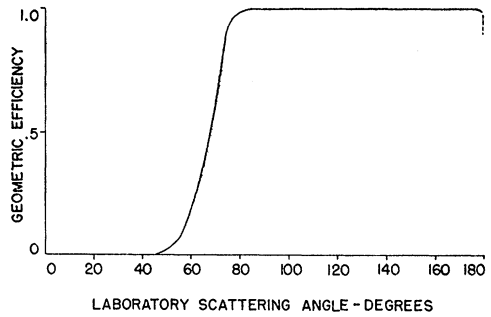

FIG. 2. The efficiency for recording pions scattered from Pb as a function of the laboratory scattering angle.

The cross section has been corrected for positive muon contamination (4 percent) and for counting losses in the pulse height discriminator (6 percent). The error consists of statistical error and uncertainty in the determination of counting losses, muon contamination and geometrical dimensions.

The cross section has not been corrected for fast proton star prongs that may have counted in the fourth crystal. On the basis of findings reported by Bernardini and Levy[5] for the absorption and scattering of positive pions of this energy in photographic emulsions, this correction may result in the increase of the quoted cross section by as much as 15 percent.

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† This material is part of a thesis submitted to the University of Rochester for the M.S. degree.
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Induced Infrared Absorption in Hydrogen and Hydrogen Foreign Gas Mixtures at Pressures up to 1500 Atmospheres

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IN previous communications[1,2] the characteristics of the normally forbidden fundamental infrared absorption in H_2 as induced by molecular collisions have been delineated for the pure gas and for H_2-He, H_2-A, and H_2-N_2 mixtures at pressures up to 150 atmos. The range of experimental conditions has now been extended to pressures of 1500 atmos at temperatures from 90°K to 376°K. The results obtained in the region of high densities, approaching and sometimes exceeding those of the corresponding liquids at their normal boiling points, have revealed new properties of induced absorption.

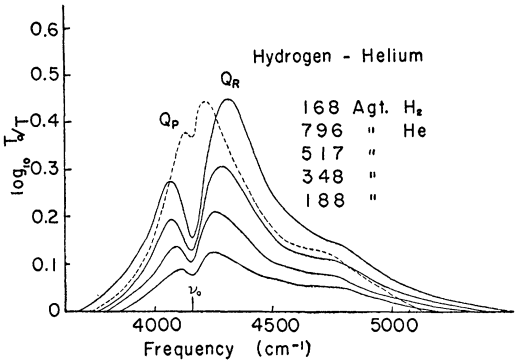

FIG. 1. Contours of the infrared absorption of hydrogen induced by various densities of helium.

A reflection cell,[3] adjusted for a path length of 2.1 cm and fitted with a Dewar-type vacuum jacket for temperature control, was used for the experiments. When fitted with a quartz window 18 mm thick, the cell withstood pressures up to 1500 atmos at all experimental temperatures.

The contours in Fig. 1 show the enhancement of the absorption in a given base density (168 amagat) of H_2 due to various densities of He at 298°K; the enhancement was obtained by subtracting the absorption of the H_2 alone from the absorption of the mixture. The dotted curve is inserted for comparison; it is the absorption contour calculated for 168 Agt of H_2 and 796 Agt of He using the specific absorption contour obtained for the lower pressure range.[2] The outstanding feature of the high density contours is the splitting of the Q branch into two well-resolved components. The higher frequency component, referred to as Q_R, corresponds to the main maximum at low densities; the lower frequency component Q_P corresponds to the weak imperfectly resolved component, which was a puzzling feature of the low density results.[2] The frequency of the minimum between Q_R and Q_P is at all densities equal to ν_0, the frequency of the fundamental vibrational transition in the free H_2 molecule. Similar splittings of the Q branch were observed at high densities with pure H_2 and with H_2-A and H_2-N_2 mixtures; in these cases, especially for H_2-N_2, the Q_R and Q_P components are not as well resolved as for H_2-He. Also from these three cases, where the $S(0)$ and $S(1)$ lines are relatively much more pronounced than in H_2-He, it was established that there is no splitting in the S lines.

The separation and relative intensities of the Q_R and Q_P components are strongly dependent on density and temperature. The observations may be summarized as follows: (a) The separation of the maxima increases linearly with density from a limiting value at low densities. The limiting value is least for H_2-A and greatest for H_2-He. The rate of increase of the separation with density is greatest for H_2-A and least for H_2-He. (b) For a given density the separation of the maxima increases with the temperature. (c) The relative intensity of the Q_P component decreases rapidly as the temperature is lowered. (d) The contours of the components show a simple intensity relationship. If $I_P(\nu-\nu_0)$ is the intensity in the Q_P component at the point $\nu-\nu_0$

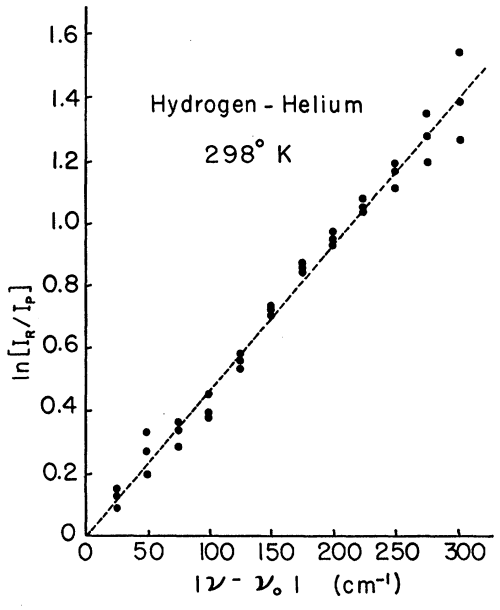

FIG. 2. An empirical relationship between $I_P(\nu-\nu_0)$ and $I_R(\nu-\nu_0)$, the intensities in the Q_P and Q_R components.

from the origin (4160 cm^{-1}) and $I_R(\nu-\nu_0)$ is the corresponding quantity for the Q_R component, the plot of $\ln[I_R(\nu-\nu_0)/I_P(\nu-\nu_0)]$ against $|\nu-\nu_0|$ is a straight line whose reciprocal slope is very nearly kT. Figure 2 shows the graph for three densities of H_2 and He at room temperature. The reciprocal slope of the line, drawn by least squares, is 212 cm^{-1}; the value of kT at 298°K is 208 cm^{-1}.

The observations indicate that the splitting of the Q branch is a kinetic phenomenon. The splitting at low densities is a property of the colliding pair alone and is probably caused by a change of the relative kinetic energy of the pair during the absorption. The increase in the splitting with increasing density suggests that the kinetic energy of one or more near neighbors can also be involved; the third molecule need not be in close collision with the absorbing pair.

In the region of high density the integrated absorption coefficient increases more rapidly than the product of the densities of the absorbing and perturbing gases; this effect, which is especially marked for H_2-N_2 and H_2-A mixtures, is related to the reduction of the free volume in a gas at high densities. The absorption coefficient also shows a marked increase with increasing temperature. These results will be published in detail.

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(γ, pn) Reaction in Phosphorus*

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MEASUREMENT of particle emission from nuclei under photon bombardment leads to values for the probability of photon capture provided one can measure the relative importance of emission of the various nuclear particles. For heavy elements, where charged particle emission is strongly inhibited by the Coulomb barrier, the (γ, n) reaction is dominant. The (γ, $2n$) reaction can, however, contribute significantly to the total cross section.[1] For light elements, where barrier effects are small and the threshold energy for proton emission can be appreciably lower than that for neutron emission, the (γ, p) reaction is as important as the (γ, n).[2] Similarly, for the light elements the (γ, pn) reaction can make a significant contribution to the total cross section.[3]

We have measured the (γ, pn) contribution in phosphorus, where the threshold for this reaction (18 Mev) is 5 Mev below the (γ, $2n$) threshold. The technique of measurement is identical with that used in the (γ, $2n$) determinations.[1] The radioactivity yields from the (γ, n) reaction is measured as a function of the maximum energy of the bremsstrahlung produced by the University of Pennsylvania betatron. This yield curve is compared with the yield curve of neutrons directly detected by a method of delayed counting.[1] Figure 1 shows the neutron yield from a 2.3-g/cm^2 target of phosphorus compared with the radioactivity yield from targets of 1.2-g/cm^2 thickness. The two curves are normalized at 18 Mev.

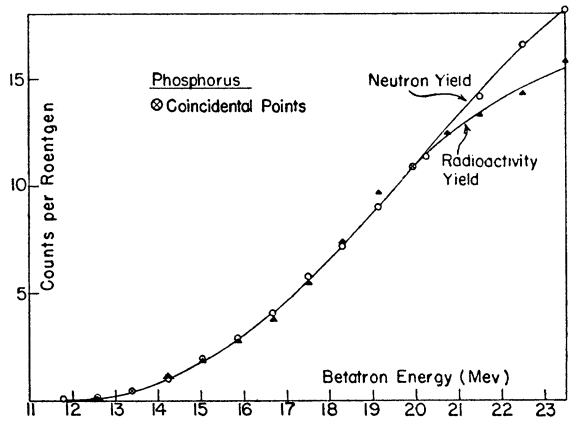

FIG. 1. Yields from the (γ, n) reaction in phosphorus as measured by neutron detection and by radioactivity.

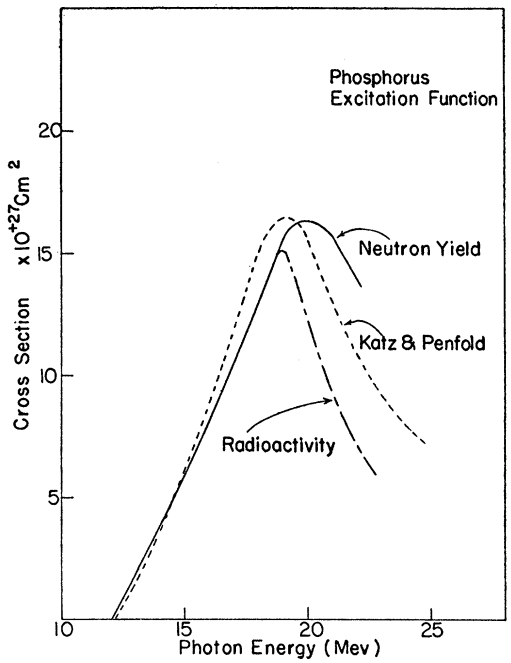

FIG. 2. Excitation functions computed from the curves of Fig. 1.

The divergence of the two curves at the upper energies is attributed to the onset of the (γ, pn) reaction. The identity of the two curves below 18 Mev indicates that the efficiency of the neutron detection apparatus does not depend on neutron energy, because from threshold to 18 Mev the photoneutron energy distribution has changed from thermal to one with a mean of approximately one Mev. Above 18 Mev the neutron energy spectrum remains essentially unchanged.

Figure 2 shows the excitation functions constructed from the yield curves of Fig. 1, using the calculated bremsstrahlung spectra at the various betatron energies. Absolute values for the cross section are obtained by a measurement of the efficiency of the neutron detection apparatus using a Ra—Be source of known strength. The excitation function of Katz and Penfold[4] obtained from radioactivity data is also shown for comparison. Although the measurements do not extend to sufficiently high energies for a precise calculation of the integrated cross sections, extrapolation of the curves of Fig. 2 give values of 99×10^{-3} and 47×10^{-3} Mev barns for the (γ, n) and (γ, pn) reactions, respectively.

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Neutron Monochromator Crystals—Fe_3O_4 and Ge†

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CRYSTAL diffraction has been widely used as a method of selection of monoenergetic neutron beams, mostly in the range of wavelengths 1–2 angstroms. In some cases, it has also