# MUTUAL NEUTRALIZATION OF IONS IN COLLISIONS

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ABSTRACT

The theoretical and experimental results for the rate constant of the pair recombination of the positive and the negative ions are compared.

In this note the theoretical results /1-3/for the rate constant of the pair recombination of the positive and the negative ions are compared with the experiment. At low values of the ion collision energy $E$ the cross section of the process considered is given as follows:

$$\sigma = \frac{\pi e^2 R_0}{E} , \qquad E \ll \frac{e^2}{R_0} , \qquad (1)$$

where $R_0$ is the distance of the closest approach during the collision, at which the valence electron transfers in the positive ion field. Thereafter the rate constant is:

$$k = \langle v\sigma \rangle = \sqrt{\frac{8\pi}{T\mu}}\, e^2 R_0 , \quad T \ll \frac{e^2}{R_0} , \qquad (2)$$

where $T$ is the gas temperature, $\mu$ is the reduced ion mass. As it has been shown recently /3/ , for the negative ions with the low binding energies as well as for the complex negative ions, $R_0 = 9{,}2\,\bar{r}$ , where $\bar{r}$ is the average size of the negative ion, an accuracy being of 20-30% at the thermal collision energies. Taking this into account the formula (3) can be written as:

$$k = \frac{7\cdot 10^{-6}}{\sqrt{T\mu\,\mathcal{E}_a}} , \quad \frac{sm^3}{sec} \qquad (3).$$

Here $T$ is the temperature in Kelvin degrees, $\mu$ is the reduced mass in atomic mass units, and $\mathcal{E}_a$ is the electron binding energy of the negative ion in eV. In Table I the experimental results /4-7/ are compared with the calculations based on formula (3).

Table I

Comparison of calculated and experimental results for the rate constant $k$.

| Colliding ions | $\mathcal{E}_a$, eV | $\mu$, a.m.u. | $k$, $10^{-8}$ $sm^3/sec$ experiment | formula (3) |
|---|---|---|---|---|
| $CCl_2^+ + Cl^-$ | 3.62 | 25 | 4.5 ± 0.5 /4/ | 4.2 |
| $CCl_3^+ + Cl^-$ | 3.62 | 27 | 4.5 ± 0.5 /4/ | 4.0 |
| $CCl_2F^+ + Cl^-$ | 3.62 | 26 | 4.1 ± 0.4 /4/ | 4.1 |
| $CCl_2F_2^+ + Cl^-$ | 3.62 | 27 | 4.1 ± 0.4 /4/ | 4.2 |
| $SF_3^+ + SF_5^-$ | 2.8 | 52 | 4.0 ± 0.5 /5/ | 3.3 |
| $SF_5^+ + SF_6^-$ | 0.6 | 68 | 3.9 ± 0.5 /5/ | 6.4 |
| $H_3O^+ \cdot (H_2O)_3 + Cl^-$ | 3.62 | 24 | 4.8 ± 0.6 /6/ | 4.3 |
| $NH_4^+ \cdot (NH_3)_2 + Cl^-$ | 3.62 | 21 | 7.9 ± 1.0 /6/ | 4.6 |
| $NH_4^+ \cdot (NH_3)_2 + NO_2^-$ | 2.4 | 24 | 4.9 ± 0.6/6/ | 5.2 |
| $H_3O^+ \cdot (H_2O)_3 + NO_3^-$ | 3.7 | 33 | 5.5 ± 1.0 /7/ | 3.6 |
| $H_3O^+ \cdot (H_2O)_3 + NO_3^- \cdot (HNO_3)$ | 3.7 | 46 | 5.7 ± 1.0 /7/ | 3.1 |
| $H_3O^+ \cdot (H_2O)_3 + NO_3^- \cdot (HNO_3)_3$ | 3.7 | 57 | 4.5 /7/ | 2.8 |

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