Infra-Red Absorption of Hydrogen and Carbon Dioxide Induced by Intermolecular Forces

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ROTATION-vibrational infra-red absorptions forbidden for the free molecules have recently been observed by us in oxygen and nitrogen at high densities.[1] We now report similar absorptions in gaseous hydrogen and carbon dioxide. As in the previous cases, for pure gases the absorption coefficients for all points in the bands vary as the square of the pressure. Enhancement of the hydrogen absorption by foreign gases (helium and nitrogen) has been observed and is proportional to the partial pressure of the foreign gas. Thus these absorptions must be induced by the forces acting during molecular collisions and support the belief that induced absorption is a general molecular phenomenon. The contours of the new bands, especially the hydrogen band for which the rotational structure is partially resolved, confirm the rotational selection rule $\Delta J=0, \pm 2$.

The absorption in hydrogen was obtained with an absorbing path length of 85 cm and gas pressures up to 100 atmospheres. The most prominent maximum (Q-branch) of the band occurs at the vibrational frequency of the H_2 molecule, 4155 cm^{-1}. Two additional maxima, only one of which is clearly resolved, occur at the frequencies predicted for the first two lines in the S-branch. The relative intensities of the O- and S-branch lines calculated from the Raman effect matrix elements are indicated by the vertical lines in Fig. 1. If the experimental half-width of the Q-branch, 250 cm^{-1}, is assumed for the theoretical components of the O- and S-branches the observed contour is reproduced. The energy levels, although greatly broadened by the collisions, are not displaced by more than ± 10 cm^{-1}, the error in our frequency calibration. The ratio of the sum of the intensities of the O- and S-branches to the total intensity in the hydrogen band is 0.4; the corresponding ratios for nitrogen and oxygen are 0.6 and 0.7, respectively. Although the maximum absorption coefficient for hydrogen is of the same order as those for oxygen and nitrogen, the integrated absorption coefficient is about four times greater because of the broadness of the band. Thus the intensity of the hydrogen band relative to that of either oxygen or nitrogen does not appear to be simply related to the polarizabilities or the derivatives of the polarizabilities of the molecules.

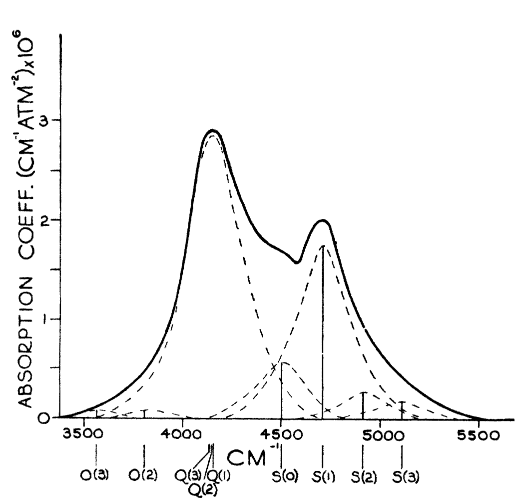

FIG. 1. The induced rotation-vibrational infra-red absorption of gaseous hydrogen.

In the previous note it was suggested that induced transitions might be responsible in part for the overtone absorptions observed in hydrogen by Herzberg.[2] Since the half-width of the lines of the induced absorption is greater by several orders of magnitude than the half-width of the lines observed by Herzberg, this suggestion is no longer plausible. An induced overtone absorption could produce at most only a continuum underlying the narrow lines arising from the quadrupole transitions.

The symmetrical frequency of carbon dioxide, normally forbidden in the infra-red, was observed with a path length of 85 cm and gas pressures up to 25 atmospheres, and with a path length of 11 meters and pressures up to 6 atmospheres. The band has two maxima at 1286 cm^{-1} and 1388 cm^{-1}. The two components arise from the Fermi resonance interaction of the symmetrical vibration and the overtone of the doubly degenerate vibration. The intensity ratio of the components is 0.8 whereas the ratio obtained in the Raman effect is 0.6.[3]

The induced absorption in oxygen at low pressures (1–10 atmos.) has been re-examined with an 11-meter path length. It was found that over this range the absorption coefficient is accurately proportional to the square of the pressure. These more accurate results prove that the slight departure from linearity of the curve in Fig. 1 of our first note is not real. There is, therefore, no evidence of quadrupole or magnetic dipole absorption.

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[2] G. Herzberg, Nature **163**, 170 (1949).
[3] A. Langseth and J. R. Nielsen, Phys. Rev. **46**, 1057 (1934).

The Alpha-Particles Emitted in Fission

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IN a recent paper in the Physical Review,[1] Dr. L. Marshall made several misleading comments on the results of our experiments on the emission of light particles in fission, as briefly reported in Nature.[2] We should like to draw attention to a detailed account of the work which was published in the Philosophical Transactions[3] of the Royal Society in August, 1948, in which the problem of nuclear recoils is fully dealt.

Confusion seems to have arisen in that we reported observations on a further group of short range particles first observed by Cassels, Feather, Dainty, and Green[4] in addition to the long range alpha-particles with which Dr. Marshall's paper is concerned. Our abundance figure for this group of long range alpha-particles is roughly in agreement with Dr. Marshall's.

Recent experiments by Allen and Dewan[5] fully substantiate the main conclusions of our paper.

[1] L. Marshall, Phys. Rev. **75**, 1339 (1949).
[2] L. L. Green and D. L. Livesey, Nature **159**, 332 (1947).
[3] L. L. Green and D. L. Livesey, Phil. Trans. **A241**, 323 (1948).
[4] Cassels, Dainty, Feather, and Green, Proc. Roy. Soc. **A191**, 428 (1947).
[5] K. W. Allen and J. T. Dewan, Phys. Rev. **76**, 181 (1949).

Magnetic Moments and Eddy Current Damping in Spherical Superconductors*

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THE magnetic moments of six spherical specimens of pure tin have been measured between 1.2°K and 3.6°K in fields up to and including those producing the intermediate state. The magnetic moments were observed in terms of the effect of magnetic fields upon the period of oscillation of the specimen suspended from a torsion wire. No magnetic moment was detected when the specimens were cooled from above the transition temperature in zero field. However, after the superconductivity had