Single-Electron Capture Cross Sections for 3.4 - 8 A MeV $Xe^{q+} + (N_2, Ar)$ Collisions.

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Charge transfer, electronic excitation, and ionization are three major categories of events that occur in an ion-atom collision [1]. Due to the Coulomb force, electrons from the neutral target may be transferred to the projectile ion in a process termed electron capture (EC). The distance between the interacting particles, their charge, and the energy at which the collision takes place are the three basic factors that govern electron capture. Since the early 1920's when EC was first observed [2] there has been a continuous interest in this process, partly due to the fact that the electron-capture exit channel is often associated with a large cross section. In addition, EC processes play important roles in the operation of thermonuclear-fusion devices [3] and in astrophysics [4].

Extensive measurements of single electron capture cross sections for the Xe^{q+} + N system were performed previously [5] at the Lawrence Berkeley National Laboratory (LBNL) for relatively high values of q. The present measurements were untertaken to extend the examination of single electron capture cross section systematics down to much lower incident projectile charge. Total cross sections were extracted from data obtained in the measurements discussed in the preceeding progress report. The measured capture cross sections for all the collision systems investigated in this work are shown in Table 1. Calculated (using the nCTMC method) capture cross sections for 3.4 and 8.0 A MeV Xe^{18+} + N are also shown in Table 1. Figure 1 compares the present and previously [5] measured single electron capture cross sections

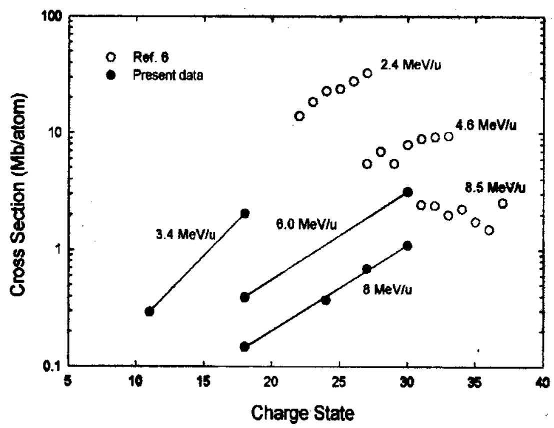

Figure 1: Present and previously [5] measured cross sections for the Xe^{q+}+N system as functions of the charge state and projectile energy.

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Figure 2 shows a plot of the reduced single-electron capture cross sections for Xe^{q+} ions incident on N_2 and Ar targets. The reduced electron-capture cross sections and the reduced projectile energies are given respectively by [5]:

$$\sigma_R = \sigma\ [\frac{Z^{1.8}}{q^{0.5}}]\ ,\quad E_R = \frac{E}{Z^{1.25}.q^{0.7}} \qquad (1)$$

where F is the measured single-electron capture cross section, Z is the atomic number of the target, q is the charge state of the projectile ion, and E is the projectile energy (keV/u). It should be noted that the electron-capture cross sections in N_2 were treated here by dividing the measured molecular cross section by 2 and then using Z=7. An empirical prediction [6] for the measured cross section, given by equation (2) (see below) is also

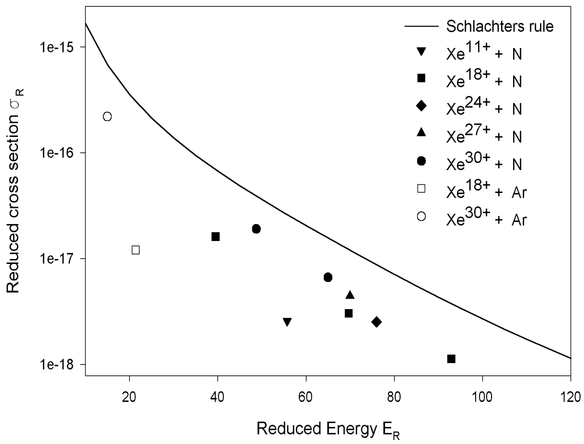

Figure 2: Reduced variable plot of the single-electron capture cross sections for Xe^{q+} ions incident on N and Ar. The solid curve is the empirical curve of Schlachter et al. [6].

shown in Figure 2. From the figure we see that the

$$\sigma_R = \frac{1.1\times 10^{-8}}{E_R^{4.8}}[1-\exp(-0.037E_R^{2.2})]$$
$$\times[1-\exp(-2.44\times 10^{-5}E_R^{2.6})] \qquad (2)$$

present electron capture cross sections exhibit large deviations from this scaling rule. For example, the cross sections for argon are as much as a factor of 10 smaller than those predicted by the empirical curve. This observation indicates that the empirical scaling rule [5] for electron-capture cross sections is not valid for the low q collision systems investigated in this work. Thus, measurements for other collision systems are planned for the future in order to establish the systematics of electron capture cross sections for projectiles with low q/Z [6].

Table 1: One-electron capture cross sections.

	Beam Energy (A MeV)		
	3.4	6.0	8.0
	Cross Section (Mb/atom)		
Xe^{11+} + N	0.258		
Xe^{18+} + N	2.060 4.39*	0.386	0.144 0.34*
Xe^{24+} + N			0.374
Xe^{27+} + N			0.693
Xe^{30+} + N		3.164	1.101
Xe^{18+} + Ar		0.281	
Xe^{30+} + Ar		6.660	

*nCTMC Calculation.

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