THE MOTIONS OF SLOW ELECTRONS IN DIATOMIC GASES

by

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1. Introduction

The work on the motions of slow electrons in gases which is described in this thesis was carried out in the Department of Physics at the University of Adelaide under the direction of Professor L. G. H. Huxley. The electron energies are small, varying from two or three times thermal energy up to several electron volts; the energies are always so small that ionizing collisions between electrons and gas molecules do not occur.

In sections 2, 3 and 4, the fundamental theory of the diffusion of electrons in gases is presented. The assumptions upon which the theory is based are stated, and discussed.

The apparatus, with which experiments on the diffusion and drift of electrons through gases are conducted, is described in section 5.

Sections 6, 7 and 8 are devoted to a description of experiments concerned with the motions of electrons through gases in the presence of both electric and magnetic fields. The aim of these experiments is to demonstrate the consistency achieved between the results obtained when different methods are used for measuring the value of a certain physical quantity. The agreement between the results obtained was good, and justifies the confidence placed in the theory as a whole, and implies that the assumptions upon which the theory is based are warranted. Further, the differential equations which govern the concentration of electrons diffusing and drifting in electric and magnetic fields, are also used to determine the drift and diffusion of charges in the ionosphere, and it is of importance that
these equations have been verified experimentally.

In a paper by Crompton, Huxley and Sutton (1953) attention was drawn to the necessity of conducting diffusion experiments at low temperatures approximating to those in the ionosphere. It was hoped that some justification would be found for the extrapolation of the results of diffusion experiments beyond the point where laboratory measurements are possible with existing techniques. Such experiments were performed and are described in section 9. The results indicate that the energies of electrons moving in a gas under the influence of an electric field are, over a large range of values of electron energies, effectively independent of the agitational motions of the gas molecules. With regard to the possibility of extrapolation of results to low electron energies, the experiments proved inconclusive.

Various attempts have been made to derive theoretical formulae which represent the observed functional dependence of the mean energy lost by an electron in a collision with a diatomic molecule on the mean electron energy. No formulae have been derived which represent the observed variation over an appreciable range of values of the electron energy. Consequently it was thought that experiments conducted in two gases which were isotopes, and thus differed only in nuclear properties, might provide some indication of the nature of the processes involved in collisions between electrons and gas molecules. In section 10 the results are given of experiments to measure the cross-sections of deuterium molecules for collisions with slow electrons, and the mean energy losses suffered by the electrons.
in collisions with the molecules. The results are available of similar experiments concerned with electrons diffusing in hydrogen (Crompton and Sutton, 1952). It was found that, for electrons of a given energy, the cross-sectional areas were the same for the two gases, whereas the mean energy lost by an electron in a collision with a hydrogen molecule was twice that lost in a collision with a molecule of deuterium. On the basis of these results, semi-empirical formulae were derived (Huxley, 1956a) which represent satisfactorily the variation with electron energy of the amount of energy lost by an electron in a collision with a gas molecule. Such formulae are useful in the deduction of information concerning the behaviour of electrons diffusing in gases when the electron energies are so nearly equal to the mean thermal energy of agitation of the gas molecules, that laboratory experiments are virtually impossible to carry out.