

Reaction of NH_2^+ with H_2 in ion trap at low temperatures

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Ammonia has been observed in many celestial objects ranging from interstellar molecular clouds to solar system planets and moons.^{1,2} One of the paths of its gas-phase formation is a sequence hydrogen abstraction reactions forming NH_4^+ from N^+ , followed by the dissociative recombination to ammonia and hydrogen.³

We present measured reaction rate coefficient of one reaction of the above mentioned chain,



which is exothermic with $\Delta H = -1.1$ eV.⁴ It has not been studied at temperatures below 300 K in previous experiments.⁵ We used a linear rf 22-pole trap⁶ to study the reaction (1) at temperatures down to 10 K, which are relevant to most interstellar molecular clouds. An example of experimental data, showing a decay of the number of trapped NH_2^+ and formation of NH_3^+ , is plotted in Figure 1. The reaction rate coefficient at 44 K obtained from the corresponding fit in Figure 1 is $7 \times 10^{-10} \text{ cm}^3 \text{ s}^{-1}$ with 20% systematic uncertainty.

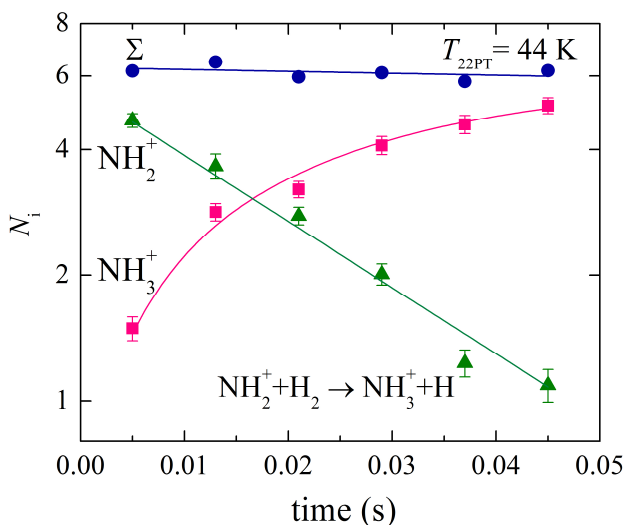


Figure 1. Decay of the number of primary NH_2^+ ions (\blacktriangle) and increase of the number of NH_3^+ product ions (\blacksquare) due to the interaction of NH_2^+ ions with H_2 . All data were fitted by a kinetic model (lines). Experiment was carried out at 44 K and H_2 number density $5 \times 10^{10} \text{ cm}^{-3}$.

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References

- (1) Cheung, A. C.; Rank, D. M.; Townes, C. H.; et al. *Phys. Rev. Lett.* **1968**, 21, 1701 – 1705.
- (2) Brooke, T.Y.; Knacke, R.F.; Encrenaz, Th.; et al. *Icarus* **1998**, 136, 1 – 13.
- (3) Herbst, E. & Klemperer, W. *Astrophys. J.* **1973**, 185, 505 – 534.
- (4) Rist, C.; Faure, A.; Hily-Blant, P.; Le Gal, R. *J. Phys. Chem. A* **2013**, 117, 9800 – 9806.
- (5) Adams, N. G.; Smith, D.; Paulson, J. F. *J. Chem. Phys.* **1980**, 72, 288 – 297.
- (6) Gerlich, D.; Jusko, P.; Roučka, Š.; et al. *Astrophys. J.* **2012**, 749, 22.