Electron Capture from Atomic Nitrogen by Protons

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Electron Capture from Atomic Nitrogen by Protons

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The total Oppenheimer-Brinkman-Kramers (OBK) cross sections for 1s-, 2s-, and 2p-orbital electron capture from atomic nitrogen by protons are adjusted to correspond to capture from N\textsubscript{1} by deuterons, and are compared with recent measurements of Berkner et al. Calculated cross sections for 1s capture are dominant above 3 MeV, and the total OBK cross section still exceeds the measured cross section at the deuteron energy of 21.5 MeV.

RECENTLY published measurements of cross sections for electron capture from N\textsubscript{1} by deuterons differ markedly from the OBK (Oppenheimer-Brinkman-Kramers) cross sections for electron capture from N by protons when expressed as cross sections per gas molecule at the appropriate impact energy for deuterons. One of the chief sources of the disagreement in this comparison originates from using calculated cross sections for only p-orbital capture at impact energies sections for Is-, 2s-, and 2p-orbital capture from N\textsubscript{1} by deuterons exceeding 3 MeV. These cross sections pertain to capture into the 1s state of atomic hydrogen only, and the n\textsuperscript{-2} rule is used to sum the cross sections into all s states of hydrogen. As for the contributions of simultaneous charge transfer and excitation, previous calculations for helium suggest that these processes can be neglected with small error. The sum of the OBK cross sections for 1s-, 2s-, and 2p-orbital capture from N\textsuperscript{(1S)} into all s states of the hydrogen atom leaving the residual ions N\textsuperscript{+}[1P;(1S)',(2S)',(2P)'], N\textsuperscript{+}[2S;1S,(1S)',(2S)',(2P)'], and N\textsuperscript{+}[2S;1S,(1S)',(2S)',(2P)'] have been multiplied by 2, and are plotted in Fig. 1.

This approximation has been used to compute cross sections for 1s capture, impact energies \( \geq 1 \) MeV; moreover, the energy range of the cross sections for 2s capture has been extended to 100 MeV. The cross sections are expressed as a function of the impact energy of the proton in the frame of reference where the atomic target is initially at rest. Perhaps the most notable distinction of these OBK cross sections is the dominance of 1s-orbital capture for impact energies exceeding 3 MeV. These cross sections pertain to capture into the 1s state of atomic hydrogen only, and the n\textsuperscript{-2} rule is used to sum the cross sections into all s states of hydrogen. As for the contributions of simultaneous charge transfer and excitation, previous calculations for helium suggest that these processes can be neglected with small error. The sum of the OBK cross sections for 1s-, 2s-, and 2p-orbital capture from N\textsuperscript{(1S)} into all s states of the hydrogen atom leaving the residual ions N\textsuperscript{+}[1P;(1S)',(2S)',(2P)'], N\textsuperscript{+}[2S;1S,(1S)',(2S)',(2P)'], and N\textsuperscript{+}[2S;1S,(1S)',(2S)',(2P)'] have been multiplied by 2, and are plotted in Fig. 1.

![Fig. 1. Electron-capture cross sections per N\textsubscript{1} molecule. E is the impact energy of the proton in MeV. Closed circles with error bar represent experimental values taken from Table I of Berkner et al. Solid curve represents the sum of the OBK cross sections for atomic nitrogen multiplied by 2. (See text for the processes represented.)](image-url)

2 R. A. Mapleton, Phys. Rev. 130, 1829 (1963). This is referred to as 1.
It is seen that the two experimental values of Berkner, et al. are less than the corresponding OBK values, which fact suggests that the asymptotic energy region may not yet be reached. Of course, it is not known whether OBK cross sections are the asymptotic values of a correct theory, and at what energy the onset of the asymptotic value would occur. Little is also known how well electron capture from N\textsubscript{2} can be described in terms of N atoms\textsuperscript{9} (factor of 2) or how much the present OBK values would be altered by a recalculation with improved wave functions. In the author’s opinion, it is very difficult to decide theoretically what the asymptotic cross section is for a target as complicated as N\textsubscript{2}.

An atomic system much more tractable to theoretical analysis is helium, and the energy range of the OBK calculations\textsuperscript{8} using the 6-parameter helium wave function have also been extended to 100 MeV. The OBK cross sections for capture from He, N, and O, described in this paper, can be obtained from the author.

Gratitude is expressed to Professor A. Dalgarno for informing the author of these measurements.

\textsuperscript{1} T. F. Tuan and E. Gerjuoy, Phys. Rev. 117, 756 (1960).

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1s-orbital capture
electronic capture
2s-, 2p-orbital capture
Atomic nitrogen