low, and at 0.15° it was 22 percent too low. It should be pointed out that the deviations occur at temperatures where thermal equilibrium is more difficult to attain and that they may possibly be due to this effect. Also it is more difficult to obtain accurate derivatives at the end of the curve. It had been expected that the estimates of temperature on the Curie scale would be too high.

During energy input the temperature of the gold induction heater was considerably above that of the calorimeter but since it had to start operating at the low temperature it was possible to conclude that gold is not a superconductor above 0.15°K. Kurti and Simon[5] have recently found that it is still not a superconductor at 0.05° (Curie-$Fe(NH_4)(SO_4)_2 \cdot 12H_2O$).

Since the above deviation from Curie's law is in a ferromagnetic direction, measurements were made to detect any permanent magnetism in gadolinium phosphomolybdate. None was found at any temperature to within an accuracy of 1/5000 of the saturation magnetic moment.

Gadolinium nitrobenzene sulfonate, $Gd(C_6H_4NO_2SO_3)_3 \cdot 7H_2O$ and gadolinium anthraquinone sulfonate, $Gd(C_{14}O_2H_7SO_3)_3 \cdot \chi H_2O$ were investigated in terms of their Curie scales. Their properties lie between those of the sulfate and phosphomolybdate as would be expected from the comparative dilution of the magnetic atoms.

All susceptibilities were independent of frequency to 1000 cycles per sec. Possible hysteresis was investigated calorimetrically with a frequency of 550 cycles per sec. Expressed in terms of the energy transferred to the substance at the maximum of the sine wave, approximately 5 parts in 10,000 were converted to heat at 0.15°. At 0.35°, and above, the effect was less than 5 parts in 100,000 which was the limit of accuracy. These figures apply to all of the above salts except the sulfate which was not investigated for hysteresis with 550 cycles/sec. None of the substances showed a detectable hysteresis at a frequency of 60 cycles/sec.

W. F. Giauque
D. P. MacDougall
Department of Chemistry, University of California,
Department of Chemistry, Harvard University,
April 16, 1935.

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[1] The results given here were presented at the meeting of the American Chemical Society in affiliation with the American Association for the Advancement of Science, Berkeley, California, June 18–23 (1934).

[2] Giauque and MacDougall, (a) Phys. Rev. **43**, 768 (1933); (b) **44**, 235 (1933).

[3] Hoard, Zeits. f. Kristallographie, **A84**, 217 (1933).

[4] Giauque and MacDougall, J. Am. Chem. Soc., in press.

[5] Kurti and Simon, Nature **135**, 31 (1935).

The Ultraviolet Absorption Bands of Diacetylene

The absorption spectrum of diacetylene was investigated with a small Hilger quartz spectrograph, by using an absorption length of about 130 cm. A discrete absorption of about seventy bands was found in the region of $\lambda\lambda 2900$–1900A. At a pressure of 1 mm or lower the most intensive bands set in at $\lambda 2430$A and extended to the short wavelength limit of the instrument. With increasing pressure, weaker bands in the less refrangible side began to appear until at a pressure of 250 mm the system extended to $\lambda 2860$A; while in the more refrangible side, the bands broadened to an apparent continuum. Part of the bands are degraded to the red.

The gross structure of the system shows a marked resemblance with the ultraviolet system of dicyanogen.[1] Three distinctive progressions approximately 2100 cm^{-1} apart can be assigned:

(I)		(II)		(III)	
$\nu(cm^{-1})$	$\Delta\nu$	$\nu(cm^{-1})$	$\Delta\nu$	$\nu(cm^{-1})$	$\Delta\nu$
41149		41276		41521	
	2113		2133		2084
43262		43409		43605	
	2091		2104		2058
45353		45513		45663	
	2065		2073		
47418		47586			

The bands of these progressions are considered to be due to transitions from the same vibrational level (presumably the vibrationless level) in the ground state to an excited electronic state, (I) with successive excitation of the symmetrical longitudinal vibration ($\nu' \sim 2100$ cm^{-1}) alone, (II) in addition to the successive longitudinal vibration with one quantum excitation of probably the asymmetrical deformation oscillation ($\nu' \sim 130$ cm^{-1}), and (III) in addition to the successive longitudinal vibration with one quantum excitation of probably the symmetrical deformation vibration ($\nu' \sim 370$ cm^{-1}). The resemblance of the structure of diacetylene and dicyanogen has been pointed out by Mecke[2] and his collaborators through an investigation of the infrared and Raman spectra. It is to be pointed out here, that the isosterism between these two compounds is also markedly shown by a comparison of their ultraviolet bands. Because of the complexity of this spectrum, a more detailed investigation with higher dispersion as well as at different temperatures is in progress. A detailed report will appear soon elsewhere.

Sho-Chow Woo
T. C. Chu
National Research Institute of Chemistry
Academia Sinica, Shanghai, China.
April 19, 1935.

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[1] S. C. Woo and R. M. Badger, Phys. Rev. **39**, 932 (1932).

[2] R. Mecke, Eucken-Wolf Hand-und-Jahrbuch der Chem. Physik **9**, II, 392 (1934); B. Timm and R. Mecke, Zeits. f. Physik **94**, 1 (1935).

The Ultraviolet Absorption Spectrum of ND_3

I have recently obtained photographs of the absorption spectrum of very pure ND_3, which was given me by Professor H. S. Taylor of Princeton University. A normal incidence vacuum spectrograph with a 120,000 line 4-inch glass grating, one-meter focus, was used. The spectral region covered was from 2300 to 770A. Six plates showing eighteen spectra at a variety of pressures of ND_3 were obtained. The spectrograph itself filled with the gas acted as the absorbing column, and so the effect of temperature on the absorption could not be observed.

The most interesting result of this work will be a detailed quantitative comparison of the spectra of NH_3 and ND_3, in light of the theory of the vibrational isotope effect for such molecules. Unfortunately the measurement and reduction of the plates cannot be begun immediately, but a few qualitative facts may be mentioned which are apparent from an inspection of the plates and enlargements.

In the spectrum of NH_3 reported by the writer in this issue of the *Physical Review,* four v' progressions in different electronic states were found. It appears that the analogs of three of these are present in the ND_3 spectrum. The three 0,0 bands of ND_3 almost coincide with the corresponding bands of NH_3, as would be expected. This may be regarded as additional evidence for the correctness of assignment of the 0,0 bands in NH_3. The fact that none of the other strong band heads and subbands of ND_3 coincide with those of NH_3 is additional confirmation of the high purity of the ND_3. The identification of all the weaker absorption requires, of course, a detailed examination, and some of it may prove to be due to NH_2D and ND_2H or even NH_3.

The strong bands in progressions II and III of ND_3 show differences of about 780 and 760. These were very crudely estimated, but appear to be upper state modifications of ν_1(745,748).[1] The predissociation in progression I appears to start at about the same point in ND_3 as in NH_3.[2] The bands in progressions II and III are very sharp in ND_3 as in NH_3. The rotational fine structure visible in NH_3 is not apparent in ND_3. If the moments of inertia are much larger in ND_3, this may be due to a lack of resolving power. The presence of NH_2D and ND_2H may cause a continuous background also, obscuring the lines of ND_3. This latter effect, if present, does not affect the sharpness of the heads. The subbands are all shaded to the red, as was observed in NH_3.

I am greatly indebted to Professor H. S. Taylor for furnishing the sample of ND_3 which made this work possible.

A. B. F. DUNCAN

Department of Chemistry,
Brown University,
May 15, 1935.

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[1] E. F. Barker and Marcel Migeotte, Phys. Rev. **47**, 702 (1935).

[2] The measurements of Dr. W. S. Benedict (Phys. Rev. **47**, 641 (1935)) in this region, which were not available to the writer, will no doubt provide a more accurate value of the predissociation limit.

The Emission of Negative Electrons from Boron Bombarded by Deuterons

In March, 1935, Professor E. O. Lawrence and Dr. R. L. Thornton informed us, in conversation, that they had obtained some evidence indicating the emission of negative electrons of very high energy from boron bombarded with deuterons, and suggested that they might arise from the reaction

$$B^{11}+H^2\rightarrow B^{12}+H^1\rightarrow C^{12}+e^-+H^1. \qquad (1)$$

We have since carried out an investigation of this question, by means of a cloud chamber, and have found such beta-ray emission. Because of the fact that the beta-ray emission does not persist for an appreciable length of time after bombardment, it was necessary to make the observations during bombardment. The experiment was performed in the following way.

A thin walled tube containing the boron (metal) target was constructed so as to project into the cloud chamber through the glass top plate, near one side of the chamber. Of the useful 180° of the target tube, a section extending around 90° was made thin enough to allow the escape of the protons belonging to the 92-cm group, which is known to result from boron bombarded with deuterons.[1] The other 90° section was about three times that thickness, and allowed only electrons to pass. Ample intensity was obtained by running at 550 kv and about ½ microampere deuteron current to the target. The electron tracks were curved by a magnetic field of 1500 gauss, to determine their energy.

ELECTRON SPECTRUM

In Fig. 1 is shown the energy spectrum obtained from the measurement of 1773 electron tracks. As is evident from the plot, the spectrum is continuous, and similar in form to the usual beta-ray spectrum. The upper energy limit, after adding 0.65 MEV to compensate for the stopping power of the tube surrounding the target, is about 11 MEV. The position of the maximum in the curve is not to be taken seriously, since the geometrical conditions of the experimental set-up were such as to favor, to some extent, the lower energy electrons.

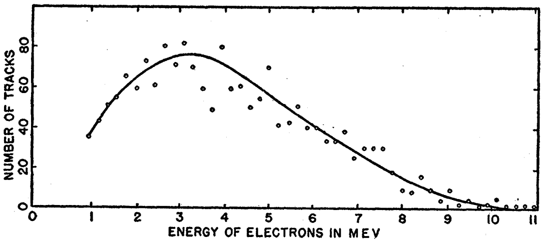

FIG. 1. Energy spectrum of negative electrons from the radioactive isotope B^{12}. To obtain the true energy, 0.65 MEV must be added to compensate for the stopping power of the wall surrounding active substance.

PROTONS

In order to compare the intensity of beta-ray emission with that of some other particle emitted under the same conditions we made a relative count of electrons and 92-cm protons, which were seen to emerge from the thin portion of the target tube. About 20 electrons were observed per proton of the 92-cm group. If we suppose that the beta-rays arise from reaction (1), the proton group associated with the beta-ray emission must necessarily be about 20 times as intense as the 92-cm group. Further, it is known from Cockroft's work that no group of that intensity exists above 10 cm range (2.5 MEV). We may therefore place an upper limit of 2.5 MEV on the energy of the proton in reaction (1).