolabo $NH_4H_2PO_4$ was used. TlH_2PO_4 was synthesized by treating TlCl with H_2SO_4, treating the Tl_2SO_4 with a $Ba(OH)_2$ soln, filtering the TlOH and adding H_3PO_4 to pH=4.7 (bromocresol was indicator). The Tl content of the TlH_2PO_4 was 67.47%; the theoretical value is 67.87%.

Estimated Error:
No information is given.

Components:
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium carbonate; $(NH_4)_2CO_3$; [506-87-6]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Dipotassium carbonate; K_2CO_3; [584-08-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:
M. N. Syromyatnikova, N. S. Torocheshnikov, A. B. Kuznetsova, Zh. Prikl. Khim. (Leningrad) **52**, 568-71 (1979).

Variables:
Composition at 0, 10, 20 and 30 °C.

Prepared By:
J. Eysseltová

Experimental Data

8.1. Solubility in the $NH_4H_2PO_4$–K_2CO_3–H_2O System

N $100w_i$	P_2O_5 $100w_i$	K_2O $100w_i$	Σ[a] $100w_i$	N:P_2O_5: K_2O	Solid phases[b]
			temp=0 °C		
2.25	11.40	—	13.65	1:5.07:0	
3.56	20.07	14.70	38.83	1:5.64:4.14	A+B+C
3.12	20.40	15.31	38.83	1:5.54:4.91	A+B+C
3.13	16.31	16.00	35.44	1:5.20:5.10	A+B
1.54	8.40	13.38	23.32	1:5.45:8.68	
1.72	9.27	14.89	25.88	1:5.40:8.50	A+D+E(tr)
1.47	8.70	19.10	29.27	1:5.92:12.99	A+D+E(tr)
1.08	9.76	26.46	37.30	1:9.07:24.60	A+D+F(tr)
0.7	6.55	29.35	36.60	1:9.34:41.81	
0.5	6.36	28.88	35.74	1:12.60:57.7	A+B+E(tr)+F(tr)
0.39	3.17	29.00	32.56	1:8.12:74.0	
			temp=10 °C		
2.77	14.10	—	16.87	1:5.09:0	
4.98	24.60	4.34	33.92	1:4.92:0.87	
6.05	26.70	9.16	41.92	1:4.40:1.51	
5.45	22.70	8.15	36.30	1:4.18:1.50	
5.18	23.60	13.14	41.92	1:4.56:2.54	
4.80	19.80	14.70	39.30	1:4.13:4.50	
4.33	21.00	15.70	41.03	1:4.85:3.64	
3.35	19.93	16.10	39.38	1:5.66:4.57	
3.05	19.40	16.25	38.70	1:6.40:5.3	
2.70	17.42	15.91	36.03	1:6.46:5.9	
2.10	13.77	16.50	32.37	1:6.58:7.96	
2.89	14.30	18.90	36.09	1:5.14:6.78	
1.59	11.70	22.10	35.39	1:7.35:13.9	
1.27	10.12	26.00	37.39	1:9.96:20.45	
0.7	12.00	26.90	39.60	1:17.10:38.20	
0.44	4.99	31.80	37.23	1:11.4:72.4	
			temp=20 °C		
3.31	16.78	—	20.09	1:5.08:0	
6.30	29.50	7.25	43.05	1:4.68:1.15	A+B+C
4.79	27.20	15.28	47.27	1:3.65:3.18	A+B+C
4.01	25.90	18.90	48.81	1:0.45:4.7	A+B+C
3.80	22.00	16.55	42.35	1:5.78:4.35	A+B+C
3.48	25.00	20.90	49.38	1:7.18:6.0	A+B+C
2.70	15.90	17.90	36.50	1:5.89:6.62	A+D
0.47	8.27	25.60	34.34	1:17.6:54.5	A+G
1.09	4.30	29.75	35.14	1:3.95:27.3	A+G
			temp=30 °C		

3.86	19.55	—	23.41	1:5.07:0
6.12	32.17	8.81	47.10	1:5.26:1.44
4.56	27.58	17.19	49.33	1:6.05:3.77
3.84	21.10	18.05	42.99	1:5.49:4.7
3.50	24.58	22.32	50.40	1:7.02:6.38
4.42	26.80	17.20	48.42	1:6.06:3.89
3.56	25.36	20.78	49.70	1:7.12:5.84
3.02	16.10	19.48	38.60	1:5.33:6.45
2.64	13.42	26.30	42.36	1:5.08:9.96
0.04	5.00	30.92	35.96	1:125:733

[a]This is the total plant nutrient.
[b]The solid phases are: A = $KHCO_3$; B = $NH_4H_2PO_4$; C = KH_2PO_4; D = K_2HPO_4; E = $(NH_4)_2CO_3 \cdot H_2O$; F = $K_2CO_3 \cdot 1.5H_2O$; G = $K_2HPO_4 \cdot 3H_2O$; (tr) = traces.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. Mixtures were prepared in 100 ml glass vessels by adding solid $NH_4H_2PO_4$ to satd solns of K_2CO_3 and by adding solid K_2CO_3 to satd solns of $NH_4H_2PO_4$. The mixtures were placed in a water thermostat and agitated for 3.5 hrs. The phases were separated from each other by filtration. The liquid phase was analyzed for ammonia,[1] phosphate ion[2] and potassium.[2] The identity of the solid phase was determined by X-ray analysis.

Source and Purity of Materials:

Pure K_2CO_3 and reagent grade $NH_4H_2PO_4$ were used.

Estimated Error:

The temperature was controlled to within ± 0.05 K.

References:

[1]I. N. Shokin, S. A. Krasheninikov, *et al.* Tekhnicheskiy Analiz i Kontrol' v Proizvodstve Neorganicheskikh Veshchestv, Izd. Vysshaya Shkola, Moscow 1968.
[2]F. N. Kel'man, E. B. Bruckus, R. F. Osherovich, Metody Analiza pri Kontrole Proizvodstva Sernoy Kisloty i Fosfornykh Udobreniy, Goskhimizdat, Moscow 1963.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Sodium dihydrogenphosphate; NaH_2PO_4; [7558-80-7]
(4) Sodium nitrate; $NaNO_3$; [7631-99-4]
(5) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

8.2. NH_4^+, $Na^+ \| H_2PO_4^-$, NO_3^-–H_2O

In contrast to other multicomponent systems involving ammonium dihydrogen phosphate, the NH_4^+, $Na^+ \| H_2PO_4^-$, NO_3^-–H_2O system has been studied in detail. Shpunt[1–3] determined solubility isotherms of this system at 253, 258, 263, 273, 293 and 303 K and also made a polythermal investigation of the stable diagonal $NH_4H_2PO_4$–$NaNO_3$–H_2O system. Figures 21–24 show a comparison of some of these solubility values with those reported earlier by Shpunt[7] as well as results reported by other investigators who studied the boundary ternary systems,[4,5,7,8] (see pp. 1343, 1351). It is obvious that the agreement is not very good even with results reported by a given author. Consequently, nothing definitive can be said about the shape of the respective phase diagram at this time.

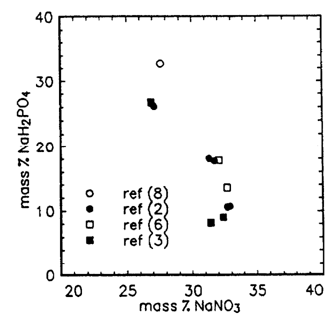

FIG. 21. The solid phases are $NaH_2PO_4 \cdot 2H_2O$ and $NaNO_3$.

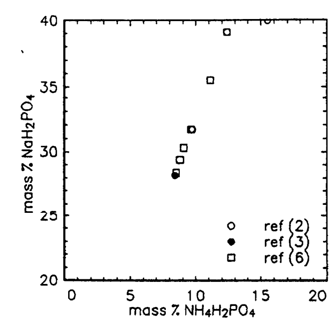

FIG. 22. The solid phases are $NaH_2PO_4 \cdot 2H_2O$ and $NH_4H_2PO_4$.

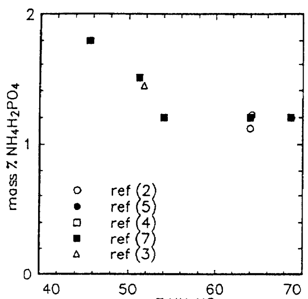

FIG. 23. The solid phases are $NH_4H_2PO_4$ and NH_4NO_3.

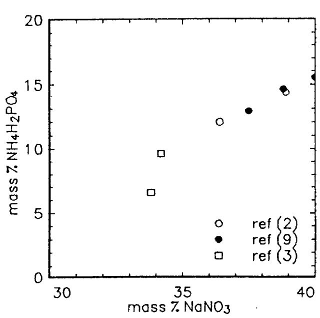

FIG. 24. The solid phases are $NH_4H_2PO_4$ and $NaNO_3$.

References:

[1] S. Ya. Shpunt, Zh. Prikl. Khim. (Leningrad) **20**, 685 (1947).
[2] S. Ya. Shpunt, Zh. Prikl. Khim. (Leningrad) **30**, 948 (1957).
[3] S. Ya. Shpunt, Zh. Prikl. Khim. (Leningrad) **30**, 1148 (1957).
[4] A. G. Bergman and P. F. Bochkarev, Izv. Akad. Nauk SSSR, Otd. Mat. Estestv. Nauk 237 (1938).
[5] P. F. Bochkarev, Tr. Vostoch.-Sibir. Gosud. Inst. 3 (1935).
[6] S. Ya. Shpunt, Zh. Prikl. Khim. (Leningrad) **13**, 9 (1940).
[7] A. G. Bergman and P.F. Bochkarev, Zh. Prikl. Khim. (Leningrad) **10**, 1531 (1937).
[8] V. I. Kol'ba, M. I. Zhikarev, and L. P. Sukhanov, Zh. Neorg. Khim. **26**, 828 (1981).
[9] A. Iovi and C. Haiduc, Rev. Roum. Chim. **16**, 743 (1971).

Components
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Sodium dihydrogenphosphate; NaH_2PO_4; [7558-80-7]
(4) Sodium nitrate; $NaNO_3$; [7631-99-4]
(5) Water; H_2O; [7732-18-5]

Original Measurements:
S. Ya. Shpunt, Zh. Prikl. Khim. (Leningrad) **20**, 685-92 (1947).

Variables:
Temperature and composition.

Prepared By:
J. Eysseltová

Experimental Data

Part 1. Composition of the relevant sections.
I 10% soln $NaNO_3 + NH_4H_2PO_4$ added.
II 20% soln $NaNO_3 + NH_4H_2PO_4$ added.
III 30% soln $NaNO_3 + NH_4H_2PO_4$ added.
IV 40% soln $NaNO_3 + NH_4H_2PO_4$ added.
V 43% soln $NaNO_3 + NH_4H_2PO_4$ added.
VI 46.7% soln $NaNO_3 + NH_4H_2PO_4$ added.
VII 6.0% soln $NH_4H_2PO_4 + NaNO_3$ added.
VIII 10.0% soln $NH_4H_2PO_4 + NaNO_3$ added.

Part 2. Crystallization temperatures

$NaNO_3$		$NH_4H_2PO_4$		H_2O		
$100w_i$	m_i/mol kg^{-1a}	$100w_i$	m_i/mol kg^{-1a}	$100w_i^a$	t/°C	Solid phases
			Section I			
10^b	1.3	—	—	90	−3.9	ice
9.6	1.3	4.1	0.41	86.3	−5.2	ice
9.1	1.3	9.1	0.97	81.8	−6.3	ice
8.7	1.3	13.0	1.44	78.3	−7.4	ice
8.1	1.3	18.7	2.22	73.2	+3.4	$NH_4H_2PO_4$
7.8	1.3	21.3	2.61	70.9	+11.5	$NH_4H_2PO_4$
7.7	1.3	23.1	2.90	69.2	+16.1	$NH_4H_2PO_4$
7.5	1.3	24.2	3.08	68.3	+19.3	$NH_4H_2PO_4$
7.4	1.3	25.4	3.29	67.2	+22.9	$NH_4H_2PO_4$
7.3	1.3	26.5	3.48	66.2	+25.7	$NH_4H_2PO_4$
7.2	1.3	27.5	3.66	65.3	+28.7	$NH_4H_2PO_4$
7.1	1.3	28.6	3.87	64.3	+31.4	$NH_4H_2PO_4$
			Section II			
20^b	2.9	—	—	80.0	−7.6	ice
19.5	2.92	2.0	0.22	78.5	−8.6	ice
18.9	2.95	5.6	0.64	75.5	−9.8	ice
18.1	2.93	9.1	1.1	72.8	−11.0	ice
17.5	2.93	12.3	1.52	70.2	−12.0	ice
16.7	2.92	16.0	2.07	67.3	+2.3	$NH_4H_2PO_4$
16.6	2.92	16.6	2.16	66.8	+3.5	$NH_4H_2PO_4$
16.1	2.93	19.3	2.60	64.6	+12.1	$NH_4H_2PO_4$
15.8	2.92	20.6	2.82	63.6	+17.2	$NH_4H_2PO_4$
15.6	2.94	22.0	3.06	62.4	+20.6	$NH_4H_2PO_4$
15.3	2.92	23.1	3.26	61.6	+25.1	$NH_4H_2PO_4$
15.1	2.93	24.2	3.47	60.7	+29.3	$NH_4H_2PO_4$
			Section III			
30^b	5.0	—	—	70.0	−13.4	ice
28.8	5.03	3.8	0.49	67.4	−15.0	ice
27.6	5.00	7.4	0.99	65.0	−16.2	ice
27.1	5.00	9.1	1.2	63.8	−16.9	ice + $NH_4H_2PO_4$
26.7	5.02	10.7	1.49	62.6	−12.0	$NH_4H_2PO_4$
26.2	5.00	12.2	1.72	61.6	[illegible]	

25.5	5.01	14.6	2.12	59.9	+3.3	$NH_4H_2PO_4$
25.4	5.03	15.2	2.22	59.4	+6.1	$NH_4H_2PO_4$
24.9	5.01	16.6	2.47	58.5	+12.0	$NH_4H_2PO_4$
24.4	5.01	18.3	2.78	57.3	+18.0	$NH_4H_2PO_4$
24.1	5.01	19.3	2.96	56.6	+21.7	$NH_4H_2PO_4$
23.7	5.01	20.6	3.21	55.7	+27.9	$NH_4H_2PO_4$
			Section IV			
40[b]	7.8	—	—	60.0	−8.0	$NaNO_3$
38.5	7.85	3.8	0.57	57.7	−6.0	$NaNO_3$
37.8	7.86	5.6	0.86	56.6	−4.7	$NaNO_3$
36.4	7.86	9.1	1.5	54.5	−3.0	$NaNO_3$
35.1	7.82	12.1	1.99	52.8	+1.6	$NH_4H_2PO_4$
34.4	7.81	13.8	2.32	51.8	+9.9	$NH_4H_2PO_4$
33.8	7.80	15.2	2.59	51.0	+16.2	$NH_4H_2PO_4$
33.3	7.82	16.6	2.88	50.1	+22.5	$NH_4H_2PO_4$
32.7	7.80	18.0	3.17	49.3	+28.0	$NH_4H_2PO_4$
			Section V			
43[b]	8.9	—	—	57.0	+4.2	$NaNO_3$
42.1	8.86	2.0	0.31	55.9	+5.3	$NaNO_3$
41.3	8.85	3.8	0.60	54.9	+5.9	$NaNO_3$
39.8	8.87	7.4	1.2	52.8	+7.5	$NaNO_3$
38.3	8.84	10.7	1.82	51.0	+9.1	$NaNO_3$
37.0	8.85	13.8	2.44	49.2	+13.8	$NH_4H_2PO_4$
36.4	8.85	15.2	2.73	48.4	+20.7	$NH_4H_2PO_4$
36.0	8.86	16.2	2.95	47.8	+26.2	$NH_4H_2PO_4$
35.2	8.85	18.0	3.34	46.8	+32.4	$NH_4H_2PO_4$
			Section VI			
46.7[b]	10.3	—	—	53.3	+19.1	$NaNO_3$
44.9	10.3	3.8	0.64	51.3	+20.1	$NaNO_3$
43.3	10.3	7.3	1.3	49.4	+20.7	$NaNO_3$
41.7	10.3	10.7	1.95	47.6	+21.9	$NaNO_3$
39.6	10.3	15.0	2.87	45.4	+24.5	$NH_4H_2PO_4$
38.9	10.3	16.6	3.24	44.5	+32.4	$NH_4H_2PO_4$
38.3	10.3	18.0	3.58	43.7	+37.1	$NH_4H_2PO_4$
			Section VII			
	--	6.0[b]	0.55	94.0	−1.8	ice
9.1	1.3	5.5	0.56	85.4	−5.5	ice
16.6	2.49	5.0	0.55	78.4	−9.0	ice
23.1	3.76	4.7	0.57	72.2	−11.7	ice
28.6	5.01	4.3	0.56	67.1	−14.7	ice
33.3	6.25	4.0	0.55	62.7	−17.4	ice
37.5	7.52	3.8	0.56	58.7	−10.4	$NaNO_3$
41.2	8.78	3.6	0.57	55.2	+4.1	$NaNO_3$
44.4	9.99	3.3	0.55	52.3	+18.0	$NaNO_3$
			Section VIII			
	--	10.0[b]	0.966	90.0	−2.8	ice
9.1	1.3	9.1	0.97	81.8	−6.5	ice
16.6	2.60	8.4	0.97	75.0	−10.0	ice
23.1	3.93	7.7	0.97	69.2	−13.2	ice
28.6	5.23	7.1	0.96	64.3	−16.5	ice
33.3	6.52	6.6	0.95	60.1	−19.0	ice
37.5	7.84	6.2	0.96	66.3	−5.3	$NaNO_3$
41.2	9.15	5.8	0.95	53.0	+9.3	$NaNO_3$
44.4	10.4	5.5	0.95	50.1	+22.5	$NaNO_3$

Part 3. Solubility isotherms in the $NaNO_3$–$NH_4H_2PO_4$–H_2O system

$NaNO_3$		$NH_4H_2PO_4$		H_2O	
$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$[a]	Solid phase[c]
		temp = −10 °C			
23.1	3.53	—	—	76.9	A
19.2	2.98	4.9	0.56	75.9	A
18.6	2.92	6.5	0.75	74.9	A
16.7	2.62	8.3	0.96	75.0	A
13.5	2.16	13.1	1.55	73.4	A+B
17.4	2.92	12.6	1.56	70.0	B
26.6	5.01	10.9	1.52	62.5	B
33.9	7.08	9.8	1.5	56.3[d]	B+D
34.4	7.23	9.6	1.5	56.0[d]	C+D
36.3	7.47	6.5	0.99	57.2	C
37.6	7.55	3.8	0.56	58.6	C
39.8	7.78	—	—	60.2	C
		temp = 0 °C			
	—	18.4	1.96	81.6	B
8.2	1.3	17.1	1.99	74.7	B
12.15	1.990	16.03	1.940	71.82[d]	B
16.7	2.90	15.5	1.99	67.8	B
24.58	4.714	14.08	1.995	61.34[d]	B
25.8	5.02	13.7	1.97	60.5	B
36.36	8.271	11.92	2.003	51.72[d]	B+C
36.4	8.30	12.0	2.02	51.6	B+C
38.8	8.31	6.3	1.0	54.9	C
39.24	8.383	5.69	0.898	55.07[d]	C
40.0	8.34	3.6	0.55	56.4	C
41.9	8.48	—	—	58.1	C
		temp = 10 °C			
	—	21.8	2.42	78.2	B
7.9	1.3	20.8	2.54	71.3	B
16.2	2.92	18.6	2.48	65.2	B
17.2	3.03	16.1	2.10	66.7	B
34.5	7.85	13.8	2.32	51.7	B
37.5	8.88	12.8	2.24	49.7	B+C
41.4	9.24	5.9	0.97	52.7	C
42.5	9.26	3.5	0.56	54.0	C
43.9	9.21	—	—	56.1	C
		temp = 20 °C			
—	—	25.9	3.03	74.1	B
7.6	1.3	24.1	3.06	68.3	B
15.7	2.95	21.6	2.99	62.7	B
18.65	3.642	21.1	3.03	60.3[d]	B
24.4	5.05	18.8	2.87	56.8	B
33.7	7.88	16.0	2.76	50.3	B
36.5	8.85	15.0	2.68	48.5	B
37.50	9.195	14.52	2.622	47.98[d]	B
38.81	9.802	14.61	2.718	46.58[d]	B+C
38.9	9.80	14.4	2.67	46.7[d]	B+C
40.87	9.793	10.03	1.770	49.1[d]	C
43.8	10.2	5.6	0.96	50.6	C
44.56	10.27	4.38	0.743	51.06[d]	C
45.2	10.3	3.2	0.54	51.6	C

46.0	10.0	—	—	54.0	C
		temp=30 °C			
		30.2	3.76	69.8	B
7.2	1.3	28.0	3.76	64.8	B
15.2	2.96	24.4	3.51	60.4	B
23.6	5.04	21.3	3.36	55.1	B
32.6	7.83	18.4	3.26	49.0	B
35.5	8.85	17.3	3.19	47.2	B
39.0	10.2	16.1	3.12	44.9	B
40.0	10.6	15.5	3.03	44.5	C+D
46.2	11.2	5.4	0.97	48.4	C
47.4	11.3	3.1	0.54	49.5	C
48.0	10.9	—	—	52.0	C
		temp=40 °C[d]			
	—	34.3	4.54	65.7	B
6.72	1.27	31.07	4.341	62.21	B
14.69	3.012	27.93	4.231	57.38	B
30.55	7.486	21.44	3.882	48.01	B
41.48	11.81	17.19	3.615	41.33	B+C
42.2	11.9	15.97	3.319	41.83	C
45.15	11.86	10.07	1.955	44.78	C
48.3	12.2	5.05	0.941	46.65	C
51.3	12.4	—	—	48.7	C
		temp=60 °C[d]			
—	—	43.8	6.77	56.2	B
11.24	2.583	37.57	6.380	51.19	B
23.21	5.983	31.15	5.933	45.64	B
34.2	10.1	26.1	5.71	39.7	B
42.97	14.54	22.27	5.569	34.76	B+C
44.93	14.61	18.90	4.542	36.17	C
47.8	14.9	14.39	3.308	37.8	C
50.04	14.28	8.72	1.84	41.24	C
55.55	14.70	—	—	44.45	C
		temp=80 °C[d]			
—	—	53.6	10.0	46.4	B
15.08	4.341	44.05	9.369	40.87	B
30.0	10.3	35.7	9.05	34.3	B
43.28	17.74	28.02	8.487	28.7	B+C
51.6	18.1	14.94	3.881	33.46	C
56.47	18.34	7.30	1.75	36.23	C
59.68	17.41	—	—	40.32	C
		temp=110 °C[d]			
—	—	67.3	17.9	32.7	B
26.27	13.48	50.8	19.3	22.9	B
43.33	30.11	39.74	20.40	16.93	B+C
57.28	26.08	16.88	5.678	25.84	C
65.7	22.5	—	—	34.3	C

Part 4. Solutions coexisting with two or three solid phases

$NaNO_3$		$NH_4H_2PO_4$		H_2O		
$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	m_i/mol kg^{-1}[a]	$100w_s$	t/°C	Solid phase[c]
8.6	1.3	14.7	1.67	76.7	−7.8	A+B
17.6	2.95	12.1	1.50	70.3	−12.0	A+B
27.2	5.03	9.2	1.3	63.6	−16.9	A+B
37.4	8.84	12.8	2.23	49.8	+9.9	B+C
39.8	10.3	14.7	2.81	45.5	+22.8	B+C
35.6	6.92	3.9	0.56	60.5	−18.4	A+C
34.1	6.74	6.4	0.94	59.5	−19.5	A+C
35.4	7.80	11.2	1.82	53.4	−1.4	B+C+D
32.7	6.47	7.8	1.1	59.5	−20.0	A+B+D
33.3	6.67	8.0	1.2	58.7	−20.6	A+C+D

[a]These values were calculated by the compiler.
[b]For these points the salt content was given as "—" in the original article. The compiler believes this to be an error and that the values should be those given in this Table.
[c]The solid phases are: A=ice; B=$NH_4H_2PO_4$; C=$NaNO_3$; D=$NaH_2PO_4 \cdot 2H_2O$.
[d]These data were obtained by the isothermic method. The rest of the data were obtained by the polythermic method.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method and the isothermal method were used but no details are given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given. The compiler believes the reproducibility of the analyses to be about 1%.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Sodium dihydrogenphosphate; NaH_2PO_4; [7558-80-7]
(4) Sodium nitrate; $NaNO_3$; [7631-99-4]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

S. Yu. Shpunt, Zh. Prikl. Khim. (Leningrad) **30**, 985-92 (1957).

Variables:

Composition at 30, 20 and 0 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Solubility isotherms in the $NaNO_3-NH_4NO_3-NH_4H_2PO_4-NaH_2PO_4-H_2O$ system

Soln no	Jänecke's indices[a] $NaNO_3$	NH_4NO_3	$NH_4H_2PO_4$	NaH_2PO_4	H_2O	Solid phases[b]
			temp = +30 °C			
1[c]	58.8	0.0	0.0	41.2	479	A+B
2	59.4	0.0	0.0	40.6	485	A+B
3[c]	43.3	0.0	17.8	38.9	378	A+B+C
4[c]	0.0	0.0	24.9	75.1	536	A+C
5	0.0	0.0	24.9	75.1	536	A+C
6[c]	13.1	0.0	22.0	64.9	445	A+C
7	25.0	0.0	22.1	52.9	456	A+C
8[c]	39.7	0.0	17.9	42.4	382	A+C
9[c]	43.3	0.0	17.8	38.9	378	A+B+C
10[c]	43.3	0.0	17.8	38.9	378	A+B+C
11[c]	59.6	0.0	19.4	21.0	400	B+C
12	77.7	0.0	22.3	0.0	408	B+C
13	67.5	24.0	8.5	0.0	377	B+C
14[c]	64.1	30.3	5.6	0.0	336	B+C
15[c]	49.4	48.2	2.4	0.0	275	B+C
16	47.5	50.6	1.9	0.0	255	B+C
17[c]	36.2	62.7	1.1	0.0	191	B+C
18[c]	27.5	71.7	0.8	0.0	147	B+C+D
19	27.1	72.9	0.0	0.0	147	B+D
20[c]	27.5	71.7	0.8	0.0	147	B+C+D
21[c]	0.0	98.8	1.2	0.0	192	C+D
22[c]	20.0	79.1	0.9	0.0	159	C+D
23	21.1	77.3	1.6	0.0	161	C+D
24[c]	27.5	71.7	0.8	0.0	147	B+C+D
			temp = +20 °C			
25[c]	71.7	0.0	0.0	28.3	540	A+B
26	71.0	0.0	0.0	29.0	542	A+B
27[c]	69.2	0.0	9.0	21.8	495	A+B
28[c]	63.4	0.0	18.5	18.1	446	A+B+C
29	0.0	0.0	24.9	75.1	621	A+C
30[c]	8.0	0.0	22.9	69.1	566	A+C
31[c]	15.1	0.0	21.6	63.3	538	A+C
32	25.0	0.0	22.0	53.0	553	A+C
33[c]	35.4	0.0	20.3	44.3	486	A+C
34[c]	61.2	0.0	18.5	20.3	447	A+C
35[c]	63.4	0.0	18.5	18.1	446	A+B+C
36[c]	63.4	0.0	18.5	18.1	446	A+B+C
37	78.5	0.0	21.5	0.0	445	B+C
38	67.9	24.1	8.0	0.0	408	B+C
39[c]	64.3	30.9	4.8	0.0	30	B+C
40[c]	49.0	48.9	2.1	0.0	267	B+C
41	47.6	50.6	1.8	0.0	276	B+C
42[c]	39.6	59.2	1.2	0.0	212	B+C
43[c]	32.7	66.2	1.1	0.0	183	B+C
44[c]	30.3	68.9	0.8	0.0	171	B+C+D
45	30.4	69.6	0.0	0.0	178	B+D
46[c]	30.3	68.9	0.8	0.0	171	B+C+D
47[c]	0.0	98.7	1.3	0.0	236	C+D
48	0.0	98.8	1.2	0.0	239	C+D
49[c]	4.8	94.0	1.2	0.0	226	C+D
50[c]	9.4	89.5	1.1	0.0	216	C+D
51[c]	17.4	81.6	1.0	0.0	199	C+D
52[c]	20.5	78.6	0.9	0.0	193	C+D
53	21.2	77.1	1.7	0.0	207	C+D
54[c]	27.4	71.7	0.9	0.0	175	C+D
55[c]	29.8	69.4	0.8	0.0	172	C+D
56[c]	30.3	68.9	0.8	0.0	171	B+C+D
57	30.9	68.2	0.9	0.0	162	B+C+D
			temp = 0 °C			
58[c]	81.3	0.0	0.0	18.7	657	A+B
59	81.4	0.0	0.0	18.6	667	A+B
60[c]	79.3	0.0	6.6	14.1	597	A+B
61	70.4	10.6	0.0	19.0	590	A+B
62[c]	79.5	0.0	20.1	0.4	558	A+B+C
63[c]	0.0	0.0	24.1	75.9	937	A+C
64	0.0	0.0	24.3	75.7	931	A+C
65[c]	21.3	0.0	23.0	55.7	852	A+C
66	25.2	0.0	21.5	53.3	825	A+C
67[c]	44.3	0.0	21.4	34.3	733	A+C
68	59.2	0.0	20.6	20.2	692	A+C
69[c]	79.5	0.0	20.1	0.4	558	A+B+C
70[c]	79.5	0.0	20.1	0.4	558	A+B+C
71	80.4	0.0	19.6	0.0	539	B+C
72[c]	71.3	21.1	7.6	0.0	483	B+C
73	68.8	24.4	6.8	0.0	477	B+C
74[c]	59.6	37.0	3.4	0.0	420	B+C
75[c]	51.1	46.9	2.0	0.0	341	B+C
76	47.8	50.8	1.4	0.0	321	B+C
77[c]	43.1	55.7	1.2	0.0	287	B+C
78[c]	37.9	61.2	0.9	0.0	255	B+C+D
79	37.4	62.6	0.0	0.0	265	B+D
80[c]	37.9	61.2	0.9	0.0	255	B+C+D
81[c]	0.0	98.1	1.9	0.0	395	C+D
82	0.0	98.0	2.0	0.0	402	C+D
83[c]	12.3	86.1	1.6	0.0	338	C+D
84	21.2	77.3	1.5	0.0	326	C+D
85[c]	27.4	71.4	1.2	0.0	292	C+D
86	30.8	68.0	1.2	0.0	289	C+D
87[c]	34.4	64.5	1.1	0.0	264	C+D
88[c]	37.9	61.2	0.9	0.0	255	B+C+D

[a]The composition units are: mol/100 mol of solute.
[b]The solid phases are: A = $NaH_2PO_4 \cdot 2H_2O$; B = $NaNO_3$; C = $NH_4H_2PO_4$; D = NH_4NO_3.
[c]An isothermal method was used for these solutions. A polythermic method was used for all the other solutions.

Part 2. The compiler has used the data in Part 1 to calculate the following values

Soln no	$NaNO_3$ 100w_i	$NaNO_3$ m_i[a]	NH_4NO_3 100w_i	NH_4NO_3 m_i[a]	$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i[a]	NaH_2PO_4 100w_i	NaH_2PO_4 m_i[a]	H_2O 100w_i
1	26.9	6.81	0.00	0.00	0.00	0.00	26.6	4.78	46.4
2	27.1	6.80	0.00	0.00	0.000	0.00	26.1	4.65	46.8
3	21.4	6.36	0.00	0.00	11.9	2.62	27.1	5.72	39.6
4	0.00	0.00	0.00	0.00	13.3	2.58	41.9	7.78	44.8
5	0.00	0.00	0.00	0.00	13.3	2.58	41.9	7.78	44.8
6	5.72	1.64	0.00	0.00	13.0	2.75	40.1	8.10	41.2
7	11.1	3.04	0.00	0.00	13.2	2.69	33.0	6.44	42.7
8	19.4	5.77	0.00	0.00	11.8	2.60	29.2	6.17	39.5
9	21.4	6.36	0.00	0.00	11.9	2.62	27.1	5.72	39.6
10	21.4	6.36	0.00	0.00	11.9	2.62	27.1	5.72	39.6
11	29.8	8.28	0.00	0.00	13.1	2.69	14.8	2.92	42.3
12	40.0	10.6	0.00	0.00	15.5	3.03	0.00	0.00	44.5
13	37.2	9.95	12.5	3.54	6.33	1.25	0.00	0.00	44.0
14	37.4	10.6	16.7	5.01	4.39	0.926	0.00	0.00	41.5
15	31.6	9.98	29.0	9.74	2.10	0.485	0.00	0.00	37.3
16	31.3	10.3	31.4	11.0	1.69	0.414	0.00	0.00	35.6
17	26.4	10.5	43.0	18.2	1.10	0.320	0.00	0.00	29.5
18	21.6	10.4	53.1	27.1	0.93	0.302	0.00	0.00	24.5
19	21.4	10.2	54.1	27.6	0.00	0.00	0.00	0.00	24.5
20	21.6	10.4	53.1	27.1	0.93	0.302	0.00	0.00	24.5
21	0.00	0.00	68.8	28.6	1.22	0.347	0.00	0.00	30.0
22	15.5	6.99	57.6	27.6	0.94	0.314	0.00	0.00	26.0
23	16.2	7.28	55.9	26.7	1.71	0.552	0.00	0.00	26.2
24	21.6	10.4	53.1	27.1	0.93	0.302	0.00	0.00	24.5
25	31.7	7.38	0.00	0.00	0.00	0.00	17.7	2.91	50.6
26	31.3	7.28	0.00	0.00	0.00	0.00	18.1	2.97	50.6
27	31.9	7.77	0.00	0.00	5.61	1.01	14.2	2.45	48.3
28	30.4	7.90	0.00	0.00	12.0	2.30	12.3	2.25	45.3
29	0.00	0.00	0.00	0.00	12.4	2.23	39.1	6.72	48.5
30	3.12	0.785	0.00	0.00	12.1	2.25	38.1	6.78	46.7
31	6.10	1.56	0.00	0.00	11.8	2.23	36.1	6.54	46.0
32	10.1	2.51	0.00	0.00	12.1	2.21	30.3	5.32	47.5
33	15.5	4.05	0.00	0.00	12.0	2.32	27.4	5.06	45.1
34	29.2	7.61	0.00	0.00	11.9	2.30	13.7	2.52	45.2
35	30.4	7.90	0.00	0.00	12.0	2.30	12.3	2.25	45.3
36	30.4	7.90	0.00	0.00	12.0	2.30	12.3	2.25	45.3
37	38.9	9.80	0.00	0.00	14.4	2.68	0.00	0.00	46.7
38	36.2	9.25	12.1	3.28	5.76	1.09	0.00	0.00	46.0
39	60.5	119.1	27.4	57.2	6.11	8.89	0.00	0.00	6.0
40	31.7	10.2	29.8	10.2	1.84	0.437	0.00	0.00	36.6
41	30.5	9.58	30.5	10.2	1.56	0.362	0.00	0.00	37.4
42	27.9	10.4	39.3	15.5	1.14	0.314	0.00	0.00	31.6
43	24.2	9.93	46.1	20.1	1.10	0.334	0.00	0.00	28.6
44	22.9	9.84	49.0	22.4	0.817	0.260	0.00	0.00	27.3
45	22.7	9.49	49.0	21.7	0.00	0.00	0.00	0.00	28.2
46	22.9	9.84	49.0	22.4	0.817	0.260	0.00	0.00	27.3
47	0.00	0.00	64.2	23.2	1.22	0.306	0.00	0.00	34.5
48	0.00	0.00	64.0	23.0	1.12	0.279	0.00	0.00	34.8
49	3.36	1.18	62.0	23.1	1.14	0.295	0.00	0.00	33.5
50	6.67	2.42	59.8	23.0	1.06	0.283	0.00	0.00	32.5
51	12.6	4.86	55.8	22.8	0.983	0.279	0.00	0.00	30.6
52	15.0	5.90	54.2	22.6	0.892	0.259	0.00	0.00	29.9
53	15.1	5.69	51.9	20.7	1.64	0.456	0.00	0.00	31.3
54	20.6	8.70	50.7	22.8	0.914	0.286	0.00	0.00	27.8
55	22.5	9.63	49.3	22.4	0.816	0.258	0.00	0.00	27.5
56	22.9	9.84	49.0	22.4	0.817	0.260	0.00	0.00	27.3
57	23.7	10.6	49.2	23.4	0.932	0.309	0.00	0.00	26.3
58	32.9	6.87	0.00	0.00	0.00	0.00	10.7	1.58	56.4
59	32.7	6.78	0.00	0.00	0.00	0.00	10.6	1.55	56.7
60	33.8	7.38	0.00	0.00	3.81	0.614	8.49	1.31	53.9
61	30.3	6.63	4.30	1.00	0.00	0.00	11.6	1.79	53.8
62	35.3	7.92	0.00	0.00	12.1	2.00	0.251	0.040	52.4
63	0.00	0.00	0.00	0.00	9.64	1.43	31.7	4.50	58.7
64	0.00	0.00	0.00	0.00	9.76	1.45	31.7	4.52	58.5
65	6.84	1.39	0.00	0.00	10.0	1.50	25.2	3.63	57.9
66	8.28	1.70	0.00	0.00	9.56	1.45	24.7	3.59	57.4
67	16.0	3.36	0.00	0.00	10.5	1.62	17.5	2.60	56.1
68	22.6	4.75	0.00	0.00	10.6	1.65	10.9	1.62	55.9
69	35.3	7.92	0.00	0.00	12.1	2.00	0.251	0.040	52.4
70	35.3	7.92	0.00	0.00	12.1	2.00	0.251	0.040	52.4
71	36.4	8.29	0.00	0.00	12.0	2.02	0.00	0.00	51.6
72	35.0	8.20	9.75	2.43	5.05	0.874	0.00	0.00	50.2
73	34.1	8.01	11.4	2.84	4.56	0.792	0.00	0.00	50.0
74	31.7	7.88	18.5	4.89	2.45	0.450	0.00	0.00	47.3
75	30.0	8.33	26.0	7.64	1.59	0.326	0.00	0.00	42.4
76	28.9	8.27	28.9	8.79	1.14	0.242	0.00	0.00	41.1
77	27.3	8.34	33.2	10.8	1.03	0.232	0.00	0.00	38.5
78	25.1	8.26	38.2	13.3	0.80	0.196	0.00	0.00	35.8
79	24.5	7.84	38.7	13.1	0.00	0.00	0.00	0.00	36.8
80	25.1	8.26	38.2	13.3	0.80	0.196	0.00	0.00	35.8
81	0.00	0.00	51.7	13.8	1.44	0.267	0.00	0.00	46.8
82	0.00	0.00	51.2	13.5	1.50	0.276	0.00	0.00	47.3
83	7.36	2.02	48.5	14.2	1.30	0.263	0.00	0.00	42.8
84	12.8	3.61	44.1	13.2	1.23	0.256	0.00	0.00	41.8
85	17.3	5.21	42.5	13.6	1.03	0.228	0.00	0.00	39.1
86	19.5	5.92	40.6	13.1	1.03	0.231	0.00	0.00	38.8
87	22.6	7.24	39.8	13.6	0.976	0.231	0.00	0.00	36.7
88	25.1	8.26	38.2	13.3	0.808	0.196	0.00	0.00	35.8

[a]The molalities are expressed as mol kg^{-1}.

Auxiliary Information

Method / Apparatus / Procedure:

No information is given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given. The compiler estimates the reproducibility of the analyses to be about ±2%.

Components	Original Measurements:
(1) Ammonium dihydrogenphosphate: $NH_4H_2PO_4$; [7722-76-1] (2) Ammonium nitrate; NH_4NO_3; [6484-52-2] (3) Sodium dihydrogenphosphate; NaH_2PO_4; [7558-80-7] (4) Sodium nitrate; $NaNO_3$; [7631-99-4] (5) Water; H_2O; [7732-18-5]	S. Ya. Shpunt, Zh. Prikl. Khim. (Leningrad) **30**, 1148-59 (1957).
Variables:	**Prepared By:**
Composition at −10, −15 and −20 °C.	J. Eysseltová

Experimental Data

Part 1. Solubility isotherms in the $NaNO_3-NH_4NO_3-NH_4H_2PO_4-NaH_2PO_4-H_2O$ system

Soln no	Jänecke's indices[a] $NaNO_3$	NH_4NO_3	$NH_4H_2PO_4$	NaH_2PO_4	H_2O	Solid phases[b]
			temp = −10 °C			
1[c]	83.5	0.0	0.0	16.5	714	A+B
2	83.7	0.0	0.0	16.3	721	A+B
3	71.0	10.8	18.2	0.0	681	A+B
4[c]	80.3	2.3	17.4	0.0	579	A+B+C
5	0.0	0.0	23.7	76.3	1141	A+C
6[c]	28.2	0.0	22.0	56.8	967	A+C
7	25.1	0.0	21.6	53.3	997	A+C
8[c]	44.5	0.0	21.5	34.0	865	A+C
9	58.9	0.0	21.1	20.1	841	A+C
10[c]	80.3	2.3	17.4	0.0	579	A+B+C
11[c]	80.3	2.3	17.4	0.0	579	A+B+C
12	82.3	0.0	17.1	0.0	638	A+B+C
13[c]	70.5	22.3	7.2	0.0	500	B+C
14	69.4	24.6	6.0	0.0	533	B+C
15[c]	51.7	46.2	2.1	0.0	369	B+C
16	47.9	50.9	1.2	0.0	348	B+C
17[c]	43.0	55.8	1.2	0.0	325	B+C+D
18	41.5	58.5	0.0	0.0	323	B+D
19[c]	43.0	55.8	1.2	0.0	325	B+C+D
20[c]	0.0	97.4	2.6	0.0	497	C+D
21	0.0	97.3	2.7	0.0	498	C+D
22[c]	17.6	80.4	2.0	0.0	426	C+D
23	21.1	77.3	1.6	0.0	401	C+D
24[c]	28.9	69.6	1.5	0.0	377	C+D
25	30.8	67.9	1.3	0.0	373	C+D
26[c]	43.0	55.8	1.2	0.0	325	B+C+D
27[c]	0.0	84.8	15.2	0.0	1243	C+E
28	0.0	85.1	14.9	0.0	1246	C+E
29	16.8	60.8	22.4	0.0	1386	C+E
30	23.7	53.0	23.3	0.0	1387	C+E
31	32.7	34.8	32.5	0.0	1500	C+E
32	42.9	15.3	41.8	0.0	1550	C+E
33	41.8	0.0	43.9	14.3	1540	C+E
34	19.5	0.0	38.6	41.9	1485	C+E
35[c]	0.0	0.0	30.8	69.2	1325	C+E
36	0.0	0.0	30.1	69.9	1364	C+E
			temp = −15 °C			
37	84.5	0.0	0.0	15.6	767	A+B
38	69.9	11.3	0.0	18.8	700	A+B
39	80.5	2.5	17.0	0.0	588	A+B+C
40	29.0	22.4	0.0	48.6	935	A+E
41	63.6	0.0	21.1	15.3	915	A+C
42	80.5	2.5	17.0	0.0	588	A+B+C
43	80.5	2.5	17.0	0.0	588	A+B+C
44	68.7	25.6	5.7	0.0	549	B+C
45	46.4	52.5	1.1	0.0	361	B+C
46	45.3	53.4	1.3	0.0	337	B+C+D
47	45.3	53.4	1.3	0.0	337	B+C+D
48	29.5	69.4	1.1	0.0	407	C+D
49	20.1	78.4	1.5	0.0	444	C+D
50	0.0	97.3	2.7	0.0	524	C+D
51	0.0	95.1	4.9	0.0	738	C+E
52	19.1	73.8	7.1	0.0	804	C+E
53	27.7	64.6	7.7	0.0	839	C+E
54	42.1	47.8	11.1	0.0	925	C+E
55	58.2	21.5	20.3	0.0	993	C+E
56	61.9	0.0	23.3	14.8	991	C+E
57	29.0	22.4	0.0	48.6	935	A+C+E
58	58.6	0.0	0.0	41.4	1073	A+E
59	48.5	7.9	0.0	43.6	975	A+E
60	29.0	22.4	0.0	48.6	935	A+C+E
			temp = −20 °C			
61	86.2	13.8	0.0	0.0	675	B+E
62	87.4	0.0	12.6	0.0	728	B+E
63	70.8	10.7	0.0	18.5	740	A+B+E
64	70.8	10.7	0.0	18.5	740	A+C+E
65	63.3	17.7	0.0	19.0	633	A+C+E
66	63.3	17.7	0.0	19.0	633	A+C+E
67	79.3	3.0	17.7	0.0	650	A+B+C
68	70.8	10.7	0.0	18.5	740	A+B+E
69	79.3	3.0	17.7	0.0	650	A+B+C
70	79.3	3.0	17.7	0.0	650	A+B+C
71	70.0	24.8	5.2	0.0	576	B+C
72	47.9	51.0	1.1	0.0	376	B+C
73	47.4	51.5	1.1	0.0	373	B+C+D
74	46.0	54.0	0.0	0.0	386	B+D
75	47.4	51.1	1.1	0.0	373	B+C+D
76	47.4	51.5	1.1	0.0	373	B+C+D
77	30.7	67.7	1.6	0.0	473	C+D
78	21.1	77.1	1.8	0.0	488	C+D+E
79	23.2	76.8	0.0	0.0	536	D+E
80	21.1	77.1	1.8	0.0	488	C+D+E
81	63.3	17.7	0.0	19.0	633	A+C+E
82	67.6	24.1	8.3	0.0	682	C+E
83	47.5	50.3	2.2	0.0	613	C+E
84	30.4	66.9	2.7	0.0	562	C+E
85	21.1	77.1	1.8	0.0	488	C+D+E

[a]The composition units are: mol/100 mol of solute.
[b]The solid phases are: A = $NaH_2PO_4 \cdot 2H_2O$; B = $NaNO_3$; C = $NH_4H_2PO_4$; D = NH_4NO_3; E = ice.
[c]An isothermal method was used for these solutions. A polythermic method was used for all the other solutions.

Part 2. The compiler has used the data in Part 1 to calculate the following values

Soln no	$NaNO_3$ $100w_i$	$NaNO_3$ m_i[a]	NH_4NO_3 $100w_i$	NH_4NO_3 m_i[a]	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ m_i[a]	NaH_2PO_4 $100w_i$	NaH_2PO_4 m_i[a]	H_2O $100w_i$
1	32.4	6.50	0.00	0.00	0.00	0.00	9.03	1.28	58.6
2	32.3	6.45	0.00	0.00	0.00	0.00	8.87	1.26	58.9
3	28.4	5.79	4.07	0.881	9.85	1.48	0.00	0.00	57.7
4	35.1	7.70	0.947	0.221	10.3	1.67	0.00	0.00	53.6
5	0.00	0.00	0.00	0.00	8.41	1.15	28.2	3.72	63.3
6	8.22	1.62	0.00	0.00	8.68	1.26	23.4	3.26	59.7
7	7.37	1.40	0.00	0.00	8.38	1.20	22.1	2.97	62.0
8	14.6	2.86	0.00	0.00	9.54	1.38	15.7	2.18	60.1
9	20.0	3.89	0.00	0.00	9.72	1.39	9.66	1.33	60.6
10	35.1	7.70	0.947	0.221	10.3	1.67	0.00	0.00	53.6
11	35.1	7.70	0.947	0.221	10.3	1.67	0.00	0.00	53.6
12	34.2	7.17	0.00	0.00	9.62	1.49	0.00	0.00	56.2
13	34.0	7.83	10.1	2.48	4.70	0.800	0.00	0.00	51.1
14	32.5	7.23	10.8	2.56	3.80	0.625	0.00	0.00	52.9
15	29.3	7.78	24.7	6.96	1.61	0.316	0.00	0.00	44.3
16	28.0	7.65	28.0	8.13	0.949	0.192	0.00	0.00	43.1
17	25.9	7.35	31.7	9.54	0.978	0.205	0.00	0.00	41.5
18	25.2	7.14	33.4	10.1	0.00	0.00	0.00	0.00	41.5
19	25.9	7.35	31.7	9.54	0.978	0.205	0.00	0.00	41.5
20	0.00	0.00	45.8	10.9	1.76	0.291	0.00	0.00	52.5
21	0.00	0.00	45.6	10.9	1.82	0.301	0.00	0.00	52.5
22	9.45	2.30	40.7	10.5	1.45	0.261	0.00	0.00	48.4
23	11.7	2.92	40.2	10.7	1.20	0.222	0.00	0.00	46.9
24	16.4	4.26	37.2	10.3	1.15	0.221	0.00	0.00	45.3
25	17.6	4.59	36.4	10.1	1.00	0.194	0.00	0.00	45.0
26	25.9	7.35	31.7	9.54	0.978	0.205	0.00	0.00	41.5
27	0.00	0.00	22.0	3.79	5.66	0.679	0.00	0.00	72.4
28	0.00	0.00	22.0	3.79	5.54	0.664	0.00	0.00	72.5
29	4.22	0.673	14.4	2.44	7.62	0.898	0.00	0.00	73.8
30	5.94	0.949	12.5	2.12	7.91	0.933	0.00	0.00	73.6
31	7.66	1.21	7.67	1.29	10.3	1.20	0.00	0.00	74.4
32	9.70	1.54	3.26	0.548	12.8	1.50	0.00	0.00	74.2
33	9.34	1.51	0.00	0.00	13.3	1.58	4.51	0.516	72.9
34	4.38	0.730	0.00	0.00	11.7	1.44	13.3	1.57	70.6
35	0.00	0.00	0.00	0.00	9.93	1.29	23.3	2.90	66.8
36	0.00	0.00	0.00	0.00	9.51	1.23	23.0	2.85	67.4
37	31.4	6.12	0.00	0.00	0.00	0.00	8.19	1.13	60.4
38	27.4	5.55	4.17	0.897	0.00	0.00	10.4	1.49	58.1
39	34.9	7.61	1.02	0.236	9.99	1.61	0.00	0.00	54.0
40	9.16	1.72	6.66	1.33	0.00	0.00	21.7	2.89	62.5
41	20.7	3.86	0.00	0.00	9.29	1.28	7.02	0.929	63.0
42	34.9	7.61	1.02	0.236	9.99	1.61	0.00	0.00	54.0
43	34.9	7.61	1.02	0.236	9.99	1.61	0.00	0.00	54.0
44	31.7	6.95	11.1	2.59	3.56	0.577	0.00	0.00	53.6
45	26.7	7.14	28.5	8.08	0.857	0.169	0.00	0.00	44.0
46	26.9	7.47	29.8	8.80	1.04	0.214	0.00	0.00	42.3
47	26.9	7.47	29.8	8.80	1.04	0.214	0.00	0.00	42.3
48	16.2	4.03	35.8	9.47	0.816	0.150	0.00	0.00	47.2
49	10.6	2.52	38.9	9.81	1.07	0.188	0.00	0.00	49.5
50	0.00	0.00	44.4	10.3	1.77	0.286	0.00	0.00	53.8
51	0.00	0.00	35.5	7.16	2.63	0.369	0.00	0.00	61.9
52	7.11	1.32	25.9	5.10	3.58	0.491	0.00	0.00	63.4
53	10.0	1.83	22.0	4.28	3.77	0.510	0.00	0.00	64.2
54	14.1	2.53	15.1	2.87	5.04	0.667	0.00	0.00	65.7
55	18.4	3.26	6.40	1.20	8.69	1.14	0.00	0.00	66.5
56	19.1	3.47	0.00	0.00	9.73	1.31	6.45	0.830	64.7
57	9.16	1.72	6.66	1.33	0.00	0.00	21.7	2.89	62.5
58	17.0	3.03	0.00	0.00	0.00	0.00	17.0	2.14	66.0
59	15.0	2.76	2.30	0.450	0.00	0.00	19.0	2.48	63.7
60	9.16	1.72	6.66	1.33	0.00	0.00	21.7	2.89	62.5
61	35.6	7.09	5.37	1.14	0.00	0.00	0.00	0.00	59.0
62	33.8	6.67	0.00	0.00	6.59	0.962	0.00	0.00	59.6
63	26.8	5.32	3.82	0.803	0.00	0.00	9.91	1.39	59.4
64	26.8	5.32	3.82	0.803	0.00	0.00	9.91	1.39	59.4
65	26.3	5.56	6.92	1.55	0.00	0.00	11.1	1.67	55.7
66	26.3	5.56	6.92	1.55	0.00	0.00	11.1	1.67	55.7
67	32.5	6.78	1.16	0.256	9.83	1.51	0.00	0.00	56.5
68	26.8	5.32	3.82	0.803	0.00	0.00	9.91	1.39	59.4
69	32.5	6.78	1.16	0.256	9.83	1.51	0.00	0.00	56.5
70	32.5	6.78	1.16	0.256	9.83	1.51	0.00	0.00	56.5
71	31.5	6.75	10.5	2.39	3.16	0.502	0.00	0.00	54.9
72	27.1	7.08	27.1	7.54	0.841	0.163	0.00	0.00	45.0
73	26.9	7.06	27.5	7.67	0.844	0.164	0.00	0.00	44.8
74	25.8	6.62	28.5	7.77	0.00	0.00	0.00	0.00	45.8
75	26.9	7.06	27.3	7.61	0.846	0.164	0.00	0.00	44.9
76	26.9	7.06	27.5	7.67	0.844	0.164	0.00	0.00	44.8
77	15.6	3.61	32.4	7.95	1.10	0.188	0.00	0.00	50.9
78	10.6	2.40	36.4	8.78	1.22	0.205	0.00	0.00	51.8
79	11.1	2.40	34.6	7.96	0.00	0.00	0.00	0.00	54.3
80	10.6	2.40	36.4	8.78	1.22	0.205	0.00	0.00	51.8
81	26.3	5.56	6.92	1.55	0.00	0.00	11.1	1.67	55.7
82	27.5	5.51	9.23	1.96	4.57	0.676	0.00	0.00	58.7
83	20.9	4.30	20.8	4.56	1.31	0.199	0.00	0.00	57.0
84	14.1	3.01	29.2	6.61	1.69	0.267	0.00	0.00	55.1
85	10.6	2.40	36.4	8.78	1.22	0.205	0.00	0.00	51.8

[a]The molalities are expressed as mol kg^{-1}.

Auxiliary Information

Method / Apparatus / Procedure:
No information is given.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given. The compiler estimates the reproducibility of the analyses to be about ±2%.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Potassium nitrate; KNO_3; [7757-79-1]
(5) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic
September, 1995

Critical Evaluation:

8.3. NH_4^+, K^+ ‖ $H_2PO_4^-$, NO_3^-–H_2O

One prominent feature of the systems containing ammonium and potassium salts is the formation of solid solutions. Because of the isomorphy in the $NH_4H_2PO_4$–KH_2PO_4–H_2O system,[2,4] the evaluator suspects that articles reporting solid $NH_4H_2PO_4$ in the presence of potassium salts, and vice versa, are in error, especially when reporting the nature of the solid phases. In the title system, the stable diagonal $NH_4H_2PO_4$–KNO_3–H_2O was studied by Bergman and Bochkarov.[1,3] From their data a reasonable phase diagram may be constructed, Figure 25, at least with respect to solutions in equilibrium with two solid phases. But, as mentioned above, there is an uncertainty with respect to the precise nature of the solid phases. The work reported by Karnaukhov[7] may be used to illustrate this uncertainty. In this article, solid solutions between each of the components and the compound $NH_4NO_3 \cdot 3KNO_3$ are reported. Furthermore, the "invariant points" reported in Ref. 10 cannot be fitted on Figure 25. The evaluator surmises that the "modifications" of KNO_3 and $NH_4H_2PO_4$[10,11] (and even ones not reported in the respective binary systems (see pp 11–14) and, e.g., Ref. 5) reflect the difficulties in stating precisely the nature of the equilibrium solid phases. Another article[6] also reports the occurrence of solid solutions between ammonium and potassium phosphates as well as chlorides in the NH_4^+, K^+ ‖$H_2PO_4^-$, NO_3^-, Cl^-–H_2O system which can be formed by adding another component to the title system. Apparently identical systems were studied by Pozin et al.[8,9] However, these data cannot be compared with each other because different sections were studied: $NH_4H_2PO_4$–KNO_3–KCl–H_2O in Ref. 6 and $NH_4H_2PO_4$–NH_4NO_3–KCl–H_2O in Refs. 8,9.

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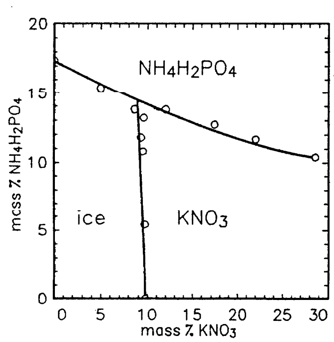

FIG. 25. Solubility in the $NH_4H_2PO_4$–KNO_3–H_2O system.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Potassium nitrate; KNO_3; [7757-79-1]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

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2. A. G. Bergman and P. F. Bochkarev, Izv. Akad. Nauk SSSR, Otd. Mat. Estestv. Nauk 237-66 (1938).

Variables:

Temperature and composition.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility in the $NH_4H_2PO_4$–KNO_3–H_2O system

$NH_4H_2PO_4$ Comp[a]	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ m_i/mol kg^{-1}[b]	KNO_3 Comp[a]	KNO_3 $100w_i$	KNO_3 m_i/mol kg^{-1}[b]	H_2O Comp[a]	H_2O $100w_i$	Solid phase[c]
				temp=0 °C				
100	18.4	2.0	0	0.0	0.0	2832	81.6	A
75.1	17.2	1.9	24.9	5	0.6	2170	77.8	A
62.3	15.8	1.8	37.7	8.4	1.1	1909	75.8	A
49.1	13.7	1.6	50.9	11.6	1.5	1773	74.7	A+B
53	11.6	1.3	47	11.5	1.5	1990	76.9	B
29.4	5.4	0.6	70.6	11.4	1.4	2892	83.2	B
0	0.0	0.0	100	11.2	1.2	4448	88.8	B
				temp=10 °C				
100	21.3	2.4	0	0.0	0.0	2360	78.7	A
78.9	20.4	2.4	21.1	4.8	0.6	1847	74.8	A
67.6	19.0	2.3	32.4	8.0	1.1	1658	73.0	A
55.2	16.4	2.0	44.8	11.7	1.6	1546	71.9	A
50.1	15.3	1.9	49.9	13.4	1.9	1491	71.3	A
41.5	13.0	1.6	58.5	16.1	2.2	1445	70.9	A+B
37.6	11	1.3	62.4	16.0	2.2	1596	73.0	B
21.7	5.1	0.6	78.3	16.2	2.0	2136	78.7	B
0	0.0	0.0	100	16.6	2.0	2819	83.4	B
				temp=20 °C				
100	25.5	3.0	0	0.0	0.0	1866	74.5	A
82.6	24.0	2.9	17.6	4.5	0.6	1568	71.5	A
80.79	22.5	2.8	19.21	7.7	1.1	1681	69.8	A
61.1	20	2.5	38.9	11.2	1.6	1342	68.8	A
50.2	17	2.2	49.8	14.8	2.1	1287	68.2	A
44	15.2	1.9	56.0	17.0	2.5	1253	67.8	A
32.2	11.8	1.5	67.8	21.8	3.2	1159	66.4	A+B
29.2	10.2	1.3	70.8	21.7	3.2	1247	68.1	B
15.5	4.7	0.6	84.5	22.4	3.0	1542	72.9	B
0	0.0	0.0	100	23.0	3.0	1781	77.0	B
				temp=30 °C				
100	30.2	3.8	0	0.0	0.0	1475	69.8	A
84.6	27.5	3.5	15.4	4.4	0.6	1338	68.1	A
75.8	26.0	3.4	24.2	7.3	1.1	1242	66.7	A
66.5	23.9	3.2	33.5	10.6	1.6	1163	65.5	A
51	19.2	2.6	49.0	16.2	2.5	1096	64.6	A
39.1	15.4	2.1	60.9	21.1	3.3	1045	63.5	A
25.6	10.6	1.5	74.4	27.0	4.3	964	62.4	A+B
23.5	9.5	1.3	76.5	27.2	4.2	1000	63.3	B
11.5	4.3	0.6	88.5	29.0	4.3	1142	66.7	B
0	0.0	0.0	100	31.0	4.4	1249	69.0	B

[a]The composition unit is: mol/100 mol solute.
[b]The molalities were calculated by the compilers.
[c]The solid phases are: A = $NH_4H_2PO_4$; B = KNO_3.

NOTE: The above data are given in both source papers, but source paper (2) also contains data for the composition of solutions in equilibrium with two or three solid phases. These data are given below.

Composition of solutions existing in equilibrium with two or three solid phases

KNO_3			$NH_4H_2PO_4$			H_2O			Solid
comp[a]	$100w_i$	m_i/mol kg^{-1} [b]	comp[a]	$100w_i$	m_i/mol kg^{-1} [b]	comp[a]	$100w_i$	t/°C	phase[c]
0	0	0	100	17.4	1.83	3032	82.6	−4.4	A+B
27.0	5.0	0.62	73.0	15.4	1.68	2410	79.6	−5.3	A+B
41.5	8.6	1.1	58.5	13.8	1.55	2101	77.6	−6.0	A+B
49.7	12.0	1.60	50.3	13.8	1.62	1726	74.2	0.4	B+C
60.9	17.4	2.46	39.1	12.7	1.58	1373	69.9	12.6	B+C
68.2	22.0	3.28	31.8	11.7	1.53	1152	66.3	20.7	B+C
75.8	28.6	4.64	24.2	10.4	1.48	907	61.0	32.7	B+C
47.8	9.5	1.2	52.2	11.8	1.30	2223	79.7	−5.7	A+C
50.1	9.5	1.2	49.9	10.8	1.18	2356	78.7	−5.4	A+C
67.2	9.7	1.1	32.8	5.4	0.55	3300	84.9	−4.2	A+C
100	9.8	1.1	0	0	0	5169	90.2	−2.5	A+C
45.3	9.6	1.2	54.7	13.2	1.49	2043	77.2	−6.3	A+B+C

[a]The composition unit is: mol/100 mol solute.
[b]The molalities were calculated by the compilers. The unit is: mol kg^{-1}.
[c]The solid phases are: A=ice; B=$NH_4H_2PO_4$; C=KNO_3.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.

Source and Purity of Materials:

Chemically pure materials were recrystallized before use.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Potassium nitrate; KNO_3; [7757-79-1]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

A. G. Bergman, L. V. Opredelenkova, and A. B. Dzuev, Ukr. Khim. Zh. 33, 285-7 (1967).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Crystallization temperature and composition of invariant points in the KNO_3–$NH_4H_2PO_4$–H_2O system

	KNO_3		$NH_4H_2PO_4$		H_2O	
t/°C	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	Solid phases[b]
−7.7	8.5	1.1	15.5	1.77	76.0	A+B+C
5.5	16.0	2.33	16.0	2.05	68.0	B+C+D
40	35.0	6.53	12.0	1.97	53.0	B+D+E
16.5	11.5	1.85	27.0	3.82	61.5	C+D+F
92.5	16.0	4.52	49.0	12.2	35.0	D+E+F

[a]These values were calculated by the compiler.
[b]The solid phases are: A=ice; B=α-KNO_3; C=α-$NH_4H_2PO_4$; D="unidentified conversion product"; E=β-KNO_3; F=β-$NH_4H_2PO_4$.

Additional Data: The relative areas of individual crystallization fields are: ice=3.76%; α-$NH_4H_2PO_4$=4.16%; β-$NH_4H_2PO_4$=22.83%; α-KNO_3=9.76%; β-KNO_3=52.93%; phase D=6.56%.

Auxiliary Information

Method / Apparatus / Procedure:

A polythermic method was used.[1] The appearance of the first crystals as well as the disappearance of the last crystals was recorded.

Source and Purity of Materials:

Reagent grade KNO_3 and $NH_4H_2PO_4$ were recrystallized and dried before being used. Their melting points were 337 and 200 °C, respectively.

Estimated Error:

The only information given is that the difference between the temperature of dissolution of the last crystal and appearance of the first crystal was kept to a minimum.

References:

[1]A. G. Bergman and N. P. Luzhnaya, Fiziko-Khimicheskie Osnovy Izucheniya i, Ispol'zovaniya Solyanykh Mestorozhdeniy, Khlorid-Sul'fatnogo Tipa, Moscow, IAN, SSSR (1951).

Components	**Original Measurements:**
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1] (2) Ammonium nitrate; NH_4NO_3; [6484-52-2] (3) Ammonium chloride; NH_4Cl; [12125-02-9] (4) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0] (5) Potassium nitrate; KNO_3; [7757-79-1] (6) Potassium chloride; KCl; [7447-40-7] (7) Water; H_2O; [7732-18-5]	A. G. Bergman and M. I. Shakhparonov, Izv. Sektora Fiz. Khim. Analiza, Inst. Obshch. Neorg. Khim. Akad. Nauk SSSR **21**, 331-45 (1953).
Variables:	**Prepared By:**
Composition and temperature.	J. Eysseltová

Experimental Data

Part 1. Six sections through the system were investigated. The sections are:

No. 1 KNO_3–(25 mol% KCl + 75 mol% $NH_4H_2PO_4$)–H_2O
No. 2 KNO_3–(50 mol% KCl + 50 mol% $NH_4H_2PO_4$)–H_2O
No. 3 KNO_3–(75 mol% KCl + 25 mol% $NH_4H_2PO_4$)–H_2O
No. 4 KNO_3–(96 mol% KCl + 4 mol% $NH_4H_2PO_4$)–H_2O
No. 5 KCl–(40 mol% KNO_3 + 75 mol% $NH_4H_2PO_4$)–H_2O
No. 6 $NH_4H_2PO_4$–(57.6 mol% KCl + 42.4 mol% KNO_3)–H_2O

Composition of saturated solutions in the $NH_4H_2PO_4$–KNO_3–KCl–H_2O system.

Section 1. Solubility Isotherms

Soln no	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
		temp = −5 °C			
1	25.0	75.0	0.0	2750	A
2	22.7	68.0	9.3	2760	A
3	23.7	72.8	3.5	2730	A
4	22.8	68.3	8.9	2780	A
5	20.6	61.9	17.5	2700	A
6	13.1	38.9	48.0	2660	A
7	12.7	38.2	49.1	2670	A
8	16.9	51.0	32.1	2240	C
9	17.6	55.6	25.8	2270	C
10	20.3	61.1	18.6	2310	C
11	22.7	68.0	9.3	2410	C
12	25.0	75.0	0.0	2530	C
		temp = 0 °C			
13	25.0	75.0	0.0	2240	D
14	22.7	68.0	9.3	2110	D
15	22.0	66.3	11.7	2060	D
16	17.9	53.8	28.3	2030	D
17	16.3	49.2	34.5	2000	D
18	14.6	43.7	41.7	1920	D
19	13.1	38.9	48.0	2000	B
20	10.8	32.5	56.7	2270	B
21	9.5	28.6	61.9	2530	B
22	6.6	20.1	73.3	2950	B
23	0.0	0.0	100.0	4280	B
		temp = 10 °C			
24	25.0	75.0	0.0	1000	D
25	22.7	68.0	9.3	1680	D
26	27.6	52.8	29.6	1640	D
27	14.0	42.2	43.8	1600	D
28	13.1	38.9	48.0	1550	D
29	22.6	38.4	49.0	1560	D
30	11.3	34.0	54.7	1490	B
31	9.5	28.6	61.9	1650	B
32	8.4	25.2	66.4	1760	B
33	4.8	14.4	80.8	2120	B
34	0.0	0.0	100.0	2720	B
		temp = 20 °C			
35	25.0	75.0	0.0	1480	D
36	22.7	68.0	9.3	1380	D
37	19.0	57.2	23.8	1330	D
38	14.6	43.8	41.6	1360	D
39	13.1	38.9	48.0	1350	D
40	11.3	34.0	54.7	1290	D
41	10.2	30.7	59.1	1250	D
42	9.5	28.6	61.9	1200	B
43	9.2	27.6	63.2	1210	B
44	6.4	19.1	74.5	1330	B
45	3.4	10.6	86.0	1540	B
46	0.0	0.0	100.0	1780	B
		temp = 30 °C			
47	25.0	75.0	0.0	1240	D
48	11.7	65.2	13.1	1180	D
49	16.0	47.7	36.3	1110	D
50	13.1	38.9	48.0	1120	D
51	12.1	26.5	51.4	1130	D
52	19.5	28.6	61.9	1030	D
53	9.3	27.8	62.9	1040	D
54	8.3	25.0	66.7	1020	D
55	7.3	22.1	70.6	970	B
56	4.9	14.8	80.3	1030	B
57	2.6	7.8	89.6	1150	B
58	0.0	0.0	100.0	1220	B
		temp = 35 °C			
59	25.0	75.0	0.0	1140	D
60	19.7	59.1	21.2	1070	D
61	14.8	44.7	40.5	1040	D
62	11.1	33.4	55.5	1040	D
63	8.4	25.5	66.1	960	D
64	7.5	22.7	69.8	930	D
65	6.4	19.4	74.2	850	B
66	4.3	13.0	82.7	910	B
67	2.2	6.7	91.1	1000	B
68	0.0	0.0	100.0	1040	B

Crystallization temperature and composition of invariant points

Soln no	t/°C	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
69	−2.7	0.0	0.0	100.0	4940	A+B
70	−5.6	22.7	68.0	9.3	2460	A+C
71	−5.4	13.1	38.9	48.0	2440	A+B
72	+4.3	13.1	38.9	48.0	1620	B+D
73	+18.7	9.5	28.6	61.9	1210	B+D
74	−4.1	9.5	28.6	61.9	3130	A+B
75	−3.9	7.8	22.2	70.0	3470	A+B
76	−5.3	12.1	36.4	51.5	2530	A+B
77	−5.6	20.7	62.5	16.8	2370	A+D
78	−5.8	17.4	52.1	30.3	2290	A+D
79	+2.0	13.5	40.4	46.1	1780	B+D
80	−6.0	19.0	57.2	23.8	2330	A+D
81	−5.3	25.0	75.0	0.0	2570	A+D
82	−6.2	14.4	43.2	42.4	2130	A+B+D

The compiler has calculated the following values from the data given above

Soln	KCl		$NH_4H_2PO_4$		KNO_3		H_2O
no	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
1	3.1	0.51	14.4	1.52	0.0	0.0	82.5
2	2.8	0.46	13.0	1.37	1.6	0.19	82.6
3	3.0	0.48	14.0	1.48	0.6	0.07	82.4
4	2.8	0.46	13.0	1.36	1.5	0.18	82.7
5	2.6	0.42	12.1	1.27	3.0	0.36	82.3
6	1.7	0.27	7.7	0.81	8.3	1.0	82.3
7	1.6	0.26	7.5	0.79	8.5	1.0	82.3
8	2.5	0.42	11.6	1.26	6.4	0.80	79.5
9	2.6	0.43	12.5	1.36	5.1	0.63	79.8
10	2.9	0.49	13.5	1.47	3.6	0.45	80.0
11	3.1	0.52	14.5	1.57	1.7	0.21	80.6
12	3.3	0.54	15.2	1.62	0.0	0.0	81.3
13	3.7	0.62	17.0	1.86	0.0	0.0	79.3
14	3.5	0.60	16.1	1.79	1.9	0.24	78.4
15	3.5	0.59	16.0	1.79	2.5	0.32	78.0
16	2.8	0.49	13.2	1.47	6.1	0.77	77.9
17	2.6	0.45	12.2	1.37	7.5	0.96	77.6
18	2.4	0.42	11.2	1.26	9.4	1.2	77.0
19	2.1	0.36	9.7	1.16	10.5	1.33	77.7
20	1.6	0.26	7.3	0.80	11.2	1.39	79.9
21	1.3	0.21	5.9	0.63	11.2	1.36	81.6
22	0.8	0.1	3.7	0.38	11.7	1.38	83.9
23	0.0	0.0	0.0	0.0	11.6	1.30	88.4
24	4.3	0.77	20.1	2.31	0.0	0.0	75.5
25	4.2	0.75	19.2	2.25	2.3	0.31	74.3
26	5.1	0.93	14.9	1.79	7.4	1.0	72.6
27	2.7	0.49	12.4	1.47	11.3	1.52	73.6
28	2.6	0.47	11.7	1.39	12.7	1.72	73.0
29	4.3	0.80	11.3	1.37	12.7	1.75	71.7
30	2.3	0.42	10.5	1.27	14.9	2.04	72.3
31	1.8	0.32	8.2	0.96	15.7	2.08	74.3
32	1.5	0.27	6.9	0.80	16.0	2.10	75.6
33	0.7	0.1	3.4	0.38	16.9	2.12	78.9
34	0.0	0.0	0.0	0.0	17.1	2.04	82.9
35	5.0	0.94	23.2	2.82	0.0	0.0	71.7
36	4.8	0.91	22.2	2.74	2.7	0.37	70.3
37	4.1	0.79	19.2	2.39	7.0	0.99	69.7
38	3.1	0.60	14.5	1.78	12.1	1.70	70.3
39	2.8	0.54	12.9	1.60	14.0	1.98	70.2
40	2.5	0.49	11.7	1.46	16.5	2.36	69.3
41	2.3	0.45	10.8	1.36	18.2	2.63	68.7
42	2.2	0.44	10.3	1.32	19.6	2.87	67.8
43	2.1	0.42	9.9	1.3	19.9	2.90	68.0
44	1.4	0.27	6.4	0.80	22.1	3.11	70.1
45	0.7	0.1	3.2	0.38	23.0	3.10	73.2
46	0.0	0.0	0.0	0.0	24.0	3.12	76.0
47	5.7	1.1	26.3	3.36	0.0	0.0	68.0
48	2.8	0.55	24.2	3.07	4.3	0.62	68.7
49	3.9	0.80	18.1	2.39	12.1	1.82	65.9
50	3.2	0.65	14.7	1.93	15.9	2.38	66.2
51	2.9	0.59	13.7	1.79	17.0	2.53	66.4
52	4.9	1.1	11.1	1.54	21.2	3.34	62.8
53	2.4	0.50	11.0	1.49	22.0	3.36	64.6
54	2.2	0.45	10.1	1.36	23.6	3.63	64.2
55	2.0	0.42	9.2	1.27	25.8	4.04	63.1
56	1.3	0.26	5.9	0.80	28.3	4.33	64.5
57	0.6	0.1	2.9	0.38	29.4	4.33	67.1
58	0.0	0.0	0.0	0.0	31.5	4.33	68.3
59	6.0	1.2	27.8	3.65	0.0	0.0	66.2
60	5.0	1.0	22.9	3.07	7.2	1.1	64.9
61	3.8	0.79	17.7	2.39	14.1	2.16	64.4
62	2.9	0.59	13.2	1.78	19.3	2.96	64.5
63	2.3	0.49	10.7	1.48	24.3	3.83	62.8
64	2.1	0.45	9.7	1.4	26.2	4.17	62.1
65	1.9	0.42	8.7	1.3	29.4	4.85	60.0
66	1.2	0.26	5.6	0.79	31.5	5.05	61.7
67	0.6	0.1	2.7	0.37	32.7	5.06	64.0
68	0.0	0.0	0.0	0.0	35.1	5.34	64.9
69	0.0	0.0	0.0	0.0	10.2	1.12	89.9
70	3.1	0.51	14.3	1.54	1.7	0.21	80.9
71	1.8	0.30	8.3	0.89	9.0	1.1	80.9
72	2.5	0.45	11.3	1.33	12.3	1.65	73.9
73	2.2	0.44	10.3	1.31	19.5	2.84	68.0
74	1.1	0.17	4.9	0.51	9.4	1.1	84.6
75	0.8	0.1	3.5	0.36	9.7	1.1	85.9
76	1.6	0.27	7.5	0.80	9.3	1.1	81.6
77	2.9	0.49	13.5	1.47	3.2	0.39	80.4
78	2.5	0.42	11.6	1.26	6.0	0.74	79.9
79	2.4	0.42	11.0	1.26	11.0	1.44	75.6
80	2.7	0.45	12.6	1.36	4.6	0.57	80.1
81	3.3	0.54	15.2	1.62	0.0	0.0	81.5
82	2.2	0.38	10.2	1.13	8.8	1.1	88.2

Section 2. Solubility Isotherms

Soln no	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
		temp = −5 °C			
1	50.0	50.0	0.0	3010	A
2	45.1	45.1	9.8	2920	A
3	42.6	42.6	14.8	2860	A
4	37.2	37.2	25.6	2400	D
5	42.6	42.6	14.8	2490	D
6	50.0	50.0	0.0	2600	D
		temp = 0 °C			
7	50.0	50.0	0.0	2330	D
8	48.0	48.0	4.0	2300	D
9	42.6	42.6	14.8	2180	D
10	31.9	31.9	36.2	2060	D
11	23.0	23.0	54.0	2450	B
12	18.7	18.7	62.6	2820	B
13	17.5	17.5	65.0	2890	B
14	0.0	0.0	100.0	4280	B
		temp = 10 °C			
15	50.0	50.0	0.0	1820	D
16	42.6	42.6	14.8	1825	D
17	37.0	37.0	26.0	1770	D
18	24.2	24.2	51.6	1570	B
19	18.7	18.7	62.6	1820	B
20	23.0	23.0	54.0	1620	B
21	13.0	13.0	74.0	2110	B
22	0.0	0.0	100.0	2720	B
		temp = 20 °C			
23	50.0	50.0	0.0	1570	D
24	46.6	46.6	6.8	1560	D
25	42.6	42.6	14.8	1510	D
26	28.4	28.4	43.2	1360	D
27	23.0	23.0	54.0	1240	D
28	19.3	19.3	61.4	1250	B
29	18.7	18.7	62.6	1250	B
30	9.3	9.3	81.4	1530	B
31	0.0	0.0	100.0	1780	B
		temp = 30 °C			
32	50.0	50.0	0.0	1330	D
33	42.6	42.6	14.8	1290	D
34	37.3	37.3	25.4	1240	D
35	23.0	23.0	54.0	1060	D
36	22.3	22.3	55.4	1070	D
37	18.7	18.7	62.6	1000	D
38	15.1	15.1	69.8	980	B
39	6.8	6.8	86.4	1120	B
40	0.0	0.0	100.0	1220	B
		temp = 35 °C			
41	50.0	50.0	0.0	1230	D
42	42.6	42.6	14.8	1200	D
43	33.6	33.6	32.8	1120	D
44	23.0	23.0	54.0	1010	D
45	18.4	18.4	60.2	950	D
46	18.7	18.7	62.6	940	D
47	13.4	13.4	73.2	860	B
48	5.8	5.8	88.4	920	B
49	0.0	0.0	100.0	1040	B

Crystallization temperature and composition of invariant points

Soln no	t/°C	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
50	−5.6	50.0	50.0	0.0	2660	A+D
51	−5.6	42.6	42.6	14.8	2520	A+D
52	−4.4	23.0	23.0	54.0	3020	A+B
53	+15.6	23.0	23.0	54.0	1320	B+D
54	−4.0	18.7	18.7	62.6	3420	A+B
55	+24.2	18.7	18.7	62.6	1090	B+D
56	−4.0	20.0	20.0	60.0	3290	A+B
57	−5.6	37.8	37.8	24.4	2450	A+D
58	+4.4	27.8	27.8	44.4	1770	B+D
59	−2.7	0.0	0.0	100.0	4940	A+B
60	−5.7	31.0	31.0	38.0	2340	A+B+D

The compiler has calculated the following values from the data given above

Soln no	KCl $100w_i$	KCl m_i/mol kg^{-1}	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ m_i/mol kg^{-1}	KNO_3 $100w_i$	KNO_3 m_i/mol kg^{-1}	H_2O $100w_i$
1	5.9	0.92	9.0	0.92	0.0	0.0	85.1
2	5.4	0.86	8.4	0.86	1.6	0.19	84.6
3	5.2	0.83	8.0	0.83	2.5	0.29	84.3
4	5.2	0.86	8.1	0.86	4.9	0.59	81.8
5	5.8	0.95	9.0	0.95	2.8	0.33	82.4
6	6.6	1.1	10.2	1.07	0.0	0.0	83.2
7	7.3	1.2	11.2	1.19	0.0	0.0	81.6
8	7.0	1.2	10.8	1.16	0.8	0.1	81.3
9	6.5	1.1	10.0	1.09	3.1	0.38	80.4
10	5.1	0.86	7.8	0.86	7.8	0.98	79.3
11	3.2	0.52	4.9	0.52	10.1	1.22	81.8
12	2.3	0.37	3.5	0.37	10.4	1.23	83.7
13	2.1	0.34	3.2	0.34	10.6	1.25	84.0
14	0.0	0.0	0.0	0.0	11.6	1.30	88.4
15	8.8	1.5	13.6	1.53	0.0	0.0	77.6
16	7.5	1.3	11.6	1.30	3.5	0.45	77.4
17	6.6	1.2	10.3	1.163	6.3	0.82	76.8
18	4.7	0.86	7.3	0.86	13.7	1.83	74.2
19	3.3	0.57	5.0	0.57	14.8	1.91	76.8
20	4.4	0.79	6.8	0.79	14.0	1.85	74.8
21	2.0	0.34	3.1	0.34	15.6	1.95	79.2
22	0.0	0.0	0.0	0.0	17.1	2.04	82.9
23	9.9	1.8	15.2	1.77	0.0	0.0	74.9
24	9.2	1.7	14.3	1.66	1.8	0.24	74.7
25	8.6	1.6	13.3	1.57	4.1	0.54	74.0
26	6.2	1.2	9.5	1.2	12.8	1.76	71.5
27	5.3	1.0	8.2	1.0	17.0	2.42	69.4
28	4.4	0.86	6.9	0.86	19.2	2.73	69.5
29	4.3	0.83	6.6	0.83	19.6	2.78	69.5
30	1.8	0.34	2.9	0.34	21.9	2.96	73.4
31	0.0	0.0	0.0	0.0	24.0	3.12	76.0
32	11.2	2.09	17.2	2.09	0.0	0.0	71.6
33	9.7	1.8	17.9	1.83	4.6	0.64	70.8
34	8.7	1.7	13.4	1.67	8.0	1.14	69.8
35	5.9	1.2	9.2	1.2	18.9	2.83	66.0
36	5.7	1.2	8.8	1.2	19.3	2.88	66.2
37	5.0	1.0	7.7	1.0	22.7	3.48	64.6
38	4.1	0.86	6.3	0.86	25.6	3.96	64.0
39	1.7	0.34	2.6	0.34	28.9	4.29	66.8
40	0.0	0.0	0.0	0.0	31.5	4.55	68.5
41	11.8	2.26	18.2	2.26	0.0	0.0	70.0
42	10.2	1.97	15.7	1.97	4.8	0.69	69.3
43	8.4	1.7	12.9	1.67	11.1	1.63	67.5
44	6.1	1.3	9.4	1.3	19.5	2.97	64.9
45	5.1	1.1	7.9	1.1	22.8	3.52	64.1
46	5.2	1.1	8.0	1.1	23.6	3.70	63.1
47	3.9	0.87	6.1	0.87	29.1	4.73	60.9
48	1.6	0.35	2.5	0.35	33.6	5.34	62.3
49	0.0	0.0	0.0	0.0	35.1	5.34	64.9
50	6.5	1.0	10.0	1.04	0.0	0.0	83.5
51	5.8	0.94	8.9	0.94	2.7	0.33	82.6
52	2.7	0.42	4.1	0.42	8.5	0.99	84.7
53	5.1	0.97	7.9	0.97	16.3	2.27	70.8
54	2.0	0.30	3.0	0.30	8.9	1.0	86.2
55	4.7	0.95	7.3	0.95	21.5	3.19	66.5
56	2.2	0.34	3.3	0.34	8.8	1.01	85.7
57	5.2	0.86	8.1	0.86	4.6	0.55	82.1
58	5.0	0.87	7.7	0.87	10.8	1.39	76.5
59	0.0	0.0	0.0	0.0	10.2	1.12	89.8
60	4.5	0.74	6.9	0.74	7.4	0.90	81.2

Section 3. Solubility Isotherms

Soln no	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
		temp = −5 °C			
1	75.0	25.0	0.0	3140	A
2	60.3	20.1	19.6	3100	A
3	47.6	15.9	36.5	2830	A
4	47.6	15.9	36.5	2420	B
5	60.3	20.1	19.6	2180	D
6	75.0	25.0	0.0	2500	D
		temp = 0 °C			
7	75.0	25.0	0.0	2300	D
8	60.3	20.1	19.6	1970	D
9	47.6	15.9	36.5	2010	B
10	34.9	11.6	53.5	2720	B
11	15.9	5.3	78.8	3560	B
12	0.0	0.0	100.0	2720	B
		temp = 10 °C			
13	75.0	25.0	0.0	1920	D
14	60.3	20.1	19.6	1670	D
15	50.5	16.8	32.7	1540	D
16	47.6	15.9	36.5	1450	D
17	34.9	11.6	53.5	1770	B
18	15.9	5.3	78.8	2260	B
19	0.0	0.0	100.0	2720	B
		temp = 20 °C			
20	75.0	25.0	0.0	1650	D
21	60.3	20.1	19.6	1420	D
22	52.5	17.5	30.0	1310	D
23	47.6	15.9	36.5	1250	D
24	39.0	13.0	48.0	1180	B
25	34.9	11.6	53.5	1230	B
26	15.9	5.3	78.8	1530	B
27	0.0	0.0	100.0	1780	B
		temp = 30 °C			
28	75.0	25.0	0.0	1430	D
29	63.0	20.1	19.6	1240	D
30	47.6	15.9	36.5	1100	D
31	37.7	12.6	49.7	940	D
32	34.9	11.6	53.5	890	D
33	30.8	10.3	58.9	940	B
34	15.9	5.3	78.8	1070	B
35	0.0	0.0	100.0	1220	B
		temp = 35 °C			
36	75.0	25.0	0.0	1330	D
37	63.0	20.1	19.6	1160	D
38	47.6	15.9	36.5	1020	D
		temp = 35 °C			
39	34.9	11.6	53.5	850	D
40	30.1	10.0	57.9	800	D
41	27.5	9.2	63.3	840	B
42	15.9	5.3	78.8	920	B
43	0.0	0.0	100.0	1040	B

Crystallization temperature and composition of invariant points

Soln no	t/°C	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
44	−6	75.0	25.0	0.0	2580	A+D
45	−5.6	60.3	20.1	19.6	2250	A+D
46	−5.5	47.6	15.9	36.5	2550	A+B
47	+5.6	47.6	15.9	36.5	1560	B+D
48	4.2	34.9	11.6	53.5	3260	A+B
49	+29.3	34.9	11.6	53.5	910	B+D
50	−3.2	15.9	5.3	78.8	4130	A+B
51	+15.8	41.4	13.0	45.6	1270	B+D
52	−2.7	0.0	0.0	100.0	4940	A+B
53	−6.8	56.2	18.8	25.0	2150	A+B+D

The compiler has calculated the following values from the data given above

Soln	KCl		$NH_4H_2PO_4$		KNO_3		H_2O
no	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
1	8.6	1.3	4.4	0.44	0.0	0.0	87.0
2	7.0	1.1	3.6	0.36	3.1	0.35	86.4
3	5.9	0.93	3.0	0.31	6.1	0.72	84.9
4	6.7	1.1	3.5	0.37	7.0	0.84	82.8
5	9.4	1.5	4.8	0.51	4.1	0.50	81.7
6	10.5	1.67	5.4	0.56	0.0	0.0	84.2
7	11.2	1.81	5.8	0.60	0.0	0.0	83.0
8	10.2	1.70	5.2	0.57	4.5	0.55	80.1
9	7.8	1.32	4.0	0.44	8.2	1.0	80.0
10	4.5	0.71	2.3	0.24	9.3	1.1	84.0
11	1.6	0.25	0.8	0.08	10.8	1.23	86.8
12	0.0	0.0	0.0	0.0	17.1	2.04	82.9
13	13.0	2.2	6.7	0.72	0.0	0.0	80.3
14	11.6	2.0	6.0	0.67	5.1	0.65	77.4
15	10.3	1.82	5.3	0.61	9.0	1.2	75.5
16	10.1	1.82	5.2	0.61	10.5	1.4	74.2
17	6.3	1.1	3.2	0.36	13.1	1.7	77.3
18	2.4	0.39	1.2	0.13	15.8	1.94	80.6
19	0.0	0.0	0.0	0.0	17.1	2.04	82.9
20	14.7	2.53	7.5	0.84	0.0	0.0	77.8
21	13.1	2.36	6.7	0.79	5.8	0.77	74.4
22	12.0	2.23	6.2	0.74	9.3	1.3	72.5
23	11.2	2.12	5.8	0.71	11.7	1.62	71.3
24	9.5	1.8	4.9	0.61	15.9	2.26	69.6
25	8.3	1.6	4.2	0.52	17.2	2.42	70.3
26	3.2	0.58	1.6	0.19	21.4	2.86	73.8
27	0.0	0.0	0.0	0.0	24.0	3.12	76.0
28	16.3	2.90	8.4	0.97	0.0	0.0	75.2
29	15.0	2.82	7.4	0.90	6.3	0.88	71.3
30	12.3	2.40	6.3	0.80	12.9	1.84	68.6
31	10.7	2.23	5.5	0.74	19.2	2.94	64.6
32	10.3	2.18	5.3	0.72	21.3	3.34	63.1
33	8.7	1.8	4.5	0.61	22.6	3.48	64.2
34	4.1	0.83	2.1	0.28	27.5	4.09	66.3
35	0.0	0.0	0.0	0.0	31.5	4.55	68.5
36	17.3	3.13	8.9	1.0	0.0	0.0	73.9
37	15.7	3.02	7.7	0.96	6.6	0.94	69.9
38	12.9	2.59	6.7	0.87	13.5	1.99	66.9
39	10.6	2.28	5.4	0.76	21.9	3.50	62.1
40	9.5	2.09	4.9	0.69	24.8	4.02	60.9
41	8.3	1.82	4.3	0.61	26.0	4.19	61.4
42	4.5	0.96	2.3	0.32	30.3	4.76	62.9
43	0.0	0.0	0.0	0.0	35.1	5.34	64.9
44	10.2	1.61	5.2	0.54	0.0	0.0	84.6
45	9.1	1.5	4.7	0.50	4.0	0.48	82.2
46	6.5	1.0	3.3	0.35	6.7	0.80	83.5
47	9.6	1.7	4.9	0.57	9.9	1.3	75.6
48	3.8	0.59	2.0	0.20	8.0	0.91	86.3
49	10.1	2.13	5.2	0.71	21.0	3.27	63.7
50	1.4	0.21	0.7	0.07	9.5	1.1	88.4
51	9.6	1.8	4.7	0.57	14.4	2.0	71.3
52	0.0	0.0	0.0	0.0	10.2	1.12	89.8
53	8.8	1.5	4.5	0.49	5.3	0.65	81.3

Section 4. Solubility Isotherms

Soln no	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
			temp = −10 °C		
1	96.0	4.0	0.0	1750	A
2	90.0	3.7	6.3	1630	A
3	90.0	3.7	6.3	1510	E
4	96.0	4.0	0.0	1620	E
			temp = −5 °C		
5	96.0	4.0	0.0	3320	A
6	90.0	3.7	6.3	3260	A
7	80.7	3.3	16.0	3190	A
8	65.6	2.7	31.7	2870	A
9	65.6	2.7	31.7	2450	B
10	80.7	3.3	16.0	1300	B
11	90.0	3.7	6.3	1410	E
12	96.0	4.0	0.0	1520	E
			temp = 0 °C		
13	96.0	4.0	0.0	1430	E
14	90.0	3.7	6.3	1320	E
15	80.7	3.3	16.0	1180	E
16	65.6	2.7	31.7	1920	B
17	42.5	1.9	55.6	2950	B
18	22.1	1.0	76.9	3730	B
19	0.0	0.0	100.0	4280	B
			temp = 10 °C		
20	96.0	4.0	0.0	1260	E
21	90.0	3.7	6.3	1180	E
22	80.7	3.3	16.0	1070	E
23	74.6	3.1	22.3	980	E
24	65.0	2.7	31.7	1240	B
25	42.5	2.8	55.7	1880	B
26	22.1	1.0	76.9	2300	B
27	0.0	0.0	100.0	2720	B
			temp = 20 °C		
28	96.0	4.0	0.0	1150	F
29	90.0	3.7	6.3	1080	F
30	80.7	3.3	16.0	980	F
31	67.3	2.8	29.9	890	B
32	65.6	2.7	31.7	920	B
33	42.5	1.8	55.7	1310	B
34	22.1	1.0	76.9	1550	B
35	0.0	0.0	100.0	1780	B
			temp = 30 °C		
36	96.0	4.0	0.0	1060	F
37	90.0	3.7	6.3	990	F
38	80.7	3.3	16.0	890	F
39	65.6	2.7	31.7	750	F
40	42.5	1.8	55.7	980	B
41	22.1	1.0	76.9	1100	B
42	58.9	2.4	38.7	880	B
43	0.0	0.0	100.0	1040	B
			temp = 35 °C		
44	96.0	4.0	0.0	1020	F
45	90.0	3.7	6.3	940	F
46	80.7	3.3	16.0	860	F
47	65.6	2.7	31.7	720	F
48	42.5	1.9	55.7	790	B
49	22.1	1.0	76.9	940	B
50	54.3	2.3	43.4	720	B
51	0.0	0.0	100.0	1040	B

Crystallization temperature and composition of invariant points

Soln no	t/°C	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
52	10.8	96.0	4.0	0.0	1650	A+E
53	+10.0	96.0	4.0	0.0	1260	E+F
54	10.9	90.0	3.7	6.7	1550	A+E
55	+10.0	90.0	3.7	6.7	1180	E+F
56	−9.9	80.7	3.3	16.0	1720	A+B
57	−4.6	80.7	3.3	16.0	1250	B+E
58	−3.8	42.5	1.8	55.7	3560	A+B
59	−5.7	65.6	2.7	31.7	2530	A+B
60	+25.4	65.6	2.7	31.7	780	B+F
61	3.2	22.1	1.0	76.9	4320	A+B
62	+10.0	80.7	3.3	16.0	1070	E+F
63	+9.0	84.1	3.5	12.4	1110	E+F
64	+10.0	74.6	3.1	22.3	980	B+F
65	2.7	0.0	0.0	100.0	4940	A+B
66	−11.2	83.7	3.5	12.8	1400	A+B+F
67	+10.0	76.5	2.0	21.5	1070	B+E+F

The compiler has calculated the following values from the data given above

Soln no	KCl $100w_i$	KCl m_i/mol kg^{-1}	$NH_4H_2PO_4$ $100w_i$	$NH_4H_2PO_4$ m_i/mol kg^{-1}	KNO_3 $100w_i$	KNO_3 m_i/mol kg^{-1}	H_2O $100w_i$
1	18.3	3.05	1.1	0.13	0.0	0.0	80.5
2	18.1	3.07	1.1	0.13	1.7	0.21	79.1
3	19.2	3.31	1.2	0.14	1.8	0.23	77.8
4	19.5	3.29	1.3	0.14	0.0	0.0	79.2
5	10.6	1.61	0.7	0.07	0.0	0.0	88.7
6	10.1	1.53	0.6	0.06	1.0	0.11	88.3
7	9.2	1.4	0.6	0.06	2.5	0.28	87.8
8	8.1	1.3	0.5	0.05	5.3	0.61	86.0
9	9.3	1.5	0.6	0.06	6.1	0.72	84.0
10	19.2	3.45	1.2	0.14	5.1	0.68	74.5
11	20.2	3.55	1.3	0.15	1.9	0.25	76.6
12	20.5	3.51	1.3	0.15	0.0	0.0	78.2
13	21.5	3.73	1.4	0.16	0.0	0.0	77.2
14	21.3	3.79	1.3	0.16	2.0	0.27	75.3
15	20.6	3.80	1.3	0.16	5.5	0.75	72.4
16	11.4	1.90	0.7	0.08	7.5	0.92	80.4
17	5.1	0.80	0.4	0.04	9.1	1.0	85.5
18	2.1	0.33	0.2	0.01	10.1	1.15	87.6
19	0.0	0.0	0.0	0.0	11.6	1.30	88.4
20	23.6	4.23	1.5	0.18	0.0	0.0	74.9
21	23.1	4.24	1.5	0.17	2.2	0.30	73.2
22	22.1	4.19	1.4	0.17	5.9	0.83	70.6
23	21.5	4.23	1.4	0.18	8.7	1.3	68.3
24	15.8	2.91	1.0	0.12	10.4	1.42	72.7
25	7.4	1.26	0.7	0.08	13.1	1.65	78.8
26	3.2	0.53	0.2	0.02	15.3	1.86	81.3
27	0.0	0.0	0.0	0.0	17.1	2.04	82.9
28	25.3	4.64	1.6	0.19	0.0	0.0	73.1
29	24.7	4.63	1.6	0.19	2.3	0.32	71.4
30	23.5	4.57	1.5	0.19	6.3	0.91	68.8
31	20.6	4.20	1.3	0.17	12.4	1.87	65.7
32	19.6	3.96	1.2	0.16	12.8	1.91	66.3
33	9.7	1.8	0.6	0.08	17.3	2.36	72.4
34	4.4	0.79	0.3	0.04	20.8	2.76	74.5
35	0.0	0.0	0.0	0.0	24.0	3.12	76.0
36	26.8	5.03	1.7	0.21	0.0	0.0	71.5
37	26.2	5.05	1.7	0.21	2.5	0.35	69.6
38	25.0	5.04	1.6	0.21	6.7	1.0	66.7
39	22.3	4.86	1.4	0.20	14.6	2.35	61.6
40	11.9	2.41	0.8	0.10	21.1	3.16	66.2
41	5.6	1.12	0.4	0.05	26.5	3.88	67.5
42	18.0	3.72	1.1	0.15	16.0	2.44	64.9
43	0.0	0.0	0.0	0.0	31.5	4.55	68.5
44	27.6	5.23	1.8	0.22	0.0	0.0	70.7
45	27.7	5.32	1.7	0.22	2.6	0.37	68.5
46	25.6	5.21	1.6	0.21	6.9	1.03	65.9
47	22.9	5.06	1.5	0.21	15.0	2.45	60.7
48	13.6	2.99	0.9	0.1	24.2	3.92	61.2
49	6.2	1.31	0.4	0.06	29.4	4.54	64.0
50	18.7	4.19	1.2	0.18	20.2	3.35	59.8
51	0.0	0.0	0.0	0.0	35.1	5.34	64.8
52	19.2	3.23	1.2	0.13	0.0	0.0	79.6
53	23.6	4.23	1.5	0.18	0.0	0.0	74.9
54	18.8	3.23	1.2	0.13	1.9	0.24	78.1
55	23.1	4.24	1.5	0.17	2.3	0.32	73.1
56	15.4	2.61	1.0	0.11	4.2	0.52	79.4
57	19.7	3.59	1.2	0.15	5.3	0.71	73.7
58	4.3	0.66	0.3	0.03	7.7	0.87	87.7
59	9.1	1.4	0.6	0.06	5.9	0.70	84.4
60	21.8	4.67	1.4	0.19	14.3	2.26	62.5
61	1.9	0.28	0.1	0.01	8.9	0.99	89.1
62	22.1	4.19	1.4	0.17	5.9	0.83	70.6
63	22.5	4.21	1.4	0.18	4.5	0.62	71.6
64	21.5	4.23	1.4	0.18	8.7	1.26	68.3
65	0.0	0.0	0.0	0.0	10.2	1.12	89.8
66	18.8	3.32	1.2	0.14	3.9	0.51	76.0
67	20.8	3.97	0.8	0.1	7.9	1.12	70.4

Section 5. Solubility Isotherms

Soln no	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
		temp = −10 °C			
1	100.0	0.0	0.0	1750	A
2	90.9	5.4	3.7	1690	A
3	90.9	5.4	3.7	1610	E
4	100.0	0.0	0.0	1660	E
		temp = −5 °C			
5	100.0	0.0	0.0	3430	A
6	90.9	5.4	3.7	3390	A
7	69.6	18.2	12.2	3180	A
8	57.8	25.4	16.8	3040	A
9	23.9	45.7	30.4	2740	A
10	0.0	60.0	40.0	2680	A
11	0.0	60.0	40.0	2060	D
12	23.9	45.7	30.4	2330	D
13	57.8	25.4	16.8	2330	D
14	83.2	16.1	10.7	1750	D
15	90.9	5.4	3.7	1480	D
16	100.0	0.0	0.0	1580	D
		temp = 0 °C			
17	100.0	0.0	0.0	1500	E
18	90.9	5.4	3.7	1370	E
19	88.1	7.1	4.8	1370	D
20	85.2	14.9	9.9	1540	D
21	57.8	25.4	16.8	2130	D
22	23.9	45.7	30.4	2100	D
23	0.0	60.0	40.0	1870	D
		temp = 10 °C			
24	100.0	0.0	0.0	1350	E
25	90.9	5.4	3.7	1210	F
26	88.3	13.0	7.7	1220	F
27	85.4	8.8	5.8	1330	D
28	57.8	25.4	16.8	1790	D
29	23.9	45.7	30.4	1740	D
30	13.5	51.9	34.6	1570	D
31	0.0	60.0	40.0	1560	D
		temp = 20 °C			
32	100.0	0.0	0.0	1200	E
33	90.9	5.4	3.7	1110	F
34	89.6	12.2	8.2	1090	F
35	82.3	10.6	7.1	1280	D
36	57.8	25.4	16.8	1530	D
37	23.9	45.7	30.4	1440	D
38	22.0	46.8	31.2	1420	D
39	0.0	60.0	10.0	1320	D
		temp = 30 °C			
40	100.0	0.0	0.0	1110	F
41	90.9	5.4	3.7	1020	F
42	87.0	7.8	5.2	1020	D
43	77.1	13.7	9.2	1200	D
44	57.8	25.4	16.8	1320	D
45	30.0	42.0	28.0	1280	D
46	23.9	45.7	30.4	1210	D
47	0.0	60.0	40.0	1110	D
		temp = 35 °C			
48	100.0	0.0	0.0	1070	F
49	90.9	5.4	3.7	970	F
50	85.5	8.7	5.8	1010	D
51	74.1	15.5	10.4	1150	D
52	57.8	25.4	16.8	1240	D
53	35.0	39.0	26.0	1180	D
54	23.9	45.7	30.4	1100	D
55	0.0	60.0	40.0	1010	D

Crystallization temperature and composition of invariant points

Soln no	t/°C	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
56	−6.4	0.0	60.0	40.0	2120	A+D
57	−5.4	23.9	45.7	30.4	2330	A+D
58	−6.3	57.8	25.4	16.8	2400	A+D
59	−8.6	81.6	17.0	11.4	1910	D+F
60	+13.0	89.0	12.6	8.4	1150	D+F
61	−10.6	90.9	5.4	3.7	1610	A+E
62	+8.2	90.9	5.4	3.7	1230	E+F
63	−3.1	88.6	6.8	4.6	1380	D+E
64	+24.0	88.7	6.8	4.5	1050	D+F
65	−11.2	88.5	6.9	4.6	1600	A+D+E
66	+7.5	88.8	6.7	4.5	1240	D+E+F

The compiler has calculated the following values from the data given above

Soln no	KCl 100w_i	KCl m_i/mol kg^{-1}	$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1}	KNO_3 100w_i	KNO_3 m_i/mol kg^{-1}	H_2O 100w_i
1	19.1	3.17	0.0	0.0	0.0	0.0	80.9
2	17.7	2.99	1.6	0.18	1.0	0.12	79.6
3	18.4	3.14	1.7	0.19	1.0	0.13	78.9
4	20.0	3.35	0.0	0.0	0.0	0.0	80.0
5	10.8	1.62	0.0	0.0	0.0	0.0	89.2
6	9.9	1.5	0.9	0.09	0.5	0.06	88.7
7	7.9	1.2	3.2	0.32	1.9	0.21	87.0
8	6.8	1.1	4.6	0.46	2.7	0.31	85.9
9	3.0	0.48	8.8	0.93	5.2	0.62	83.0
10	0.0	0.0	11.7	1.24	6.8	0.83	81.5
11	0.0	0.0	14.4	0.62	8.4	1.1	77.2
12	3.4	0.57	10.1	1.09	5.9	0.72	80.6
13	8.5	1.4	5.7	0.61	3.3	0.40	82.4
14	15.3	2.64	4.6	0.51	2.7	0.34	77.5
15	19.7	3.41	1.8	0.20	1.1	0.14	77.4
16	20.8	3.52	0.0	0.0	0.0	0.0	79.2
17	21.6	3.70	0.0	0.0	0.0	0.0	78.4
18	20.9	3.69	1.9	0.22	1.2	0.15	76.0
19	20.2	3.57	2.5	0.29	1.5	0.19	75.8
20	17.3	3.07	4.7	0.54	2.7	0.36	75.3
21	9.1	1.5	6.2	0.66	3.6	0.44	81.1
22	3.7	0.63	11.0	1.21	6.4	0.80	78.9
23	0.0	0.0	15.5	1.78	9.1	1.2	75.4
24	23.5	4.12	0.0	0.0	0.0	0.0	76.5
25	22.9	4.17	2.1	0.25	1.3	0.17	73.7
26	21.4	4.02	4.9	0.59	2.5	0.35	71.2
27	20.0	3.57	3.2	0.37	1.8	0.24	75.0
28	10.5	1.79	7.1	0.79	4.1	0.52	78.3
29	4.3	0.76	12.7	1.46	7.4	0.97	75.6
30	2.6	0.48	15.4	1.84	9.0	1.22	73.0
31	0.0	0.0	17.7	2.14	10.4	1.42	71.9
32	25.7	4.63	0.0	0.0	0.0	0.0	74.3
33	24.4	4.55	2.2	0.27	1.3	0.19	71.9
34	23.4	4.92	4.9	0.56	2.9	0.42	68.8
35	19.7	3.57	3.9	0.46	2.3	0.31	74.1
36	11.8	2.10	8.0	0.92	4.7	0.61	75.5
37	4.9	0.92	14.6	1.76	8.5	1.2	71.9
38	4.6	0.86	15.1	1.83	8.8	1.2	71.5
39	0.0	0.0	19.9	2.53	11.7	1.68	68.4
40	27.2	5.00	0.0	0.0	0.0	0.0	72.8
41	25.9	4.95	2.4	0.29	1.4	0.20	70.3
42	24.7	4.74	3.4	0.42	2.0	0.28	69.9
43	19.3	3.57	5.3	0.63	3.1	0.43	72.3
44	13.2	2.43	8.9	1.07	5.2	0.71	72.7
45	6.8	1.30	14.7	1.82	8.6	1.22	69.9
46	5.6	1.10	16.5	2.10	9.6	1.40	68.3
47	0.0	0.0	22.3	3.00	13.1	2.00	64.6
48	27.9	5.19	0.0	0.0	0.0	0.0	72.1
49	26.9	5.21	2.5	0.31	1.5	0.21	69.1
50	24.4	4.70	3.8	0.48	2.2	0.32	69.6
51	19.0	3.58	6.1	0.75	3.6	0.50	71.2
52	13.8	2.59	9.3	1.1	5.4	0.75	71.5
53	8.4	1.6	14.5	1.84	8.5	1.2	68.6
54	6.0	1.2	17.6	2.31	10.3	1.54	66.1
55	0.0	0.0	23.7	3.30	13.9	2.20	62.4
56	0.0	0.0	14.1	1.57	8.2	1.05	77.7
57	3.4	0.57	10.1	1.09	5.9	0.72	80.6
58	8.3	1.3	5.6	0.59	3.3	0.39	82.8
59	14.0	2.37	4.5	0.49	2.6	0.33	78.9
60	22.4	4.30	4.9	0.61	2.9	0.41	69.8
61	18.4	3.14	1.7	0.19	1.0	0.13	78.9
62	22.7	4.11	2.1	0.24	1.2	0.17	74.0
63	20.2	3.57	2.4	0.27	1.4	0.19	76.0
64	24.7	4.69	2.9	0.36	1.7	0.24	70.7
65	18.0	3.07	2.2	0.24	1.3	0.16	78.6
66	21.9	3.98	2.6	0.30	1.5	0.20	74.0

Soln no	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
		temp = −5 °C			
1	46.4	19.6	34.0	3020	A
2	38.5	33.2	28.3	2860	A
3	26.8	53.5	19.7	2960	A
4	17.6	69.4	13.0	2810	A
5	14.5	74.9	10.6	2680	A
6	21.3	63.0	15.7	2280	D
7	26.8	53.5	19.7	2320	D
8	48.7	15.7	35.6	2410	B
		temp = 0 °C			
9	57.6	0.0	42.4	2360	B
10	49.9	13.5	36.6	2040	B
11	38.5	33.2	28.3	2170	D
12	26.9	53.5	19.6	2100	D
13	24.8	56.9	18.3	2060	D
14	14.5	74.9	10.6	2280	D
15	47.0	18.5	34.5	1890	D
16	0.0	100.0	0.0	2810	D
		temp = 10 °C			
17	57.6	0.0	42.4	1610	B
18	42.2	26.8	31.0	1700	D
19	52.3	9.3	38.4	1420	B
20	38.5	33.2	28.3	1770	D
21	30.2	47.7	29.1	1730	D
22	26.9	53.5	19.7	1730	D
23	14.5	74.9	10.6	1830	D
24[c]	0.0	100.0	0.0	2230	D
		temp = 20 °C			
25	57.6	0.0	42.4	1140	B
26	53.8	6.6	39.6	1012	B
27	48.8	15.0	35.2	1210	D
28	38.5	33.2	28.3	1480	D
29	36.7	36.4	26.9	1480	D
30	34.2	40.7	25.1	1470	D
31	26.9	53.5	19.6	1460	D
32	14.5	74.9	10.6	1460	D
33[c]	0.0	100.0	0.0	1790	D
		temp = 30 °C			
34	57.6	0.0	42.4	810	B
35	54.7	5.0	40.3	760	B
36	53.1	7.9	39.0	890	D
37	46.4	19.5	34.1	1150	D
38	37.5	35.0	27.5	1270	D
39	31.2	45.9	22.9	1260	D
40	26.8	53.5	19.7	1210	D
41	14.5	74.9	10.6	1190	D
42[c]	0.0	100.0	0.0	1480	D
		temp = 35 °C			
43	57.6	0.0	42.3	710	B
44	55.1	4.3	40.6	660	B
45	52.2	9.4	38.4	880	D
46	44.8	22.3	32.9	1110	D
47	38.8	32.7	28.5	1180	D
48	28.4	50.7	20.9	1150	D
49	26.9	53.4	19.7	1090	D
50	14.5	74.9	10.6	1080	D
51[c]	0.0	100.0	0.0	1310	D

Crystallization temperature and composition of invariant points

Soln no	$t/°C$	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]	Solid phase[b]
52	4.3	57.6	0.0	42.4	2740	A+B
53	5.7	38.5	33.2	28.3	2440	A+D
54	6.0	26.8	53.5	19.7	2400	A+D
55	5.3	14.5	74.9	10.6	2490	A+D
56	+0.1	47.0	18.4	34.6	1900	B+D
57	+13.0	50.2	12.8	37.0	1250	B+D
58	+24.6	54.0	6.3	39.7	900	B+D
59	6.0	48.4	16.1	35.5	2480	A+B
60	5.7	20.8	63.5	15.7	2300	A+D
61	7	44.2	23.3	32.5	2360	A+B+D

The compiler has calculated the following values from the data given above

Soln	KCl		$NH_4H_2PO_4$		KNO_3		H_2O
no	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
1	5.4	0.85	3.5	0.36	5.4	0.63	85.6
2	4.7	0.75	6.3	0.64	4.7	0.55	84.3
3	3.2	0.50	9.7	1.0	3.1	0.37	84.0
4	2.1	0.35	13.0	1.37	2.1	0.26	82.7
5	1.8	0.30	14.6	1.55	1.8	0.22	81.8
6	3.1	0.52	14.1	1.54	3.1	0.38	79.7
7	3.8	0.64	11.9	1.28	3.8	0.47	80.5
8	6.9	1.1	3.4	0.36	6.9	0.82	82.8
9	8.4	1.4	0.0	0.0	8.4	1.0	83.2
10	8.1	1.4	3.4	0.37	8.1	1.0	80.4
11	5.9	0.99	7.9	0.85	5.9	0.72	80.3
12	4.2	0.71	12.8	1.42	4.1	0.52	78.8
13	3.9	0.67	13.8	1.53	3.9	0.49	78.4
14	2.1	0.35	16.6	1.83	2.1	0.26	79.2
15	8.1	1.4	4.9	0.54	8.1	1.01	78.9
16	0.0	0.0	18.5	1.98	0.0	0.0	81.5
17	11.4	1.99	0.0	0.0	11.4	1.46	77.2
18	7.9	1.4	7.7	0.88	7.8	1.01	76.6
19	11.3	2.05	3.1	0.36	11.3	1.50	74.3
20	6.9	1.2	9.2	1.0	6.9	0.89	76.9
21	5.4	0.97	13.1	1.53	7.0	0.93	74.5
22	4.9	0.86	14.9	1.72	4.8	0.63	75.4
23	2.5	0.44	19.7	2.27	2.5	0.32	75.3
24	0.0	0.0	22.1	2.47	0.0	0.0	77.9
25	14.8	2.81	0.0	0.0	14.7	2.07	70.5
26	14.9	2.95	2.8	0.36	14.8	2.17	67.5
27	11.9	2.24	5.6	0.69	11.6	1.62	70.9
28	7.9	1.4	10.6	1.25	7.9	1.1	73.6
29	7.5	1.4	11.5	1.37	7.5	1.0	73.4
30	7.0	1.3	12.9	1.54	7.0	0.95	73.0
31	5.5	1.0	16.9	2.04	5.4	0.75	72.2
32	2.9	0.55	23.3	2.85	2.9	0.40	70.9
33	0.0	0.0	26.3	3.10	0.0	0.0	73.7
34	18.5	3.95	0.0	0.0	18.5	2.91	62.9
35	18.2	4.00	2.6	0.37	18.2	2.95	61.0
36	15.9	3.31	3.7	0.49	15.9	2.43	64.5
37	11.6	2.24	7.5	0.94	11.6	1.65	69.3
38	8.6	1.6	12.4	1.53	8.6	1.2	70.4
39	7.1	1.4	16.2	2.02	7.1	1.0	69.6
40	6.3	1.2	19.3	2.46	6.2	0.90	68.2
41	3.4	0.68	26.8	3.50	3.3	0.49	66.5
42	0.0	0.0	30.2	3.75	0.0	0.0	69.8
43	20.1	4.51	0.0	0.0	20.0	3.31	59.9
44	20.0	4.64	2.4	0.36	19.9	3.42	57.7
45	15.8	3.30	4.4	0.59	15.7	2.42	64.1
46	11.4	2.24	8.8	1.12	11.4	1.65	68.4
47	9.4	1.8	12.2	1.54	9.4	1.3	69.0
48	6.9	1.4	19.0	2.45	6.9	1.0	67.2
49	6.7	1.4	20.6	2.72	6.7	1.0	65.9
50	3.6	0.75	28.5	3.85	3.5	0.55	64.4
51	0.0	0.0	32.8	4.24	0.0	0.0	67.2
52	7.4	1.2	0.0	0.0	7.4	0.86	85.2
53	5.4	0.88	7.1	0.76	5.4	0.64	82.1
54	3.7	0.62	11.5	1.24	3.7	0.46	81.0
55	1.9	0.32	15.5	1.67	1.9	0.24	80.6
56	8.1	1.37	4.9	0.54	8.1	1.0	78.9
57	11.9	2.23	4.7	0.57	11.9	1.64	71.5
58	16.1	3.33	2.9	0.39	16.1	2.45	64.9
59	6.7	1.1	3.4	0.36	6.7	0.80	83.1
60	3.0	0.50	14.1	1.53	3.1	0.38	79.8
61	6.4	1.0	5.2	0.55	6.4	0.77	82.0

[a]The composition unit is: mol/100 mol of solute.

[b]The solid phases are: A=ice; B=KNO_3; C=$(K,NH_4)H_2PO_4$; D=$(NH_4,K)H_2PO_4$; E=α-$(NH_4,K)Cl$; F=β-$(NH_4,K)Cl$.

[c]$NH_4H_2PO_4$ is the equilibrium solid phase for these solutions (compiler).

Compiler's Comment: The authors do not discuss the difference between solid phases C and D. Very likely these phases are identical and should be understood as "solid solution."

Part 2. Composition of solutions saturated simultaneously with KNO_3, $(NH_4,K)Cl$ and $(NH_4,K)H_2PO_4$

Soln no	t/°C	KCl comp[a]	$NH_4H_2PO_4$ comp[a]	KNO_3 comp[a]	H_2O comp[a]
1	5.0	82.5	5.0	12.5	1400
2	0.0	72.5	7.0	20.5	1150
3	10.0	71.0	6.0	23.0	920
4	20.0	67.0	6.5	26.5	770
5	30.0	62.0	4.0	34.0	700

[a]The composition unit is: mol/100 mol of solute.

The compiler has calculated the following values from the data given above

Soln	KCl		$NH_4H_2PO_4$		KNO_3		H_2O
no	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
1	18.5	3.27	1.7	0.20	3.8	0.50	75.9
2	18.7	3.50	2.8	0.34	7.2	0.99	71.4
3	21.3	4.29	2.8	0.36	9.4	1.4	66.6
4	22.4	4.83	3.4	0.47	12.0	1.91	62.2
5	21.9	4.92	2.2	0.32	16.3	2.70	59.6

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Ammonium chloride; NH_4Cl; [12125-02-9]
(4) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(5) Potassium nitrate; KNO_3; [7757-79-1]
(6) Potassium chloride; KCl; [7747-40-7]
(7) Water; H_2O; [7732-18-5]

Original Measurements:

M. E. Pozin, B. A. Kopylev, and N. K. Shilling, Zh. Prikl. Khim. (Leningrad) 37, 2341-8 (1964).

Variables:

Composition at 15 and 25 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. The authors present their solubility isotherms in the following form: Solubility in the $NH_4H_2PO_4-NH_4NO_3-H_2O$ system

Soln no	Solute $100w_i$	NH_4NO_3 comp[a]	$NH_4H_2PO_4$ comp[a]	KCl comp[a]	N comp[a]	P_2O_5 comp[a]	K_2O comp[a]
			temp=15 °C				
1	32	34.00	17.00	49.00	25.30	19.00	55.70
2	32	52.35	26.15	21.50	42.00	31.50	26.50
3	30	62.00	31.00	7.00	51.00	38.00	11.00
4	30	42.80	34.20	23.00	35.00	38.50	26.50
5	30	35.00	35.00	30.00	29.00	37.90	33.10
6	30	28.25	28.25	43.50	22.90	30.00	47.10
7	30	30.55	24.45	45.00	23.80	26.40	49.80
8	28	49.70	39.80	10.50	41.65	45.95	12.50
9	28	41.75	51.75	16.50	35.30	46.10	18.60
10	28	27.85	44.65	27.50	25.40	45.80	28.8
11	28	24.20	38.80	37.00	22.00	39.50	38.5
12	28	23.00	23.00	54.00	18.40	24.10	57.50
13	28	20.55	16.45	63.00	16.50	17.00	66.50
14	28	16.68	13.32	70.00	12.50	13.75	73.75
15	28	11.25	11.25	77.50	8.70	11.30	80.00
16	25	36.50	58.50	5.00	31.20	56.40	12.40
17	25	23.80	63.20	13.00	25.50	61.60	13.00
18	25	15.30	40.70	44.00	16.10	39.00	44.90
19	25	15.20	24.30	60.50	13.50	24.50	62.00
			temp=25 °C				
20	34	61.00	30.50	8.50	51.0	38.00	11.00
21	34	33.00	33.00	34.00	27.15	35.55	37.30
22	34	32.00	32.00	36.00	26.25	34.25	39.50
23	34	30.55	24.75	44.50	24.05	27.95	48.00
24	32	27.25	37.75	25.00	39.20	43.20	17.60
25	32	42.50	42.50	15.00	36.00	47.00	17.00
26	32	26.00	41.50	32.50	24.05	42.25	39.70
27	32	26.00	26.00	48.00	21.00	27.40	51.60
28	32	26.13	20.85	53.00	20.20	22.10	57.70
29	30	46.25	46.25	7.50	39.66	51.78	8.56
30	30	33.80	54.20	12.00	31.00	56.30	12.70
31	30	20.50	54.25	25.00	21.70	53.70	24.60
32	30	18.00	48.00	34.00	19.20	46.80	34.00
33	30	21.90	35.10	43.00	19.70	35.70	44.60
34	30	22.50	22.50	50.00	18.00	23.50	58.50
35	28	24.50	65.00	10.50	26.00	63.50	10.50
36	28	15.50	41.50	43.00	16.60	40.40	43.00
37	28	16.35	26.15	57.50	14.50	26.30	59.20

[a]The composition unit is g/100 g of solute.

Part 2. The compiler has calculated the following solubility values from the data in Part 1

Soln no	NH_4NO_3 100w_i	NH_4NO_3 m_i/mol kg^{-1}	$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ m_i/mol kg^{-1}	KCl 100w_i	KCl m_i/mol kg^{-1}	H_2O 100w_i
1	10.88	2.00	5.44	0.70	15.68	3.09	68.00
2	16.75	3.08	8.37	1.07	6.88	1.36	68.00
3	18.60	3.32	9.30	1.15	2.10	0.40	70.00
4	12.84	2.29	10.26	1.27	6.90	1.32	70.00
5	10.50	1.87	10.50	1.30	9.00	1.72	70.00
6	8.48	1.51	8.48	1.05	13.05	2.50	70.00
7	9.17	1.64	7.34	0.91	13.50	2.59	70.00
8	13.92	2.41	11.14	1.35	2.94	0.55	72.00
9	11.69	2.03	14.49	1.75	4.62	0.86	72.00
10	7.80	1.35	12.50	1.51	7.70	1.43	72.00
11	6.78	1.18	10.86	1.31	10.36	1.93	72.00
12	6.44	1.12	6.44	0.78	15.12	2.82	72.00
13	5.75	1.00	4.61	0.56	17.64	3.29	72.00
14	4.67	0.81	3.73	0.45	19.60	3.65	72.00
15	3.15	0.55	3.15	0.38	21.70	4.04	72.00
16	9.13	1.52	14.63	1.70	1.25	0.22	75.00
17	5.95	0.99	15.80	1.83	3.25	0.58	75.00
18	3.83	0.64	10.18	1.18	11.00	1.97	75.00
19	3.80	0.63	6.08	0.70	15.13	2.70	75.00
20	20.74	3.93	10.37	1.37	2.89	0.59	66.00
21	11.22	2.12	11.22	1.48	11.56	2.35	66.00
22	10.88	2.06	10.88	1.43	12.24	2.49	66.00
23	10.39	1.97	8.42	1.11	15.13	3.07	66.00
24	8.72	1.60	12.08	1.54	8.00	1.58	68.00
25	13.60	2.50	13.60	1.74	4.80	0.95	68.00
26	8.32	1.53	13.28	1.70	10.40	2.05	68.00
27	8.32	1.53	8.32	1.06	15.36	3.03	68.00
28	8.36	1.54	6.67	0.85	16.96	3.35	68.00
29	13.88	2.48	13.88	1.72	2.25	0.43	70.00
30	10.14	1.81	16.26	2.02	3.60	0.69	70.00
31	6.15	1.10	16.28	2.02	7.50	1.44	70.00
32	5.40	0.96	14.40	1.79	10.20	1.95	70.00
33	6.57	1.17	10.53	1.31	12.90	2.47	70.00
34	6.75	1.20	6.75	0.84	15.00	2.87	70.00
35	6.86	1.19	18.20	2.20	2.94	0.55	72.00
36	4.34	0.75	11.62	1.40	12.04	2.24	72.00
37	4.58	0.79	7.32	0.88	16.10	3.00	72.00

Auxiliary Information

Method / Apparatus / Procedure:

A polythermic method was used.[1] Because of the tendency for supersaturation, the temperature of disappearance of the last crystal was observed. The experiments were performed in 250 ml glass vessels. The solutions were stirred at 900–1200 rpm. The speed of heating was 1 deg/min. The compiler assumes that the isotherms were derived graphically from experimental results

Source and Purity of Materials:

Chemically pure salts were recrystallized two or three times before use.

Estimated Error:

The mean relative error of the experiments was specified as 1.6%. The reproducibility of temperature measurements was 0.25 K.

References:

[1] A. G. Bergman and N. P. Luzhnaya, Fiziko-Khimicheskiye Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow, IAN SSSR (1951).

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Ammonium chloride; NH_4Cl; [12125-02-9]
(4) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(5) Potassium nitrate; KNO_3; [7757-79-1]
(6) Potassium chloride; KCl; [7747-40-7]
(7) Water; H_2O; [7732-18-5]

Original Measurements:

M. E. Pozin, B. A. Kopylev, and N. K. Shilling, Izv. Vissh. Ucheb. Zaved., Khim. Khim. Tekhnol. **8**, 883-8 (1965).

Variables:

Composition at 15 °C.

Prepared By:

J. Eysseltová

Experimental Data

Supersaturation in the $NH_4H_2PO_4$–NH_4NO_3–KCl–H_2O system at 15 °C

Part 1. The authors' data:

Point No.	Σ[a]	NH_4NO_3 comp[b]	$NH_4H_2PO_4$ comp[b]	KCl comp[b]	Total nutrition solute	Total nutrition soln	Solid phase[c]
1	32	41	41	18	55.93	17.9	A
2	32	17	17	66	60.12	19.25	B
3	32	28.8	46.2	25	59.93	19.1	A
4	32	24.2	38.8	37	60.46	19.3	B
5	32	19.2	50.8	30	63.11	20.2	A+B
6	30	33.8	54.2	12	59.51	17.85	A
7	30	17.3	27.7	55	61.18	18.35	C
8	30	23.8	63.2	13	63.23	18.95	A
9	30	15.9	42.1	42	63.10	18.93	C
10	28	35	56	9	58.29	16.30	A
11	28	7.7	12.3	80	62.18	17.4	C
12	28	27.25	72.25	0.5	63.17	17.7	A
13	28	13.7	36.3	50	63.13	17.65	C

[a]This is the total solute 100w_i value.
[b]The composition unit is: 100w_i of solute.
[c]The solid phases are: A=$NH_4H_2PO_4$; B=KNO_3; C=KH_2PO_4.

Part 2. The compiler has calculated the following solubility values from the data in Part 1

Point	NH_4NO_3		$NH_4H_2PO_4$		KCl		H_2O
no.	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
1	13.1	2.41	13.1	1.68	5.8	1.1	68
2	5.4	1.0	5.4	0.70	21.1	4.2	68
3	9.2	1.7	14.8	1.89	8.0	1.7	68
4	7.7	1.4	12.4	1.59	11.8	2.33	68
5	6.1	1.1	16.3	2.08	9.6	1.9	68
6	10.1	1.81	16.3	2.02	3.6	0.69	70
7	5.2	0.93	8.3	1.0	16.5	3.16	70
8	7.1	1.3	19.0	2.35	3.9	0.75	70
9	4.8	0.85	12.6	1.57	12.6	2.41	70
10	9.8	1.7	15.7	1.89	2.5	0.47	72
11	2.2	0.37	3.4	0.42	22.4	4.17	72
12	7.6	1.3	20.2	2.44	0.1	0.03	72
13	3.8	0.67	10.2	1.23	14.0	2.61	72

Auxiliary Information

Method / Apparatus / Procedure:

Mixtures of dry salts and water were stirred vigorously (900–1200 rpm) and heated 1–2 °C above the temperature at which the last crystal disappeared. The solution was then cooled at the rate of 1–2 deg/hr and the temperature at which the last crystal disappeared was observed. The supersaturation isotherms were constructed graphically.

Source and Purity of Materials:

Chemically pure salts were recrystallized three times before use.

Estimated Error:

No information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Diammonium thiosulfate; $(NH_4)_2S_2O_3$; [7783-18-8]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Dipotassium thiosulfate; $K_2S_2O_3$; [10294-66-3]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

A. M. Babenko and A. M. Andrianov, Zh. Neorg. Khim. **29**, 1578-82 (1984).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Part. 1. Points of simultaneous crystallization of two or three solid phases in the $NH_4H_2PO_4-K_2S_2O_3-H_2O$ system

$NH_4H_2PO_4$		$K_2S_2O_3$		H_2O		Solid
$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	t/°C	phases[b]
18.0	1.91	0	0	82.0	−4.4	A+B
18.0	2.12	8.2	0.58	73.8	−5.4	A+B
12.0	1.48	17.6	1.31	70.4	−7.1	A+B
6.0	0.79	28.2	2.25	65.8	−8.4	A+B
4.0	0.60	38.4	3.50	57.6	−12.0	A+B
7.4	0.97	26.0	2.05	66.6	−8.0	A+B
13.2	1.53	12.0	0.84	74.8	−5.6	A+B
2.4	0.43	48.8	5.25	48.8	−18.6	A+B
2.0	0.39	53.9	6.42	44.1	−7.4	B+C
1.47	0.269	51.0	5.64	47.53	−18.8	A+B+C

[a]These values were calculated by the compiler.
[b]The solid phases are: A=ice; B=$NH_4H_2PO_4$; C=$K_2S_2O_3$.

Part 2. Solubility isotherms in the $NH_4H_2PO_4-K_2S_2O_3-H_2O$ system

$NH_4H_2PO_4$		$K_2S_2O_3$		H_2O	Solid
$100w_i$	m_i/mol kg^{-1a}	$100w_i$	m_i/mol kg^{-1a}	$100w_i$	phases[b]
		temp = −10 °C			
0	0	37.0	3.09	63.0	A
1.95	0.269	35.0	2.92	63.05	A
2.6	0.46	48.7	5.25	48.7	B
4.0	0.60	38.4	3.50	57.6	B
1.42	0.268	52.5	6.00	46.08	C
		temp = −5 °C			
0	0	21.5	1.44	78.5	A
6.0	0.69	18.8	1.31	75.2	A
13.17	1.534	12.2	0.859	74.63	A
16.0	1.84	8.4	0.58	73.6	A
18.0	2.12	8.2	0.58	73.8	B
12.0	1.48	17.6	1.31	70.4	B
7.4	0.96	26.0	2.05	66.6	B
6.0	0.79	28.2	2.25	65.8	B
2.6	0.46	48.7	5.25	48.7	B
1.4	0.27	53.5	6.23	45.1	C
		temp = 0 °C			
19.1	2.28	8.1	0.58	72.8	B
13.1	1.54	13.0	0.92	73.9	B
6.4	0.85	28.08	2.252	65.52	B
4.4	0.67	38.24	3.503	57.36	B
2.8	0.50	48.6	5.25	48.6	B
1.3	0.25	54.2	6.40	44.5	C
2.0	0.39	53.0	6.19	45.0	C
		temp = 10 °C			
21.4	2.63	7.86	0.584	70.74	B
13.0	1.62	17.4	1.31	69.6	B
7.2	0.97	28.0	2.27	64.8	B
3.0	0.54	48.5	5.25	48.5	B
2.2	0.43	53.8	6.42	44.0	B
1.31	0.268	56.2	6.945	42.49	C
0	0	60.0	7.88	40.0	C

[a]These values were calculated by the compiler.
[b]The solid phases are: A = ice; B = $NH_4H_2PO_4$; C = $K_2S_2O_3$.

Auxiliary Information

Method / Apparatus / Procedure:
An improved visual polythermic method[1] was used.

Source and Purity of Materials:
Reagent grade or chemically pure $NH_4H_2PO_4$ was recrystallized twice and dried at 30–50 °C. $K_2S_2O_3$ (pur., TU 6-09-44-70) was recrystallized twice and dried at 105 °C.

Estimated Error:
Precision of temperature measurement was ± 0.4 K.

References:

[1]L. N. Erayzer and I. M. Kaganskiy, Zavod. Lab. 1, 119 (1967).

Components
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Sodium dihydrogenphosphate; NaH_2PO_4; [7558-80-7]
(4) Sodium chloride; NaCl; [7647-14-5]
(5) Water; H_2O; [7732-18-5]

Original Measurements:
A. P. Solov'ev, E. F. Balashova, N. A. Verendyakina, L. F. Zyuzina, Resp. Sb. Nauch. Tr.-Yaroslav. Gos. Pedagog. In-t. **169**, 79-84 (1978).

Variables:
Composition at 25 °C.

Prepared By:
J. Eysseltová

Experimental Data

Solubility in the Na^+, $NH_4^+ \| Cl^-$, $H_2PO_4^- - H_2O$ system at 25 °C

NaH_2PO_4		NaCl		$NH_4H_2PO_4$		NH_4Cl		Na^+	$H_2PO_4^-$	Solid
$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	m_i[a]	comp[c]	comp[c]	phase[b]
25.01	3.48	15.13	4.33	—	—	—	—	100.0	44.63	A+B
24.74	3.63	13.97	4.21	4.55	0.70	—	—	91.75	50.72	A+B
23.26	3.51	12.90	4.00	8.59	1.35	—	—	84.69	54.92	A +B
24.19	3.85	11.01	3.60	12.40	2.06	—	—	78.31	62.25	A+B+C
43.47	8.12	—	—	11.93	2.35	—	—	77.68	100.0	B+C
38.32	7.25	4.54	1.76	13.11	2.59	—	—	77.69	84.72	B+C
32.90	5.20	8.00	2.96	12.79	2.40	—	—	78.74	73.75	B+C
30.54	5.37	9.33	3.37	12.78	2.35	—	—	78.86	69.71	B+C
12.30	1.78	16.87	4.96	12.58	1.88	—	—	78.20	42.40	A+C
	—	20.85	5.75	17.10	2.40	—	—	70.77	29.23	A+C
	—	16.07	4.21	5.64	0.75	12.93	3.70	48.58	8.66	A+C+D
	—	17.07	4.41	2.82	0.37	13.88	3.92	50.69	4.34	A+D
	—	17.15	4.40	—	—	16.14	4.52	49.24	—	A+D
	—	8.68	2.18	4.48	0.57	18.75	5.15	27.55	7.26	C+D
	—	5.89	1.48	5.15	0.66	21.11	5.82	18.67	8.32	C+D
	—	1.59	0.39	5.60	0.70	22.91	6.13	5.36	9.72	C+D
—	—	—	—	6.12	0.78	25.54	6.98	—	10.17	C+D

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = NCl; B = $NaH_2PO_4 \cdot 2H_2O$; C = $NH_4H_2PO_4$; D = NH_4Cl.
[c]In the original article these values were designated as ion %. The compiler believes that the units here are: mol/100 mol of solute.

Auxiliary Information

Method / Apparatus / Procedure:
The method of invariant points was used. A third component was added to eutectic systems until a new solid phase appeared. At equilibrium both liquid and solid phases were analyzed. Chloride ion content was determined by the Volhard method. $H_2PO_4^-$ ions were precipitated as $NH_4MgPO_4 \cdot 6H_2O$, and the excess of Mg was titrated complexometrically.[1] Ammonium ions were removed and the excess of base was titrated with HCl.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given.

References:

[1]F. M. Shemyakin, E. N. Zelenina, Zavod. Lab. 6 (1969).

Components
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Potassium chloride; KCl; [7747-40-7]
(5) Water; H_2O; [7732-18-5]

Evaluator:
J. Eysseltová, Charles University, Prague, Czech Republic
September 1995

Critical Evaluation:

8.4. NH_4^+, $K^+ \| H_2PO_4^-$, $Cl^- - H_2O$

The NH_4^+, $K^+ \| H_2PO_4^-$, $Cl^- - H_2O$ system has been studied either in broader extent[1,3] or in terms of the diagonal $NH_4H_2PO_4$ – KCl – H_2O.[2,4] Formation of solid solutions between both dihydrogenphosphates and chlorides is the prominent feature of this system. The data in the different reports cannot be compared with each other because of different experimental conditions. The phase diagram of Ref. 2 —see Figure 26—can be accepted tentatively.

References:

[1]P. Askenasy and F. Nessler. F. Z. Anorg. Chem. **189**, 305 (1930).
[2]V. A. Polosin and M. I. Shakhparonov, Zh. Fiz. Khim. **21**, 119 (1947).
[3]A. Iovi and C. Haiduc, Rev. Roum. Chim. **16**, 743 (1971).
[4]Z. N. Fokina, E. N. Kornishina, and P. P. Kim, Tekhnologiya Mineral'nykh Udobreniy (Leningrad) 63 (1977).

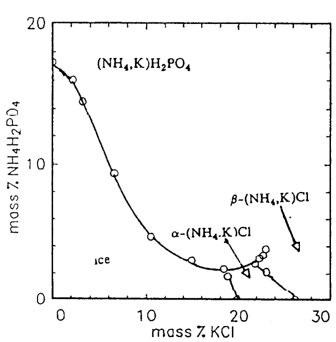

FIG. 26. Solubility in the $H_4H_2PO_4$–KCl–H_2O system.

Components
(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Potassium chloride; KCl; [7747-40-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:
P. Askenasy, F. Nessler, Z. Anorg. Chem. **189**, 305-28 (1930).

Variables:
Composition at 0 °C.

Prepared By:
J. Eysseltová

Experimental Data

Part 1. The authors' data:

Points of simultaneous crystallization of several solid phases in the K^+, $NH_4^+ \| Cl^-$, $H_2PO_4^- - H_2O$ system at 0 °C

Soln no	Density g cm^{-3}	Mol/100 mol solute $H_2PO_4^-$	Cl^-	K^+	NH_4^+	H_2O	Solid phases[a]
1	1.1100	7.6	92.4	8.0	92.0	925	"NH_4Cl"+"$NH_4H_2PO_4$"
2	1.1134	7.7	92.3	12.1	87.9	905	"NH_4Cl"+"$NH_4H_2PO_4$"
3	1.1300	8.1	91.9	17.9	82.1	888	"NH_4Cl"+"$NH_4H_2PO_4$"
4	1.1335	8.5	91.5	24.4	75.6	850	"NH_4Cl"+"$NH_4H_2PO_4$"
5	1.1385	8.7	91.3	28.7	71.3	810	ternary eutectic point
6	1.1504	8.3	91.7	29.8	70.2	865	"KCl"+"KH_2PO_4"
7	1.1514	8.3	91.7	32.7	67.3	887	"KCl"+"KH_2PO_4"
8	1.1657	7.5	92.5	66.6	33.4	1135	"KCl"+"KH_2PO_4"
9	1.1695	7.7	92.3	85.8	14.2	1310	"KCl"+"KH_2PO_4"
10	1.1740	7.3	92.7	90.0	10.0	1380	"KCl"+"KH_2PO_4"
11	1.1272	3.6	96.4	28.2	71.8	845	"KCl"+"NH_4Cl"

[a]A formula in quotation marks refers to a solid solution rich in that component.

Distribution of K^+ and NH_4^+ in the solid and liquid phases of the solutions existing in equilibrium with $(K,NH_4)H_2PO_4$

Soln no	Liquid phase mol/100 mol solute $H_2PO_4^-$	Cl^-	K^+	NH_4^+	H_2O	Solid phase mol % K^+	NH_4^+
12	9.8	90.2	57.8	42.2	1090	85.5	14.5
13	45.9	54.1	49.2	50.8	1690	78.9	21.1
14	33.8	66.2	45.5	54.5	1680	71.7	28.3
15	27.4	72.6	42.7	57.3	1450	66.1	33.9
16	27.2	72.8	43.3	56.7	1565	64.8	35.2
17	19.7	80.3	40.9	59.1	1135	62.2	37.8
18	13.1	86.9	38.9	61.1	1130	62.2	37.8
19	26.7	73.3	44.2	55.8	1555	56.4	45.6
20	24.5	75.5	36.9	63.1	1665	55.7	44.3
21	9.8	90.2	26.6	73.4	925	31.2	68.8
22	18.3	81.7	28.7	71.3	1235	29.2	70.8

Part 2. The compiler has recalculated the authors' data to give the following values:

Soln no	$H_2PO_4^-$ 100w_i	m_i	Cl^- 100w_i	m_i	K^+ 100w_i	m_i	NH_4^+ 100w_i	m_i	H_2O 100w_i	Solid phase[a]
1	3.25	0.45	14.47	5.54	1.38	0.48	7.32	5.52	73.55	A+B
2	3.33	0.47	14.63	5.66	2.11	0.74	7.08	5.39	72.82	A+B
3	3.53	0.50	14.67	5.74	3.15	1.11	6.66	5.13	71.96	A+B
4	3.80	0.55	14.96	5.98	4.39	1.59	6.28	4.94	70.54	A+B
5	4.00	0.59	15.36	6.26	5.32	1.96	6.10	4.89	69.19	C
6	3.64	0.53	14.74	5.88	5.28	1.91	5.73	4.50	70.58	D+E
7	3.57	0.51	14.44	5.74	5.67	2.04	5.39	4.21	70.91	D+E
8	2.63	0.36	11.86	4.52	9.41	3.25	2.17	1.63	73.90	D+E
9	2.39	0.32	10.48	3.91	10.74	3.63	0.82	0.60	75.54	D+E
10	2.17	0.29	10.10	3.73	10.81	3.62	0.55	0.40	76.34	D+E
11	1.63	0.23	15.99	6.33	5.15	1.85	6.05	4.72	71.15	D+F
12	3.54	0.49	11.94	4.59	8.43	2.94	2.84	2.15	73.23	G
13	11.23	1.50	4.84	1.77	4.85	1.61	2.31	1.66	76.65	G
14	8.48	1.11	6.07	2.18	4.60	1.50	2.54	1.80	78.28	G
15	7.80	1.04	7.56	2.78	4.90	1.63	3.03	2.19	76.68	G
16	7.30	0.96	7.15	2.58	4.68	1.53	2.83	2.01	78.02	G
17	6.86	0.96	10.22	3.93	5.74	2.00	3.82	2.89	73.34	G
18	4.65	0.64	11.28	4.27	5.56	1.91	4.03	3.00	74.46	G
19	7.21	0.95	7.23	2.61	4.81	1.57	2.80	1.99	77.93	G
20	6.31	0.81	7.12	2.51	3.83	1.23	3.02	2.10	79.69	G
21	4.10	0.58	13.81	5.41	4.49	1.59	5.71	4.40	71.88	G
22	6.05	0.82	9.88	3.67	3.82	1.29	4.38	3.20	75.84	G

[a]The solid phases are: A = "NH_4Cl"; B = "$NH_4H_2PO_4$"; C = ternary eutectic point; D = "KCl"; E = "KH_2PO_4"; F = "NH_4Cl"; G = a precipitate designated as $(K,NH_4)H_2PO_4$. The quotation marks have the same meaning as on the preceding page.

Auxiliary Information

Method / Apparatus / Procedure:

Binary eutonic solutions were prepared on the basis of a preliminary investigation of the boundary ternary systems. Samples on the curve for the simultaneous crystallization of two salts were then prepared by adding a third component. The mixtures were shaken in a thermostat for 2–4 days. The solid phase was isolated by centrifuging. The analytical methods are not described.

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was controlled to within ± 0.1 K. No other information is given.

Components

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Potassium chloride; KCl; [7747-40-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

V. A. Polosin and M. I. Shakhparonov, Zh. Fiz. Khim. **21**, 119-23 (1947).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Solubility isotherms in the KCl–$NH_4H_2PO_4$–H_2O system

KCl 100w_i	comp[a]	m_i/mol kg^{-1}[b]	$NH_4H_2PO_4$ 100w_i	comp[a]	m_i/mol kg^{-1}[b]	H_2O 100w_i	comp[a]	Solid phase[c]
				temp = −10 °C				
19.10	100.0	3.171	0.00	0.00	0.00	80.90	1744	A
17.75	94.40	2.954	1.65	5.60	0.178	80.60	1772	A
19.12	84.40	3.242	1.78	5.60[d]	0.196	79.10	1613	B
9.80	100.0	1.46	0.00	0.00	0.00	90.20	1668	C
				temp = 0 °C				
21.65	100.0	3.707	0.00	0.00	0.00	78.35	1496	C
21.32	94.40	3.728	1.98	5.60	0.224	76.70	1404	B
19.00	91.20	3.260	2.83	8.80	0.315	78.17	1552	D
11.76	77.60	1.900	5.24	22.40	0.549	83.00	2266	D
8.20	58.00	1.33	9.18	42.00	0.966	82.62	2415	D
6.10	40.00	1.02	14.08	60.00	1.533	79.82	2170	D
2.39	17.00	0.402	17.81	83.00	1.940	79.80	2371	D
0.00	0.00	0.00	18.50	100.0	1.973	81.50	2813	E
				temp = 10 °C				
23.50	100.0	4.120	0.00	0.00	0.00	76.50	1348	C
23.33	94.40	4.200	2.17	5.60	0.253	74.50	1246	F
23.10	93.00	4.175	2.69	7.60[d]	0.315	74.21	1226	F
13.56	77.60	2.262	6.04	22.40	0.653	80.40	1903	D
10.90	65.40	1.823	8.91	34.60	0.966	80.19	1991	D
8.10	47.50	1.39	13.78	52.50	1.533	78.12	1898	D
5.00	32.20	1.03	18.84	67.80	2.173	75.36	1734	D
2.85	17.00	0.504	21.25	83.00	2.434	75.90	1890	D
0.00	0.00	0.00	22.10	100.0	2.466	77.90	2251	E
				temp = 20 °C				
25.70	100.0	4.639	0.00	0.00	0.00	74.30	1195	C
24.89	94.40	4.586	2.31	5.60	0.276	72.80	1135	F
22.63	90.40	4.120	3.70	9.60	0.437	73.67	1218	F
15.36	77.60	2.648	6.84	22.40	0.764	77.80	1625	D
13.70	71.00	2.366	8.63	29.00	0.966	77.67	1666	D
10.20	53.90	1.792	13.47	46.10	1.534	76.33	1671	D
8.00	40.10	1.46	18.40	59.90	2.173	73.60	1529	D
3.90	20.00	0.726	24.02	90.00[d]	2.897	72.08	1533	D
3.30	17.00	0.615	24.70	83.00	2.982	72.00	1544	D
0.00	0.00	0.00	26.30	100.0	3.102	73.70	1789	E
				temp = 25 °C				
26.50	100.0	4.836	0.00	0.00	0.00	73.50	1147	G
25.62	94.40	4.772	2.38	5.60	0.287	72.00	1096	F
25.00	91.10	4.709	3.80	8.90	0.464	71.20	1072	F

22.56	89.70	4.120	4.00	10.30	0.473	73.44	1208	D
16.26	77.60	2.851	7.24	22.44[d]	0.823	76.50	1510	D
15.00	73.30	2.630	8.50	26.70	0.966	76.50	1544	D
11.30	56.70	2.010	13.30	43.30	1.533	75.40	1567	D
9.10	43.50	1.68	18.18	56.50	2.173	72.72	1441	D
6.40	29.60	1.32	28.40	70.40	3.787	65.20	1347	D
3.54	17.00	0.678	26.46	83.00	3.286	70.00	1401	D
0.00	0.00	0.00	28.40	100.0	3.448	71.60	1476	E
				temp=35 °C				
27.70	100.0	5.138	0.00	0.00	0.00	72.30	1077	G
27.17	94.40	5.184	2.53	5.60	0.313	70.30	1010	F
24.96	90.70	4.712	4.00	9.30	0.489	71.04	1067	D
22.28	86.90	4.121	5.20	13.10	0.623	72.52	1170	D
18.00	77.60	3.262	8.00	22.40	0.940	74.00	1320	D
17.80	77.00	3.227	8.22	23.00	0.966	73.98	1323	D
14.00	62.60	2.569	12.90	37.40	1.534	73.10	1353	D
11.40	49.30	2.157	17.72	50.20	2.173	70.88	1282	D
9.60	39.60	1.899	22.60	60.40	2.898	67.80	1152	D
4.01	17.00	0.717	20.99	83.00	2.433	75.00	1165	D

[a]The composition unit is: mol/100 mol of solute.
[b]These values were calculated by the compiler based on the mass % values of the components.
[c]The solid phases are: A=ice; B=α-$(NH_4,K)Cl$; C=α-KCl; D=$(NH_4,K)H_2PO_4$; E=$NH_4H_2PO_4$; *F*=β-$(NH_4,K)Cl$; G = β-KCl.
[d]This is an obvious error.

Part 2. Monovariant and invariant points

KCl 100w_i	KCl comp[a]	KCl m_i[b]	$NH_4H_2PO_4$ 100w_i	$NH_4H_2PO_4$ comp[a]	$NH_4H_2PO_4$ m_i[b]	H_2O 100w_i	H_2O comp[a]	t/°C	Solid phase[c]
19.80	100.0	3.311	0.00	0.00	0.00	80.20	1680	−10.4	A+C
26.20	100.0	4.761	0.00	0.00	0.00	73.80	1165	22.2	B+F
0.00	0.00	0.00	17.30	100.0	1.819	82.70	3053	−2.4	A+E
18.40	92.40	3.114	2.35	7.60	0.258	79.25	1645	−11.2	A+B+E
22.30	91.70	4.012	3.15	8.30	0.367	74.55	1267	12.5	B+D+F
18.80	94.40	3.176	1.80	5.60	0.197	79.40	1645	−11.0	A+B
23.05	94.40	4.133	2.15	5.60	0.250	74.80	1266	8.0	B+F[d]
2.15	17.00	0.353	16.05	83.00	1.706	81.80	2698	−4.9	A+D
3.20	25.30	0.522	14.52	74.70	1.534	82.28	2701	−5.0	A+D
6.60	52.20	1.05	9.34	47.80	0.966	84.06	2750	−5.7	A+D
10.52	77.60	1.664	4.68	22.40	0.480	84.80	2589	−6.5	A+D
14.90	88.50	2.434	2.98	11.50	0.315	82.12	2020	−8.6	A+D
21.80	92.50	3.875	2.74	7.50	0.316	75.46	1324	2.7	B+D
22.70	61.30[e]	4.117	3.35	8.70	0.394	73.95	1230	9.8	D+F
25.00	91.10	4.709	3.80	8.90	0.464	71.20	1072	24.0	D+F

[a]The composition unit is: mol/100 mol of solute.
[b]The molalities were calculated by the compiler and are based on the mass % values of the components.
[c]The solid phases are: A=ice; *B*=α-$(NH_4,K)Cl$; C=α-KCl; D=$(NH_4,K)H_2PO_4$; E=$NH_4H_2PO_4$; F=β-$(NH_4,K)Cl$; G= β-KCl.
[d]In this line, the expression "β-$(NH_4H_2K)Cl$" stands for one of the solid phases. The compiler believes that this is an error.
[e]This is obviously an error. The correct value is 91.30.

Auxiliary Information

Method / Apparatus / Procedure:

A polythermic method was used. Solid carbon dioxide served as the cooling agent.

Source and Purity of Materials:

All materials were recrystallized twice and analyzed before being used. No further details are given.

Estimated Error:

No information is given.

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Potassium dihydrogenphosphate; KH_2PO_4; [7778-77-0]
(4) Potassium chloride, KCl; [7747-40-7]
(5) Water, H_2O, [7732-18-5]

Original Measurements:

A. Iovi and C. Haiduc, Rev. Roum. Chim. **16**, 1743-7 (1971).

Variables:

Temperature. Equimolar mixtures of KCl + $NH_4H_2PO_4$ or NH_4Cl and KH_2PO_4 are used.

Prepared By:

J. Eysseltová

Experimental Data

Molar solubility in equimolar mixtures in the K^+, NH_4^+ ‖ Cl^-, $H_2PO_4^-$ – H_2O system

Soln		(A) KCl + $NH_4H_2PO_4$				(B) NH_4Cl + KH_2PO_4				
no	t/°C	$H_2PO_4^-$	Cl^-	K^+	NH_4^+	$H_2PO_4^-$	Cl^-	K^+	NH_4^+	d/g cm^{-3}
1	20	0.60	4.77	2.18	3.19	0.60	4.77	2.18	3.19	1.1585
2	25	0.70	4.76	2.18	3.28	0.70	4.72	2.18	3.24	1.1640
3	40	1.00	4.49	2.31	3.18	1.00	4.39	2.31	3.08	1.1690
4	60	1.50	4.36	2.44	3.42	1.50	4.36	2.44	3.42	1.1880
5	75	2.20	4.36	2.82	3.74	2.20	4.26	2.82	3.64	1.2360
6	80	2.50	4.23	2.95	3.78	2.50	4.22	2.95	3.77	1.2479

The compiler has recalculated these values as follows:

Soln	$H_2PO_4^-$		Chloride		Potassium		Ammonium	
no	$100w_i$	m_i	$100w_i$	m_i	$100w_i$	m_i	$100w_i$	m_i
1(A,B)	5.02	0.76	14.60	6.04	7.35	2.76	4.95	4.03
2(A)	5.83	0.89	14.50	6.07	7.32	2.78	5.07	4.18
2(B)	5.83	0.89	14.38	6.01	7.32	2.77	5.01	4.11
3(A)	8.29	1.30	13.62	5.86	7.72	3.01	4.89	4.14
3(B)	8.29	1.29	13.32	5.69	7.72	2.99	4.74	3.99
4(A,B)	12.24	2.05	13.01	5.96	8.03	3.33	5.18	4.67
5(A)	17.26	3.18	12.51	6.31	8.92	4.08	5.44	5.40
5(B)	17.26	3.16	12.22	6.12	8.92	4.05	6.30	5.22
6(A)	19.43	3.72	12.02	6.29	9.24	4.39	5.45	5.61
6(B)	19.43	3.71	11.99	6.27	9.24	4.38	5.43	5.59

Molar solubility in equimolar mixtures in the K^+, NH_4^+ ‖ Cl^-, $H_2PO_4^-$ – H_2O system. The following concentrations are expressed as mol/100 mol of solute.

Soln no	H_2PO_4	Chloride	Potassium	Ammonium	Water
1(A,B)	11.17	88.83	40.64	59.36	818
2(A)	12.78	87.22	39.94	60.06	798
2(B)	12.80	87.10	40.26	59.74	807
3(A)	18.15	81.85	42.83	57.17	804
3(B)	18.48	81.52	42.78	57.22	796
4(A,B)	25.59	74.41	41.62	58.38	694
5(A)	33.50	66.50	41.03	56.97	586
5(B)	34.05	65.95	43.68	56.32	599
6(A)	37.16	62.84	43.90	56.10	556
6(B)	37.17	62.83	43.93	56.07	557

Auxiliary Information

Method / Apparatus / Procedure:

The samples were equilibrated by stirring for 10 hrs in a thermostat. The potassium content was determined with the use of a type C Zeiss Jena Model III flame photometer and gravimetrically as $KClO_4$, phosphate ion was determined by a compleximetric titration with $MgCl_2$ using Eriochrome Black T as indicator,[1] chloride was determined by potentiometric titration with $AgNO_3$, and NH_3 was determined by the Kjeldahl method.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

References:

[1]C. Liteanu, Chimie anilitica Cantitativa, Ed. didactica si pedagogica, Bucuresti, p. 508 (1964).

Components:

(1) Ammonium dihydrogenphosphate; $NH_4H_2PO_4$; [7722-76-1]
(2) Potassium chloride; KCl; [7747-40-7]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

Z. N. Fokina, E. N. Kornishina, and P. P. Kim, Tekhnologiya Mineral'nykh, Udobreniy (Leningrad), 63-8 (1977).

Variables:

Composition at 60 °C

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $NH_4H_2PO_4$ - KH_2PO_4 - NH_4Cl - KCl - H_2O system at 60 °C

Soln No	K_2O $100w_i$	NH_3 $100w_i$	P_2O_5 $100w_i$	Solid phases
1	1.6	6.5	26.6	$NH_4H_2PO_4$
2	3.7	5.9	24.1	$(K,NH_4)H_2PO_4$
3	6.1	4.2	16.9	$(K,NH_4)H_2PO_4$
4	7.9	3.9	15.9	$(K,NH_4)H_2PO_4$
5	9.8	3.5	14.6	$(K,NH_4)H_2PO_4$
6	10.5	3.2	13.1	KH_2PO_4
7	11.0	3.0	12.2	KH_2PO_4
8	11.3	2.4	11.0	KH_2PO_4
9	16.4	0.9	3.7	KH_2PO_4
10	17.5	0.7	3.0	KH_2PO_4
11	20.2	0.4	1.7	KH_2PO_4

The compilers have recalculated the authors' data to give the following values

Soln	H_2PO_4		Chloride		Potassium		Ammonium		H_2O
no	$100w_i$	m_i	$100w_i$	m_i	$100w_i$	m_i	$100w_i$	m_i	$100w_i$
1	36.0	0.375	1.5	0.043	1.3	0.034	6.9	0.38	55.8
2	32.6	0.340	3.0	0.086	3.1	0.079	6.2	0.35	58.1
3	22.9	0.230	4.9	0.14	5.1	0.13	4.4	0.25	67.6
4	21.5	0.224	6.1	0.17	6.6	0.17	4.1	0.23	67.8
5	19.8	0.206	7.3	0.21	8.1	0.21	3.7	0.21	68.4
6	17.7	0.185	8.0	0.23	8.7	0.22	3.4	0.19	70.2
7	16.5	0.172	8.4	0.24	9.1	0.23	3.2	0.18	71.2
8	14.9	0.155	7.9	0.23	9.4	0.24	2.5	0.14	73.2
9	5.0	0.052	12.2	0.349	13.6	0.340	0.95	0.053	80.4
10	4.1	0.042	13.0	0.370	14.5	0.372	0.74	0.041	80.7
11	2.3	0.024	15.0	0.420	16.8	0.429	0.42	0.024	80.5

Auxiliary Information

Method / Apparatus / Procedure:

No information is given. The compilers assume that the methods were the same as those given earlier.[1]

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

References:

[1]T. N. Baranova, N. T. Semkin, P. P. Kim, E. N. Kornishina, and I. S. Nikandrov, Tekhnologiya Mineral'nykh Udobreniy (Leningrad), 55 (1977).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic
September 1995

Critical Evaluation:

9.1. $(NH_4)_2HPO_4$–Urea–H_2O

Two investigations of the composition and temperature of the invariant points in this system are available.[1,2] But these two sets of data do not agree with each other even with respect to the nature of the equilibrium solid phase. The modifications of urea are the main source of the uncertainty. The evaluation of this question, however, is beyond the scope of this volume. The closely related system $(NH_4)_2HPO_4$–$CO(NH_2)_2\cdot$ HNO_3–H_2O was studied by Nabiev et al.[3]

References:

[1]A. G. Treshchov, Dokl. Timiryazevsk. S.-kh. Akad. **29**, 402 (1957).
[2]V. I. Vereshchagina and M. P. Endovitskaya, Zh. Neorg. Khim. **15**, 2818 (1970).
[3]M. N. Nabiev, S. Tukhtaev, A. Kh. Narkhodzaev, and D. Kh. Yunusov, Zh. Neorg. Khim. **21**, 3152 (1976).

Components:
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
A. G. Treshchov, Dokl. Timiryazevsk. S.-kh. Akad. **29**, 402-8 (1957).

Variables:
Temperature and composition.

Prepared By:
L. V. Chernykh and J. Eysseltová

Experimental Data

Monovariant and invariant points in the $(NH_4)_2HPO_4-CO(NH_2)_2-H_2O$ system

$CO(NH_2)_2$		$(NH_4)_2HPO_4$		H_2O			Solid
$100w_2$	m_2/mol kg^{-1a}	$100w_1$	m_1/mol kg^{-1a}	$100w_3$	comp[b]	t/°C	phases[c]
32.90	8.16	0.00	0.00	67.10	680	−11	A+B
40.70	11.43	0.00	0.00	59.30	489	1.1	B+C
54.50	19.94	0.00	0.00	45.50	279	24.4	C+D
0.00	0.00	29.60	3.18	70.40	1730	−6.7	A+E
0.00	0.00	4.60	0.37	95.40	1397	−8.6	E+F(metastable)
25.40	6.79	12.30	1.49	62.30	670	−17.0	A+B+E
26.70	7.74	15.90	2.10	57.40	563	−16.2	B+E+F

[a]These values were calculated by the compilers.
[b]The composition unit is: mol/100 mol of solute.
[c]The solid phases are: A = ice; B = α-$CO(NH_2)_2$; C = β-$CO(NH_2)_2$; D = γ-$CO(NH_2)_2$; E = $(NH_4)_2HPO_4\cdot 2H_2O$; F = $(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:
A visual polythermic method was used.

Source and Purity of Materials:
No information is given.

Estimated Error:
No information is given.

Components:
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
V. I. Vereshchagina and M. P. Endovitskaya, Zh. Neorg. Khim. **15**, 2818-20 (1970).

Variables:
Temperature and composition.

Prepared By:
J. Eysseltová

Experimental Data

Composition and crystallization temperature of invariant points in the $(NH_4)_2HPO_4-CO(NH_2)_2-H_2O$ system

$CO(NH_2)_2$		$(NH_4)_2HPO_4$		H_2O		
$100w_2$	m_2/mol kg^{-1a}	$100w_1$	m_1/mol kg^{-1a}	$100w_3$	t/°C	Solid phases[b]
45.0	16.7	10.0	1.68	45.0	16	A+B+C
26.0	7.80	18.5	2.52	55.5	−6	A+C+D
27.0	7.75	15.0	1.96	58.0	−16	A+D+E
26.0	7.0	12.5	1.54	61.5	−17	A+D+ice

[a]These values were calculated by the compiler.
[b]The solid phases are: A = β-urea; B = γ-urea; C = $(NH_4)_2HPO_4$; D = $(NH_4)_2HPO_4\cdot 2H_2O$; E = α-urea.

In addition to the above data, the authors also give the following data for the binary system $(NH_4)_2HPO_4-H_2O$.

$(NH_4)_2HPO_4$			
$100w_1$	m_1/mol kg^{-1a}	t/°C	Solid phases
28.0	2.94	−5.5	ice+$(NH_4)_2HPO_4\cdot 2H_2O$
39.5	4.94	15.2	$(NH_4)_2HPO_4\cdot 2H_2O$ + $(NH_4)_2HPO_4$

[a]These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:
A visual polythermic method was used.[1] Solid carbon dioxide was used as the cooling agent. The temperature was measured with the aid of Assman's thermometer, the scale of which was divided in steps of 0.2 K.

Source and Purity of Materials:
No information is given

Estimated Error:
The temperature was constant to within ± 0.40 °C.

References:
[1]A. G. Bergman and N. P. Luzhnaya, Fiziko-Khimicheskie Osnovy Izucheniya I Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow, IAN SSSR (1951).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Urea nitrate; $CO(NH_2)_2 \cdot HNO_3$; [17687-37-5]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

M. N. Nabiev, S. Tukhtaev, A. Kh. Narkhodzhaev, and D. Kh. Yunusov, Zh. Neorg. Khim. **21**, 3152-4 (1976).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Nonvariant and monovariant points in the $(NH_4)_2HPO_4-CO(NH_2)_2 \cdot HNO_3-H_2O$ system

$CO(NH_2)_2 \cdot HNO_3$		$(NH_4)_2HPO_4$		H_2O		
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	t/°C	Solid phases[b]
8.0	0.7	0.0	0.0	92.0	−2.8	ice+A
9.8	0.9	2.0	0.2	88.2	−3.6	ice+A
15.8	1.7	8.4	0.8	75.8	−8.0	ice+A
17.8	2.0	11.0	1.2	71.2	−12.4	ice+A+B
23.0	3.0	15.4	1.9	61.6	−8.5	A+B
32.0	5.4	20.0	3.2	48.0	−5.5	A+B
32.6	5.6	20.2	3.2	47.2	−7.0	A+B
40.0	9.0	24.0	5.0	36.0	30.0	A+B
12.4	1.4	17.4	1.9	70.2	−9.0	ice+B+C
8.0	0.9	20.0	2.1	72.0	−7.2	ice+C
0.0	0.0	25.0	2.5	75.0	−5.5	ice+C
12.0	1.5	22.0	2.5	66.0	−10.0	B+C
11.0	1.4	26.6	3.2	62.4	−17.5	B+C+D
6.8	0.9	31.3	3.8	61.9	−10.5	C+D
0.0	0.0	39.2	4.9	60.8	15.0	C+D
13.8	2.0	31.0	4.3	55.2	−11.0	B+D
15.6	2.5	33.6	5.0	50.8	−2.0	B+D
19.6	4.0	40.2	7.6	40.2	28.0	B+D
22.2	5.4	44.4	10.1	33.4	49.0	B+D

[a]The molalities were calculated by the compiler.
[b]The solid phases are : A = $CO(NH_2)_2 \cdot HNO_3$; B = $NH_4H_2PO_4$; C = $(NH_4)_2HPO_4 \cdot 2H_2O$; D = NH_4NO_3; E = $(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

Presumably some sort of visual polythermic method was used (compiler), but no details are given.

Source and Purity of Materials:

Diammonium hydrogenphosphate was recrystallized before use. Urea nitrate was synthesized from urea and reagent grade nitric acid.

Estimated Error:

No details are given.

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

G. L. Tudorovskaya and F. G. Margolis, Khim. Prom. (Moscow) **42**, 678-80 (1966).

Variables:

Composition at 50 °C.

Prepared By:

J. Eysseltová

Experimental Data

Part 1. Solubility in the $(NH_4)_2HPO_4-NH_4NO_3-CO(NH_2)_2-H_2O$ system at 50 °C

Soln	$CO(NH_2)_2$		NH_4NO_3		$(NH_4)_2HPO_4$		H_2O	Solid
no	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	phase[b]
1	0.000	0.000	67.95	30.39	4.12	1.12	27.93	A+B
2	9.44	7.15	65.77	37.36	2.80	0.964	21.99	A+B
3	16.65	14.51	62.59	40.92	1.65	0.654	19.11	A+B
4	29.86	50.22	58.77	74.16	1.47	1.12	9.90	A+B
5	38.74	71.19	51.00	70.32	1.20	1.00	9.06	A+B
6	46.50	XX[c]	52.08	XX[c]	1.42	XX[c]	—	A+B
7	48.80	XX[c]	49.35	XX[c]	1.85	XX[c]	—	B+C
8	49.70	106.09	41.30	66.14	1.20	1.16	7.80	B+C
9	53.41	48.25	26.20	17.76	1.96	0.805	18.43	B+C
10	56.54	42.64	19.32	10.93	2.06	0.706	22.08	B+C
11	60.96	37.72	9.37	4.35	2.76	0.777	26.91	B+C
12	61.00	34.09	5.61	2.35	3.60	0.915	29.79	B+C
13	62.77	35.54	0.000	0.000	7.82	2.01	29.41	B+C
14	0.000	0.000	77.05	41.94	0.000	0.000	22.95	A
15	66.52	33.08	0.000	0.000	0.000	0.000	33.48	C
16	0.000	0.000	0.000	0.000	46.50	6.58	53.50	B

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = NH_4NO_3; B = $(NH_4)_2HPO_4$; C = $CO(NH_2)_2$.
[c]The molalities designated as XX cannot be calculated, because the solutions are anhydrous.

Part 2. The authors express the composition of the solutions in Part 1 in the following way also

Soln no	$CO(NH_2)_2$ comp[a]	NH_4NO_3 comp	$(NH_4)_2HPO_4$ comp	H_2O comp
1		94.28	5.72	38.45
2	12.20	84.21	3.59	28.19
3	20.55	77.41	2.04	23.61
4	33.17	65.20	1.63	11.10
5	42.80	56.25	0.94	9.90
6	46.50	52.08	1.42	—
7	48.80	49.35	1.85	—
8	53.90	44.80	1.30	8.45
9	65.45	32.15	2.40	22.60
10	72.56	24.80	2.64	28.33
11	83.40	12.85	3.75	36.83
12	86.86	8.00	5.14	42.42
13	88.91	..	11.09	41.66
14		100.00	--	29.78
15	100.00	---	--	50.33
16		-	100.00	115.04

[a]The authors state that the composition unit is g H_2O/100 g solute. The compiler's opinion is that this is a typographical error and the composition unit is g/100 g solute.

Auxiliary Information

Method / Apparatus / Procedure:

An isothermal method was used. Equilibrium was checked by repeated analysis.

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was kept constant to within 0.1 K.

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Urea; CH_4N_2O; [57-13-6]
(3) Potassium nitrate; KNO_3; [7757-79-1]
(4) Water; H_2O; [7732-18-5]

Original Measurements:

M. R. Endovitskaya and V. I. Vereshchagina, Zh. Neorg. Khim. **17**, 825-8 (1972).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Crystallization temperature and composition of invariant points in the $KNO_3-(NH_4)_2HPO_4-CO(NH_2)_2-H_2O$ system

	KNO_3		$(NH_4)_2HPO_4$		$CO(NH_2)_2$		H_2O	
t/°C	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	m_i[a]	$100w_i$	Solid phases[b]
−18	5	0.8	13	1.6	20.5	5.55	61.5[c]	A+B+C
−3	4.5	0.79	21.5	2.88	17.5	5.16	56.5[c]	B+C+D
−17	5	0.9	13	1.8	26.3	7.86	55.7	A+B+C
−7.5	4.5	0.83	19	2.7	23	7.2	53.5	B+C+D
−4	5	0.9	21	2.9	20	6.1	54.0	C+D+E

[a]The molalities were calculated by the compiler and are expressed as mol kg^{-1}.
[b]The solid phases are: A = ice; B = $(NH_4)_2HPO_4 \cdot 2H_2O$; C = α-KNO_3; D = $(NH_4)_2HPO_4$; E = β-KNO_3.
[c]In the original article there are misprints for these data (61.95 and 57.5, respectively).

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.[1]

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

References:

[1]A. G. Bergman and N. P. Luzhnaya, Fizikokhimicheskiye Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow, IAN SSSR (1951).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Thiourea; CH_4N_2S; [62-56-6] or
(2) Methionine; $C_5H_{11}NO_2S$; [59-51-8] or
(2) Triethylamine hydrochloride; $C_6H_{16}ClN$; [554-68-7]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic. September 1995

Critical Evaluation:

9.2. $(NH_4)_2HPO_4$–Organic Compound–H_2O

Systems with diammonium hydrogenphosphate, oprganic compound and water.

The $(NH_4)_2HPO_4$ - $CS(NH_2)_2$–H_2O system is described in two articles.[2,3] The 298 K isotherm and the complete phase diagram are given. These data are consistent with each other, but no critical evaluation can be made because there are no other data available.

As far as similar systems containing diammonium hydrogenphosphate and an organic compound (which is both solid and water-soluble under ordinary room conditions) are concerned, there are two systems that have been studied: (a) the $(NH_4)_2HPO_4$–methionine–water system described by Beglov et al.;[4] and (b) the $(NH_4)_2HPO_4$–$(C_2H_5)_3N \cdot HCl$–H_2O system.[1,5] No other independent data are available for these systems and, therefore, the information cannot be evaluated.

References:

[1] O. E. Sosnina and A. A. Volkov, Uch. Zap. Perm. Gos. Univ., Ser. Khim. **289**, 20 (1973).
[2] B. S. Zakirov, S. Tukhtaev, and B. M. Beglov, Dokl. Akad. Nauk Uzb. SSR, 40 (1974).
[3] B. S Zakirov, S. Tukhtaev, B. M. Beglov, and B. M. Khaymov, Dokl. Akad. Nauk Uzb. SSR, 31 (1977).
[4] B. M. Beglov, B. S. Zakirov, and D. A. Amilova, Uzb. Khim. Zh., 61 (1985).
[5] S. A. Mazunin, O. E. Sosnina, A. A. Volkov, and T. L. Danina, Termicheskiy Analiz i Fazovye Ravnovesiya, Perm, 79 (1985).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Thiourea; CH_4N_2S; [62-56-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

B. S. Zakirov, S. Tukhtaev, and B. M. Beglov, Dokl. Akad. Nauk. Uzb. SSR, 40-2 (1974).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Points of simultaneous crystallization of two or three solid phases in the $(NH_4)_2HPO_4$–$CS(NH_2)_2$–H_2O system

$(NH_4)_2HPO_4$ 100w_i	$(NH_4)_2HPO_4$ m_i/mol kg^{-1} [a]	$CS(NH_2)_2$ 100w_i	$CS(NH_2)_2$ m_i/mol kg^{-1} [a]	H_2O 100w_i	t/°C	Solid phases[b]
0	0	5.2	0.72	94.8	−0.6	A+B
9.5	0.84	4.8	0.74	85.7	−2.5	A+B
18.0	1.75	4.1	0.69	77.9	−4.2	A+B
19.2	1.89	4.0	0.68	76.8	−4.5	A+B
23.4	2.43	3.6	0.65	73.0	−5.6	A+B+C
25.0	2.52	0	0	75.0	−5.5	A+C
24.4	2.49	1.4	0.25	74.2	−5.5	A+C
29.0	3.25	3.4	0.66	67.6	2.5	B+C
33.8	4.06	3.2	0.67	63.0	9.8	B+C
37.0	4.67	3.0	0.66	60.0	13.8	B+C+D
39.2	4.88	0	0	60.8	15.0	C+D
38.0	4.73	1.2	0.26	60.8	14.3	C+D
38.0	5.03	4.8	1.1	57.2	29.0	B+D
38.4	5.25	6.2	1.5	55.4	34.5	B+D

[a] The molalities were calculated by the compiler.
[b] The solid phases are: A = ice; B = $CS(NH_2)_2$; C = $(NH_4)_2HPO_4 \cdot 2H_2O$; D = $(NH_4)_2HPO_4$.

Additional Data: Solubility isotherms in the 10 to 40 °C temperature range are given, but only in graphical form.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.

Source and Purity of Materials:

"Chemically pure" $(NH_4)_2HPO_4$ was used. The thiourea was recrystallized twice.

Estimated Error:

No information is given.

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Thiourea; CH_4N_2S; [62-56-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

B. S. Zakirov, S. Tukhtaev, B. M. Beglov, and B.M. Khaymov, Dokl. Akad. Nauk. Uzb. SSR, 31-2 (1977).

Variables:

Composition at 25 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the $(NH_4)_2HPO_4$–$CS(NH_2)_2$–H_2O system at 25 °C

$CS(NH_2)_2$		$(NH_4)_2HPO_4$		H_2O	
$100w_1$	m_1/mol kg^{-1a}	$100w_1$	m_1/mol kg^{-1a}	$100w_1$	Solid phase
14.23	2.180	—	—	85.77	$CS(NH_2)_2$
13.19	2.156	6.44	0.607	80.37	$CS(NH_2)_2$
11.76	2.017	11.64	1.151	76.60	$CS(NH_2)_2$
9.58	1.80	20.71	2.249	69.71	$CS(NH_2)_2$
8.16	1.62	25.49	2.909	66.35	$CS(NH_2)_2$
6.74	1.39	29.65	3.529	63.61	$CS(NH_2)_2$
5.19	1.15	35.46	4.524	59.35	$CS(NH_2)_2$
4.24	0.978	38.81	5.160	56.95	$CS(NH_2)_2+(NH_4)_2HPO_4$
1.98	0.449	40.07	5.236	57.95	$(NH_4)_2HPO_4$
		41.4	5.35	58.6	$(NH_4)_2HPO_4$

[a]The molalities were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used with mechanical stirring. Equilibrium was determined by repeated analysis of the liquid phase. Equilibrium was attained in 24 hrs. The composition of the solid phases was determined by the Schreinemakers' method.

Source and Purity of Materials:

Nothing is stated. The compiler assumes the materials are the same as those used in Ref. 1.

Estimated Error:

The only information given is that the temperature was controlled to within ± 0.2 K.

References:

[1]B. S. Zakirov, B. M. Khaymov, S. Tukhtaev, and B. M. Beglov, Dokl. Akad. Nauk. Uzb. SSR, 48 (1978).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Methionine; $C_5H_{11}NO_2S$; [59-51-8]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

B. M. Beglov, B. S. Zakirov, and D. A. Amilova, Uzb. Khim. Zh., 61-2 (1985).

Variables:

Temperature and composition.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Crystallization temperatures in the $(NH_4)_2HPO_4$–methionine–H_2O system

$(NH_4)_2HPO_4$		Methionine		H_2O		
$100w_1$	m_1/mol kg^{-1a}	$100w_2$	m_2/mol kg^{-1a}	$100w_3$	t/°C	Solid phases[b]
45.7	6.46	0.7	0.09	53.6	51.2	A+B
39.8	5.06	0.6	0.07	59.6	24.2	A+B
38.8	4.80	0	0	61.2	15.0	A+C
38.7	4.81	0.35	0.038	60.95	14.8	A+C
38.6	4.80	0.5	0.05	60.9	14.7	A+B+C
33.8	3.90	0.5	0.05	65.7	9.0	B+C
31.9	3.58	0.55	0.055	67.55	6.2	B+C
29.9	3.26	0.6	0.06	69.5	3.3	B+C
25.2	2.55	0	0	74.8	−5.5	C+D
25.1	2.55	0.4	0.04	74.5	−5.6	C+D
24.8	2.53	0.9	0.08	74.3	−5.7	B+C+D
19.8	1.92	2.1	0.18	78.1	−4.2	B+D
9.8	0.84	1.5	0.11	88.7	−1.8	B+D
0	0	1.7	0.12	98.3	−0.1	B+D

[a]The molalities were calculated by the compilers.
[b]The solid phases are: A=$(NH_4)_2HPO_4$; B=$(NH_4)_2HPO_4\cdot 2H_2O$; C = methionine; D = ice.

Evaluator's Comment: The identities of the solid phases appear to be incorrect. It is more likely that the identities of B and C should be reversed, i.e., B = methanione and C = $(NH_4)_2HPO_4\cdot 2H_2O$.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used, but no details are given.

Source and Purity of Materials:

Pure methionine and reagent grade $(NH_4)_2HPO_4$ were recrystallized before being used.

Estimated Error:

No information is given.

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Triethylamine hydrochloride; $C_6H_{16}ClN$; [554-68-7]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

1. O. E. Sosnina and A. A. Volkov, Uch. Zap. Perm. Gos. Univ., Ser. Khim. **289**, 20-5 (1973). 2. S. A. Mazunin, O. E. Sosnina, A. A. Volkov, and T. L. Danina, Termicheskiy Analiz i Fazovye Rovnovesiya, Perm, 79-88 (1985).

Variables:

Composition at 20 and 60 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $(NH_4)_2HPO_4$–$(C_2H_5)_3N\cdot HCl$–H_2O system

$(NH_4)_2HPO_4$		$(C_2H_5)_3N\cdot HCl$		H_2O	Refractive	Solid
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	index[b]	phase[c]
			temp = 20 °C			
40.8[d]	5.22	-		59.2	1.4100	A
27.0	3.11	7.3	0.84	65.7	1.3950	A
16.8	1.91	16.6	1.88	66.6	1.3890	A
6.0	0.69	28.2	3.23	65.8	1.3900	A
3.3	0.40	34.0	4.08	62.7	1.3930	A
2.0	0.26	39.2	5.02	58.8	1.4020	A
0.6[e]	0.1	56.7	10.0	42.7		A+B
		57.2	10.1	42.8	1.4295	B
			temp = 60 °C[e]			
43.8	6.48	5.0	0.74	51.2		A
19.0	2.37	20.4	2.54	60.6		A[f]
35.3	4.90	10.1	1.39	54.6		
10.3	1.29	29.3	3.65	60.4		A
5.3	0.70	37.1	4.85	57.6		A
2.4	0.37	48.2	7.35	49.4		A
1.3	0.23	56.4	10.0	42.3		A
0.8	0.2	64.2	13.8	35.0		A+B

[a]The molalities were calculated by the compilers.
[b]The refractive indices are given in source paper (1) only.
[c]The solid phases are: A = $NH_4H_2PO_4$; B = $(C_2H_5)_3N\cdot HCl$.
[d]These data are given in source paper (1) only.
[e]These data are given in source paper (2) only.
[f]At this experimental point, two immiscible layers were formed. The upper and lower lines refer to the upper and lower layers, respectively.

Auxiliary Information

Method / Apparatus / Procedure:

The refractometric variation of the isothermal method was used. The compilers assume that it was the method described elsewhere.[1] $(NH_4)_2HPO_4$ was determined by potentiometric titration. The composition of the solid phase was determined by the Schreinemaker's method.

Source and Purity of Materials:

Reagent grade $(NH_4)_2HPO_4$ and pure $(C_2H_5)_3N\cdot HCl$ were recrystallized before being used.

Estimated Error:

The $(NH_4)_2HPO_4$ content has a precision of ± 0.6%.

References:

[1]E. F. Zhuravlev and A. D. Sheveleva, Zh. Neorg. Khim. **5**, 2630 (1960).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Diammonium carbonate; $(NH_4)_2CO_3$; [506-87-6]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

I. N. Belyaev, N. P. Sigida, and T. D. Stepanenko, Zh. Prikl. Khim. (Leningrad) **43**, 178-81(1970).

Variables:

Composition at 10 °C.

Prepared By:

J. Eysseltová

Experimental Data

9.3. Solubility in the $(NH_4)_2HPO_4$–$(NH_4)_2CO_3$–H_2O System at 10 °C

$(NH_4)_2CO_3$		$(NH_4)_2HPO_4$		H_2O	Solid
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	phase[b]
0.000	0.000	39.00	4.84	61.00	A
2.32	0.394	36.47	4.51	61.21	A
5.35	0.884	31.64	3.80	63.01	A+B
7.79	1.19	24.24	2.70	67.97	B
10.62	1.56	18.39	1.96	70.99	B
11.35	1.58	13.73	1.39	74.92	B
13.45	1.83	10.26	1.02	76.29	B
16.40	2.23	6.97	0.689	76.63	B
20.60	2.70	0.000	0.000	79.40	B

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = $(NH_4)_2CO_3$; B = $(NH_4)_2HPO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. The mixtures were equilibrated for 8–9 hrs in 150–200 ml vessels made of Mo-glass. Mechanical stirring was used. The thermostat contained a 50% glycerol solution. The NH_4^+, HPO_4^{2-} and CO_3^{2-} ions were determined by the use of standard methods.[1,2]

Source and Purity of Materials:

Chemically pure salts were recrystallized before use. The $(NH_4)_2CO_3$ was recrystallized from 25% ammonia and used in the form of a solution of known concentration.

Estimated Error:

The temperature was kept constant to within ± 0.1 K. No other information is given.

References:

[1]A. K. Babko and I. V. Pyatnickiy, Kolichestvennyi Anuliz, Moscow, Goskhimizdat (1956).
[2]V. F. Gillebrand, *et al.*, Prakticheskoe Rukovodstvo po Neorganicheskomu Analizu, Moscow, Goskhimizdat (1960).

Components:
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Evaluator:
J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

9.4 $(NH_4)_2HPO_2-NH_4NO_3-H_2O$

There are two reports of the temperature and composition of the invariant points in the title system.[2,4] However, while these two reports agree with respect to the temperatures of the invariant points, they do not agree about the compositions. For the invariant point at about 301.8 K they even disagree with respect to the nature of the equilibrium solid phase. In view of the region of existence of $(NH_4)_2HPO_2 \cdot 2H_2O$ (see p. 14) it is probable that the correct composition of the solid is that reported by Bergman and Velikanova,[2] but additional experimental work is needed before any recommendation can be made about the composition of the invariant solutions. The isotherms measured at 323 K[1] and 283 K[3] cannot help to solve this problem.

References:

[1] D. I. Kuznetsov, A. A. Kozhukhovskiy, and E. E. Borovaya, Zh. Prikl. Khim. (Leningrad) **21**, 1278 (1948).
[2] A. G. Bergman and L. V. Velikanova, Zh. Neorg. Khim. **11**, 2370 (1966).
[3] I. N. Belyaev, N. P. Sigida, and T. D. Stepanenko, Zh. Prikl. Khim. (Leningrad) **43**, 178 (1970).
[4] L. P. Torokhtey, S. N. Ganz, and R. I. Braginskaya, Izv. Vissh. Ucheb. Zaved., Khim. Khim. Tekhnol. **15**, 320 (1972).

Components:
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammoniun nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
D. I. Kuznetsov, A. A. Kozhukhovskiy, and F. E. Borovaya, Zh. Prikl. Khim. (Leningrad) **21**, 1278-81 (1948).

Variables:
Composition and vapor pressure at 50 °C.

Prepared By:
J. Eysseltová

Experimental Data

Solubility and vapor pressure in the $NH_4NO_3-(NH_4)_2HPO_2-H_2O$ system at 50 °C

NH_4NO_3 100w_i	NH_4NO_3 m_i/mol kg^{-1} [a]	$(NH_4)_2HPO_4$ 100w_i	$(NH_4)_2HPO_4$ m_i/mol kg^{-1} [a]	H_2O 100w_i	p_{water} (mm Hg)	$p_{ammonia}$ (mm Hg)
77.0	41.8	—	—	23.0	44.4	0
75.6	41.1	1.4	0.5	23.0	42.9	1.4
74.4	40.2	2.5	0.8	23.1	48.0	1.3
68.9	31.0	3.3	0.9	27.8	50.0	1.4
55.6	18.9	7.6	1.6	36.8	66.4	1.3
45.6	13.0	10.7	1.9	43.7	72.0	2.3
42.3	11.5	11.8	1.9	45.9	71	2.9
27.9	6.7	20.3	3.0	51.8	77	4.3
21.8	5.1	25.3	3.6	52.9	75	2.0
13.3	3.0	32.2	4.5	54.5	78	3.4
—	—	47.05	6.73	52.95	82	5.3

[a] The molalities were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:
An isothermal method[1] was used. The mixtures were prepared from finely powdered salts. The system was equilibrated for 3 days although 2 days proved to be sufficient. The phosphorus content of the saturated solutions was determined gravimetrically as NH_4MgPO_4. The ammonium content was determined by the distillation method and total nitrogen content was determined using Devarda's alloy. The vapor pressure was measured by the technique described elsewhere.[1]

Source and Purity of Materials:
Reagent grade salts were recrystallized three times and dried at approximately 100 °C.

Estimated Error:
No information is given.

References:

[1] M. S. Vrevskiy, N. N. Zavaritskiy, and L. E. Sharlova, Zh. Russ. Fiz.-Khim. Obsh. **54**, 360 (1923).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

A. G. Bergman and L. V. Velikanova, Zh. Neorg. Khim. **11**, 2370-3 (1966).

Variables:

Temperature and composition

Prepared By:

J. Eysseltová

Experimental Data

	$(NH_4)_2HPO_4$		NH_4NO_3		H_2O	
$t/°C$	$100w_i$	$m_i/mol\ kg^{-1a}$	$100w_i$	$m_i/mol\ kg^{-1a}$	$100w_i$	Solid phases[b]
17.8	4.5	0.62	40.5	9.20	55	A+B+C
4.2	5.5	0.95	50.5	14.3	44	B+C+D
28.5	2.5	0.60	66	26.2	31.5	C+D+E

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = ice; B = $(NH_4)_2HPO_2 \cdot 2H_2O$; C = α-NH_4NO_3; D = $(NH_4)_2HPO_2$; E = β-NH_4NO_3.
Solubility isotherms in the temperature range of −5 to +50 °C are given in graphical form only.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.[1] Solid carbon dioxide was used as the cooling agent. In the situations where it was difficult to obtain a crystalline solid phase, the solutions were seeded to avoid supersaturation.

Source and Purity of Materials:

No information is given.

Estimated Error:

Precision of temperature measurement was not worse than ± 0.4 K in the crystallization area of $(NH_4)_2HPO_4$ and ± 0.2 K in the rest of the system.

References:

[1]A. G. Bergman and N. P. Luzhnaya, Fiziko-Khimicheskiye Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow IAN SSSR (1951).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

I. N. Belyaev, N. P. Sigida, and T. D. Stepanenko, Zh. Prikl. Khim. (Leningrad) **43**, 178-81 (1970).

Variables:

Composition at 10 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the $(NH_4)_2HPO_2$–NH_4NO_3–H_2O system at 10 °C

NH_4NO_3		$(NH_4)_2HPO_4$		H_2O	Solid
$100w_i$	$m_i/mol\ kg^{-1a}$	$100w_i$	$m_i/mol\ kg^{-1a}$	$100w_i$	phase[b]
—	—	60.08	18.80	39.92	A
2.66	0.492	56.40	17.21	40.94	A
3.46	0.638	55.47	16.87	41.07	A+B
6.93	1.13	46.57	12.51	46.50	B
10.20	1.42	35.24	8.07	54.56	B
17.05	2.17	23.57	4.96	59.38	B
27.71	3.36	9.928	1.99	62.36	B
29.13	3.46	7.15	1.40	63.72	B
30.97	3.76	6.62	1.33	62.41	B
31.75	3.84	5.60	1.12	62.65	B
34.19	4.20	4.14	0.839	61.67	B
37.46	4.69	2.03	0.419	60.51	B
39.00	4.60	—	—	61.00	B

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = NH_4NO_3; B = $(NH_4)_2HPO_2$.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. The mixtures were equilibrated for 8–9 hrs in 150–200 ml vessels made of Mo-glass. Mechanical stirring was used. The thermostat contained a 50% glycerol solution. The NH_4^+, HPO_4^{2-} and NO_3^- ions were determined by the use of standard methods.[1,2]

Source and Purity of Materials:

Chemically pure salts were recrystallized before use.

Estimated Error:

The temperature was kept constant to within ± 0.1 K. No other information is given.

References:

[1]A. K. Babko and I. V. Pyatnickiy, Kolichestvennyy Analiz, Moscow, Goskhimizdat (1956).
[2]V. F. Gillebrand, *et al.*, Prakticheskoe Rukovodstvo po Neorganicheskomu Analizu, Moscow, Goskhimizdat (1960).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

L. P. Torokhtey, S. N. Ganz, and R. I. Braginskaya, Izv. Vissh. Ucheb. Zaved. Khim. Khim. Tekhnol. **15**, 320-2 (1972).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Nonvariant points in the $NH_4NO_3-(NH_4)_2HPO_2-H_2O$ system

	NH_4NO_3		$(NH_4)_2HPO_4$		H_2O	
t/°C	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	Solid phases[b]
17.5	35.5	7.65	6.5	0.849	58.0	A+B+C
3.7	65.0	26.2	4.0	0.977	31.0	B+C+D
28.6	53.0	15.8	5.0	0.901	42.0	B+D+E

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = ice; B = $(NH_4)_2HPO_2 \cdot 2H_2O$; C = α-NH_4NO_3; D = $(NH_4)_2HPO_2$; E = β-NH_4NO_3.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method[1] was used. Solid CO_2 was the cooling agent.

Source and Purity of Materials:

Reagent grade NH_4NO_3 and $(NH_4)_2HPO_4$ were recrystallized twice.

Estimated Error:

The reproducibility is given as "minimal difference between the temperatures of appearance of the first crystal and the disappearance of the last crystal."

References:

[1]A. G. Bergman and N. P. Luzhnaya, Fiziko-khimicheskiye Osnovy Izucheniya i Ispol'zovaiya Solyanyh Mestorozhdeniy Khlorid-sul'fatnogo Tipa, Moscow, IAN SSSR (1951).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7783-20-2]
(3) Water; H_2O; [7732-18-5]

Evaluator:

J. Eysseltová, Charles University, Prague, Czech Republic, September 1995

Critical Evaluation:

9.5. $(NH_4)_2HPO_2-(NH_4)_2SO_4-H_2O$

Only a very limited amount of data is available for this system. There is a report of the 298 K isotherm.[1] Another report[2] presents the values for the isotherms at 273, 283 and 293 K. And Akiyama, et al.[3] have developed the following smoothing equation for this system:

$$S = A/(M+1.2) \tag{1}$$

where S is the solubility of $(NH_4)_2HPO_4$ expressed as mass %; m is the mole ratio SO_4/PO_4 in the saturated solution; and A is a constant having the following values:

t/°C	A
0	43.6
25	49.9
50	56.4

A graphical comparison of some of the data at 293 and 298 K as well as results calculated from Eq. (1) are shown in Figure 27. From this comparison it appears, again, as if the work of Vol'fkovich, et al.[1] is affected with a systematic error.

References:

[1]S. I. Vol'fkovich, L. E. Berlin, and B. M. Mantsev, Tr. NIUIFa, 228 (1940).
[2]K. S. Chernova and E. V. Korzh, Zh. Obshch. Khim. **16**, 171 (1946).
[3]T. Akiyama, H. Kanzaki, and S. Minagawa, Nippon Dojo Hiryogaku Zasshi **49**, 243 (1978).

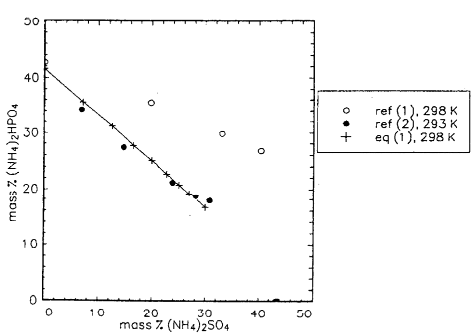

FIG. 27. Solubility of $(NH_4)_2HPO_4$ in the $(NH_4)_2HPO_4-(NH_4)_2SO_4-H_2O$ system.

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7783-20-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

S. I. Vol'fkovich, L. E. Berlin, and B. M. Mantsev, Tr. NIUIFa, 228-42 (1940).

Variables:

Composition at 25 °C.

Prepared By:

L.V. Chernykh and J. Eysseltová

Experimental Data

Solubility in the $(NH_4)_2HPO_2$–$(NH_4)_2SO_4$–H_2O system at 25 °C

$(NH_4)_2HPO_4$ comp[a]	$100w_i$[b]	m_i/mol kg^{-1}[b]	$(NH_4)_2SO_4$ comp[a]	$100w_i$[b]	m_i/mol kg^{-1}[b]	H_2O $100w_i$[b]	Solid phase[c]
74.5	42.7	5.64	0.0	0.0	0.0	57.3	A
55.0	35.5	6.01	24.7	19.8	3.35	44.7	A
42.7	29.9	6.12	49.5	33.1	6.77	37.0	A
36.6	26.8	6.19	67.7	40.4	9.32	32.8	A+B
0.0	0.0	0.0	76.4	43.3	5.78	56.7	B

[a]The composition units are: g/100g H_2O.
[b]These values were calculated by the compilers.
[c]The solid phases are: A=$(NH_4)_2HPO_2$; B=$(NH_4)_2SO_4$.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used. Equilibration required 4 to 5 days. The composition of the solid phases was determined by the Schreinemakers method. More experimental details have been described previously.[1]

Source and Purity of Materials:

No information is given.

Estimated Error:

The temperature was kept constant within ± 0.05 K. No other information is given.

References:

[1]L. E. Berlin and B. M. Mantsev, Zh. Prikl. Khim. (Leningrad) **6**, 385 (1933).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Diammonium sulfate; $(NH_4)_2SO_4$; [7783-20-2]
(3) Water; H_2O; [7732-18-5]

Original Measurements:

K. S. Chernova and E. V. Korzh, Zh. Obshch. Khim. **16**, 171-7 (1946).

Variables:

Composition at 0, 10 and 20 °C.

Prepared By:

L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility isotherms in the $(NH_4)_2HPO_2$–$(NH_4)_2SO_4$–H_2O system

$(NH_4)_2HPO_4$ comp[a]	$100w_i$	m_i/mol kg^{-1}[b]	$(NH_4)_2SO_4$ comp[a]	$100w_i$	m_i/mol kg^{-1}[b]	H_2O $100w_i$	Solid phase[c]
			temp=0 °C				
43.20	27.80	3.27	12.1	7.8	0.92	64.40	A
35.90	22.20	2.71	25.5	15.80	1.93	62.00	A
30.49	17.50	2.30	43.5	25.00	3.29	57.50	A
25.00	14.00	1.89	53.7	30.00	4.05	56.00	A
24.10	13.20	1.83	58.9	32.10	4.44	54.70	A
—	0.00	0.00	71.2	41.60	5.39	58.40	B
			temp=10 °C				
49.40	30.40	3.73	12.81	7.90	0.97	61.70	A
40.0	24.20	3.04	25.65	15.50	1.95	60.30	A
35.30	19.80	2.67	42.90	24.10	3.25	56.10	C
30.00	16.40	2.27	52.80	28.90	4.00	54.70	C
30.50	16.00	2.31	60.20	31.60	4.56	52.40	C
—	0.00	0.00	73.48	42.40	5.57	57.60	B
			temp=20 °C				
58.3	34.20	4.40	11.78	6.90	0.89	58.90	C
47.5	27.40	3.58	25.5	14.70	1.92	57.90	C
38.48	21.20	2.92	43.40	23.80	3.27	55.00	C
34.9	18.60	2.65	52.90	28.20	4.01	53.20	C
34.6	17.80	2.62	59.80	30.80	4.53	51.40	C
—	0.00	0.00	77.30	43.60	5.85	56.40	B

[a]The composition unit is: g/100g H_2O.
[b]The molalities were calculated by the compilers.
[c]The solid phases are: A=$(NH_4)_2HPO_2\cdot 2H_2O$; B=$(NH_4)_2SO_4$; C=$(NH_4)_2HPO_2$.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used. The isotherms were derived from the results of this investigation. No other details are given.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]

(2) Diammonium persulfate; $(NH_4)_2S_2O_8$; [7727-54-0]

(3) Water, H_2O; [7732-18-5]

Original Measurements:

A. M. Babenko and A. M. Andrianov, Ukr. Khim. Zh. **48**, 15-8 (1982).

Variables:

Composition and temperature

Prepared By:

J. Eysseltová

Experimental Data

9.6. Solubility in the $(NH_4)_2HPO_2$–$(NH_4)_2S_2O_8$–H_2O System

$(NH_4)_2S_2O_8$		$(NH_4)_2HPO_4$		H_2O		
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	t/°C	Solid phases[b]
32.0	2.06	0.0	0.0	68.0	−7.3	A+X
28.0	1.89	7.2	0.84	64.8	−8.3	A+X
27.9	1.88	7.1	0.81	65.1	−9.0	A+X
22.0	1.54	15.6	1.89	62.4	−9.0	A+X
21.0	1.46	16.0	1.92	63.0	−10.2	A+X
16.0	1.14	22.68	2.801	61.32	−10.5	A+X
15.2	1.10	24.0	2.99	60.8	−11.0	A+X
12.0	0.879	28.16	3.563	59.84	−11.8	A+X+B
0.0	0.0	26.3	2.70	73.7	−5.4	A+B
7.2	0.49	28.0	3.27	64.8	−9.0	A+B
0.0	0.0	39.6	4.96	60.4	+16.0	B+C
3.0	0.23	40.74	5.483	56.26	+29.0	B+C
6.0	0.49	40.0	5.61	54.0	+32.5	B+C+D
8.0	0.60	33.12	4.259	58.88	+13.0	B+D
6.4	0.49	36.0	4.73	57.6	+27.8	B+D
13.8	1.10	31.0	4.25	55.2	+22.5	B+D+X
29.4	2.36	16.0	2.22	54.6	+14.5	D+X
34.4	2.92	14.0	2.05	51.6	+23.0	D+X
19.0	1.46	24.0	3.19	57.0	+12.2	D+X
24.0	1.88	20.0	2.70	56.0	+11.0	D+X
21.0	1.46	16.0	1.92	63.0	−10	A
15.6	1.10	22.0	2.67	62.4	−10	A
14.0	0.977	22.22	2.802	62.78	−10	A
21.125	1.4607	15.5	1.85	63.375	−10	X
16.1	1.15	22.653	2.8007	61.247	−10	X
15.16	1.096	24.2	3.02	60.64	−10	X
12.2	0.895	28.096	3.5634	59.704	−10	X
23.0	1.31	0.00	0.0	77.0	−5	A
15.0	0.859	8.5	0.84	76.5	−5	A
8.5	0.49	15.0	1.48	76.5	−5	A
18.8	1.10	6.0	0.60	75.2	−5	A
0.0	0.0	24.3	2.43	75.7	−5	A
0.0	0.0	26.4	2.72	73.6	−5	A
33.4	2.20	0.0	0.0	66.6	−5	X
29.5	2.04	7.05	0.841	63.45	−5	X
27.6	1.80	8.0	0.94	64.4	−5	X
23.5	1.68	15.3	1.89	61.2	−5	X
20.875	1.461	16.5	2.00	62.625	−5	X
18.0	1.32	22.14	2.801	59.86	−5	X
13.0	0.963	27.84	3.563	59.16	−5	X
15.0	1.10	25.0	3.16	60.0	−5	X
7.2	0.49	28.0	3.27	64.8	−5	B
35.6	2.42	0.0	0.0	64.4	0	X
31.5	2.24	6.85	0.841	61.65	0	X
25.5	1.87	14.9	1.89	59.6	0	X
20.0	1.50	21.6	2.80	58.4	0	X
7.14	0.487	28.6	3.37	64.26	0	X
14.9	1.10	25.5	3.24	59.6	0	X
20.5	1.46	18.0	2.22	61.5	0	X
26.7	1.88	11.0	1.34	62.3	0	X
0.0	0.0	27.8	2.92	72.2	0	B
39.6	2.87	0.0	0.0	60.4	10	X
35.0	2.62	6.5	0.84	58.5	10	X
29.5	1.95	4.1	0.47	66.4	10	X
24.0	1.82	18.24	2.391	57.76	10	X
16.0	1.23	26.88	3.563	57.12	10	X
24.6	1.88	18.0	2.37	57.4	10	X
19.25	1.461	23.0	3.02	57.75	10	X
6.5	0.46	31.0	3.76	62.5	10	B
0.0	0.0	35.0	4.08	65.0	10	B
14.5	1.10	27.5	3.59	58.0	10	B
33.5	2.76	13.3	1.89	53.2	20	D
28.0	2.33	19.44	2.801	52.56	20	D
18.0	1.41	26.24	3.563	55.76	20	D
10.2	0.778	32.328	4.2594	57.472	20	D
6.6	0.49	34.0	4.33	59.4	20	B
14.0	1.10	30.0	4.06	56.0	20	D
18.5	1.46	26.0	3.55	55.5	20	D
39.0	3.11	6.1	0.84	54.9	20	X

[a]The molalities were calculated by the compiler.

[b]The solid phases are: A = ice; B = $(NH_4)_2HPO_2 \cdot 2H_2O$; C = $(NH_4)_2HPO_2$; D = $(NH_4)_2S_2O_8$; X = "$m(NH_4)_2S_2O_8 \cdot n(NH_4)_2HPO_2$" (an unidentified solid phase—either solid solution or a compound).

Auxiliary Information

Method / Apparatus / Procedure:

An improved visual polythermic method[1] was used.

Source and Purity of Materials:

Reagent grade salts were recrystallized and dried at 40–50 °C.

Estimated Error:

Precision of temperature measurement was ± 0.4 K.

References:

[1]L. N. Erayzer and I. M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components:
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
A. A. Volkov and O. E. Sosnina, Uch. Zap. Perm. Univ. **229**, 35-9 (1970).

Variables:
Composition at 20 °C.

Prepared By:
L. V. Chernykh and J. Eysseltová

Experimental Data

9.7. Solubility in the NH_4Cl–$(NH_4)_2HPO_2$–H_2O System at 20 °C

NH_4Cl		$(NH_4)_2HPO_4$		H_2O	Refractive	
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$ [a]	index	Solid phase
0	0	40.80	5.215	59.20	1.4100	$(NH_4)_2HPO_4$
3.0	0.92	36.0	4.46	61.0	1.4050	$(NH_4)_2HPO_4$
5.50	1.64	31.75	3.829	62.75	1.4020	$(NH_4)_2HPO_4$
7.0	2.1	29.5	3.52	63.5	1.4010	$(NH_4)_2HPO_4$
9.5	2.8	26.75	3.175	63.75	1.3985	$(NH_4)_2HPO_4$
11.7	3.39	23.75	2.784	64.55	1.3980	$(NH_4)_2HPO_4$
14.0	4.03	21.0	2.44	65.0	1.3975	$(NH_4)_2HPO_4$
16.25	4.691	19.0	2.22	64.75	1.3970	$(NH_4)_2HPO_4$
19.00	5.443	15.75	1.827	65.25	1.3980	$(NH_4)_2HPO_4$
21.50	6.231	14.0	1.64	64.5	1.3990	$(NH_4)_2HPO_4+NH_4Cl$
22.75	6.593	12.75	1.496	64.50	1.400	NH_4Cl
23.00	6.563	11.50	1.329	65.50	1.3970	NH_4Cl
24.00	6.597	8.00	0.890	68.00	1.3930	NH_4Cl
26.0	6.94	4.0	0.43	70.0	1.3890	NH_4Cl
27.1	6.95	0	0	62.9	1.386	NH_4Cl

[a]These values were calculated by the compilers.

Auxiliary Information

Method / Apparatus / Procedure:
The isothermal method of sections[1,2] was used with the aid of refractive index measurements.

Source and Purity of Materials:
Chemically pure NH_4Cl and pure $(NH_4)_2HPO_4$ were used.

Estimated Error:
No information is given.

References:

[1]R. V. Merclin, Izv. biolog. n.-i. in-ta pri Permsk. un-te. **11**, 1 (1937).
[2]E. F. Zhuravlev and A. D. Sheveleva, Zh. Neorg. Khim. **5**, 2360 (1960).

Components:
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Disodium hydrogenphosphate; Na_2HPO_4; [7558-79-4]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
R. F. Platford, J. Chem. Eng. Data **19**, 169-8 (1974).

Variables:
Composition at 25 °C.

Prepared By:
J. Eysseltová

Experimental Data

9.8. Solubility in the Na_2HPO_4–$(NH_4)_2HPO_2$–H_2O System at 25 °C

Na_2HPO_4		$(NH_4)_2HPO_4$		Solid
$100w_i$	m_i/mol kg^{-1} [a]	$100w_i$	m_i/mol kg^{-1} [a]	phase[b]
10.4	0.82	0.00	0.00	A
12.3	1.01	2.0	0.18	A
16.0	1.39	3.3	0.31	A+B
15.6	1.38	4.6	0.44	B
13.6	1.19	5.9	0.55	B
11.3	0.97	7.0	0.65	B
10.5	0.92	8.9	0.84	B
9.7	0.88	12.8	1.25	B
9.1	0.84	14.4	1.42	B
8.2	0.78	18.0	1.85	B
8.4	0.83	20.4	2.17	B
8.0	0.85	25.5	2.90	B
7.8	0.90	31.2	3.87	B
8.5	1.16	40.1	5.91	B+C
7.1	0.97	41.3	6.06	C
4.8	0.62	40.8	5.68	C
1.8	0.22	41.3	5.50	C
0.0	0.00	41.5	5.37	C

[a]The molalities were calculated by the compiler.
[b]The solid phases are: A = $Na_2HPO_4 \cdot 12H_2O$; B = $NaNH_4HPO_4 \cdot 4H_2O$; C = $(NH_4)_2HPO_2$.

Auxiliary Information

Method / Apparatus / Procedure:
Conventional measurements were made on aliquots of saturated solutions. The ammonium salt was determined gravimetrically as ammoniumtetraphenyl borate[1] and the total salt content was determined by evaporation to constant weight in vacuum over H_2SO_4. The sodium salt was then estimated by difference. The composition of the eutonics was determined by an isopiestic method.[2]

Source and Purity of Materials:
The AR grade phosphates were recrystallized once from water. The Na_2HPO_4 was dried at 105 °C. The $(NH_4)_2HPO_4$ was dried in vacuum over sulfuric acid at room temperature.

Estimated Error:
No information is given.

References:

[1]A. I. Vogel, Quantitative Inorganic Analysis, Wiley, New York, p. 566 (1961). 2. R. F. Platford, Amer. J. Sci. **272**, 959 (1972).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Diammonium carbonate; $(NH_4)_2CO_3$; [506-87-6]
(3) Dipotassium hydrogenphosphate; K_2HPO_4; [7758-11-4]
(4) Dipotassium carbonate; K_2CO_3; [584-08-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

M. N. Syromyatnikova, N. S. Torocheshnikov, and A. B. Kuznetsova, Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol. **21**, 1336-8 (1978).

Variables:

Composition at 0, 10, 20 and 30 °C.

Prepared By:

J. Eysseltová

Experimental Data

10. Quaternary Systems With $(NH_4)_2HPO_4$

The authors present the following equation: $y = A + 0.11x$, where y = total plant nutrient, and x = the mass ratio K_2O/N. The following values for the parameter, A, are given:

t/°C	A
0	26.11
10	28.4
20	30.48
30	33.0

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method was used with 3.5 hours allowed for equilibration. Both liquid and solid phases were analyzed. NH_4^+ was determined by a distillation method,[1] P_2O_5 by the citrate method[2] and potassium gravimetrically as the tetraphenylborate. The solid phase was analyzed by the Schreinemaker's method.

Source and Purity of Materials:

No information is given.

Estimated Error:

No information is given.

References:

[1] I. N. Shokin, S. A. Krasheninikov, *et al.*, Tekhnicheskiy Analiz i Kontrol'v Proizvodstve Neorganicheskikh Veshchestv, Izd. Vysshaya Shkola, Moscow (1968).
[2] F. N. Kel'man, E. B. Bruckus, and R. F. Osherovich, Metody Analiza pri Kontrole Proizvodstva Sernoy Kisloty i Fosfornykh Udobreniy, Goskhimizdat, Moscow (1963).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammonium nitrate; NH_4NO_3; [6484-52-2]
(3) Dipotassium hydrogenphosphate; K_2HPO_4; [7758-11-4]
(4) Potassium nitrate; KNO_3; [7757-79-1]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

M. R. Endovitskaya and V. I. Vereshchagina, Zh. Neorg. Khim. **15**, 2265-7 (1970).

Variables:

Temperature and composition.

Prepared By:

J. Eysseltová

Experimental Data

Composition and crystallization temperatures of invariant points in the $(NH_4)_2HPO_2-KNO_3-H_2O$ system

KNO_3		$(NH_4)_2HPO_4$		H_2O		
$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	t/°C	Solid phases[b]
9.0	1.4	28.5	3.45	62.5	0	A+B+C
10	1.5	26	3.1	64	−4	A+C+D
9.0	1.2	18	1.9	73	−8	D+E+F
8.5	1.2	22	2.4	69.5	−12	A+D+E

[a] These values were calculated by the compiler.
[b] The solid phases are: A = $(NH_4)_2HPO_2 \cdot 2H_2O$; B = $(NH_4)_2HPO_2$; C = γ-KNO_3; D = β-KNO_3; E = ice; F = α-KNO_3.

Note: The rest of the data in the article are given only in graphical form.

Auxiliary Information

Method / Apparatus / Procedure:

A visual polythermic method was used.[1]

Source and Purity of Materials:

Pure KNO_3 and reagent grade $(NH_4)_2HPO_4$ were used.

Estimated Error:

No information is given.

References:

[1] A. G. Bergman and N. P. Luzhnaya, Fizikokhimicheskiye Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow, IAN SSSR (1951).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Diammonium thiosulfate; $(NH_4)_2S_2O_3$; [7783-18-8]
(3) Dipotassium hydrogenphosphate; K_2HPO_4; [7758-11-4]
(4) Dipotassium thiosulfate; $K_2S_2O_3$; [10294-66-3]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

A. M. Babenko and A. M. Andrianov, Zh. Neorg. Khim. **29**, 1578-82 (1984).

Variables:

Composition and temperature.

Prepared By:

J. Eysseltová

Experimental Data

Part. 1. Points of simultaneous crystallization of two or three solid phases in the $(NH_4)_2HPO_2-K_2S_2O_3-H_2O$ system

$(NH_4)_2HPO_4$ 100w_i	$(NH_4)_2HPO_4$ m_i/mol kg^{-1} [a]	$K_2S_2O_3$ 100w_i	$K_2S_2O_3$ m_i/mol kg^{-1} [a]	H_2O 100w_i	t/°C	Solid phases[b]
24.0	3.42	22.8	2.25	53.2	−18.6	A+B
20.0	3.15	32.0	3.50	48.0	−23.6	A+B
12.0	1.89	40.0	4.38	48.0	−23.6	A+B
16.0	2.52	36.0	3.94	48.0	−24.2	A+B
26.0	3.33	14.8	1.31	59.2	−12.8	A+B+C
0	0	52.0	5.70	48.0	−21.5	A+D
5.4	0.84	46.0	4.97	48.6	−20.0	A+D
12.0	1.99	42.24	4.850	45.76	−28.0	A+B+D
29.6	3.18	0	0	70.4	−6.5	A+C
30.0	3.61	7.0	0.58	63.0	−10.4	A+C
39.0	4.84	0	0	61.0	16.5	B+C
36.0	4.73	6.4	0.58	57.6	14.4	B+C
32.0	4.46	13.6	1.31	54.4	11.6	B+C
33.12	4.259	8.0	0.71	58.88	12.6	B+C
29.04	3.727	12.0	1.07	58.96	11.6	B+C
11.0	2.08	48.95	6.422	40.05	4.2	B+D
9.0	1.9	54.6	7.88	36.4	16.0	B+D

[a]These values were calculated by the compiler.
[b]The solid phases are: A = ice; B = $(NH_4)_2HPO_2$; C = $(NH_4)_2HPO_2 \cdot 2H_2O$; D = $K_2S_2O_3$.

Part 2. Solubility isotherms in the $(NH_4)_2HPO_2-K_2S_2O_3-H_2O$ system

$(NH_4)_2HPO_4$ 100w_i	$(NH_4)_2HPO_4$ m_i/mol kg^{-1} [a]	$K_2S_2O_3$ 100w_i	$K_2S_2O_3$ m_i/mol kg^{-1} [a]	H_2O 100w_i	Solid phases[b]
		temp = −20 °C			
5.8	0.90	45.3	4.87	48.9	A
11.9	1.89	40.4	4.45	47.7	A
15.0	2.23	34.0	3.50	51.0	A
17.4	2.52	30.4	3.06	52.2	A
20.2	3.19	31.9	3.50	47.9	B
15.5	2.52	38.0	4.29	46.5	B
12.5	2.08	42.0	4.85	45.5	B
0	0	52.6	5.83	47.4	D
		temp = −10 °C			
0	0	38.0	3.22	62.0	A
10.0	1.20	27.0	2.25	63.0	A
21.0	2.52	15.8	1.31	63.2	A
28.0	3.27	7.18	0.582	64.82	C
29.0	3.44	7.1	0.58	63.9	C
30.0	3.61	7.0	0.58	63.0	C
24.6	3.53	22.7	2.26	52.7	B
21.0	3.35	31.6	3.50	47.4	B
11.4	1.88	42.8	4.91	45.8	B
5.2	0.85	48.6	5.53	46.2	D
0	0	55.0	6.42	45.0	D
		temp = 0 °C			
27.8	2.92	0	0	72.2	C
27.4	3.57	14.5	1.31	58.1	B
21.8	3.51	31.2	3.49	47.0	B
14.0	2.53	44.0	5.50	42.0	B
4.8	0.84	52.0	6.32	43.2	D
7.2	1.312	51.15	6.452	41.65	D
0	0	57.4	7.08	42.6	D
		temp = 10 °C			
33.1	3.75	0	0	66.9	C
33.6	4.26	6.64	0.584	59.76	C
31.0	4.25	13.8	1.31	55.2	B
22.6	3.68	30.9	3.49	46.5	B
4.6	0.85	54.4	6.97	41.0	D
0	0	60.0	7.88	40.0	D

[a]These values were calculated by the compiler.
[b]The solid phases are: A = ice; B = $(NH_4)_2HPO_2$; C = $(NH_4)_2HPO_2 \cdot 2H_2O$; D = $K_2S_2O_3$.

Auxiliary Information

Method / Apparatus / Procedure:

An improved visual polythermic method[1] was used.

Source and Purity of Materials:

All materials were of chemically pure grade. $(NH_4)_2HPO_4$ was recrystallized twice and dried at 30–40 °C. $K_2S_2O_3$ (pur., TU 6-09-44-70) was recrystallized twice and dried at 105 °C.

Estimated Error:

Precision of temperature measurement was ± 0.4 K.

References:

[1]L. N. Erayzer and I. M. Kaganskiy, Zavod. Lab. **1**, 119 (1967).

Components:

(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Dipotassium hydrogenphosphate; K_2HPO_4; [7758-11-4]
(4) Potassium chloride; KCl; [7747-40-7]
(5) Water; H_2O; [7732-18-5]

Original Measurements:

I. Karshev and K. Asitska, God. na VKhTI, Sofiya, 101-9 (1970).

Variables:

Composition at 15 to 48 °C

Prepared By:

J. Eysseltová

Experimental Data

Solubility isotherms for the $(NH_4)_2HPO_2$–KCl–H_2O system

KCl		$(NH_4)_2HPO_4$		H_2O
$100w_i$	m_i/mol kg^{-1}	$100w_i$	m_i/mol kg^{-1}	$100w_i$
		temp=25 °C		
0.0	0.0	41.1	5.28	58.9
4.4	1.0	36.8	4.74	58.8
12.4	2.86	29.5	3.84	58.1
15.4	3.59	27.1	3.57	57.5
16.9	3.98	26.2	3.49	56.9
17.2	4.06	26.0	3.47	56.8
17.3	4.04	25.2	3.32	57.5
17.7	4.09	24.2	3.15	58.1
18.0	4.11	23.2	2.99	58.8
		temp=35 °C		
0.0	0.0	43.2	5.76	56.8
9.0	2.2	34.9	4.71	56.1
15.1	3.65	29.4	4.01	55.5
18.1	4.37	26.4	3.60	55.5
18.3	4.38	25.6	3.46	56.1
18.8	4.43	24.3	3.23	56.9
19.2	4.48	23.3	3.07	57.5
19.7	4.55	22.2	2.89	58.1
20.0	4.56	21.2	2.73	58.8

The data are also presented in the form of isoconcentrations:

	KCl		$(NH_4)_2HPO_4$		H_2O
comp[a]	$100w_i$[b]	m_i/mol kg^{-1}[b]	$100w_i$[b]	m_i/mol kg^{-1}[b]	$100w_i$[b]
		total salt = 700 g/1000 g H_2O			
0.0	0.0	0.0	41.2	5.30	58.8
11.1	4.6	1.0	36.6	4.71	58.8
12.5	5.1	1.2	36.0	4.64	58.8
25.0	10.3	2.35	30.9	3.98	58.8
33.4	13.8	3.14	27.4	3.53	58.8
39.5	16.3	3.71	24.9	3.21	58.8
40.0	16.5	3.76	24.7	3.18	58.8
41.3	17.0	3.88	24.2	3.11	58.8
45.3	18.7	4.25	22.5	2.90	58.8
46.6	19.2	4.38	22.0	2.83	58.8
51.6	21.2	4.84	19.9	2.57	58.8
		total salt=720 g/1000 g H_2O			
0.0	0.0	0.0	41.9	5.45	58.1
11.1	4.6	1.1	37.2	4.85	58.1
15.0	6.3	1.4	35.6	4.63	58.1
26.7	11.2	2.58	30.7	4.00	58.1
30.0	12.6	2.90	29.3	3.82	58.1
35.8	15.0	3.46	26.9	3.50	58.1
38.2	16.0	3.69	25.9	3.37	58.1
39.5	16.5	3.81	25.3	3.30	58.1
41.0	17.2	3.96	24.7	3.22	58.1
42.2	17.7	4.08	24.2	3.15	58.1
44.2	18.5	4.27	23.4	3.04	58.1
46.5	19.5	4.49	22.4	2.92	58.1
49.1	20.6	4.74	21.3	2.77	58.1
		total salt=740 g/1000 g H_2O			
0.0	0.0	0.0	42.5	5.60	57.5
11.1	4.7	1.1	37.8	4.98	57.5
20.0	8.5	2.0	34.0	4.48	57.5
27.3	11.6	2.71	30.9	4.07	57.5
33.3	14.2	3.30	28.4	3.74	57.5
38.5	16.4	3.82	26.2	3.45	57.5
39.5	16.8	3.92	25.7	3.39	57.5
40.1	17.1	3.98	25.5	3.36	57.5
42.0	17.9	4.17	24.7	3.25	57.5
44.4	18.9	4.41	23.6	3.12	57.5
46.7	19.9	4.63	22.7	2.99	57.5
49.0	20.8	4.86	21.7	2.86	57.5
		total salt=760 g/1000 g H_2O			
0.0	0.0	0.0	43.2	5.75	56.8
11.1	4.8	1.1	38.4	5.12	56.8
20.0	8.6	2.0	34.5	4.60	56.8
30.0	13.0	3.06	30.2	4.03	56.8
32.8	14.2	3.34	29.0	3.87	56.8
35.0	15.1	3.57	28.1	3.74	56.8
39.0	16.8	3.98	26.3	3.51	56.8
39.5	17.1	4.03	26.1	3.48	56.8
40.0	17.3	4.08	25.9	3.45	56.8
40.8	17.6	4.16	25.6	3.41	56.8
41.6	18.0	4.24	25.2	3.36	56.8
42.2	18.2	4.30	25.0	3.33	56.8

43.4	18.7	4.42	24.4	3.26	56.8
44.9	19.4	4.58	23.8	3.17	56.8
45.8	19.8	4.67	23.4	3.12	56.8
		total salt = 780 g/1000 g H_2O			
0.0	0.0	0.0	43.8	5.91	56.2
11.1	4.9	1.2	39.0	5.25	56.2
20.0	8.8	2.1	35.1	4.72	56.2
26.0	11.4	2.72	32.4	4.37	56.2
34.2	15.0	3.58	28.8	3.89	56.2
37.3	16.3	3.90	27.5	3.70	56.2
39.7	17.4	4.15	26.4	3.56	56.2
41.0	18.0	4.29	25.8	3.48	56.2
42.4	18.6	4.44	25.2	3.40	56.2
44.0	19.3	4.60	24.5	3.31	56.2
45.0	19.7	4.71	24.1	3.25	56.2
		total salt = 800 g/1000 g H_2O			
0.0	0.0	0.0	44.4	6.06	55.6
10.0	4.4	1.1	40.0	5.45	55.6
20.0	8.9	2.1	35.6	4.85	55.6
28.0	12.4	3.00	32.0	4.36	55.6
33.6	14.9	3.61	29.5	4.02	55.6
36.0	16.0	3.86	28.4	3.88	55.6
38.0	16.9	4.08	27.6	3.76	55.6
39.5	17.6	4.24	26.9	3.66	55.6
41.0	18.2	4.40	26.2	3.57	55.6
43.0	19.1	4.61	25.3	3.45	55.6
45.0	20.0	4.83	24.4	3.33	55.6

[a] The composition unit is: mass % KCl in solute.
[b] These values were calculated by the compiler.

Auxiliary Information

Method / Apparatus / Procedure:

The isothermal method and a visual polythermic method[1] were used. In the isothermal studies, NH_3 was determined by the formaldehyde method, HPO_4^{2-} by direct titration with $MgCl_2$, Cl^- by the Volhard method, and K^+ by titration with tetraphenylborate.

Source and Purity of Materials:

Carlo Erba reagent grade KCl and $(NH_4)_2HPO_4$ were used.

Estimated Error:

No information is given.

References:

[1] A. G. Bergman and N. P. Luznaya, Fiziko-Khimicheskiye Osnovy Izucheniya i Ispol'zovaniya Solyanykh Mestorozhdeniy Khlorid-Sul'fatnogo Tipa, Moscow, IAN SSSR (1951).

Components:

(1) Triammonium phosphate; $(NH_4)_3PO_4$; [10361-65-6]
(2) Triethylamine hydrochloride; $C_6H_{16}ClN$; [554-68-7]
(3) Water; H_2O; [7732-18-5]]

Original Measurements:

O. E. Sosnina and A. A. Volkov, Uch. Zap. Perm. Gos. Univ., Ser. Khim. **289**, 20 5 (1973).

Variables:

Composition at 20 °C.

Prepared By:

J. Eysseltová

Experimental Data

Solubility in the $(NH_4)_3PO_4$–$(C_2H_5)_3N \cdot HCl$–H_2O system at 20 °C

$(NH_4)_3PO_4$ 100w_i	$(NH_4)_3PO_4$ m_i/mol kg^{-1} [a]	$(C_2H_5)_3N \cdot HCl$ 100w_i	$(C_2H_5)_3N \cdot HCl$ m_i/mol kg^{-1} [a]	H_2O 100w_i	Refractive index	Solid phases[b]
12.5	0.985	—	—	87.5	1.3580	A
9.2	0.78	9.1	0.84	81.7	1.3650	A
7.3	0.68	18.5	1.88	74.2	1.3730	A
4.1	0.42	28.8	3.23	67.1	1.3865	A
3.3	0.37	35.0	4.27	61.7	1.3950	A
1.8	0.21	39.3	5.03	58.9	1.3995	A
0.7	0.1	49.7	7.55	49.6	1.4160	A
—	—	57.2	10.1	42.8	1.4295	B

[a] The molalities were calculated by the compiler.
[b] The solid phases are: A = $(NH_4)_3PO_4$; B = $(C_2H_5)_3N \cdot HCl$.

Auxiliary Information

Method / Apparatus / Procedure:

The refractometric variation of the isothermal method was used.[1] An IRF-22 refractometer was used.

Source and Purity of Materials:

$(NH_4)_3PO_4$ was synthesized according to directions given by others.[2] Its composition was checked by analyzing it periodically.

Estimated Error:

No information is given.

References:

[1] E. F. Zhuravlev and A. D. Sheveleva, Zh. Neorg. Khim. **5**, 2630 (1960).
[2] Yu. V. Karyakin, Chistye Khimicheskiye Reaktivy, Goskhimizdat, Moscow-Leningrad (1947).

Components:
(1) Triammonium phosphate; $(NH_4)_3PO_4$; [10361-65-6]
(2) Ammonium chloride; NH_4Cl; [12125-02-9]
(3) Water; H_2O; [7732-18-5]

Original Measurements:
A. A. Volkov and O. E. Sosnina, Uch. Zap. Perm. Univ. **229**, 35-9 (1970).

Variables:
Composition at 20 °C.

Prepared By:
L. V. Chernykh and J. Eysseltová

Experimental Data

Solubility in the NH_4Cl–$(NH_4)_3PO_4$–H_2O system at 20 °C

NH_4Cl		$(NH_4)_3PO_4$		H_2O	Refractive	Solid
$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	index	phase[b]
0	0	12.80	0.9979	87.20	1.3580	A
4.50	0.981	9.80	0.777	85.70	1.3620	A
9.11	2.08	8.90	0.738	81.99	1.3680	A
13.80	3.294	7.90	0.686	78.30	1.3750	A
18.50	4.676	7.55	0.694	73.95	1.3820	A
21.30	5.568	7.20	0.685	71.50	1.3860	A
24.10	6.557	7.20	0.712	68.70	1.3860	A
24.50	6.685	7.00	0.695	68.50	1.3920	A+B
24.50	6.542	5.50	0.534	70.00	1.3905	B
25.60	6.674	2.70	0.256	71.70	1.3860	B
27.10	6.948	0	0	72.90	1.3860	B

[a]These values were calculated by the compilers.
[b]The solid phases are: A = $(NH_4)_3PO_4 \cdot 3H_2O$; B = NH_4Cl.

Auxiliary Information

Method / Apparatus / Procedure:
The isothermal method of sections[1,2] was used with the aid of refractive index measurements

Source and Purity of Materials:
Chemically pure NH_4Cl and $(NH_4)_3PO_4$ were prepared according to directions given elsewhere.[3]

Estimated Error:
No information is given.

References:

[1]R. V. Merclin, Izv. biolog. n.-i. in-ta pri Permsk. un-te. **11**, 1 (1937).
[2]E. F. Zhuravlev and A. D. Sheveleva, Zh. Neorg. Khim. **5**, 2360 (1960).
[3]Yu. V. Karyakin, Chistye Khimicheskie Reaktivy, Moscow, p. 58 (1947).

Components:
(1) Diammonium hydrogenphosphate; $(NH_4)_2HPO_4$; [7783-28-0]
(2) Ammonium chlorate; NH_4ClO_3; [10192-29-7]
(3) Magnesium hydrogenphosphate; $MgHPO_4$; [7757-86-0]
(4) Magnesium chlorate; $Mg(ClO_3)_2$; [10326-21-3]
(5) Water; H_2O; [7732-18-5]

Original Measurements:
S. Tukhtaev, Kh. Kucharov, and M. K. Askarova, Uzb. Khim. Zh. 61-2 (1985).

Variables:
Temperature and composition.

Prepared By:
L. V. Chernykh and J. Eysseltová

Experimental Data

Solutions co-existing with three solid phases in the $(NH_4)_2HPO_2$–$Mg(ClO_3)_2$–H_2O system

$Mg(ClO_3)_2$		$(NH_4)_2HPO_4$		H_2O		
$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	m_i/mol kg^{-1}[a]	$100w_i$	t/°C	Solid phases[b]
36.3	2.99	0.20	0.024	63.5	−52.1	A+B+C
40.4	3.56	0.20	0.025	59.4	−21.8	B+C+D
43.8	4.09	0.25	0.034	55.95	−7.6	C+D+E
0.3	0.02	25.1	2.55	74.6	−5.7	A+C+F
0.4	0.03	38.8	4.83	60.8	−14.9	C+F+G

[a]The molalities were calculated by the compilers.
[b]The solid phases are: A = ice; B = $Mg(ClO_3)_2 \cdot 16H_2O$; C = $Mg_3(PO_4)_2 \cdot 18H_2O$; D = $Mg(ClO_3)_2 \cdot 12H_2O$; E = $Mg(ClO_3)_2 \cdot 6H_2O$; F = $(NH_4)_2HPO_2 \cdot 2H_2O$; G = $(NH_4)_2HPO_2$.

Auxiliary Information

Method / Apparatus / Procedure:
A visual polythermic method and the isothermal method were used but details are not given.

Source and Purity of Materials:
Chemically pure $(NH_4)_2HPO_4$ was recrystallized twice. $Mg(ClO_3)_2$ was recrystallized from ether. After the final recrystallization its purity was 99.1%.

Estimated Error:
No information is given.

11. SYSTEM INDEX

Page numbers preceded by E refer to evaluation text whereas those not preceded by E refer to compilation tables.

12. REGISTRY NUMBER INDEX

Page numbers preceded by E refer to evaluation text whereas those not preceded by E refer to compilation tables.

13. AUTHOR INDEX

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