§10. Charge Transfer Cross Sections in Slow Impurity Ion — Molecule Collisions Relevant to Fusion Edge Plasmas

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In the edge plasmas of recent large tokamak devices with low-Z plasma facing components such as carbon materials, there are many kinds of low charge state ions and carbon containing molecules. Among many collision processes relevant to low temperature fusion edge plasmas, charge transfer of these ions with molecules are important and play a key role in determining properties of high temperature plasmas at the core region.

We therefore systematically measured the charge transfer cross sections of H^+, C^+ and O^+ ions in collisions with various molecules. In this work, as a continuing study, we have measured the charge transfer cross sections of the ground state He^+ ions, which will be mostly produced by fusion reaction in the fusion plasma, in collisions with H_2, N_2, CO, CO_2, CH_4, C_2H_6 and C_3H_8 in the energy range between 0.2 and 4 keV.

In order to produce the ground state $He^+ (^1S)$ ions, electron energy of an electron impact ion source was set to 30.3 eV. The cross sections of charge transfer were determined by the growth rate method with a position - sensitive michrochannel plate detector.

All the present collision systems for the ground state - ground state transition are exoergic and have large energy defects ΔE. Therefore, it is expected that the target molecule may dissociate, as represented with the following reaction channel,

$$He^+ (^1S) + AB \rightarrow He(^2S) + A^+ + B \quad (1)$$

where AB means a diatomic molecule.

Figure 1 shows the present cross sections for the charge transfer into He^+ ions from H_2 molecules, together with the other experimental data reported previously. The present cross sections for He^+ ions increase gradually as the collision energy increases and reaches a maximum at energies about 2 keV. The data for this collision system are found to be very scarce and in a rather confusing situation at energies below about 10 keV. The present data can be smoothly connected with the low energy data of Rozett and Koski [1] who measured the dissociative fragments of target hydrogen molecules, while the early measurements of Stedeford and Hasted [2] are overestimated.

Similar dependence of the cross section values on the impact energy of the primary ions has been observed for other target molecules investigated. Therefore, the charge transfer accompanied by dissociation of product molecular ion can be dominant at low energies in these collisions presently studied. It should be noted that the electron transfer at higher energies results in the following simple process without dissociation:

$$He^+ (^1S) + AB \rightarrow He(^2S) + AB^+. \quad (2)$$

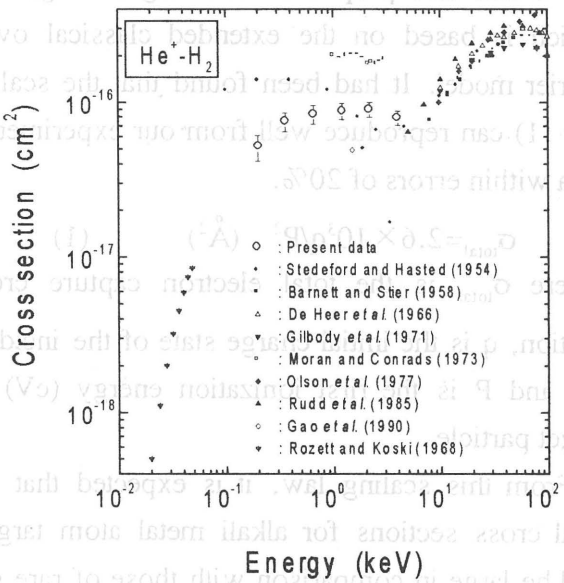

Fig. 1. Charge transfer cross sections for He^+ ions colliding with H_2 molecules.

References

1) Rozett, R. W., Koski, W. S., J. Chem. Phys. **49**, (1968) 2691
2) Stedeford, J. B. H., Hasted, J. B., Proc. Roy. Soc. London **227**, (1955) 466