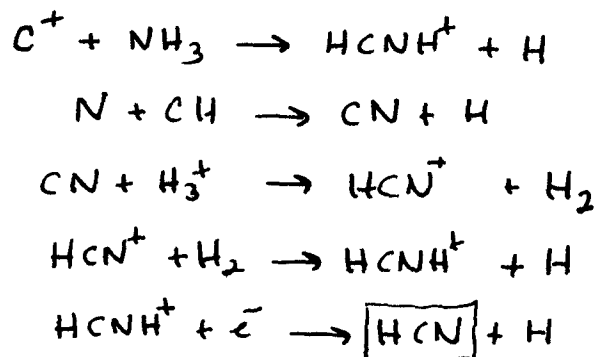
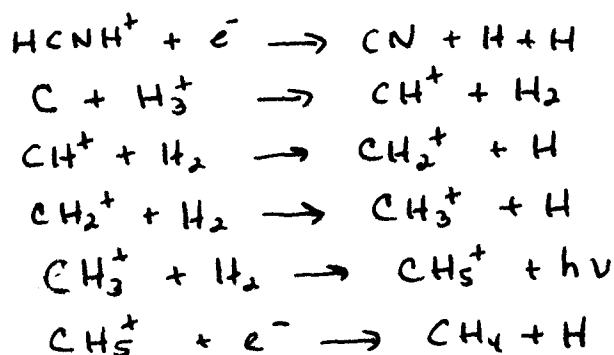
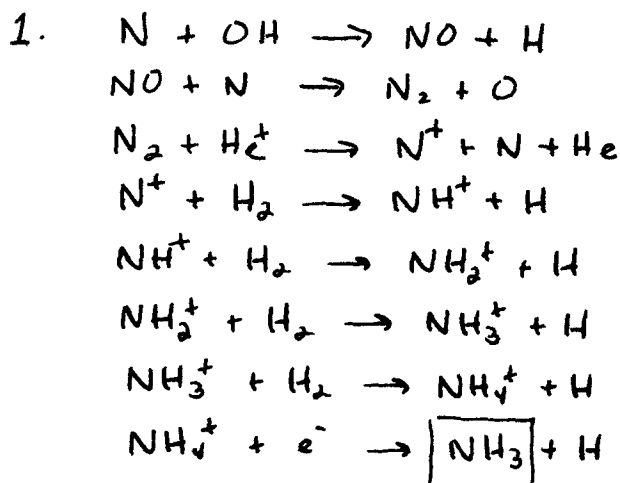
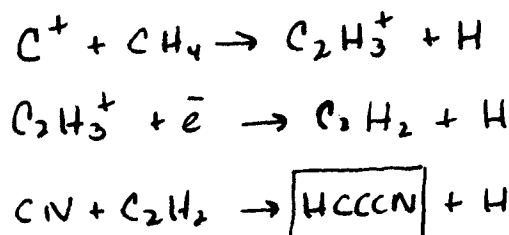


Answers To Homework Set #6

Both  $\text{NH}_3$  +  $\text{HCN}$  (as well as  $\text{HCCCN}$ ) are destroyed by a variety of ions:  $\text{H}_3^+$ ,  $\text{He}^+$ ,  $\text{H}^+$ , etc.



2. First consider  $\text{H}_3^+$ : as shown in class

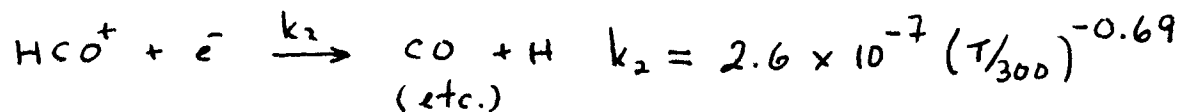
$$[\text{H}_3^+] = \mathcal{J}[\text{H}_2]/k_1[\text{CO}] \quad \mathcal{J} = 1.3 \times 10^{-17} \text{ s}^{-1}$$

$$\text{where } \text{H}_3^+ + \text{CO} \xrightarrow{k_1} \text{HCO}^+ + \text{H}_2; \quad k_1 = 1.6 \times 10^{-9} \text{ cm}^3 \text{ s}^{-1}$$

$$[\text{H}_3^+] = \mathcal{J}/k_1 f_{\text{CO}} \quad f_{\text{CO}} = 10^{-4}$$

$$\therefore [\text{H}_3^+] = 8.1 \times 10^{-5}$$

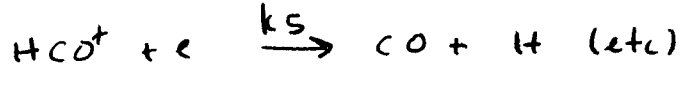
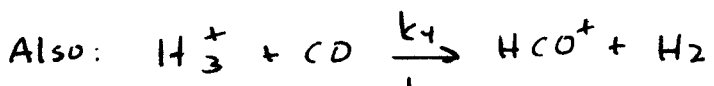
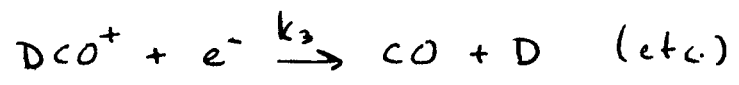
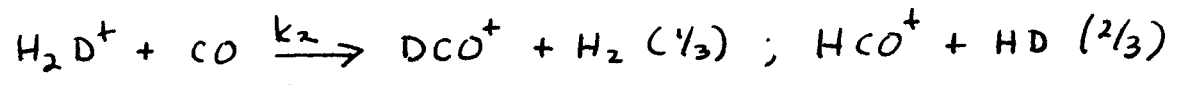
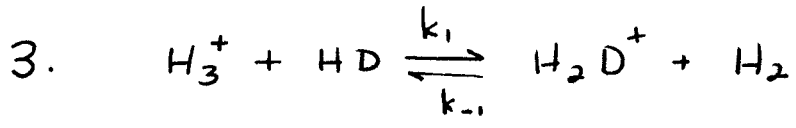
$$\frac{d[\text{HCO}^+]}{dt} = k_1[\text{H}_3^+][\text{CO}] - k_2[\text{HCO}^+][e^-] = 0$$



$$k_2(10 \text{ K}) = 2.7 \times 10^{-6} \text{ cm}^3 \text{ s}^{-1}$$

$$[HCO^+] = \frac{k_1 [H_3^+] [CO]}{k_2 [e^-]} = \frac{k_1 [H_3^+] f_{CO}}{k_2 f_{e^-}}$$

$$[HCO^+] = 5 \times 10^{-5} \text{ cm}^{-3} \quad f_{HCO^+} = 5 \times 10^{-9}$$



$$f_{HD} = 2 \times 10^{-5}$$

$$[H_2D^+] = \frac{k_1 [H_3^+] [HD]}{k_{-1} [H_2] + k_2 [CO]}$$

$$[DCO^+] = \frac{\frac{1}{3} k_2 [H_2D^+] [CO]}{k_3 [e^-]}$$

$$[HCO^+] = \frac{k_4 [H_3^+] [CO]}{k_5 [e^-]}$$

$$\frac{[DCO^+]}{[HCO^+]} = \frac{\frac{1}{3} \frac{[H_2D^+]}{[H_3^+]}}{k_2 \approx k_4 \quad k_3 \approx k_5}$$

$$\frac{[H_2D^+]}{[H_3^+]} = \frac{k_1 [HD]}{k_{-1} [H_2] + k_2 [CO]} = \frac{k_1 f_{HD}}{k_{-1} + k_2 f_{CO}}$$

$$K = k_1/k_{-1} \approx e^{230/T} \quad k_1 \sim 10^{-9} \text{ cm}^3 \text{ s}^{-1}$$

$$k_2 \approx 1.6 \times 10^{-9} \text{ cm}^3 \text{ s}^{-1}$$

$$T = 10 \text{ K} \quad K = 9.7 \times 10^9 \Rightarrow k_{-1} = 1.0 \times 10^{-19} \text{ cm}^3 \text{ s}^{-1}$$

$$T = 20 \text{ K} \quad K = 9.9 \times 10^4 \Rightarrow k_{-1} = 1.0 \times 10^{-14} \text{ cm}^3 \text{ s}^{-1}$$

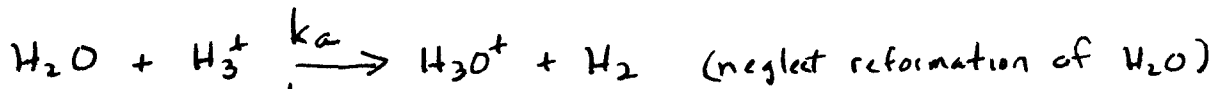
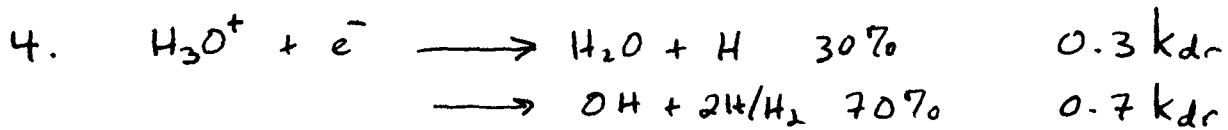
$$T = 10K \quad \frac{[H_2O^+]}{[H_3^+]} = \frac{k_1 f_{HD}}{k_{-1} + k_2 f_{CO}} = \frac{k_1 f_{HD}}{k_2 f_{CO}} = 0.13$$

ting  $\rightarrow 10^{-19} \text{ cm}^3 \text{ s}^{-1}$

$$\frac{[Oco^+]}{[Hco^+]} = \frac{1}{3} \frac{[H_2O^+]}{[H_3^+]} = 0.043$$

$$T = 20K \quad \frac{[H_2O^+]}{[H_3^+]} = \frac{k_1 f_{HD}}{1 \times 10^{-14} + 1.6 \times 10^{-13}} = 0.12$$

$$\frac{[Oco^+]}{[Hco^+]} = 0.040 \quad \text{small effect}$$



$$[H_2O] = 0.3 k_{dr} [H_3O^+] [e^-] / k_a [H_3^+]$$

$$[OH] = 0.7 k_{dr} [H_3O^+] [e^-] / k_b [O]$$

$$\frac{[H_2O]}{[OH]} = \frac{3}{7} \frac{k_b [O]}{k_a [H_3^+]} = \frac{3}{7} \frac{k_b f_o}{k_a f_{H_3^+}}$$

$$f_o \sim 10^{-4} \quad f_{H_3^+} \sim 8 \times 10^{-9}$$

osu.2007 network 10K

$$O + OH \quad k_b = 7.5 \times 10^{-11} (T/300)^{-0.25} = 1.76 \times 10^{-10} \text{ cm}^3 \text{ s}^{-1}$$

$$H_2O + H_3^+ \quad k_a = 4.5 \times 10^{-9} (T/300)^{-0.5} = 2.46 \times 10^{-8} \text{ cm}^3 \text{ s}^{-1}$$

$$\frac{[H_2O]}{[OH]} = \frac{3}{7} \frac{1.76 \times 10^{-10} 10^{-4}}{2.46 \times 10^{-8} 8 \times 10^{-9}} = 38$$