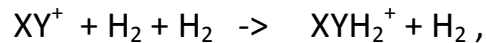


Molecular Astrophysics: Exercise 5

1)

Assume that the rate of a 3-body reaction between a molecular ion XY^+ and two H_2 molecules



is given by

$$R = k_3 n(H_2)^2.$$

Where k_3 is the three-body rate coefficient $k_3 = 1.5 \times 10^{-29} \text{ cm}^6 \text{ s}^{-1}$, and the H_2 density is given by $n(H_2)$.

Calculate the reaction rate R for an H_2 pressure of 1 bar (at room temperature, make sure to use consistent units for the ideal gas equation) and for interstellar cloud conditions with $n(H_2) = 1000 \text{ cm}^{-3}$. What do we learn from the result? Do we need to consider three-body processes in the Interstellar Medium?

2)

The classical Langevin collision rate coefficient between an ion and a neutral collision partner is given by

$$R_L = 2.34 \times 10^{-9} \left(\frac{\alpha}{\mu} \right)^{1/2},$$

where α is the polarizability (in 10^{-24} cm^3) of the neutral, and μ is the reduced mass

$$\mu = \frac{m_1 m_2}{m_1 + m_2}.$$

The polarizability of H_2 molecules is $\alpha = 4.29 \times 10^{-25} \text{ cm}^3$, and the polarizability of H atoms is $\alpha = 6.66 \times 10^{-25} \text{ cm}^3$.

Calculate the Langevin rate coefficient R_L for collisions of

- a) H_2^+ with H,
- b) H_2^+ with H_2 ,
- c) CO^+ with H,
- d) CO^+ with H_2 .

How does the Rate coefficient vary with mass? Consider collisions of heavier molecular ions with hydrogen atoms and molecules. What range of values do you expect for the classical Langevin rate coefficient?