AN EXPERIMENTAL STUDY OF THE PRODUCTS OF DISSOCIATIVE RECOMBINATION OF MOLECULAR IONS WITH ELECTRONS.

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ABSTRACT. A new experimental method has been developed which allows determination of the products nature in dissociative recombination (D.R.) of molecular ions. Results are presented on H_2O^+ D.R. which show that there is a large yield of oxygen atoms in this reaction. The measurements give a total yield for the two channel O + H + H and O + H_2 of 0.45 and therefore a yield of 0.55 for OH + H. H_2O^+ ions are formed by charge exchange from N^+ ions and are probably vibrationally excited in this experiment.

1. INTRODUCTION.

Dissociative recombination (D.R.) of molecular ions with electrons is a very important process for interstellar chemistry as a source of neutral molecules (1). It is also a source of excited atoms and radicals both in comet tails and planetary atmospheres leading sometimes to radiation (as the green line of OI or the fourth positive system of CO) (2). However the very few experiments which have been done in this field deal mainly with the problem of the state of the atoms formed in diatomic ions D.R. and the nature of D.R. products of polyatomic ions is essentially unknown at the present time.

2. EXPERIMENTAL.

In our laboratory* a new technique has been developed in order to study the products yield in D.R. reactions.The fundamentals of the method, which has been described elsewhere (3), (4) lie in creating molecular ions M^+ by chemionization via charge exchange reaction with a monoatomic ion Ar^+, He^+ or N^+. The molecular parent gas M is injected inside the highly ionized plasma flow created in a water cooled tube using an arc plasma generator (3). The plasma generator exit is the throat of a copper nozzle which constitutes the anode and is set at ground potential. The flow in the tube is then a flowing afterglow with thermalized electrons. A Langmuir probe allows determination of electron density and

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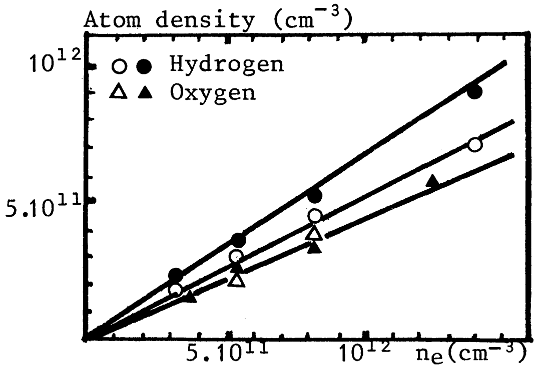
temperature and a quadrupole mass spectrometer checks the ion masses. Due to the very high electron density achived in this system (10^{11} to 10^{13} cm^{-3} for a total density of 10^{15} to 10^{16} cm^{-3}) D.R. quickly destroys M^+ ions and the neutral product densities can be determined by vacuum ultraviolet absorption. Results on H_2O^+ D.R. are presented below.

3. RESULTS AND DISCUSSION.

In order to create H_2O^+ ions an helium buffer was used in which nitrogen is introduced downstream of the arc discharge. He^+ ions (and H_e^M metastables) are quickly converted into N^+ and N_2^+, this later ion being recombined by D.R. yielding $N(^2D)$ (4). This metastable state is efficiently quenched by superelastic collision with electrons. At the H_2O entry port (further downstream) the main species are He, N^+, $N(^4S)$ and electrons e. However $N(^2D)$ is not completely destroyed as shown by absorption measurements.



● ▲ with ∿ 100 scc/mn H_2O
○ △ with ∿ 10 scc/mn H_2O

Fig. 1 : Atom density versus n_e

Figure 1 shows the oxygen and hydrogen atoms densities (respectively n_O and n_H) obtained as a function of the initial electron density n_e in the centre of the flow. The electron density was varied by varying the helium buffer flow and two different H_2O flow rate were used. The difference in the two sets of H measurements could come from H_3O^+ formation. A complete discussion of these results is not possible here and will be published elsewhere (5).

The different possible channels for H_2O^+ D.R. are OH + H, O + H_2 and O + H + H and the branching ratio (respectively α_1, α_2, α_3) satisfy the three equations : $\alpha_1 + \alpha_2 + \alpha_3 = 1$; $\alpha_2 + \alpha_3 = n_O/n_e$; $\alpha_1 + 2\alpha_3 = n_H/n_e$. From where it follows: $\alpha_1 = 0.55$ $\alpha_2 + \alpha_3 = 0.45$ with $\alpha_3 \geqslant 0.22$.

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