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Report of Committee on Atomic Weights

BY G. E. F. LUNDELL, *Chairman*

The following pieces of work have been reported since the material was gathered for the Report which was published in *Chemical and Engineering News*, **26**, 1619 (1948), and reprinted in the *Journal of the American Chemical Society*, **70**, 3531 (1948).

Cerium and Lanthanum.—Inghram, Hayden and Hess[1] determined the isotopic constitution of cerium and of lanthanum by means of a mass spectrometer.

The abundances of the cerium isotopes of masses 136, 138, 140 and 142 were shown to be 0.193 ± 0.005, 0.250 ± 0.005, 88.48 ± 0.10, and 11.07 ± 0.01%, respectively. Calculation of the chemical atomic weight of cerium from these abundances, assuming a packing fraction of -3.0×10^{-4}, and the factor 1.000275 in converting from physical to chemical atomic weights, gives 140.10, a value which is in agreement with the chemically determined International value of 140.13.

The abundances of the lanthanum isotopes of masses 138 and 139 were found to be 0.089 ± 0.001 and 99.911 ± 0.001%, respectively. Calculation of the chemical atomic weight from these abundances, using Dempster's value[2] of -3.2×10^{-4} for the packing fraction and the conversion factor 1.000275, gives 138.92, a value which is in complete agreement with the chemically determined International value of 138.92.

Neodymium and Praseodymium.—Inghram, Hess and Hayden[3] determined the isotopic constitution of neodymium and of praseodymium by means of a mass spectrometer.

The abundances of the neodymium isotopes of masses 142, 143, 144, 145, 146, 148 and 150 were found to be 27.13 ± 0.2, 12.20 ± 0.1, 23.87 ± 0.2, 8.30 ± 0.05, 17.18 ± 0.2, 5.72 ± 0.06 and 5.60 ± 0.06%, respectively. Assuming a packing fraction of -2.7×10^{-4}, and with the conversion factor 1.000275, the chemical atomic weight is 144.25, which is in good agreement with the International chemical value of 144.27.

Assuming a packing fraction of -3.0×10^{-4} for praseodymium with its single isotope at mass 141, and with the conversion factor 1.000275, the chemical atomic weight is 140.92, which is in complete agreement with the International value of 140.92.

Samarium.—Inghram, Hess and Hayden[4] determined the isotopic composition of samarium.

The abundances of the samarium isotopes of masses 144, 147, 148, 149, 150, 152 and 154 were found to be 3.16 ± 0.10, 15.07 ± 0.15, 11.27 ± 0.11, 13.84 ± 0.14, 7.47 ± 0.07, 26.63 ± 0.26 and 22.53 ± 0.22%, respectively. Calculation of the chemical atomic weight from these abundances, assuming a packing fraction for samarium of -2.4×10^{-4}, and with the conversion factor 1.000275, gives a value of 150.35. The International value is 150.43.

Cadmium and Zinc.—Leland and Nier[5] determined the relative abundances of the isotopes of cadmium and of zinc. The abundances of the cadmium isotopes of masses 106, 108, 110, 111, 112, 113, 114 and 116 were found to be 1.215, 0.875, 12.39, 12.75, 24.07, 12.26, 28.86 and 7.58% respectively. By using a packing fraction of -6.0×10^{-4} and the conversion factor 1.000275, the calculated value of the chemical atomic weight is 112.42, which agrees very well with the International chemical value of 112.41.

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[1] Mark G. Inghram, Richard J. Hayden and David C. Hess, Jr., *Phys. Rev.*, **72**, 967–970 (1947).

[2] A. J. Dempster, *ibid.*, **33**, 869 (1938).

[3] Mark G. Inghram, David C. Hess, Jr., and Richard J. Hayden, *ibid.*, **74**, 98–99 (1948).

[4] Mark G. Inghram, David C. Hess, Jr., and Richard J. Hayden, *ibid.*, **73**, 180 (1948).

[5] Wallace T. Leland and Alfred O. Nier, *ibid.*, **73**, 1206–1207 (1948).

The relative abundances of the isotopes of zinc of masses 64, 66, 67, 68 and 70 were found to be 48.89, 27.81, 4.07, 18.61 and 0.620%, respectively. With a packing fraction of -7.0×10^{-4} and the conversion factor 1.000275, the computed chemical atomic weight is 65.40, whereas the International chemical value is 65.38.

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[CONTRIBUTION FROM DEPARTMENT OF CHEMISTRY, STATE COLLEGE OF WASHINGTON, AND DIVISION OF INDUSTRIAL RESEARCH, WASHINGTON STATE INSTITUTE OF TECHNOLOGY]

The System Aluminum Sulfate–Sulfuric Acid–Water at 60°

BY JACK L. HENRY[1] AND G. BROOKS KING

This report is part of a study of the more extensive system aluminum oxide–sulfur trioxide–water at 60° which is being investigated in connection with the development of an alumina-from-clay extraction process. The temperature 60° has been found most advantageous for the process as determined with laboratory scale and pilot plant extraction towers.[2] Although the leach operations are carried on within the basic region, it was felt desirable to conduct a study of the system in its entirety. In connection with the acid system presented in this paper, no complete ternary systems have been reported. F. Wirth[3] has studied the solubility of aluminum sulfate in sulfuric acid solutions of concentrations up to 75% at 25° and has reported but one solid phase, the 18 hydrate. At the same temperature Motida[4] has found the 16 hydrate in addition to the 18 hydrate, but presented no data for sulfuric acid concentrations above 48%. Kremann and Hüttinger[5] in their work on the solubility of freshly precipitated aluminum hydroxide in aluminum sulfate solutions report that the 16 hydrate exists as the solid phase in the less basic region at 20, 40 and 60°. This would seem to be in agreement with the views of P. M. Delacharlonny,[6] who favors the 16 hydrate. Horan and Skarulis,[7] however, failed to prepare the 18 hydrate and suggest the possibility of $Al_2(SO_4)_3 \cdot 17H_2O$ at the temperature 0°. Following this work, N. O. Smith,[8] by repeating at 25° the parts of three ternary systems which involve hydrated aluminum sulfate as the solid phase, showed further evidence in favor of the 17 hydrate. The following hydrates of aluminum sulfate have been found reported in the literature: 2, 3, 6, 9, 10, 12, 14, 16, 17, 18, 22, 24 and 27. That they are all true chemical individuals, however, seems questionable. The present paper treats the system over sulfuric acid concentrations up to 96.08% and shows the presence of the four solid phases at 60°: $Al_2(SO_4)_3 \cdot 16H_2O$, $Al_2(SO_4)_3 \cdot 9H_2O$, $Al_2(SO_4)_3 \cdot 3H_2SO_4 \cdot 12H_2O$ and $Al_2(SO_4)_3$.

Experimental

Materials and Apparatus.—Mallinckrodt analytical reagent aluminum sulfate and sulfuric acid were employed throughout the system. Aluminum sulfate was recrystallized from a solution of specific gravity about 1.33 as suggested by Horan and Skarulis.[7] Extensive solubility studies on the system at 60° showed, however, that any deviations caused by impurities present in the unrecrystallized reagent could not be detected by the analytical methods used. Because of the high percentage of waste involved in recrystallization and the large amount of aluminum sulfate used, the unrecrystallized salt was employed in more than half the studies.

An electrically controlled thermostat which held the temperature at 60 ± 0.1° was employed. Evaporation loss from the bath was limited by a fabricated sheet aluminum cover. Glass-stoppered Pyrex tubes of about 40-ml. capacity which held the solutions under investigation were fitted with cotton-filled caps and secured to a wheel which rotated continually beneath the water surface of the bath. Such tumbling action provided efficient agitation during the time required for the solutions to reach equilibrium.

Methods of Analysis.—Aluminum sulfate was determined gravimetrically as Al_2O_3 by ignition at 1150°. Sulfuric acid was titrated directly in the presence of aluminum sulfate with standard sodium hydroxide solution. The aluminum which was combined in a complex by use of an excess of sodium oxalate[9] did not interfere with the titration. In regions of low sulfuric acid concentration the titrations were carried out electrometrically, whereas phenol red indicator was used at higher concentrations. The volumetric method for sulfuric acid gave satisfactory checks against the gravimetric barium sulfate procedure and proved to be much more rapid.

Solubility Determinations.—Various mixtures of aluminum sulfate, sulfuric acid and water were weighed out approximately and placed in the described tubes. The mixtures were brought to equilibrium from the supersaturated condition in most cases. Tubes were removed from the wheel at intervals and samples taken for analysis to determine the progress in attainment of equilibrium. Time for establishment of equilibrium conditions increased with increasing sulfuric acid concentration. Equilibrium was attained in the less acidic regions within forty-eight hours, but in no case did the time exceed six days. At lower sulfuric acid concentrations the crystals, although quite small, separated quickly and completely. Above 50% sulfuric acid the equilibrium mixture proved difficult to handle in that the resulting viscous slurries failed to separate well into liquid and solid phases. A constant temperature centrifuge was designed and built in which the samples could be centrifuged at 60 ± 0.1°. This incor-

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(1) Submitted in partial fulfillment of the requirements for the Ph.D. degree, the State College of Washington.

(2) *Ind. Eng. Chem.*, **38**, 1181 (1946).

(3) F. Wirth, *Z. anorg. Chem.*, **79**, 360 (1912).

(4) Motida, *Science Repts. Tohôku Imp. Univ.*, First Ser., **26**, 611–617 (1938).

(5) R. Kremann and K. Hüttinger, *Jahrbuch d. k. k. geol. Reichsanstalt. Wien*, **58**, 637 (1908).

(6) P. M. Delacharlonny, *Compt. rend.*, **96**, 844 (1883).

(7) Horan and Skarulis, THIS JOURNAL, **61**, 2689 (1939).

(8) N. O. Smith, *ibid.*, **64**, 41 (1942).

(9) M. F. Adams (not yet published), presented at American Chemical Society regional meeting, Seattle, Washington, 1945.