Charge Transfer of Multiply Charged C, N and O Ions in Collisions with H₂ at Low Energies below 1 keV/u

Y. Inoue, K. Ishii¹, H. Ogawa¹, A. Itoh² and N. Sakamoto¹

Graduate school of Humanities and Science, Nara Women’s University, Nara, 630-8506, JAPAN
¹Dept. of Physics, Nara Women’s University, Nara, 630-8506, JAPAN
²Dept. of Nuclear Engineering, Kyoto University, Kyoto, 606-8501, JAPAN

ABSTRACT

We have measured energy gain spectra for single-electron capture in collisions of He-like C, N and O ions with H₂ and N₂ at 50 and 1000 eV/u. Energy gain spectra were examined with energy gain functions calculated from a classical over barrier model, and we obtained fairly good agreement between experimental and calculated results. We find that single electron capture occurs predominantly for C⁴⁺ + H₂, O⁶⁺ + H₂ and N⁵⁺ + N₂, while for N⁶⁺ + H₂ double electron capture followed by transfer ionization is the dominant process in the formation of N⁷⁺ ions.

RESULTS and DISCUSSION

We calculated energy window functions in the COB frames by Niehaus.

Figures 1, 2, 3 and 4 display the experimental setup and measured energy gain spectra for C⁴⁺ + H₂, O⁶⁺ + H₂ and N⁵⁺ + N₂ at 50 and 1000 eV/u. Results are in fair agreement with calculated energy gain functions based on COB model. We find that single electron capture is the predominant process for C⁴⁺ + H₂, O⁶⁺ + H₂ and N⁵⁺ + N₂, while double electron capture into auto-ionizing states is predominant in the collision system of N⁶⁺ + H₂.

In this work, in order to understand these characteristics for above features, we have measured energy gain spectra for He-like C, N and O ions with H₂ at 50 and 1000 eV/u. Results are examined within the framework of the classical over barrier (COB) model.

EXPERIMENTAL SETUP

Figure 1: Absolute total electron capture cross sections and state selective electron capture cross sections of He-like C, N and O ions in collisions with H₂ molecules below 1 keV/u [1,2].

Figure 2: Schematic diagram of experimental setup.

Figure 3: Measured energy gain spectra of C⁴⁺, N⁵⁺ and O⁶⁺ in collisions with H₂ and N₂ at 50 and 1000 eV/u. (Black lines). Calculated energy gain functions (Red, blue and green lines) and energy states are also shown [3,4].

• Single electron capture is the predominant process for C⁴⁺ + H₂, O⁶⁺ + H₂ and N⁵⁺ + N₂ while double electron capture into auto-ionizing states is predominant in the collision system of N⁶⁺ + H₂.

=> N⁷⁺ ions independent target molecular.

SUMMARY

We have
- measured energy gain spectra for single-electron capture in collisions of He-like C, N and O ions with H₂ and N₂ at 50 and 1000 eV/u.
- reproduced measured results by estimated energy gain functions based on COB model.
- confirmed that the predominant channels for C⁴⁺ + H₂, O⁶⁺ + H₂ and N⁵⁺ + N₂ were single electron capture but that for N⁶⁺ + H₂ was TI process.

FUTURE PLAN

To understand more precisely for this work,
- measurements of energy gain spectra with high resolution.
- coincidence measurements with fragment ions from target molecules.

PROGRESS REPORT

Recently, we have studied that collisions between highly charged ion and molecular target at collision energies below 500 eV/u to understand dynamics of molecular fragmentation at low energies.

• We have measured TOF of fragment ion from target molecules.

= Figure 4

Molecular ion peaks (j and j) move to the left-hand side with decreasing collision energy. This phenomenon is called the “Peak Shifting.”

The “Peak Shifting” can be explained by the transverse recoil momentum; eq.(1). The collision energy dependence of the scattering angle is eq.(2). Therefore, we obtain eq.(3). In other words, the transverse recoil momentum decrease with increasing collision energy.

F(j) = ±νj ωl j ∝ -Ej

Pj = E(j)²

• We are planning to measure coincidence TOF of fragment ion pair from target molecules with charge transferred HCl.

REFERENCES