Bond Effect in the Action of Protons on Neutrons

The marked ability of protons bound in hydrocarbons to slow neutrons down to thermal equilibrium with the hydrocarbon, as indicated in the preceding letter and earlier work[1–5] induced the authors to undertake a systematic investigation of different types of hydrogenous molecules to discover any dependence of this phenomenon upon the character of the molecule and the bond. The experiments with liquid hydrogen here described reveal the existence of a remarkable difference between the H_2 molecule and the hydrocarbons.

The apparatus used is shown in Fig. 1 of the preceding communication with the exception that the copper container used for the heptane was removed, leaving the space between the inner soft glass Dewar and the outer metal Dewar empty. The procedure used was to determine the activity of the silver targets (1) with the Dewar empty, (2) with the Dewar filled with liquid or solid hydrogen to a level approximately 5 cm above the top of the silver target, (3) same as the preceding but with the liquid hydrogen nearest the inner Dewar replaced by a 1.5 cm cylinder of paraffin, and (4) at room temperature, the Dewar being filled with a solution of methyl alcohol in acetic acid (21 percent alcohol by volume) which contained the same number of protons per cubic centimeter as does liquid hydrogen. Table I presents the results corrected for radon decay. The solid hydrogen was obtained by exhausting the Dewar until an equilibrium vapor pressure of 3.8 cm of mercury was obtained.

The comparison of Experiments 2*a*–*b* either with Experiment 3 or with the experiments described in the preceding communication shows the great difference between liquid or solid hydrogen and a hydrocarbon. A comparison of Experiments 2 and 4 shows a nearly identical activity whether the Dewar is filled with hydrogen at very low temperatures or with a solution of the same proton density at room temperature. Moreover, the same result had been obtained in a preliminary experiment in a smaller Dewar in which the thickness of the liquid hydrogen layer around the soft glass Dewar was 3.5 cm instead of 5.5 cm. It would not be correct to conclude, however, that the liquid and solid hydrogen do not cool at all. The experiments indicate, rather, that the low speed neutrons have been cooled by liquid hydrogen at 20°K, and by solid hydrogen at 12°K, to a mean temperature of perhaps 150°K and that the increase in silver activity which should be thus produced has been nearly offset by the increase in capture by protons. This view is in agreement with the results of Fomin, Houtermans, Leipunsky and Schubnikow,[6] on the backward scattering of slow neutrons from liquid hydrogen and from water at room temperature.

In interpreting Experiment 3 we assume, therefore, that the 300°K neutrons which enter the Dewar have been partly cooled by the liquid hydrogen and then brought to very low velocities and consequently absorbed by the thin layer of paraffin. It must in any case be concluded that at very low temperatures paraffin has a much greater effect either in decelerating or absorbing these neutrons than cold hydrogen. Unless this difference can be ascribed to the carbon nucleus itself, and experiments with which we are now engaged should soon settle this question, the difference in behavior between very cold hydrogen and paraffin must be ascribed to the chemical bond.

TABLE I.

Experiment	Description	Activity of Ag (140 seconds)
1	Empty Dewar (300°K)	593±15
2*a*	Liquid hydrogen (20°K)	769±15
b	Solid hydrogen (12°K)	758±15
3	1.5 cm paraffin cylinder+liquid (20°K) hydrogen	579±15
4	Acetic acid solution (300°K)	776±15

Our experiments are analogous to those of Westcott and Niewodniczanski[4] on paraffin and hydrogen at 20°K. They performed two sets of experiments and found it impossible to reconcile their first set with their second. Our results agree closely with their first set.

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Resonance Energy of Cadmium for Neutron Capture

The experiments of Rasetti, Segrè, Fink, Dunning and Pegram[1] on the absorption of slow (thermal) neutrons by a layer of cadmium moving with a velocity relative to the neutron source have indicated that the collision cross section remains practically constant in an energy interval of about 20 percent of $3kT/2$. On the other hand Powers, Fink and Pegram[2] have reported a 7 percent increase in the absorption coefficient on lowering the neutron temperature from 300°K to 95°K.

It is of interest to consider these two sets of experimental data in terms of the Breit-Wigner formula for the cross section here involved. For this purpose the latter formula can be written in the form:

$$\sigma = 1/E^{\frac{1}{2}}\{(E\pm 1)^2+B^2\},$$

where E and B are measured in energy units E_0; and σ, in arbitrary units. E_0 represents the resonance energy; and B, the half-width of the virtual level responsible for the capture. The plus sign refers to the case of positive resonance energy; and the minus sign, to the case of negative resonance energy.