INTRODUCTION

Argon has long been favored for used in experiments on ionized gases. The reasons are many: it is relatively cheap and convenient to use, it is ionized at easily attainable temperatures with considerably less energy input than for gases in molecular form at room temperature, and its physical properties are reasonably well-known.

One set of properties needed for interpretation and design of experiments involving ionized gases is the transport coefficients--electrical and thermal conductivity, viscosity and thermal and ordinary diffusion coefficients. These properties were computed for argon in chemical equilibrium at atmospheric pressure several years ago.[1] Since that time better values of the necessary intermolecular potentials and cross sections have become available and experimental measurements of these coefficients have improved in accuracy to the point where a recalculation using the new values is warranted. In addition, it is desirable to extend the calculations to the gas in an imposed steady magnetic field and to pressures considerably above atmospheric. This paper reports the results of such calculations.

CROSS SECTIONS

The average cross sections necessary for computations of transport coefficients with the Chapman-Enskog method are given by the expression[2]

$$\overline{Q}^{(\ell,s)}(T) = \frac{2(\ell+1)}{(s+1)![2\ell+1-(-1)^\ell]} \int_0^\infty e^{-x} x^{s+1} Q^{(\ell)}(kTx)\, dx \tag{1}$$

where $x = \mu g^2/2kT = E/kT$ and μ is the reduced mass of the colliding species, ℓ and s are integers whose values depend on the level of approximation used in the Chapman-Enskog method and $Q^{(\ell)}(E)$ is related to the differential cross section $\sigma(E,\chi)$ by

$$Q^{(\ell)}(E) = 2\pi \int_0^\pi \sigma(E,\chi)(1 - \cos^\ell \chi) \sin\chi\, d\chi \tag{2}$$

$Q^{(1)}$ is the well-known momentum-transfer cross section, and $Q^{(2)}$ is sometimes called the thermal conductivity or viscosity cross section, since it is the most important for these coefficients.

Data for the evaluation of Eq. (1) come from two sources: intermolecular potentials and known values of $Q^{(\ell)}$. For most pairs of particles in the gas the collision is described well by classical mechanics, so that $Q^{(\ell)}$ and thus $\overline{Q}^{(\ell,s)}$ can be evaluated by a three-fold quadrature once the intermolecular potential is known. These computations have already been carried out for certain standard potential forms which are employed in the present work. These are the repulsive exponential potential

$$\varphi(r) = \varphi_0\, e^{-r/\rho}, \tag{3}$$

the shielded-Coulomb potential

$$\varphi(r) = \varphi_0 \left(\frac{\rho}{r}\right) e^{-r/\rho}, \tag{4}$$