Cross sections for single electron capture as well as single and multiple electron loss of Xe\(^{18+}\) projectiles in single collisions with N\(_2\) molecules were measured as a function of the beam energy \([1]\). The objective of this report is to examine the systematics of the results and to provide the means for making reliable estimates of other cross sections that were not directly measured.

It was found that the logarithms of cross sections \(F(q)(E)\) for single and multiple electron loss as a function of beam energy \(E\) can be reasonably well represented with straight lines, i.e.,

\[
\log F_{\Delta q}(E) = c_o(\Delta q) + c_1(\Delta q) E, \tag{1}
\]

where \(E\) is in MeV/u and \(F\) is in Mb per atom. The intercept \(c_o\) and the slope \(c_1\) of these lines are found to be smooth functions of \(\Delta q\), the number of electrons stripped from the projectile. Specifically, the intercepts \(c_o\) were represented by a third-order polynomial in \(\Delta q\), i.e.,

\[
c_o(\Delta q) = b_o - b_1 \Delta q + b_2(\Delta q)^2 - b_3(\Delta q)^3, \tag{2}
\]

while the slopes were represented by the sum of a constant and a Gaussian function of \(\Delta q\), i.e.

\[
c_1(\Delta q) = -a_0 + a_1 \exp[-0.5(\Delta q - a_2)^2/a_3^2]. \tag{3}
\]

Initially, the parameters \(a_0, a_1, a_2, b_0, b_1, b_2,\) and \(b_3\) were determined simultaneously in a least squares fitting procedure using all available experimental data. However, in this process it was found that the best-fit value of \(c_1(\Delta q)\) differed significantly from the value obtained from the fit of the double loss cross section data alone using eq. (1) and varying \(c_o(\Delta q)\) and \(c_1(\Delta q)\) as independent parameters. Therefore, the measured double-electron loss cross sections were excluded from the data set and the best-fit values of the parameters \(a_0, a_1, a_2, b_0, b_1, b_2,\) and \(b_3\) were re-evaluated. The results are shown in Table I.

**Table I:** Best-fit values of the parameters \(a_0, a_1, a_2,\) and \(a_3\) from eq. (3) and \(b_0, b_1, b_2,\) and \(b_3\) from eq. (2) based on the simultaneous fit to the complete set of measured electron loss cross sections, excluding those related to double-electron loss.

<table>
<thead>
<tr>
<th>Par.</th>
<th>Value</th>
<th>Par.</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a_0)</td>
<td>7.61435E-02</td>
<td>(b_0)</td>
<td>6.90499E-01</td>
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<tr>
<td>(a_1)</td>
<td>1.78906E+00</td>
<td>(b_1)</td>
<td>1.23032E-01</td>
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<tr>
<td>(a_2)</td>
<td>2.83733E+00</td>
<td>(b_2)</td>
<td>8.96020E-03</td>
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</tbody>
</table>

The best-fit values of \(c_o(\Delta q)\) and \(c_1(\Delta q)\) obtained from an independent fit of the double-electron capture cross sections were found to be 0.884187 and \(-8.20030 \times 10^{-3}\), respectively. The reason for this non-systematic behavior of \(c_1(\Delta q)\) is yet unclear. The measured total projectile stripping cross sections were analyzed in the same way. The results are: \(c_o(\text{total}) = 1.63121, c_1(\text{total}) = -0.033088\). Logarithms of the cross sections for single-electron capture by the projectile were fitted by a quadratic function of \(E\), i.e.,

\[
\log F(E) = d_o + d_1 E + d_2 E^2. \tag{4}
\]

The best-fit values of the parameters of eq. (4) were found to be \(d_o = 1.65999, d_1 = -0.457390,\) and \(d_2 = 0.0180006\). The measured cross sections and the best-fit functions are shown in Fig. 1. The quality of the fits is good, considering the number of data points and the overall number of fitting parameters.
Figure 1: The symbols represent the measured cross sections for single electron capture as well as the single and multiple electron loss by the projectile. The lines represent the best-fit functions, as described in the text.

References