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

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Charge transfer collisions of low charge state carbon and oxygen ions with molecules are relevant to low temperature edge plasma region, in particular, in devices with carbon-coated or graphite-lined walls and play an important role in determining properties of high temperature plasmas at the core region. Therefore we have systematically measured the charge transfer cross sections of C^+ and O^+ ions in collisions with some kinds of carbon containing molecules, such as CO, CO_2, CH_4, C_2H_6, C_3H_8 and their isomers, in the energy range between 0.2 and 4.5 keV.

Among them, some collision systems for ground state - ground state transition have exoergic reaction channnels. Figure 1 shows the present cross sections for the charge transfer into O^+ ions from C_2H_6 molecules, together with theoretical calculation. The present cross sections for the ground state $O^+(^4S)$ ions decrease gradually as the collision energy increases.

Some curves on Fig. 1 are the calculated results based on Olson-Demkov theory [1] applied to the following reaction channnels of charge transfer

$$O^+(^4S) + C_2H_6(v=0)$$

$$\rightarrow O(^3P) + C_2H_6^+(v'=0) \quad (1)$$

$$\rightarrow O(^1D) + C_2H_6^+(v'=0) \quad (2)$$

$$\rightarrow O(^1D) + C_2H_6^+(v' \neq 0) \quad (3)$$

$$\rightarrow O(^1S) + C_2H_6^+(v'=0), \quad (4)$$

where v and v' are the vibrational quantum numbers of target molecules and product molecular ions. The channel (1) and (2) are exoergic, whereas the channel (4) is endoergic. All of theoretical curves for these three reaction channels have the energy dependence different from experimental data, namely they increase with increasing incident energy and reaching maximum.

The reaction channel (3) means "charge transfer with vibrational excitation of product molecular ions". The energy defect for this charge transfer reaction is found to be zero, so that this channel correspond to so called "resonant charge transfer". The calculated result for the channel (3) satisfactorily reproduces the present data as can be seen in Fig. 1.

Therefore, the charge transfer with vibrational excitation of product molecular ion is presumed to be dominant in the case of exoergic reaction channel at low energy region.

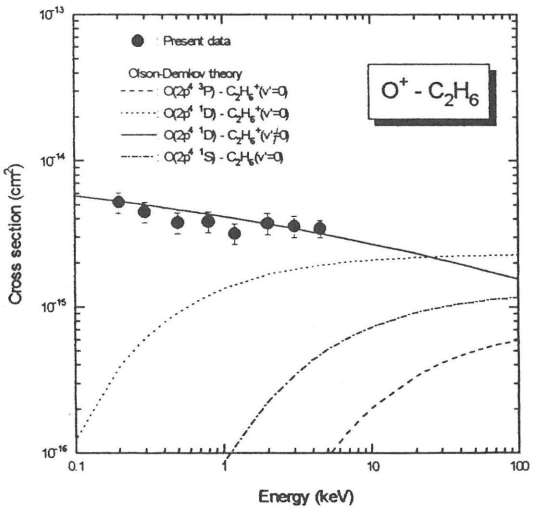

Fig. 1. Charge transfer cross sections for O^+ ions colliding with C_2H_6 molecules.

References
1) Olson, R. E., Phys. Rev. A6 (1972) 1822.