LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twentieth of the preceding month; for the second issue, the fifth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Communications should not in general exceed 600 words in length.

On the Rotation-Vibration Spectrum of Acetylene in the Photographic Infrared

We have reinvestigated the absorption spectrum of C_2H_2 in the photographic infrared in order to obtain more information about the rotational and vibrational structure of this molecule. Using an absorbing length of 16.5 m and pressures up to 1.6 atmos., we have found 9 new absorption bands and in connection with that have remeasured some bands which were formerly incompletely known. Table I gives the wave-lengths and the wave numbers of the origins of the newly found bands as well as their probable interpretation following the scheme recently proposed by Herzberg and Spinks.[1] Two very weak bands have been added in parentheses, which, because of bad overlapping involve some uncertainty. As is well known C_2H_2 is a *linear* polyatomic molecule. It therefore shows $\parallel$ and $\perp$ bands depending on the direction of the oscillations of the dipole moment. The $\parallel$ bands have P and R branches only, whereas the $\perp$ bands have in addition one strong Q branch. Three of our new bands show Q branches and are therefore $\perp$ bands. For two of these, however, only the heads of the Q branches have been measured so far on account of their weakness. The third $\perp$ band which could be completely resolved and measured is rather interesting because from it information may be derived about the doubling of the degenerate upper state. This, according to theory,[2] is expected to be similar to the Λ-type doubling of diatomic molecules. We in fact found a slight but definite doubling which increases proportionally to $J(J+1)$ as does also Λ-doubling. The difference is that in this case the doubling originates not in an electronic but in a vibrational degeneracy.

Two or possibly three of the new bands (9801.7 cm^{-1} 12,618.4 cm^{-1} (11,591.0 cm^{-1})) do not show the usual alternation of intensities. In order to explain this the same assumption has been made as was advanced by Herzberg and Spinks for the band at 10,410A; namely, that both in the upper and in the lower state the transverse vibration ν_5 is excited. Then both the upper and the lower states are degenerate for zero rotation. If the splitting occurring at higher rotations is small then no intensity alternation should occur. This is quite analogous to the case of $\Pi-\Pi$ transitions of diatomic homonuclear molecules. In order to test this assumption we have made exposures with the absorption tube imbedded in solid carbon dioxide. At the corresponding temperature (−80°C) the percentage of molecules excited to the first vibrational state (ν_5) is greatly diminished. In fact we found as is to be expected on the above assumption, that the band 10,410A disappeared completely, whereas the bands *with* alternating intensities did not change their total intensities.

TABLE I.

λ(A)	ν(cm^{-1})	INTERPRETATION	TYPE	
11007	9085	$\nu_1+\nu_2+\nu_3+\nu_5$	$\perp$	Q only
10924	9151.7	$3\nu_1+\nu_3$	$\parallel$	
10677	9366	$2\nu_1+\nu_2+3\nu_4$?	$\perp$	Q only
10202	9801.7	$2\nu_2+\nu_3+\nu_5-\nu_5$	$\parallel$	
9645	10364.8	$\nu_2+2\nu_3+\nu_4$	$\perp$	*
8640	11570.8	$2\nu_1+2\nu_2+\nu_4+\nu_5$	$\parallel$	
(8625	11591.0	$\nu_1+3\nu_3+\nu_5-\nu_5$)	$\parallel$	
(8614	11605.0)	?	$\parallel$	
7923	12618.4	$\nu_2+3\nu_3+\nu_5-\nu_5$	$\parallel$	
7865	12710.7	$\nu_1+3\nu_3+2\nu_5$	$\parallel$	**
7671	13033.3	$3\nu_2+\nu_3$	$\parallel$	
6839	14617.0	$\nu_1+\nu_2+3\nu_3$	$\parallel$	

* The occurrence of this band has previously been noted by K. Hedfeld and P. Lueg (Zeits. f. Physik **77**, 446 (1932)) but was not measured by them. R. Mecke in his report (Hand- and Jahrbuch d. Chem. Phys. **9**, II (1934)) mentions that it is a $\perp$ band though he, too, gives no data.

** This band has already been found by C. A. Bradley and A. McKellar, Phys. Rev. **47**, 914 (1935) who have given a slightly different origin.

The experimental work was carried out at the Physikalisches Institut der Technischen Hochschule Darmstadt, Germany. Our thanks are due to the Agfa firm which generously supplied us with its excellent new infrared plates.

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[1] G. Herzberg and J. W. T. Spinks, Zeits. f. Physik **91**, 386 (1934).

[2] Cf. D. M. Dennison, Rev. Mod. Phys. **3**, 280 (1931); R. S. Milliken, Phys. Rev. **42**, 364 (1932).

Alpha-Particle Yield from Lithium under Proton Bombardment

Cockcroft and Walton,[1] Henderson,[2] and Oliphant and Rutherford[3] have studied the yield of 8.5-cm alpha-particles from lithium under proton bombardment. The results of these studies have been interpreted as indicating that the probability of disintegration of Li^7 tends to become constant for proton energies around 400 kv. More recently Herb, Parkinson and Kerst[4] have measured the yield from both thick and thin films of lithium at voltages ranging from 70 to 400 kv. Their results indicate that the disintegration probability increases practically uniformly between 200 and 400 kv, with no appreciable tendency toward a constant value in this range. Further, the thick film yield of the latter observers is of the order of ten times that reported by Cockcroft and Walton around 400 kv. Also Hafstad and Tuve,[5] using thin films, have determined the excitation function of the disintegration in question at voltages up to above 1000 kv, and found that the probability increases continually in the observed

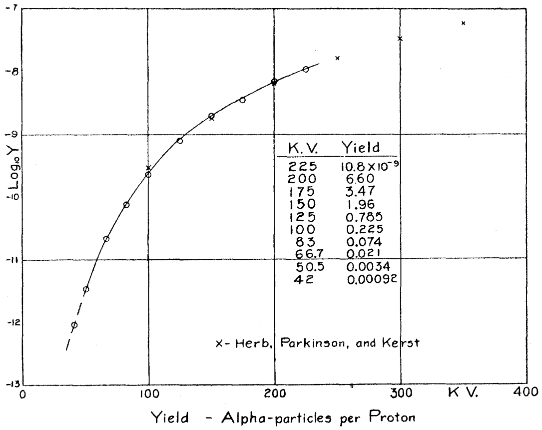

FIG. 1.

range of voltage, but tends to increase less rapidly at the higher voltages.

It is of interest for the theory of the nucleus to know the yield also at lower voltages than those covered so far because more accurate information can then be obtained about the potential inside the nucleus.[6] Since the data of Herb, Parkinson and Kerst are less accurate at the lower voltages it was thought worth while to extend observations to still lower voltages as well as to repeat them in a region overlapping theirs in order to obtain an independent determination with a different experimental arrangement.

Observations have been made of the thick film yield for proton energies ranging from 40 to 225 kv. Ions, including protons, were obtained from a low voltage hydrogen arc of the type described by Tuve, Dahl and Van Atta.[7] The high voltage was generated by a doubling rectifier circuit of the type used by Cockcroft and Walton. The ions were drawn from the arc by a small probe, focused by a metal cylinder, and then accelerated down a tube consisting of four glass sections separated by metal plates. The potential adjustment of the focusing cylinder and the potential distribution down the accelerating tube were maintained by corona leaks. The protons were separated from the other ions in the beam by passing them through a magnetic field, which after careful plotting and numerical integration served also to measure their equivalent voltage.

The protons were allowed to fall onto a lithium target, obtained by evaporation in vacuum onto a small sheet of nickel, and placed at an angle of 45° to the beam. The alpha-particles were let pass through a mica window into an ionization chamber, and then counted by means of a linear amplifier, of the type used by Dunning, together with a scale-of-four thyratron circuit coupled to a mechanical counter. The average proton current was measured by taking continuous readings on a galvanometer.

The absolute yields were calculated on the assumption of uniform angular distribution of the alpha-particles, and are expressed as the total number of alpha-particles per impinging proton. The results are shown in the accompanying figure together with the data of Herb, Parkinson and Kerst, both plotted on a logarithmic scale. Except for the lowest two points the yield values correspond to observations of from 5000 to 20,000 counts. At the lowest point about 90 counts were observed; and at the next point, about 900—so that these two points are subject to correspondingly greater statistical errors. It is seen from Fig. 1 that, within the limits of experimental error, these data are in good agreement with those of Herb, Parkinson and Kerst (except for their lowest point at 100 kv, for which they do not claim as high accuracy as for the other points). The theoretical significance of these data is discussed in an article by Ostrofsky, Briet and Johnson.[6]

The authors wish to express their thanks to Professor G. Breit, at whose instigation this problem was undertaken, for his generous interest and advice throughout the progress of the work. It is also desired to acknowledge indebtedness for grants-in-aid made to G. Breit by the Carnegie Institution of Washington and to C. E. Mendenhall and G. Breit by the American Philosophical Society, which made it possible to carry on this work.

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[1] J. D. Cockcroft and E. T. S. Walton, Proc. Roy. Soc. **A137**, 229 (1932).

[2] M. C. Henderson, Phys. Rev. **43**, 98 (1933).

[3] M. E. Oliphant and Lord Rutherford, Proc. Roy. Soc. **A141**, 259 (1933).

[4] R. G. Herb, D. B. Parkinson and D. W. Kerst, Phys. Rev. **48**, 118 (1935).

[5] L. R. Hafstad and M. A. Tuve, Phys. Rev. **48**, 314 (1935).

[6] See M. Ostrofsky, G. Breit and D. P. Johnson, this issue.

[7] M. A. Tuve, O. Dahl and C. M. Van Atta, Phys. Rev. **46**, 1027 (1934).
We are indebted to Dr. Tuve for providing us with detailed specifications for the construction of this arc.

Ionic Dispersion in the Extreme Infrared

In many respects the following problem resembles that of the application of Maxwell's equations to the reflection and absorption of infrared radiation by thin metallic films, except that in the case of electrolytes the mass of an ion is sufficiently greater than the mass of an electron to introduce an inertia term.

Assuming the motion of an ion to satisfy the equation

$$Mdv/dt+\rho v=e\mathcal{E}e^{i\omega t}, \tag{1}$$

where M is the mass of an ion, ρv the frictional force and $e\mathcal{E}e^{i\omega t}$ force from the alternating electric field, a characteristic value is obtained when $\rho=\omega M$. If Stokes' law of friction is applied, the characteristic wave-length, λ_0 (in μ) for which the inertia of an ion becomes important is given by:

$$\lambda_0=1.65M/\eta r, \tag{2}$$

where r is the radius of an ion (in A) and η is the specific viscosity of the solution. For electrolytes of KCl and KI, $\lambda_{\text{K}}=48\mu$, $\lambda_{\text{Cl}}=32\mu$ and $\lambda_{\text{I}}=95\mu$.

In Fig. 1 are shown the absorption coefficients and the reflecting powers of water, 3 normal KCl and 4 normal KI solutions. These data are chosen as illustrative of ionic dispersion and are taken from investigations on different concentrations of HCl, LiCl, NaCl, KCl, KBr, LiI, KI, ZnI_2, H_2SO_4, $MgSO_4$ and KOH.