Title: Reactions of astrophysically important positive ions with molecules and atoms at low temperatures

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Abstract: In the present work, the results of the experimental study of reactions of ions with atomic and molecular hydrogen are presented. Experiments were performed using a cold radiofrequency 22-pole ion trap apparatus in the temperature range, relevant for interstellar clouds (from 300 down to 15 K).

The present study is devoted to experimental investigation of the reactions of NH^+, NH_2^+ and NH_3^+ ions with H_2. The reaction of NH^+ with H_2 has two channels, which lead to NH_2^+ (about 97 %) and H_3^+ (3 %) formation with nearly constant reaction rate coefficients. The reaction of $NH_2^+ + H_2$ produces only NH_3^+ ions and the measured reaction rate coefficient is decreasing with increasing temperature from $6 \cdot 10^{-10}$ cm^3s^{-1} to $2 \cdot 10^{-10}$ cm^3s^{-1}. The measured reaction rate coefficient of NH_3^+ with H_2, producing NH_4^+, is increasing with decreasing temperature from 80 K down to 15 K, confirming predicted mechanism of tunneling through a potential barrier.

Reaction of $NH^+ + H$ was studied using a combination of the 22-pole ion trap apparatus and hydrogen atom source. The measured reaction rate coefficient was at least one order of magnitude lower than the Langevin rate coefficient (~10^{-10} cm^3s^{-1}). Comparison of the data with theoretical calculations and other measurements that were carried out earlier in our laboratory suggests that the reaction ($NH^+ + H$) is extothermic.

This work also includes a brief description and results of our recent investigation – reactions of doubly charged carbon cations C^{2+} with molecular hydrogen. The results of these studies are significant for understending the processes which may play an important role in the interstellar medium.

Keywords: cations, 22-pole ion trap, astrochemistry, ion-molecule reactions, interstellar medium.