U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

NBS Special Publication 699

A Bibliography of Sources of Thermodynamic Data for the Systems: $CO_2 + NH_3 + H_2O$, $CO_2 + H_2S + H_2O$, $H_2S + NH_3 + H_2O$, and $CO_2 + NH_3 + H_2S + H_2O$

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[2] Some divisions within the center are located at Boulder, CO 80303.

[3] Located at Boulder, CO, with some elements at Gaithersburg, MD.

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ABSTRACT

Contained herein is a bibliography of sources of experimental and correlated thermodynamic data for the systems CO_2 + NH_3 + H_2O, CO_2 + H_2S + H_2O, H_2S + NH_3 + H_2O, and CO_2 + NH_3 + H_2S + H_2O. The types of data in this bibliography include all types of equilibrium data, including both equilibria in solution and vapor-liquid equilibrium data, enthalpies, heat capacities, and densities. There are 215 references cited.

KEY WORDS: ammonia; ammonium carbamate; bibliography; carbon dioxide; enthalpy; equilibrium constants; heat capacity; hydrogen sulfide; sour water; thermodynamics; urea; vapor-liquid equilibria; water.

INTRODUCTION

The thermodynamics of mixtures of $CO_2 + NH_3 + H_2O$, $CO_2 + H_2S + H_2O$, $NH_3 + H_2S + H_2O$, and $CO_2 + NH_3 + H_2S + H_2O$ are of importance for a variety of industrial applications which include the synthesis of urea, the utilization of sour water systems, gas production, and environmental concerns. The purpose of this bibliography is to identify papers which contain either experimental thermodynamic data for these systems or reviews or correlations of this data. The thermodynamic properties of interest include all types of equilibrium data, including both equilibria in solution and vapor-liquid equilibrium data, enthalpies, heat capacities, and densities. The principal species in aqueous solutions are CO_2^0, CO_3^{2-}, HCO_3^-, $H_2CO_3^0$, NH_3^0, NH_4^+, HS^-, S^{2-}, $CO(NH_2)_2$, and ammonium carbamate, NH_2COONH_4. Our search of the literature was based upon a search of the following sources: a computer aided one of Chemical Abstracts from 1967 to 1983, the Bulletin of Chemical Thermodynamics [1] from 1960 to 1981, the files of the Chemical Thermodynamics Data Center at the National Bureau of Standards, and, finally, of the references found in the papers identified in the search itself. The authors would appreciate learning of any papers which we have missed in our search.

The papers are listed alphabetically by first author. Each bibliographic citation includes a brief reference citation (the year and three letters from the names of the first two authors), the authors names, the title of the article and the source. In one instance only an abstract was available and there we have also given the Chemical Abstracts citation. The last column contains a capital letter(s) which serves to identify which systems are found in the paper. The letter codes used are: (A) $CO_2 + H_2S + H_2O$, (B) $CO_2 + NH_3 + H_2O$, (C) $H_2S + NH_3 + H_2O$, and (D) $CO_2 + H_2S + NH_3 + H_2O$.

Each paper has been annotated to show the type of data, the temperature range and, if appropriate, the pressure, solution composition, and pH. The property codes which we have used are from the Bulletin of Chemical Thermodynamics [1]; they are reproduced in Table I. In specifying the compositions of ternary systems, we have frequently used the quantities L and W, which are defined to be the mole ratios NH_3/CO_2 and H_2O/CO_2, respectively. Note that, using existing conventions, the value of W can be negative [2]. We have attempted to adhere to the journal abbreviations used in the Chemical Abstracts Service Source Index [3].

The Japanese, Russian, and Polish titles have been translated into English. These translations come, by preference, from the papers themselves or from Chemical Abstracts. The titles from the latter source may be condensations of the originals.

This bibliography was sponsored by the Design Institute for Physical Property Data (DIPPR) of the American Institute of Chemical Engineers. Bibliographies on the binary systems CO_2 + H_2O, NH_3 + H_2O, and H_2S + H_2O have also been compiled for DIPPR under the direction of Drs. David Garvin, David Smith-Magowan, and Bert R. Staples. These bibliographies have been used in developing the present listing, but those papers which treat only the binaries have not been repeated here. We thank Mr. T. B. Selover of the Standard Oil Company for bringing several references to our attention for inclusion in this bibliography, Dr. Hideo Okabe for his assistance with the papers written in Japanese, and Dr. Ewa Gajewski for her help with the papers in Polish.

REFERENCES

[1] Bulletin of Chemical Thermodynamic, R. D. Freeman, editor, Thermochemistry, Inc., Stillwater, OK, 1977 to 1981.

[2] Durisch, W.; Lemkowitz, S. M.; van den Berg, P. J.; Chimia; *34, 314 (1980); "Constituent and Component Measurements and Calculations of the Vapor/Liquid Equilibrium of the Ternary System Carbon Dioxide-Ammonia-Water under Urea Synthesis Conditions."

[3] Chemical Abstracts Service Source Index: 1907-1979 Cumulative, in two volumes; American Chemical Society, Washington, DC, 1979.

TABLE I

Property Symbol: Category	Property Symbol: Subgroup	Description of Properties
D		Derived Quantities of Special Interest (not listed elsewhere)
	Da	Activity, fugacity
	Dm	Partial molar quantities
	Dx	Excess functions for mixtures
H		Enthalpy Changes for Processes, by Calorimetry
	Hc	for combustion in O_2 or F_2
	Hr	for other chemical reactions
	Hm	for mixing: solution, dilution, etc.
	Hp	for phase transitions, fusion, vaporization
	Hs	for surface processes: adsorption, desorption, etc.
K		Reaction Equilibria and Related Data
	Kd	Dissociation/decomposition pressures and derived enthalpy/entropy changes.
	Ke	Electrochemical cell potentials, etc. and derived enthalpy/entropy changes.
	Kk	Equilibrium constants for chemical reactions and derived enthalpy/entropy changes.
M		Thermodynamic Quantities Calculated from Molecular Parameters
	Md	Data (e.g., structural or spectroscopic) for molecular parameters; atomic energy levels; ionization potentials.
	Mi	Ideal gases: thermodynamic functions (e.g., tabulations).
	Mg	Real gases: intermolecular potentials, derived equations of state
	Mm	Mixtures
	Mx	Crystal, solid and liquid states.
	Mb	Bond energies; non-bonded interactions.

P		Phase Equilibria
	Pt	Temperatures: freezing point, boiling point, triple point, other phase transitions.
	Pp	Vapor pressure and derived quantities for vaporization and/or sublimation, pure substances
	Pv	Vapor/liquid equilibria and related phase diagrams, mixtures
	Px	Condensed phase equilibria: solubility, freezing points, phase diagrams.
	Po	Osmotic pressure/membrane equilibria
	Ps	Surface phenomena: surface tension, surface energy, adsorption, etc.
Q		Thermal Properties for Non-Reacting Systems, by Calorimetry
	Ql	Condensed phase, T ≦ 400 K: heat capacity, enthalpy, entropy, etc.
	Qh	Condensed phase, T ≧ 400 K: heat capacity, enthalpy, entropy, etc.
	Qg	Gas phase: heat capacity, enthalpy, entropy etc. as f(T,P).
V		Volume as f(T,P); Empirical Equations of State
	Vg	Gases: PVT, and related data
	Vc	Critical state properties
	Vx	Condensed phases: compressibility, thermal expsansivity
	Vt	Tables and charts of data, e.g., Mollier diagrams.
X		Physical Properties of a Single Phase
	Xd	Density
	Xv	Viscosity
	Xr	Refractive index
Z		Compilations, Correlations and Reviews
	Za	Analysis of experimental data and of errors
	Zc	Empirical Correlations
	Ze	Evaluations and compilations
	Zr	Reviews

Physical States:	(c)rystal, solid	(aq)ueous
	(amorp)hous	(nonaq)ueous, includes fused salts, solid solutions
	(liq)uid	
	(g)as	(Ads)orbed

39ARD: Ardeeva, V. A.; "Partial pressures of NH_3, CO_2 and H_2O in liquids in reflux-condensors"; Zh. Khim. Prom.; *16, 26 (1939) — Pv, 70-90 °C. — B

47BAD/WIL: Badger, E. H. M.; Wilson, D. S.; "Vapour pressures of ammonia and carbon dioxide in equilibrium with aqueous solutions. Part VI"; J. Soc. Chem. Ind. London; *66, 84 (1947) — Zc, Kk, Pv, 0-100 °C. — B

63BAR: Baranski, A.; "Study of the kinetics of the synthesis and decomposition of urea. II. Kinetics of the decomposition of urea"; Chem. Stosow.; *4, 567 (1963) — Kk, 150-180 °C. — B

64BAR: Baranski, A.; "Study of the kinetics of the synthesis and decomposition of urea. III. Kinetics of the decomposition of urea"; Chem. Stosow.; *3A, 281 (1964) — Kk, 120-150 °C. — B

78BEU/REN: Beutier, D.; Renon, H.; "Representation of NH_3-H_2S-H_2O, NH_3-CO_2-H_2O, and NH_3-SO_2-H_2O vapor-liquid equilibria"; Ind. Eng. Chem. Process Des. Dev.; *17, 220 (1978) — Zc, Kk, Da, Pv, 0-100 °C. — B,C

63BLA/BAR: Blasiak, E.; Baranski, A.; Matuszewski, Z.; "On the kinetics of the reactions of synthesis and decomposition of urea"; Bull. Acad. Pol. Sci.; *11, 261 (1963) — Kk, 150-180 °C. — B

80BLA/SWA: Blauwhoff, P. M. M.; van Swaaij, W. P. M.; Enschede, N.; "Gas-liquid equilibria between H_2S, CO_2 and aqueous amine solutions"; EFCE Pub. Ser. 80, Phase Equil. Fluid Prop. Chem. Ind.; *11, 78 (1980) — Zc, Pv, 40-66 °C. — A

37BOL/LEM: Bolotov, V. A.; Leman, V. R.; Popova, A. N.; "Synthesis of ammonia-urea fluids in large-scale laboratory installations in continuous operation"; Khim. Promst. (Moscow); *14, 707 (1937) — Kk, Pv, 160-185 °C. — B

37BOL/LEM2: Bolotov, V. A.; Leman, V. R.; Popova, A. N.; Shanoshchnikov, V. S.; "Synthesis of urea from ammonia and carbon dioxide at installations in continuous operation"; Khim Promst. (Moscow); *14, 1693 (1937) — Kk, Pv, 160-185 °C. — B

40BOL/LEM: Bolotov, V. A.; Leman, V. R.; "Study of Partial Pressures of NH_3, CO_2, and H_2O over aqueous solutions of ammonium carbamate at 140 - 200 °C"; J. Chem. Ind. (USSR); pp. 28-32 (1940). — Kk, 140-200 °C — B

34BOL/POP: Bolotov, B. A.; Popova, A. N.; "The synthesis of urea from ammonia and carbon dioxide"; Zh. Khim. Promsti.; *11, 32 (1934) — Kk, Pv, 155-270 °C. — B

37BOL/POP: Boltov, V. A.; Popova, A. N.; Sokolova, Yu K.; "Synthesis of urea from ammonia in carbonic acid in an abundance of ammonia"; Khim. Promst. (Moscow); *14, 631 (1937) — Kk, Pv, 135-175 °C. — B

37BOL/TUG: Bolotov, V. A.; Tugai, D. G.; "Regeneration of gases after the synthesis of urea from ammonia and carbonic acid"; Zh. Khim. Prom.; *14, 991 (1937) — Kk, Pv, 100-140 °C. — B

75BRO/LEM: Broers, J. N.; Lemkowitz, S. M.; van den Berg, P. J.; "Densities of urea-ammonia-water-carbon dixoide solutions in chemical equilibrium at and above urea synthesis conditions"; J. Appl. Chem. Biotechnol.; *25, 769 (1975) — Pv, Vc, Vq, Xd, 150-260 °C — B

10BUC: Buch, K.; "Die Hydrolyse der Ammoniumsalze fluchtiger Sauren"; Z. Physik. Chim. (Leipzig); *70, 66 (1910) — Kk, Pv, 18-25 °C. — B

75BUC/RAT: Buck, A.; Rathgeb, K.; "Gleichgewicht des Systems CO_2-NH_3-H_2O Harnstoff im Gebiet kleiner Wassergehalte"; Helv. Chim. Acta; *58, 81 (1975) — Kk, Pv, 160-180 °C. — B

65BUN/KHA:	Bunakov, N. G.; Kharlampovich, G. D.; "The solubility of acidic gases (carbon dioxide and hydrogen sulfide) in aqueous ammonium orthophosphate solutions"; J. Appl. Chem. USSR (Eng. Trans.); *38, 1879 (1965)	Kk, Pv, 293-363 K, H_3PO_4 present in solutions studied.	D
81CHE:	Chen, C. C.; "Computer simulation of chemical processes with electrolytes" Dissertation, Massachusetts Institute of Technology, Cambridge, Masachusetts (1981).	Zc, Kk, 293-413 K	B,C,D
79CHE/BRI:	Chen, C. C.; Britt, H. I.; Boston, J. F.; Evans, L. B.; "Extension and application of the Pitzer equation for vapor-liquid equilibrium of aqueous electrolyte systems with molecular solutes"; AIChE J.; *25, 820 (1979)	Zc, Kk, 293-413 K	B
80CHE/BRI:	Chen, C. C.; Britt, H. I.; Boston, J. F.; "Two new activity coefficient models for the vapor liquid equilibrium of electrolyte systems"; Evans, L. B.; Am. Chem. Soc. Symp. Ser. No. 133, pp. 63-89 (1980)	Zc, Da, Kk, Pv, 20-25 °C.	B
71CHE:	Chernen'kaya, E. I.; "Experimental determination of the specific heats of aqueous solutions of NH_4HCO_3, $NaHCO_3$, Na_2CO_3, NH_3, and of liquors of the soda industry at 25 °C"; J. Appl. Chem. USSR (Eng. Trans.); *44, 1562 (1971)	Q1, 25 °C.	B
72CHE/BRA:	Chernenkaya, E. I.; Bratash, E. G.; "Experimental determination of the specific heats of aqueous solutions of Na_2CO_3, $NaHCO_3$, NH_4HCO_3, and of liquors of the soda industry at 35 and 50 °C"; J. Appl. Chem. USSR (Eng. Trans.); *45, 2325 (1972)	Q1, 25-50 °C.	B
75CHE/BRA:	Chernen'kaya, E. I.; Bratash, E. G.; "Calculation of specific heats of aqueous salt systems over a wide temperature range"; J. Appl. Chem. USSR (Eng. Trans.); *48, 1910 (1975)	Zc, Q1, 25-90 °C, empirical method for the calculation of Cp of aqueous salt sols.	B

81CHE/TRO:	Chertokova, L. V.; Troyanov, S. I.; "Equilibrium method for determination of dissolved gases"; Vulkanolog. Seismolog.; *6, 115 (1981)	Kk, Pv, 33-130 °C.	A
33CLA/GAD:	Clark, K. G.; Gaddy, V. L.; Rist, C. E.; "Equilibria in the ammonium carbamate urea-water system"; Ind. Eng. Chem.; *25, 1092 (1933)	Kk, 135-200 °C, equilibrium study of the conversion of ammonium carbamate into urea and water.	B
74CZA/HAB:	Czarnecki, J.; Haber, J.; Pawlikowski-Czubak, J.; Pomianowski, A.; "Thermodynamic equilibria in the system SO_2, NH_3, H_2O, and CO_2"; Z. Anorg. Allg. Chem.; *410, 213 (1974)	Kk, Pv, 25-60 °C.	B
62DAN/FRE:	D'Ans, J.; Freund, H. E.; "Anorganische Stoffe in Wasser, ternäre Systeme"; Landolt-Bornstein: Numerical Data and Functional Relationships in Science and Technology, 6th Edition, Volume II, Part 2, page 3-225, Springer Verlag, Berlin (1962)	Zc, Px, -95 to + 34 °C	B
80DAV/GOO:	Dave, S. M.; Goomer, N. C.; Sadhukan, H. K.; "Molecular distribution of deuterated hydrogen, water, hydrogen sulphide, methyl amine and ammonia"; Ind. J. Chem.; *19A, 733 (1980)	Zc, K, 193-883 K, calculated values of molecular distributions of deuterated derivatives of H2, H_2O, H_2S, CH_3NH_2, and NH_3.	C
47DRY:	Dryden, I. G. C.; "Equilibrium between gaseous carbon dioxide and hydrogen sulphide and solutions of alkali carbonates, bicarbonates, and hydrosulphides. Part I. Potassium salts"; J. Soc. Chem. Ind. London; *66, 59 (1947)	Kk, 0-60 °C, 0.2 to 2.0 N.	A
78DUR:	Durisch, W.; "Experimentelle and thermodynamische Untersuchung des Siedegleichgewichts des Systems $CO_2/NH_3/H_2O$ unter Harnstoffsynthese - Bedingungen" Dissertation, Eidgenössischen Technischen Hochschule, Zürich, Switzerland (1978)	Px, 150-220 °C, 70 to 280 bar	B

81DUR:	Durisch, W.; "Siedegleichgewicht chemisch reagierender Mehrstoffsysteme unter hohem Druck und bei hoher Temperatur"; Chimia; *35, 19 (1981)	Zc, Pv, 180 °C.	B
79DUR/BER:	Durisch, W.; van den Berg, P. J.; "Die Dichte gasformiger Kohlendioxid-Ammoniak Wasser-Gemische unter Harnstoffsynthese-Bedingungen"; Chimia; *33, 200 (1979)	Pv, Vc, Vg, Xd, 160-200 °C, CO_2: 40 to 65 mole percent, NH_3: 35 to 55 mole percent.	B
75DUR/BUC:	Durisch, V. W.; Buck, A.; "Zusammensetzung und Dichte der Harnstoffschmelze und der koexistierenden Gasphase"; Chimia; *29, 436 (1975)	Kk, 170 °C, L = 2, W = 0.	B
77DUR/BUC:	Durisch, W.; Buck, A.; Luder, J.; "Der Gleichgewichtsdruck des systems $CO_2/NH_3/H_2O$ bei Harnstoffsynthese-Bedingungten"; Chimia; *31, 296 (1977)	Pv, Xd, Vg, 160-200 °C, W = 0 to -0.6, L = 2.	B
79DUR/BUC:	Durisch, W.; Buck, A.; Lemowitz, S. M.; van den Berg, P. J.; "Vapour/liquid equilibria under high pressure with chemical reactions"; Delft. Prog. Rep.; *4, 159 (1979)	Pv, Vg, Xd, 160-180 °C, L = 2, -0.6 < W < 0.	B
79DUR/BUC2:	Durisch, W.; Buck, A.; Lemkowitz, S. M.; van den Berg, P. J.; "Experimental investigation of the vapour-liquid equilibrium of the carbon dioxide ammonia-water system at urea synthesis conditions"; Chimia; *33, 293 (1979)	Pv, Vg, Xd, 160-180 °C, L = 2, -0.6 < W < 0.	B
80DUR/LEM:	Durisch, W.; Lemkowitz, S. M.; van den Berg, P. J.; "Constituent and component measurements and calculations of the vapour/liquid equilibrium of the ternary system carbon dioxide ammonia-water under urea synthesis conditions"; Chimia; *34, 314 (1980)	Zc, Kk, Pv, 160-180 °C, L = 2, -0.6 < W < 0.	B
78EDW/MAU:	Edwards, T. J.; Maurer, G.; Newman, J.; Prausnitz, J. M.; "Vapor-liquid equilibria in multi-component aqueous solutions of volatile weak electrolytes"; AIChE J.; *24, 966 (1978)	Zc, Da, Pv, 0-170 °C, 0 < I < 6 mol kg-1.	D

75EDW/NEW:	Edwards, T. J.; Newman, J.; Prausnitz, J. M.; "Thermodynamics of aqueous solutions containing volatile weak electrolytes"; AIChE J.; *21, 248 (1975)	Zc, Da, Kk, Pv, 0-100 °C, 10-4 to 2 mol Kg-1.	D
62EFR/LEO:	Efremova, G. D.; Leont'eva, G. G.; "Compressibility of mixtures of ammonia and carbon dioxide and the equilibrium reaction for the synthesis of ammonia"; Khim. Promst. (Moscow); *10, 742 (1962)	Kk, Pv, 200-400 °C.	B
54EGA/VAN:	Egalon, R.; Vanhille, R.; Willemyn, M.; "Tensions de vapeur de l'ammoniac et de l'anhydride carbonique en equilibre avec les solutions de carbonate et de bicarbonate d'ammonium"; Ind. Chim. (Paris); *41, 293 (1954)	Kk, Pv 21-52 °C.	B
79EKG/STA:	Ekgauz, V. I.; Starodubtstsev, A. N.; Nazorov, V. G.; Zabello, L. A.; "Equilibrium distribution of ammonia, hydrogen sulfide, and carbon dioxide after absorption from water"; Vopr. Tekhnol. Ulavlivan. Pererab. Prod. Koksovaniya; *8, 16 (1979)	Kk, Pv, 30 °C.	C
04FED:	Fedotieff, P. P.; "Der Ammoniaksodaprozess vom Standpunkte der Phasenlehre"; Z. Phys. Chem. (Leipzig); *49, 162 (1904)	Px, 0-45 °C, in NaCl sols.	B
11FIC/BEC:	Fichter, F.; Becker, B.; "Uber die Bildung von Harnstoff durch Erhitzen von Ammonium-carbaminat"; Ber. Bunsenges. Phys. Chem.; *44, 3433 (1911)	Kk, 115-150 °C.	B
48FRE:	Frejacques, M.; "Les bases theoriques de la synthese industrielle de l'uree"; Chim. Ind.; *60, 22 (1948)	Hr, Kk, Pv, -20 to 150 °C.	B
57FRO:	Frolich, G. J.; "Vapor liquid equilibria of aqueous systems containing ammonia and carbon dioxide"; Thesis, Polytechnic Institute of Brooklyn; (1957).	Hr, Kk, Pv, -20 to 150 °C.	B

79GAU:	Gautam, R.; "Computation of physical and chemical Equilibria"; Dissertation, University of Pennsylvania, Philadelphia, (1979).	Zc, Kk, 20 °C	C
79GAU/SEI:	Gautam, R.; Seider, W. D.; "Computation of phase and chemical equilibrium. Part I. Local and constrained minima in Gibbs free energy"; AIChE J.; *25, 991 (1979)	Zc, Kk, 20 °C	C
80GIG:	Giggenbach, W. F.; "Geothermal gas equilibria"; Geochim. Cosmochim. Acta; *44, 2021 (1980)	Zc, Kk, Pv, 100-350 °C.	D
65GIN:	Ginzburg, D. M.; "The System NH_3-CO_2-H_2O"; J. Appl. Chem. USSR (Eng. Trans.); *38, 2157 (1965)	Kk, Pt, Pv, 55-90 °C.	B
72GIN/MAR:	Ginzburg, D. M.; Markel', S. A.; Detinich, L. P.; "The system NaCl-NH_4Cl-NH_3-CO_2-H_2O at p = 1 atm"; J. Appl. Chem. USSR (Eng. Trans.); *45, 1762 (1972)	Kk, Pv 60-105 °C.	B
65GIN/PIK:	Ginzburg, D. M.; Pikulina, N. S.; Litvin, V. P.; "The system NH_3-H_2S-H_2O"; J. Appl. Chem. USSR (Eng. Trans.); *38, 2071 (1965)	Pv, 64-90 °C.	C
66GIN/PIK:	Ginzburg, D. M.; Pikulina, N. S.; Litvin, V. P.; "The system NH_3-H_2S-H_2O at 600 mm"; J. Appl. Chem. USSR (Eng. Trans.); *39, 2225 (1966)	Kk, Pv, 59-84 °C.	C
67GIO:	Gioa, F.; "Assorbimento simultaneo de H_2S e CO_2 in soluzioni tampone di carbonate e bicarbonate di potassio"; Chim. Ind.; *49, 1287 (1967)	Kk, 20 °C.	A
36GME:	Gmelins Handbuch der Anorganischen Chemie; pp. 327-362, Verlag Chemie, Berlin, Germany (1936)	Ze, Zr, Kk, Px, Pv, -15 to 197 °C	B

62GOL/ALT:	Goldberg, N. A.; Altschuler, L. N.; "Microscopic kinetics and mechanism for the synthesis of urea from ammonia and carbon dioxide"; Khim. Promst. (Moscow); *9, 638 (1962)	Zc, Kk, 165-195 °C.	B
64GOL/ALT:	Goldberg, N. A.; Altschuler, L. N.; "Macroscopic kinetics and mechanism for the synthesis of urea from ammonia and carbon dioxide"; Khim. Promst. (Moscow); *1, 54 (1964)	Zc, Kk, 170-210 °C.	B
58GOL/MAL:	Golutvin, Yu. M.; Malysheva, T. V.; Skorobogatova, V. I.; "The solubility of hydrogen sulfide and carbon dioxide in water and aqueous solutions of ammonia and phenol"; Akad. Nauk SSSR. Sibir. Otdel. Izvest. Novos.; *8, 83 (1958)	Kk, Pv 20 °C.	B,C
72GOR/GOR:	Gorlovskii, D. M.; Gorbushenkov, V. A.; Kucheryavyi, V. I.; "Experimental values of the equilibrium degree of conversions of carbon dioxide into urea by the Bazarov reaction"; J. Appl. Chem. USSR (Eng. Trans.); *45, 1596 (1972)	Kk, Pv, 165-230 °C, L = 2.9 to 6.3, W = 0 to 1.6.	B
71GOR/KOS:	Gorlovskii, D. M.; Koshcherenkov, N. N.; Kurcheryavyi, V. I.; "Equilibrium pressure in the system NH_3-CO_2-$CO(NH_2)_2$-H_2O"; J. Appl. Chem. USSR (Eng. Trans.); *44, 2478 (1971)	Kk, Pv, 220-230 °C, L = 2 to 5, W = 0 to 15.	B
73GOR/KOS:	Gorlovskii, D. M.; Koshcherenkov, N. N.; Kucheryavyi, V. I.; "Equilibrium pressure in the system NH_3-CO_2-$CO(NH_2)_2$-H_2O"; J. Appl. Chem. USSR (Eng. Trans.); *46, 2618 (1973)	Kk, Pv 160-220 °C, L = 0.5 to 5.0, W = 0.	B
73GOR/KOS2:	Gorlovskii, D. M.; Koshcherenkov, N. N.; Kucheryavyi, V. I.; "Influence of excess carbon dioxide on equilibrium in the Bazarov reaction"; J. Appl. Chem. USSR (Eng. Trans.); *46, 2780 (1973)	Kk, Pv 160-220 °C, L = 0.5 to 5.0, W = 0.	B

76GOR/KOS:	Gorlovskii, D. M.; Koscherenkov, N. N.; Kucheryavyi, V. I.; "Diagrams of the thermodynamics properties of the system NH_3-CO_2-$CO(NH_2)_2$-H_2O during the synthesis of urea"; J. Appl. Chem. USSR. (Eng. Trans.); *49, 780 (1976)	Kk, Pv, 150-250 °C, L = 4, W = 0.	B
78GOR/KOS:	Gorlovskii, D. M.; Koscherenkov, N. N.; Kucheryavyi, V. I.; "Inter polation formulas for calculation of the pressure in the system NH_3-CO_2-$CO(NH_2)_2$-H_2O with the synthesis of urea"; J. Appl. Chem. USSR (Eng. Trans.); *51, 471 (1978)	Zc, Kk, Pv, 160-220 °C, L = 2.5 to 5.0, W = 0 to 1.5.	B
74GOR/KUC:	Gorlovskii, D. M.; Kucheryavyi, V. I.; "Weight ratio of the phases in the equilibrium liquid-gas system NH_3-CO_2-$CO(NH_2)_2$-H_2O during synthesis of urea"; J. App. Chem. USSR (Eng. Trans.); *47, 205 (1974)	Zc, Kk, Pv, 160-200 °C, L = 2 to 5, W = 0 to 1.5.	B
74GOR/KUC2:	Gorlovskii, D. M.; Kucheryavyi, V. I.; Koscherenkov, N. N.; "Equation for the dependence of the equilibrium urea yield by the Bazarov reaction on temperature, composition, and reactor charge density"; J. Appl. Chem. USSR (Eng. Trans.); *47, 230 (1974)	Zc, Kk, Pv, 160-200 °C, L = 2 to 5, W = 0 to 1.5.	B
44GUY/PIE:	Guyer, A.; Piechowicz, T.; "Losungleichgewichte in wassrigen systement. Das System CO_2-NH_3-H_2O bei 20° and 50°"; Helv. Chim. Acta; *27, 858 (1944)	Pv, 20-50 °C, 0 to 35 percent CO_2, 0 to 35 percent NH_3.	B
79HAL/DRE:	Hales, J. M.; Drewes, D. R.; "Solubility of ammonia in water at low concentrations"; Atmos. Environ.; *13, 1133 (1979)	Kk, Pv , 277-296 K, H_2SO_4 also present.	B
79HEG/MOL:	Hegner, B.; Molzahn, M.; "Simulation of mass transfer controlled countercurrent separation processes accompanied by chemical reactions"; Inst. Chem. Eng. Symp. Ser. No. 56; pp. 81-100 (1979)	Zc, Kk, 60-90 °C	B
28HOL:	Hollings, H.; "Some application of chemistry in gas making"; Trans. Inst. Gas. Eng.; (1927-28), pp. 495-545	Kk, 50-90 °F, 3.5 percent CO_2.	B

42HOR/OGA:	Hori, S.; Ogami, N.; "The synthesis of urea from ammonia and carbon dioxide"; Koatsu Gasu Kyokaishi; *6, 256 (1942)	Kk, 119-220 °C.	B
61IKE:	Ikeno, S.; "Granulation of fertilizer from ammonium carbamate solution"; Kogyo Kagaku Zasshi; *64, 627 (1971)	Pv, 15-40 °C.	B
72INO/KAN:	Inoue, S.; Kanai, K.; Otsuka, E.; "Equilibrium of urea synthesis. I"; Bull. Chem. Soc. Japan; *45, 1339 (1972)	Kk, Pv, 160-220 °C, L = 0 to 8, W = 0 to 1.2.	B
72INO/KAN2:	Inoue, S.; Kanai, K.; Otsuka, E.; "Equilibrium of urea synthesis. II"; Bull. Chem. Soc. Japan; *45, 1616 (1972)	Kk, Pv, 160-220 °C, L = 0 to 8, W = 0 to 1.2.	B
77ISA/OTT:	Isaacs, E. E.; Otto, F. D.; Mather, A. E.; "The solubility of mixtures of carbon dioxide and hydrogen sulphide in an aqueous DIPA solution"; Can. J. Chem. Eng.; *55, 210 (1977)	Pv, 40-100 °C, in sols of di-isopropanol-amine, $p(CO_2)$ = 2 to 5991 kPa, $p(H_2S)$ = 1.3 to 4126 kPa.	A
80ISA/OTT:	Isaacs, E. E.; Otto, F. D.; Mather, A. E.; "Solubility of mixtures of H_2S and CO_2 in amonoethanolamine solution at low partial pressures"; J. Chem. Eng. Data; *25, 118 (1980)	Pv, 100 °C. in monoethanolamine, $p(CO_2)$ = 7 to 1360 Pa, $p(H_2S)$ = 0 to 3920 Pa.	A
29JAN:	Janecke, E.; "Uber das System H_2O, CO_2 und NH_3"; Z. Elektrochem.; *35, 716 (1929)	Pv, 0-90 °C.	B
30JAN:	Janecke, E.; "Uber das System" H_2O-CO_2-NH_3, Fortsetzung"; Z. Elecktronchem.; *36, 645 (1930)	Pv, Px, -78 to 132 °C	B
59JON/FRO:	Jones, J. H.; Froning, H. R.; Claytor, Jr., E. E.; "Solubility of acidic gases in aqueous monoethanolamine"; J. Chem. Eng. Data; *4, 85 (1959)	Pv, 40-140 °C, in monoethanolamine.	A

71KAA:	Kaasenbrood, P. J. C.; "The urea stripping process: The technical manufacture of urea, with carbon dioxide used both as reactant and as stripping gas"; Proc. Fourth European Symposium held in Brussels, Sept. 9-11, 1968, Supplement to Chemical Engineering Science, Pergamon Press, Oxford (1971)	Zr, Px, 150-190 °C	B
77KAA/CHE:	Kaasenbrood, P. J. C.; "Stripping technology, phase equilibria and thermodynamics of the stamicarbon urea stripping process"; Chermin, H. A. G.; Proc. Fert. Soc. 3, (1977)	Zr; Kk, Pv, 155-190 °C, 0 to 35 mass percent CO_2, 0 to 35 mass percent NH_3.	B
74KAT/VAI:	Katkovskaya, K. Ya.; Vaineikis, A. A.; Dubrovskii, I. Ya.; "Influence of temperature on pH in the system H_2O-CO_2-NH_3"; Teploenergetika (Moscow); *7, 8 (1974)	Ke, 25-250 °C.	B
51KAW:	Kawasumi, S.; "Equilibrium of the CO_2-NH_3-Urea-H_2O system under high temperature and pressure. I. Equilibrium pressure of reaction in urea-synthesis from ammonia and carbon dioxide"; Bull. Chem. Soc. Japan; *24, 148 (1951)	Kk, Pv, 130-170 °C, 30 to 185 atm.	B
52KAW:	Kawasumi, K.; "Equilibrium of the CO_2-NH_3-Urea-H_2O system under high temperature and pressure. II. Liquid-vapor equilibrium in the loading mole ratio of NH_3 to CO_2"; Bull. Chem. Soc. Japan; *25, 227 (1952)	Pv, Xd, 140-180 °C, L = 2.	B
53KAW:	Kawasumi, S.; "Equilibrium of the CO_2-NH_3-Urea-H_2O system under high temperature and pressure. III. Effect of water added on liquid-vapor equilibrium"; Bull. Chem. Soc. Japan; *26, 218 (1953)	Kk, Pv, 130-190 °C, L = 1.5 to 4.0.	B
53KAW2:	Kawasumi, S.; "Equilibrium of the CO_2-NH_3-urea-H_2O system under high temperature and pressure. IV. Effect of loading NH_3-CO_2 mole ratio on equilibrium pressure and vapor composition"; Bull. Chem. Soc. Japan; *26, 222 (1953)	Kk, Pv, 130-190 °C, L = 1.5 to 4.0.	B

54KAW:	Kawasumi, S.; "Equilibrium of the CO_2-NH_3-urea-H_2O system under high temperature and pressure. V. Liquid-vapor equilibrium in the presence of excess ammonia or carbon dioxide"; Bull. Chem. Soc. Japan; *27, 254 (1954)	Kk, Pv, 160 °C, L = 1.5 to 3.3.	B
76KEN/EIS:	Kent, R. L.; Eisenberg, B.; "Better data for amine treating"; Hydrocarbon Process.; *55, 87 (1976)	Zc, Kk, Pv, 0-140 °C,	A
73KHE/SAM:	Khetchikov, L. N.; Samoilovich, L. A.; "Correlation of experimental data (p-ρ-T-x) in salt-water and salt-gas-water systems"; Exp. Miner. Petrogr.; pp. 112-121 (1973)	Pv, Xd, 160-400 °C,	B
51KIN:	Kinoshita, H.; "Equilibrium of urea-water system. II"; Rev. Phys. Chem. Japan; *21, 16 (1951)	Pv, 150-210 °C, 32 to 306 atm.	B
51KIY/KIN:	Kiyama, R.; Kinoshita, H.; "Equilibrium of urea-water system. I"; Rev. Phys. Chem. Japan; *21, 9 (1951)	Pv, 130-240 °C, 0 to 500 atm.	B
71KON/BOL:	Koneczny, H.; Bolinski, L.; "Nature of the equilibrium of the sodium process at 25 °C"; Przem. Chem.; *50, 657 (1971)	Kk, Pv, 25 °C, NaCl present.	B
74KON/TRY:	Koneczny, H.; Trypuc, M.; "Influence of temperature on the equilibrium pressure over the system $NaNO_3$-NH_3-CO_2-H_2O"; Chem. Stosow.; *18, 15 (1974)	Kk, 20-40 °C.	B
79KOT/DUK:	Kotula, E.; Dukowicz, J.; Wojcicka, K.; "Determination of the specific heat of ammonia carbon dioxide-water-urea solutions"; Pr. Nauk. Inst. Technol. Nieorg. Nazow Miner. Politech. Wroclaw.; *15, 153 (1979); [CA 92-136312k].	Q1, 303-393 K, 2.5 MPa, 0-60 wt% urea, 1-40 wt% NH_3, 0-44 wt% CO_2.	B
80KOT/KOW:	Kotula, E.; Kowalik, W.; "Determination of the equilibrium pressure of ammonia in the system NH_3-CO_2-H_2O-urea up to pressures of 2.5 MPa"; Chem. Stosow.; *24, 561 (1980)	Pv, 80-1120 °C, 1.8 to 2.5 MPa	B

75KOU:	Koubsky, P.; "Vodivost vodneho rotoku systemu NH_3-CO_2-H_2O"; Chem. Prum.; *25, 291 (1975)	Zc, Kk, Pv, 25 °C.	B
74KOU/HLA:	Koubsky, P.; Hladky, V.; "Zpracovani polynovych kondensatu pri vyrobe svitiplynu-reseni systemu NH_3-CO_2-H_2O"; Plyn.; *54, 337 (1974)	Zc, Kk, Pv, 25-80 °C.	B
75KOU/HLA:	Koubsky, P.; Hladky, V.; "Vypocet rovnovah v systemu NH_3-CO_2-H_2O"; Chem. Prum.; *25, 234 (1975)	Zc, Kk, Pv, 25-80 °C.	B
76KOU/HLA:	Koubsky, P.; Hladky, V.; "Equilibrium calculations in the system NH_3-CO_2-H_2O"; Int. Chem. Eng.; *16, 392 (1976)	Zc, Kk, Pv, 25-80 °C	B
63KOZ/KAR:	Kozin, V. M.; Karpukhin, A. M.; Momot, M. V.; Volkov, B. V.; "Study of the equilibrium of ammonia and carbon dioxide over boric acid-glycerol aqueous solutions"; Khim. Prom. Nauk. Tekhn. Zb.; pp. 10-14 (1963)	Kk, Pv, 50-150 °C, boric acid and glycerol are also present.	B
22KRA/GAD:	Krase, N. W.; Gaddy, V. L.; "Synthesis of urea from ammonia and carbon dioxide"; Ind. Eng. Chem.; *14, 611 (1922)	Kk, Pv, 70-200 °C.	B
30KRA/GAD:	Krase, H. J.; Gaddy, V. L.; "Equilibria in the ammonium carbamate-urea-water ammonia system"; J. Am. Chem. Soc.; *52, 3088 (1930)	Kk, 155 °C.	B
38KRA:	Krasil'shchikov, A. I.; "The physical chemical basis for the synthesis of urea"; Usp. Khim.; *7, 1042 (1938)	Zc, Kk, 135-200 °C.	B
49KRE/HOF:	van Krevelen, D. W.; Hoftijzer, P. J.; Huntjens, F. J.; "Composition and vapour pressures of aqueous solution of ammonia, carbon dioxide and hydrogen sulphide"; Rec. Trav. Chem. *68, 191 (1949)	Kk, Pv, 20-60 °C.	A,B,C,D

69KUC/GOR:	Kucheryavyi, V. I.; Gorbushenkov, V. A.; "Reaction kinetics for the synthesis of urea using Bazarov's process"; Dokl. Akad. Nauk SSSR; *188, 868 (1969)	Pv, Xd, 150-210 °C, L = 2 to 5, W = 0 to 1.0.	B
69KUC/GOR2:	Kucheryavyi, V. I.; Gorlovakii, D. M.; "Reaction equilibria for the synthesis of urea from ammonia and carbon dioxide"; Khim. Promst. (Moscow); *11, 836 (1969)	Pv, Xd, 150-210 °C, L = 2 to 5, W = 0 to 1.0.	B
69KUC/GOR3:	Kucheryavyii, V. I.; Gorlovskii, D. M.; "The physical chemical behavior of vapor liquid equilibria in the system NH_3-CO_2-$CO(NH_2)_2$-H_2O with parameters for the synthesis of urea"; Dokl. Akad. Nauk SSSR; *186, 891 (1969)	Zc, Kk, 170-210 °C, L = 2 to 6, W = 0 to 1.	B
69KUC/GOR4:	Kucheryavyii, V. I.; Gorlovskii, D. M.; Konkina, T. N.; "The steps of the equilibria for the conversion of carbon dioxide to urea"; Khim. Promst. (Moscow); *3, 200 (1969)	Zc, Kk, 100-220 °C, L = 0 to 7.6, W = 0 to 7.	B
69KUC/GOR5:	Kucheryavyi, V. I.; Gorlovskii, D. M.; Polyakov, E. V.; "Dependence of equilibrium pressure in the system NH_3-CO_2-$CO(NH_2)_2$-H_2O (gas-liquid) on the temperature, autoclave charge density and NH_3:CO_2 ratio in the original component mixture"; J. Appl. Chem. USSR (Eng. Trans.); *42, 591 (1969)	Pv, 133-241 °C, L = 4.	B
69KUC/GOR6:	Kucheryavyi, V. I.; Gorlovskii, D. M.; Konkina, T. N.; "Volume fractions of liquid and gas phases in the equil ibrium system NH_3-CO_2-$CO(NH_2)_2$-H_2O at high temperatures and pressures"; J. Appl. Chem. USSR (Eng. Trans.); *42, 1020 (1969)	Pv, 169-190 °C, L = 2 to 3.3, W = 0 to 1.0.	B
69KUC/GOR7:	Kucheryavyi, V. I.; Gorbushenkov, V. A.; "Influence of excess water and ammonia on the rate of synthesis of urea from ammonia and carbon dioxide"; J. Appl. Chem. USSR (Eng. Trans.); *42, 2459 (1969)	Kk, 190 °C, L = 4, W = 0.5.	B

69KUC/GOR8:	Kucheryavyi, V. I.; Gorbushenkov, V. A.; "Kinetics of urea synthesis from ammonia and carbon dioxide"; J. Appl. Chem. USSR (Eng. Trans.); *42, 2293 (1969)	Kk, Pv, 165-210 °C, L = 4.	B
70KUC/GOR:	Kucheryavyi, V. I.; Gorbushenkov, V. A.; "Dependence of the rate of urea synthesis from ammonia and carbon dioxide on the density of gas-liquid mixture"; J. Appl. Chem. USSR (Eng. Trans.); *43, 218 (1970)	Pv, Xd, 140-190 °C, L = 2 to 5, W = 0.2 to 1.0.	B
70KUC/GOR2:	Kucheryavyi, V. I.; Gorlovskii, D. M.; "Densities of coexisting phases in the equilibrium gas-liquid system NH_3-CO_2-$CO(NH_2)_2$-H_2O at high temperatures and pressures"; J. Appl. Chem. USSR (Eng. Trans.); *43, 1693 (1970)	Pv, Xd, 140-190 °C, L = 2 to 5, W = 0.2 to 1.0.	B
72KUC/GOR:	Kucheryavyi, V. I.; Gorlovskii, D. M.; Koshcherenkov, N. N.; "Influence of excess urea on equilibrium in the Bazarov reaction"; J. Appl. Chem. USSR (Eng. Trans.); *45, 70 (1972)	Kk, Pv, 165-200 °C, L = 2.5 to 5.0, W = 0.0 to 0.8.	B
75KUC/GOR:	Kucheryavyi, V. I.; Gorlovskii, D. M.; Koshcherenkov, N. N.; "Phase diagram, critical parameters, and azeotropy of the system NH_3-CO_2-$CO(NH_2)_2$-H_2O"; J. Appl. Chem. USSR (Eng. Trans.); *48, 320 (1975)	Pt, Pv, 150-240 °C, L =4.	B
68KUC/ZIN:	Kucheryavyi, V. I.; Zinov'ev, G. N.; Koshcherenkov, N. N.; "Liquid-vapor equilibrium in the system ammonia-carbon dioxide-urea-water at pressures up to 50 atm and temperatures in the range of 100-160°"; J. Appl. Chem. USSR (Eng. Transl.); *41, 795 (1968)	Kk, Pv, 100-160 °C.	B
69KUC/ZIN:	Kucheryavyii, V. I.; Zinov'ev, G. N.; "Calculation of the equilibrium distribution of NH_3, CO_2, and H_2O between fluids due to both transport and pressure in the systems NH_3-CO_2-H_2O and NH_3-CO_2-$CO(NH_2)_2$-H_2O"; Khim. Promst. (Moscow); *5, 354 (1969)	Zc, Pv, 100-150 °C, 20 to 50 atm.	B

70KUR/ILI:	Kurshev, I.; Ilieva, E.; Shishkov, D.; "A new modification of a dynamic method for determining equilibrium partial pressures of water, ammonia, and carbon dioxide"; God Nauchnoizsled. Inst. Khim. Promst.; *8, 81 (1971)	Pv, t = ?	B
70KUR/ILI2:	Kurshev, I.; Ilieva, E.; Shishkov, D.; "A new modification of a dynamic method for determining equilibrium partial pressure of water, ammonia, and carbon dioxide"; Khim. Ind. (Sofia); *10, 440 (1970)	Pv, t = ?	B
71KUR/ILI:	Kurshev, I.; Ilieva, E.; "Determination of equilibrium partial pressures of ammonia and carbon dioxide in the ammonia-carbon dioxide-ammonium nitrate-water system"; God. Nauchnoizsled. Inst. Khim. Promst.; *8, 87 (1971)	Pv, 20-40 °C, L = 1.7 to 4.5.	B
79LAB/EKG:	Labedeva, G. N.; Ekgauz, V. I.; Anikina, T. G.; Zabello, L. A.; "Partial pressures of ammonia, hydrogen sulfide, and hydrogen cyanide over their aqueous solution"; J. Appl. Chem. USSR (Eng. Trans.); *7, 1424 (1979)	Pv, 20-40 °C, HCN also present.	D
76LAW/GAR:	Lawson, J. D.; Garst, A. W.; "Gas sweetening data: equilibrium solubility of hydrogen sulfide and carbon dioxide in aqueous monoethanolamine and aqueous diethanolamine solutions"; J. Chem. Eng. Data; *21, 20 (1976)	Kk, Pv, 100-300 °F, in monoethanolamine and diethanolamine sols.	A
74LEE/OTT:	Lee, J. I.; Otto, F. D.; Mather, A. E.; "The solubility of mixtures of carbon dioxide and hydrogen sulphide in aqueous diethanolamine solutions"; Can. J. Chem. Eng.; *52, 125 (1974)	Kk,Pv, 40 °C and 100 °C, in monoethanolamine sols, $p(CO_2)$ = 0.1 to 1000 psia, $p(H_2S)$ = 0.3 to 650 psia.	A
74LEE/OTT2:	Lee, J. I.; Otto, F. D.; Mather, A. E.; "The solubility of H_2S and CO_2 in aqueous monoethanolamine solutions"; Can. J. Chem. Eng.; *52, 803 (1974)	Kk,Pv, 40 °C and 100 °C, in monoethanolamine sols, $p(CO_2)$ = 0.1 to 1000 psia, $p(H_2S)$ = 0.3 to 650 psia.	A

75LEE/OTT:	Lee, J. I.; Otto, F. D.; Mather, A. E.; "Solubility of mixtures of carbon dioxide and hydrogen sulfide in 5.0N monoethanolamine solution"; J. Chem. Eng. Data; *20, 161 (1975)	Kk, Pv, 40 °C and 100 °C, in 5.0 N monoethanolamine sols, $p(CO_2)$ = 0.1 to 810 psia, $p(H_2S)$ = 0.1 to 510 psia.	A
76LEE/OTT:	Lee, J. I.; Otto, F. D.; Mather, A. E.; "The measurement and prediction of the solubility of mixtures of carbon dioxide and hydrogen sulphide in a 2.5 N monoethanolamine solution"; Can. J. Chem. Eng.; *54, 214 (1976)	Kk, Pv, 40 °C and 100 °C. in 2.5 N monoethanolamine sols, $p(CO_2)$ = 0.7 to 5630 kPa, $p(H_2S)$ = 0.7 to 3780 kPa.	A
50LEI/SHE:	Leibush, A. G.; Sheerson, A. L.; "Solubility of hydrogen sulfide in mixtures containing carbon dioxide and ethanolamine"; Zh. Prikl. Khim. (Leningrad); *23, 145 (1950)	Pv, 25 °C. in ethanolamine sols, $p(H_2S)$ = 1.3 to 240 mmHg, $p(CO_2)$ = 0 to 75 mmHg.	A
75LEM:	Lemkowitz, S. M.; "Phase and corrosion studies of the ammonia-carbon dioxide-water system at the conditions of the hot gas recirculation process for the synthesis of urea"; Dissertation, Delft, The Netherlands (1975).	Px	B
72LEM/COO:	Lemkowitz, S. M.; de Cooker, M. G. R. T.; van den Berg, P. J.; "Some fundamental aspects of urea technology"; Proc. Fert. Soc. No. 131; pp. 3 - 115 (1972)	Zc,Kk, Pv, Pt, Pt, Pv, 130-200 °C	B
73LEM/COO:	Lemkowitz, S. M.; de Cooker, M. G. R. T.; van den Berg, P. J.; "An empirical thermodynamic model for the ammonia water-carbon dioxide system at urea synthesis conditions"; J. Appl. Chem. Biotechnol.; *23, 63 (1973)	Zc, Kk, Pt, Pv, 140-200 °C. 50 to 250 atm, L = 2.4 to 6, W F 0.5.	B
77LEM/DIE:	Lemkowitz, S. M.; Diepen, G. A. M.; van den Berg, P. J.; "A phase model for the gas-liquid equilibria in the ammonia-carbon dioxide water-urea system in chemical equilibrium at urea synthesis conditions. I. Theory"; J. Appl. Chem. Biotechnol; *27, 327 (1977)	Zc, Kk, Pv, Pt, 140-220 °C, 10 to 300 atm.	B

71LEM/GOE:	Lemkowitz, S. M.; Goedegebuur, J.; van den Berg, P. J.; "Bubble-point measurements in the ammonia-carbon dioxide system"; J. Appl. Chem. Biotechnol.; *21, 229 (1971)	Pt, Pv, 130-185 °C, 30 to 175 atm.	B
78LEM/ERP:	Lemkowitz, S. M.; van Erp, J. C. V.; van den Berg, P. J.; "Dew-point measurements of ammonia-water-carbon dioxide mixtures at urea syntheses conditions"; Chem. Chem. Eng.; *3, 83 (1978)	Kk, Pt, Pv, 140-180 °C, 30 to 200 atm, 0 to 15 mole percent H_2O.	B
80LEM/ERP:	Lemkowitz, S. M.; van Erp, J. C.; Rekers, D. M.; van den Berg, P. J.; "Phase equilibria in ammonia-carbon dioxide systems at and above urea synthesis conditions"; J. Chem. Techn. Biotechnol.; *30, 85 (1980)	Kk, Pt, Pv, 150-300 °C, L = 2.	B
77LEM/VER:	Lemkowitz, S. M.; Verbrugge, P.; van den Berg, P. J.; "A phase model for the gas-liquid equilibria in the ammonia-carbon dioxide water-urea system in chemical equilibrium at urea synthesis conditions. III. Comparison of the phase model with an empirical thermodynamic model"; J. Appl. Chem. Biotechnol.; *27, 349 (1977)	Zc, Pv, 160-180 °C.	B
77LEM/VET:	Lemkowitz, S. M.; Vet, E.; van den Berg, P. J.; "A phase model for the gas-liquid equilibria in the ammonia-carbon dioxide water-urea system in chemical equilibrium at urea synthesis conditions. II. Experimental verification"; J. Appl. Chem. Biotechnol.; *27, 335 (1977)	Kk, Pt, Pv, 140-200 °C, 15 to 400 atm.	B
72LEM/ZUI:	Lemkowitz, S. M.; Zuidam, J.; van den Berg, P. J.; Phase behavior in the ammonia-carbon dioxide system at and above urea synthesis conditions"; J. App. Chem. Biotechnol.; *22, 727 (1972).	Px, Vc, 160-260 °C, 50-950 atm, L = 2 to 100% NH_3	B
12LEW/BUR:	Lewis, G. N.; Burrows, G. H.; "The free energy of organic compounds. I. The reversible synthesis of urea and of ammonium cyanate"; J. Am. Chem. Soc.; *34, 1515 (1912)	Kk, Pv, 77-132 °C.	B

59LEY:	Leyko, J.; "Pressure over solutions of ammonium sulphide and polysulphides"; Bull. Acad. Pol. Sci.; *9, 675 (1959)	Pv, 20-50 °C.	C
64LEY/PIA:	Leyko, J.; Piatkiewicz, J.; "Equilibrium studies on the H_2S-NH_3-H_2O system. II"; Bull. Acad. Pol. Sci.; *12, 445 (1964)	Pv, 80-110 °C.	C
58LIN:	Linke, W. F.; "Solubilities: inorganic and metal-organic compounds - a compilation of solubility data from the periodical literature: Vol. I: A-Ir"; p. 1156; D. Van Nostrand, Princeton, NJ (1958).	Zr, Px, 25 °C, in various salt sols.	A
65LIN:	Linke, W. F.; "Solubilities: inorganic and metal organic compounds - a compilation of solubility data from the periodical literature: Vol. II: K-Z"; pp. 638-650; American Chemical Society, Washington, DC (1965).	Zr, Px, -90 to 110 °C.	B
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84LUD/BUC:	Luder, J.; Buck, A.; "Partial condensation of gaseous mixtures of CO_2-NH_3-H_2O"; Chimia; *38, 321 (1984).	Pv, 165-180 °C, 68 to 131 bar	B
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80MAT/DES:	Mather, A. E.; Deshmukh, R. D.; "Phase equilibria in aqueous electrolyte solutions"; Am. Chem. Soc. Symp. Ser. No. 133; pp. 49-59 (1980)	Zc, Kk, Pv, 100 °C.	B

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22MAT/FRE:	Matignon, C.; "La preparation synthetique de l'uree a partir de l'ammoniaque"; Frejacques, M.; Ann. Chem. *17, 257 (1922)	Kk, Pv, 100-150 °C.	B
22MAT/FRE2:	Matignon, C.; Frejacques, M.; "Etude de la transformation du carbamate d'ammonique"; Bull. Soc. Chim.; *31, 394 (1922)	Kk, Pv, 100-150 °C.	B
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25MEZ/PAY:	Mezger, R.; Payer, T.; "Kohlensaure Ammoniumverbindungen"; GWF, Gas. Wasserfach; *68, 651 (1925)	Pv, 10-40 °C. 5 to 68 mmHg.	B
25MEZ/PAY2:	Mezger, I. R.; Payer, P. T.; "Kohlensaure Ammoniumvergindungen"; GWF, Gas. Wasserfach; *68, 687 (1925)	Pv, 10-40 °C. 5 to 68 mmHg.	B
66MOS:	Mostofin, A. A.; "Calculation of the effects of pH and specific electrolytes in gaseous solutions of NH_3 and CO_2"; Vodn. Rezhim. Khim. Kont. Paros. Ustand. Moscow; *2, 178 (1966)	Zc, Kk, 25 °C, pH = 4-12.	B
57MUH/MON:	Muhlbauer, H. G.; Monaghan, P. R.; "Sweetening natural gas with ethanolamine solutions"; Oil Gas J.; *55, 139 (1957)	Pv, 25-100 °C. in ethanolamine sols.	A
77NAS/MAT:	Nasir, P.; Mather, A. E.; "The measurement and prediction of the solubility of acid gases in monoethanolamine solutions at low partial pressures"; Can. J. Chem. Eng.; *55, 715 (1977)	Pv, 80 and 100 °C, in monoethanolamine sols.	A

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64ORA/GAM:	Oratovskii, V. I.; Gamol'skii, A. M.; Klimenko, N.N.; "Composition of the saturated vapor over aqueous ammonium sulfide solutions at high temperatures";J. Appl. Chem. USSR (Eng. Trans.); *37, 2363 (1964)	Kk, Pv, 70-90 °C.	C
64OTH/FRO:	Othmer, D. F.; Frohlich, G. J.; "Carbon dioxide and ammonia in aqueous ammonium nitrate solutions"; Ind. Eng. Chem. Proc. Des. Dev.; *3, 279 (1964)	Kk, Pv, 90-150 °C, in aqueous ammonium nitrate sols.	B
59OTS/HIR:	Otsuka, E. N.; Hirose, E.; Mitsunaga, M.; "Equilibrium pressure of urea synthesis"; Koatsu Gasu Kyokashi; *23, 534 (1959)	Pv, 120-230 °C.	B
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60OTS/TAK:	Otsuka, E.; Takahashi, T.; "Equilibrium in the system Na_2CO_3-NH_3-CO_2-H_2O"; Kogyo Kogaku Zasshi; *63, 1218 (1960)	Pv, 71-161 °C.	B
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82OWE/CUN:	Owens, J. L.; Cunningham, J.R.; Wilson, G. M.; 'Vapor-liquid equilibria for sour water systems with inert gases present', Research Report RR-52; Gas Producer's Association, Tulsa, OK (1982).	Kk, Pv, 100-400 °F, CO, CH_4, N_2, and H_2 also added to mixture.	D
83OWE/CUN:	Owens, J. L.; Cunningham, J. R.; Wilson, G. M.; 'Vapor liquid equilibria for sour water systems at high temperatures', Research Report RR-65; Gas Producer's Association, Tulsa, OK (1983).	Pv, 200-500 °F.	B,C,D
70PAT/LEB:	Patrikeev, V. S.; Lebedeva, G. N.; "Phase equilibrium of the ammonia-hydrogen sulfide-water system"; Khim. Prod. Koks. Uglev. USSR; *6, 3 (1970)	Pv, 70-90 °C.	C
82PAW/NEW:	Pawlikowski, E. M.; Newman, J.; Prausnitz, J. M.; "Phase equilibria for aqueous solutions of ammonia and carbon dioxide"; Ind. Eng. Chem. Proc. Des. Dev.; *21, 764 (1982)	Kk, Pv, 100 and 150 °C, measurements also done in aqueous KNO_3 and K_2SO_4.	B
83PAW/NEW:	Pawlikowski, E. M.; Newman, J.; Prausnitz, J. M.; "Vapor-liquid equilibrium calculations for aqueous mixtures of volatile, weak electrolytes and other gases for coal-gasification processes"; Chemical Engineering Thermodynamics, pp. 323-337, Ann Arbor Science Publishers, Ann Arbor, Michigan (1983)	Zc, Kk, Pv, 80 °C	C
38PEX/BAD:	Pexton, S.; Badger, E. H. M.; "Vapour pressures of ammonia and carbon dioxide in equilibrium with aqueous solutions"; J. Soc. Chem. Ind. London; *57, 106 (1938)	Pv, 20-90 °C.	A,B,C,D
73RAT:	Rathgeb, K.; "Untersuchung des Gas-Flüssigkeits - Gleichgewichts CO_2-NH_3-H_2O Urea", Dissertation, Eidgenössischen Technischen Hochschule, Zürich, 1973	Pv	B
75RAT/BUC:	Rathgeb, K.; "Fluide Mischphasen und Phasengleichgewicht"; Buck, A.; Chimia, *29, 434 (1975)	Pv, 160 °C.	B

80REN:	Renon, H.; "Representation of NH_3-H_2S-H_2O, NH_3-SO_2-H_2O, and NH_3-CO_2-H_2O vapor-liquid equilibria"; Am. Chem. Soc. Symp. Ser. No. 133; pp. 173-186 (1980)	Zc, Da, Kk, Pv, 20-120 °C.	B,C
82ROB/HUA:	Robinson, D. B.; Huang, S.-S.; Leu, A.-D; Ng, H.-J.; 'The phase behavior of two mixtures of methane, carbon dioxide, hydrogen sulfide, and water', Research Report RR-57, Gas Producer's Association, Tulsa, OK; (1982).	Kk, Pv, 37.8 to 204 °C, 0.4 to 18.5 MPa, methane also present.	A
76SCH:	Schmidt, D. A.; "Enthalpie/Zusammensetzungs-Diagramm fur Dresitoff systeme am Beispiel des Systems $NH_3/CO_2/H_2O$"; Chem. Ing. Tech.; *48, 577 (1976)	Zc, Vt, 30-95 °C.	B
80SZA:	Szarawara, J.; Piotrowski, J.; Zolotajkin, M.; "Equilibrium pressures over the system NH_3-CO_2-H_2O-urea"; Zesz. Nauk. Poltech. Slask. Chem.; *677, 43 (1980)	Zc, Pv, 170-210 °C, L = 2 to 6, W = 0 to 1.2.	B
73SZA/BUC:	Szarawara, J.; Buczek, Z.; "Examination of the phase equilibria in the system H_3O-CO_2-NH_3-$CO(NH_2)_2$ from 20 to 80 ~C"; Przem. Chem.; *52, 691 (1973)	Pv, 20-80 °C.	B
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79SZA/PIO2:	Szarawara, J.; Piotrowski, J.; Zolotajkin, M.; "Partial molar volumes of urea in solutions of NH_3-CO_2-H_2O-urea"; Zesz. Nauk Politech. Slask.; *87, 13 (1979)	Xd, 20-50 °C.	B
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62TAK/YOS:	Takahashi, T.; Yoshimura, S.; Fujii, K.; Otsuka, E.; "Equilibrium pressures of ammonia, carbon dioxide, and water"; Kogyo Kagaku Zasshi; *65, 743 (1962)	Kk, Pv, 63-173 °C.	B

80TAL:	Talwalker, A. (editor): "Preparation of a coal conversion systems technical data book"; Institute of Gas Technology, Chicago, Illinois (1980)	Zc, Pv, Kk	D
57TER/ATT:	Terres, V. E.; Attig, W.; Tscherter, F.; "Zur Kenntnis der Vorgange ei der Ammoniak-wasche von Steinkohlenrohgas und der Ammoniakwasser-Konzentration"; GWF, Gas. Wasserfach; *98, 512 (1957)	Pv, 10-40 °C.	B
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28TER/BEH:	Terres, E.; Behrens, H.; "Zur Kenntnis der physikalisch-chemischen Grundlagen der Harnstoffsynthese aus Ammoniak, Kohlensaure und Wasser"; Z. Phys. Chem. (Leipzig); *139A, 695 (1928)	Pv, 0-135 °C.	B
20TER/WEI:	Terres, V. E.; Weiser, H.; "Determination of the partial and total pressures of aqueous solutions of NH_3-CO_2 and their application to ammonia scrubbing and the concentration of ammoniacal liquor"; J. Gasbel.; *63, 705 (1970) (1920)	Pv, 20-95 °C.	B
21TER/WEI:	Terres, V. E.; Weiser, H.; "Beitrag zur Kenntnis der Amoniak-Kohlensaure-Verbindungen im Gleichgewicht mit ihren Wässerigen Lösungen"; Z. Electrochem.; *27, 25 (1921)	Px, 0-60 °C	B
34TOK:	Tokuoka, M.; "On urea synthesis from carbon dioxide and ammonia"; Nippon Nogei Kagaku Kaishi; *10, 1333 (1934)	Kk, 72-160 °C.	B
35TOK:	Tokuoka, M.; "On urea synthesis from carbon dioxide and ammonia Part II"; Nippon Nogei Kagaku Kaishi; *11, 107 (1935)	Kk, 130-160 °C.	B

35TOK2:	Tokuoka, M.; "On urea synthesis from carbon dioxide and ammonia Part III"; Nippon Nogei Kagaku Kaishi; *11, 174 (1935)	Kk, 130-160 °C.	B
59TOS/FIE:	Tosh, J. S.; Field, J. H.; Benson, H. E.; Anderson, R. B.; "Equilibrium pressures of hydrogen sulfide and carbon dioxide over solutions of potassium carbonate"; U.S. Bur Mines Rep. Invest. No. 5622; 25 pp. (1959)	Pv, 70-130 °C.	A
73TRY:	Trypuc, M.; "Examination of the equilibrium of the system $KCl-NH_3-CO_2-H_2O$ in the presence of urea at 30 °C"; Chem. Stosow; *17, 135 (1973)	Px, 30 °C.	B
75TRY:	Trypuc, M.; "Examination of the equilibrium of the system $KCl-NH_3-CO_2-H_2O$ and $KNO_3-NH_3-CO_2-H_2O$ at the triple point"; Chem. Stosow; *25, 177 (1975)	Px, 20-40 °C, in KCl and KNO_3 sols.	B
81TRY:	Trypuc, M.; "Examination of the equilibrium of the system $NaCl-NH_3-CO_2-H_2O$ in the presence of urea at 30 °C"; Chem. Stosow; *25, 95 (1981)	Px, 30 °C, in KCl and $NaHCO_3$ sols.	B
81TRY2:	Trypuc, M.; "Examination of the equilibrium of the system $NaCl-NH_3-CO_2-H_2O$ at 30 °C. and a urea molality of 8.26 mol kg^{-1} at the crystallization point of $NaHCO_3$"; Chem. Stosow; *25, 261 (1981)	Px, 30 °C, in KCl and $NaHCO_3$ sols.	B
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80TSE:	Tseitlin, M. A.; "On the calculation of vapor-liquid equilibria for the system $NH_3-CO_2-H_2O-NaCl$"; Zh. Prikl. Khim. (Leningrad); *53, 2343 (1980)	Zc, Pv, 60 °C.	B

56TSI/KOF:	Tsiklis, D. S.; Kofman, A. N.; "Solubility of carbon dioxide in carbonated copper-ammonia solutions"; Khim. Promst. (Moscow); *14, 398 (1956)	Pv, 0-60 °C.	B
57TSI/KOF:	Tsiklis, D. S.; Kofman, A. N.; "Partial pressures of ammonia, water, and carbon dioxide over carbonated copper ammonia solutions"; Khim. Promst. (Moscow); *15, 277 (1957)	Pv, 10-60 °C.	B
83TU/CHA:	Tu, H. S.; Chang, R. A.; Selleck, F. T.; "Three phase equilibria computation in hydrocarbon-sour water processing"; Chemical Engineering Thermodynamics, pp. 405-416, Ann Arbor Science Publishers, Ann Arbor, Michigan (1983)	Zc, Kk, Pv, 322 K	C
79VER:	Verbrugge, P.; "Vapor-liquid equilibria of the ammonia carbon dioxide-water system"; Delft University Press, The Netherlands; (1979).	Zc, Kk, Pv, 40-90 °C, pressures up to 0.1 MPa.	B
65VLA/SHO:	Vlasov, V. F.; Shokin, I. N.; Krasheninnikov, S. A.; "Investigation of the equilibria in the gas phase over solutions containing carbon dioxide, ammonia, and sodium carbonate"; Tr. Mosk. Khim. Teknol.; pp. 52-55 (1965)	Pv, 100-180 °C, in the presence of Na_2CO_3.	B
63WIC:	Wicar, S.; "Calculation of vapour-liquid equilibrium in the system urea, ammonia, carbon dioxide, and water"; Brit. Chem. Eng.; *8, 818 (1963)	Zc, Kk, Pv, 60-160 °C.	B
78WIL:	Wilson, G. M.; "A new correlation of NH_3, CO_2, and H_2S volatility data from aqueous sour water systems"; API Publication 955, American Petroleum Institute, Washington, DC; (1978).	Zc, Kk, Pv, 20-140 °C, 0 to 50 psia.	A,B,C,D
80WIL:	Wilson, G. M.; "A new correlation of NH_3, CO_2, and H_2S volatility data from aqueous sour water systems"; Report to U.S. Environmental Protection Agency, EPA-600/2-80-0679; Ada, OK (1980).	Zc, Kk, Pv, 20-140 °C, 0 to 50 psia.	A,B,C,D

78WIL/OWE:	Wilson, G. M.; Owens, R. S.; Roe, M. W.; "Sour water equilibria: ammonia volatility down to ppm levels effect of electrolytes on ammonia volatility pH vs. composition"; Research Report RR-34; Gas Producers Association, Tulsa, OK (1978).	Kk, Pv, 25-120 °C.	B,C,D
80WIL/OWE:	Wilson, G. M.; Owens, R. S.; Roe, M. W.; "Sour water equilibria"; Am. Chem. Soc. Symp. Ser. No. 133; pp. 187-226 (1980)	Kk, Pv, 25-120 °C.	B
83WON:	Won, K. W.; "Sour-water stripper efficiency"; Plant/Operations Progess; *2, 108 (1983)	Zc, Kk, 205-250 °C	C
28YAK:	Yakovkin, G. A.; "On the synthesis of carbamate from ammonia and carbon dioxide"; Zh. Prikl. Khim. (Leningrad); *1, 69 (1928)	Kk, 130-200 °C.	B
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75YAN/HAR2:	Yanagisawa, Y.; Yano, M.; Marano, Y.; Imoto, T.; "Vapor liquid equilibrium for quarternary system of urea-ammonia carbon dioxide-water"; Nippon Kagaku Kaishi; *6, 976 (1975)	Pv, 100-150 °C.	B
67ZAI/FUR:	Zaitsev, V. N.; Furmer, I. E.; Kuznetsov, D. A.; "Investigation of equilibrium in the system cuprammonium acetate carbonate solution-carbon monoxide"; J. Appl. Chem. USSR (Eng. Trans.); *40, 1463 (1967)	Pv, 0-60 °C, in sols containing Cu^+, Cu^{2+}, and CO.	B

80ZEM:	Zemaitis, J. F.; "Predicting vapor-liquid-solid equilibria in multicomponent aqueous solutions of electrolytes"; Am. Chem. Soc. Symp. Ser. No. 133; pp. 227-246 (1980)	Zc, Kk, Pv, 80 °C	B
40ZHA/CHA:	Zhaveronokov, N. M.; Chagunava, V. T.; "On the solubility of carbon dioxide and carbonate formation in copper ammonia solutions"; Zh. Khim. Prom.; *17, 25 (1940)	Pv, 0-80 °C, in sols containing Cu^+, Cu^{2+}, and HCOOH.	B
75ZIN/ZIN:	Zinov'ev, G. N.; Zinov'eva, L. K.; Kucheryavyi, V. I.; "Specific heats of urea - ammonium carbamate ammonia - water mixtures at 25°"; J. Appl. Chem. USSR (Eng. Trans.); *98, 2730 (1975)	Ql, 25 °C.	B

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