

HOMEWORK ASSIGNMENT # 6

Due: Thursday, 6 March

1. Write a sequence of reactions starting from nitrogen atoms and other initial ingredients to form and destroy ammonia, HCN, and cyanoacetylene in cold dark interstellar clouds.

In the following problems you can either calculate the rate coefficients needed or use the values in our network of gas-phase reactions (see the osu models under “research” on our web site). The problems all refer to cold dense clouds with $T = 10$ K and $n = 10^4$ cm⁻³ unless stated otherwise.

2. Estimate the fractional abundance of HCO⁺ at steady-state. Assume that HCO⁺ is formed from the reaction between H₃⁺ and CO, and that $f_{\text{CO}} = \text{CO}/n = 10^{-4}$. The HCO⁺ (formyl) ion is destroyed mainly by dissociative recombination reactions with electrons ($f_e = 10^{-7}$).

3. Estimate the abundance ratio of DCO⁺/HCO⁺ you would expect at steady-state in a dark cloud at 10 K and at 20 K. The ion DCO⁺ is formed via the reaction between H₂D⁺ and CO on 1/3 of the reactive collisions.

4. Estimate the steady-state abundance ratio between water and OH radicals using the following assumptions:

(a) Both are formed from the dissociative recombination reaction of H₃O⁺ with electrons, where H₂O is produced on 30% of collisions and OH on 70% of collisions.

(b) Water is destroyed mainly by the reaction with H₃⁺ while OH is destroyed mainly by the reaction with atomic O (the fractional abundance of which is 10⁻⁴).