

samarium, praseodymium, neodymium, gadolinium, ytterbium gave a series of bands.

Spectrograms were also taken with a spark passing through the flame directly over the inner cone. A Thordarson 1 kilowatt 20,000-volt transformer was used. The spark gap electrodes were made of 1 mm tungsten wire. The condenser was made with two 600 cc beakers used as Leyden jars. The auxiliary spark gap used by Hultgren was omitted. The photographic plates showed the same bands as in the flame alone but the time of exposure was considerably shortened. Solutions of the acetate, nitrate, chloride and sulfates were used all giving the same bands insofar as we were able to ascertain. A Hilger constant deviation spectrograph with a low dispersion prism was used.

With LaCl_3 , 19 bands were observed with heads at 4372, 4379, 4383, 4418, 4423, 4428, 4433, 4437, 4442, 5378, 5403, 5428, 5600, 5628, 5650, 5675, 5706, 5923, and 5957A. These bands were obtained in the spectrum of LaO reported by Meggers and Wheeler² in their paper in which they report some 300 band heads.

With PrCl_3 seven bands with heads at 6015, 5950, 5755, 5743, 5715, 5685, 5528, and a sharp line at 4223 were observed.

Neodymium acetate gave 26 bands with heads at 4369, 4377, 5475, 5565, 5625, 5973, 5993, 6010, 6266, 6278, 6295, 6347, 6365, 6382, 6415, 6425, 6441, 6460, 6492, 6513, 6533, 6546, 6580, 6598, 6623, and 6647.

SmCl_3 gave bands at 4338, 4444, 5520, 5617, 5808, 5818, 5847, 5868, 5908, 5924, 5947, 5964, 5983, 6015, 6032,

6047, 6066, 6087, 6108, 6138, 6150, 6163, 6182, 6223, 6242, 6253, 6333, 6344, 6388, 6405, 6417, 6455, 6480, 6506, 6528, 6553, 6575, 6615, 6646, 6679, and 6702.

GdCl_3 gave 16 bands at 6232, 6214, 6192, 6171, 6147, 6126, 6098, 6077, 6055, 5982, 5952, 5935, 5917, 5676, 5692, 5662.

YbCl_3 gave bands which were very fuzzy at 4682, 4768, 4858, 4985, 5183, 5340, 5460, 5542, 5758, 5867, 6540. A line at 5556 and a doublet at 3986-3988 were also observed.

With YCl_3 Megger's and Wheeler's² system III transition ${}^2\Pi_1 - {}^2\Sigma_1$ and system $V {}^2\Pi_1 - {}^2\Pi_1$ with the heads at 5972 and 6132 respectively were the most prominent. Weaker bands at 4650, 4676, 4706, 4817, 4842, 5694, 5714, 5730, 5747, 5764, and 5783 were also obtained. Piccardi³ has obtained bands with La_2O_3 , Pr_2O_3 , Nd_2O_3 and Sm_2O_3 which he attributes to the MO molecule, M being the rare earth metal. Since the spectrograph used had low dispersion, no analysis of the bands was attempted.

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² Meggers and Wheeler, Bur. Standards J. Research **6**, 239 (1931).

³ Piccardi, Nature **124**, 129 (1929).

The Concentration of H^3 and O^{18} in Heavy Water

A large amount of work in recent years on the two well-known hydrogen isotopes has led to much speculation on the existence of a third isotope of mass 3. Lewis and Spedding¹ concluded that ordinary hydrogen contained less than one part of H^3 in six million. Since then Latimer and Young,² using the magneto-optic method of Allison, have found evidence for this isotope in 2 percent heavy water. An attempt has been made to confirm this conclusion with the mass-spectrograph without success. The results are presented graphically in Fig. 1. The partial pressure of deuterium as measured by the intensity of the $(\text{H}^2\text{H}^2)^+$ peak is plotted horizontally and the ordinates represent the intensity of some other peak divided by this partial pressure. This procedure has been described at some length in a previous paper.³ The upper curve represents this relation for the triatomic ion $(\text{H}^2\text{H}^2\text{H}^2)^+$ of mass 6. Since the experimental points may be accurately fitted to a straight line passing through the origin this curve constitutes a proof that at low pressures the number of triatomic ions formed is proportional to the square of the pressure. In previous work this fact was assumed without proof in this method of analysis. It is significant also that the experimental points for this curve were obtained from three different samples varying in concentration from 70 to 98 percent deuterium.

Curves II and III represent in a similar way the data for ions of mass 5 which may exist both as $(\text{H}^2\text{H}^3)^+$ and

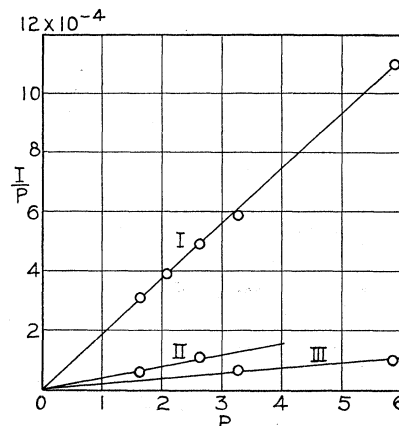


FIG. 1.

$(\text{H}^2\text{H}^2\text{H}^2)^+$. The intercept on the vertical axis should give the abundance ratio $\text{H}^2\text{H}^3 : \text{H}^2\text{H}^2$ which within the limits

¹ G. N. Lewis and F. H. Spedding, Phys. Rev. **43**, 964 (1933).

² W. M. Latimer and H. A. Young, Phys. Rev. **44**, 690 (1933).

³ W. Bleakney, Phys. Rev. **41**, 32 (1932).

of measurement is zero. The hydrogen which yielded the data for curve II was prepared by dissociating heavy water on hot iron and on analysis showed a concentration of 91 percent deuterium. The sample for curve III was obtained by electrolysis of nearly pure heavy water and in this case a concentration of 98 percent was found. These two curves do not coincide because as we go to samples richer in deuterium there is less chance of the formation of triatomic ions of mass 5. From these results we conclude that $H^3 : H^2$ is less than one in 10^5 in the samples tested. This means that in ordinary hydrogen $H^3 : H^1$ is less than one in 5×10^8 if we take our previous value⁴ for the $H^2 : H^1$ ratio of 1 : 5000 and assume there has been no fractionation at all between H^3 and H^2 upon electrolysis of water. Actually, we would expect some separation so that H^3 must be extremely rare in natural hydrogen. Since the great sensitivity claimed for the magneto-optic method reaches considerably beyond this limit there is no essential contradiction between the conclusions of Latimer and Young and those presented here.

From the same cell which yielded 98 percent electrolytic deuterium a sample of oxygen was collected and examined for increased concentration of the O^{18} isotope. A control run was carried out at the same time with electrolytic oxygen from ordinary water. No increase in the $O^{18} : O^{16}$ ratio could be observed although a ten percent change should have been detectable. We are unable to reconcile this result with the work of Washburn, Smith and Frandsen.⁵

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⁴ W. Bleakney and A. J. Gould, Phys. Rev. **44**, 265 (1933).

⁵ E. W. Washburn, E. R. Smith and M. Frandsen, Bur. Standards J. Research **11**, 453 (1933).

About the Production of "Colloidal Single Crystals"

Professor K. S. Krishnan¹ has recently pointed out that the method employed by us^{2,3} to fix small suspended particles of anisotropic substances in a position of mutual crystallographic parallelity fails in case of graphite. This objection is perfectly justified by the fact that we have not yet published the method in detail. In order to avoid similar doubts it may thus be mentioned in which way it is possible to line up small particles of a crystalline sub-

stances up in a liquid suspending medium when exposed to a magnetic field *only with reference to one direction*—one of the directions of maximum paramagnetism—, i.e., for graphite the (0001) planes will be parallel to the lines of force, though the axis [0001] can be orientated in any azimuthal direction. This azimuthal orientation can be



FIG. 1.

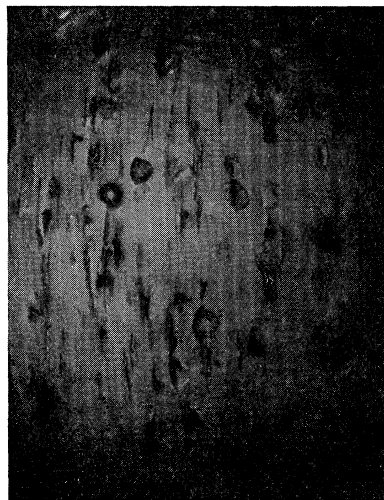


FIG. 2.

stance which has more than *one* axis of maximum paramagnetism, like graphite (in contradistinction to, for instance Bi, where there is more than one direction of maximum diamagnetism but only one of maximum paramagnetism [111]). Particles of the former type will line

¹ K. S. Krishnan, Phys. Rev. **45**, 115 (1934).

² A. Goetz, A. B. Focke and A. Faessler, Phys. Rev. **39**, 169, 553 (1932).

³ A. Goetz and A. Faessler, Phys. Rev. **40**, 1053A (1932).