Resonance Capture of Slow Electrons in Ethane

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GRÜNBERG 1 has found that the drift velocity of electrons at room temperature in hydrogen and nitrogen at a given \( E/p \) (\( E \) field strength) is dependent on the pressure \( p \). For example at \( E/p = 0.03 \) [V/cm·Torr], the drift velocity \( v_- \) in \( H_2 \) decreases to 78% of its value at \( p = 775 \) Torr, if one measures at \( p = 31350 \) Torr. In \( N_2 \) he found a similar effect (but not so strong).

To obtain a better insight into the physical process it was of interest to measure the \( p \)-dependence in other gases.

The value of \( v_- \) in ethane (\( C_2H_6 \)), obtained by the method described in 1, is given in Table 1 as function of \( E/p \) at a pressure of 900 Torr. If one measures at different pressures between 600 and 24 000 Torr and plots \( v_- \) at this pressure divided by \( v_- \) at 900 Torr \([v_- (p)/v_- (900) = q]\) as function of \( E/p \), one obtains Fig. 1. It demonstrates, that \( q \) decreases with smaller \( E/p \), the more the higher the pressure, as was found in 2.

\[
\begin{align*}
E/N \cdot 10^4 \text{ [V/cm]} & \quad E/p \text{ [V/cm·Torr]} & \quad v_- \cdot 10^{-5} \text{ [cm/sec]} \\
1 & & 0.033 & 3.66 \\
2.2 & & 0.073 & 8.65 \\
3.6 & & 0.119 & 14.2 \\
6 & & 0.198 & 24.8 \\
8 & & 0.264 & 30.4 \\
10 & & 0.33 & 33.9 \\
22 & & 0.73 & 47.6 \\
36 & & 1.19 & 51.3 \\
60 & & 1.98 & 53.9 \\
80 & & 2.64 & 55.2 \\
100 & & 3.30 & 54.6 \\
\end{align*}
\]

Table 1. Drift velocity in ethane measured at 20 °C and \( p = 900 \) Torr. The error of the \( v_- \)-values is 3%.

\[
N \cdot 10^{-20} \text{ [cm}^{-3}\text{]} & \quad p \text{ [Torr]} & \quad q \quad \frac{1-q}{p \cdot q} = c \quad \cdot 10^4 \\
1.5 & & 4.550 & 0.96 & 9.2 \\
4 & & 12140 & 0.90 & 9.2 \\
5 & & 15180 & 0.88 & 9.0 \\
7 & & 21250 & 0.82 & 10.3 \\
8 & & 24290 & 0.81 & 9.7 \\
\]

Table 2. Relative drift velocity \( q \) at \( E/p = 0.2 \) [V/cm Torr].

\[1 \text{ R. GRÜNBERG, Z. Phys. 204, 12 [1967].}\]

\[2 \text{ See e.g. R. H. RITCHIE and J. E. TURNER, Z. Phys. 200, 259 [1967].}\]
meV. With an assumed cross section of $10^{-14}\text{cm}^2$ the value of $r$ becomes in its maximum about $10^{-13}\text{sec}$. More detailed experiments are necessary to understand this resonance interaction at these very low electron energies.

Apparently similar processes produce the decrease of $\nu_\gamma$ in $\text{H}_2$ and $\text{N}_2$; however, the minima of $q$ lie probably at lower energies in the region of the thermal velocity, so that Grünberg did not reach the minimum and the comeback to $q = 1$.

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The $^{12}\text{C}(n,a_2)\text{Be}$ Reaction at 13.9 and 15.6 MeV

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The investigation of $(n,\alpha)$ reactions has previously shown that both compound and direct processes are involved. The energy and angular distributions of the alpha particles from $(n,\alpha)$ reactions on heavy nuclei at 14 . . . 16 MeV show that the direct mechanism predominates. In the case of medium mass nuclei, evaporation spectra and angular distributions which are symmetrical about $90^\circ$ are observed. However, the few angular distributions of ground state transitions, which have previously been measured, indicate the $(n,\alpha)$ reaction to be a direct process even in this region of mass numbers. In the case of light nuclei it is less difficult to separate different alpha particle groups. Angular distributions corresponding to defined states of the final nucleus may therefore be obtained. In addition to information about the reaction mechanism, spectroscopical results may also be expected.

During the last year, some $(n,\alpha)$ reactions on light nuclei have been studied with neutrons near 14 MeV. In the present work, the differential cross section of the reaction $^{12}\text{C}(n,\alpha)_2\text{Be}$ has been measured at 13.9 and 15.6 MeV.

The neutrons were generated by the $^3\text{H}(d,n)^4\text{He}$ reaction, using a Van de Graaff accelerator. The neutron current density at the carbon target was approximately $5 \times 10^8 \text{sec}^{-1}\text{cm}^{-2}$. Natural carbon targets of 0.4 mg cm$^{-2}$ and 1.0 mg cm$^{-2}$ thickness were used with tantalum as a backing. In order to correct for the background, each carbon run was followed by a background run with the carbon target replaced by a tantalum target.

The alpha particles were detected with a counter telescope in which two proportional counters filled with 150 Torr CO$_2$ were followed by a Si semiconductor detector. The angular distribution function of the telescope was calculated with a Monte-Carlo-technique. The full width at half maximum is typically $15^\circ$.

The proportional counter pulses were added to give a single $\Delta E$-pulse. This was analysed in a two-dimensional pulse height analyser together with the $E$-pulses from the semiconductor detector. The resolution was 32 channels for the $\Delta E$-pulses and 128 channels for the $E$-pulses. Timing information was obtained from each of the three counter pulses by means of the zero-crossing method. The gate of the analyser was opened by the presence of a triple coincidence; the resolution time was 100 nsec. For 5 MeV $\alpha$-particles, the resolution is approximately 10% in the $\Delta E$-channel and is better than 100 keV in the $E$-channel. For alpha particle energies greater than 2.5 MeV, the detection efficiency is 100%.

A long counter was used as a neutron monitor. In order to obtain the neutron current density in the position of the carbon target, it was replaced by a helium gas target. The recoil alpha particles were thus detected in the same arrangement as the alpha particles from the $(n,\alpha)$ process. The differential cross section for the elastic $n-^4\text{He}$-scattering was calculated from the phase shifts of Hoop and Barschall.

Fig. 1 shows the energy spectrum of the alpha particles from the reaction $^{12}\text{C}+n$ at a telescope angle of $0^\circ$ and with a carbon target thickness of 400 $\mu$g cm$^{-2}$. The mean neutron energy was 13.9 MeV; upper and lower limits were 14.05 MeV and 13.75 MeV. The ground-state transition of the reaction $^{12}\text{C}(n,\alpha)_2\text{Be}$ is clearly separated from the lower part of the spectrum; the $\alpha_1$, $\alpha_2$- and $\alpha_3$-groups are visible as well. At the lower energies however, alpha particles of the $\alpha_3$ breakup reactions contribute to the spectrum of the $^{12}\text{C}(n,\alpha)_2\text{Be}$ reaction. The difference in energy between the ground state: $^9\text{Be}+\alpha$ and the state: 3 $\alpha+n$ is 1.5 MeV approximately. Therefore only the $\alpha_3$ transition has been analysed.

Alpha particle spectra of the reaction $^{12}\text{C}(n,\alpha)_2\text{Be}$ have been measured several times. However, the experimental techniques used (emulsion technique, . . . )