CROSS SECTIONS FOR DISSOCIATION OF D_2^+ IONS IN COLLISIONS WITH D_2 MOLECULES IN THE ENERGY RANGE FROM 3.5 TO 100 keV

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The cross sections for deuteron formation as a result of the dissociation of 3.5—100 keV D_2^+ ions in single collisions with D_2 molecules were determined with a double mass spectrometer. The shape of the dependence of the cross sections on the D_2^+ ion energy agrees with the dependence reported by Fedorenko et al,[3] but for the same energies the present cross sections are about 30% lower.

UP to the present, several papers[1-6] have been published reporting studies of the processes of dissociation of H_2^+ or D_2^+ ions. There are very large differences between the results reported in these papers. For example, the dissociation cross sections determined by Fedorenko et al[3] and by Barnett[4] differ by a factor of 3—4.

Since these cross sections are important in some methods of filling thermonuclear traps with ions, we investigated the dissociation of D_2^+ ions occurring in single collisions with deuterium molecules. The cross sections were determined using a double mass-spectrometric apparatus, consisting of two electromagnetic analyzers, between which a collision chamber was placed. An important difference between our method and those used by others[1-6] lies in the ion source, in which ionization was produced by means of electrons of definite and controlled energy.

The effect of the experimental conditions on the measured dissociation cross sections was investigated. It was found that the ratio between the dimensions of the slits delimiting the ion beams is particularly important. This is due to the larger (by a factor of 2—4) width of the dissociated-ion beam, compared with the original beam. This broadening of the beam of secondary D^+ ions is mainly due to the initial kinetic energy obtained by these ions at the moment of dissociation, through electron transitions from the ground level to discrete levels and to a continuous spectrum. Consequently if narrow slits are used the secondary-ion beam may be recorded only partially. This reduces the dissociation cross section values, which is obviously what happened in the work of Barnett.[4]

Visual observation (with a phosphor) of the primary D_2^+ and secondary D^+ ion beams confirmed the results obtained in the study of the effect of the slit widths on the cross sections. Consequently we selected the following conditions: width of the entry slit of the collision chamber 0.5—1 mm, width of the exit slit 2—3 mm, width of the slit in front of the ion receiver 10—14 mm; pressure in the collision chamber $\approx 2 \times 10^{-4}$ mm Hg; length of the collision chamber 15 cm; energy of the ionizing electrons 125 eV. The pressure was determined with a McLeod gauge and an ionization gauge based on the LM-2 tube.

Under these conditions we found the cross sections for formation of deuterons in the processes

$$D_2^+ \to D^+ + D^0, \qquad D_2^+ \to D^+ + D^+.$$

The following results were obtained:

Ion energy, keV:	3,5	13,5	20	30	40	50	60	70	80	90	100
Cross section (10^{-16} cm²/atom):	0.65	0,95	1,05	1,10	1.10	1.06	1.15	1.20	1.30	1.32	1.35

The shape of our energy dependence of the dissociation cross sections for D_2^+ ions agrees with that reported by Fedorenko et al[3] for the dissociation of H_2^+ ions, but our cross sections are 30% lower than Fedorenko's. At 100 keV our cross section agrees to within 5% with that of Sweetman,[5] who investigated the dissociation of H_2^+ ions in the energy range 100—800 keV.

The error in the cross section values quoted above does not exceed ±(10—15)% for all ion energies except 3.5 keV for which the cross section is obviously about 30% too low.

The kinetic energy of the D^+ ions, estimated from the secondary-ion peak, was found to be ≈ 3 eV.

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