

1(75). For the reaction



the temperature dependence of the equilibrium constant is given by

$$\ln K_p = (-2.33966) - \frac{(1020.3)}{[T/\text{(K)}]} + (0.6833) \ln [T/\text{(K)}]$$

A(10). Calculate  $K_p$  at 400 K.

B(15). Calculate  $\Delta_r H^\circ$  at 400 K.

C(20). If a reaction mixture contains  $P(\text{HI}) = 1.0 \times 10^{-3}$  bar,  $P(\text{H}_2) = 1.1 \times 10^{-6}$  bar, and  $P(\text{I}_2) = 0.52$  bar, is the reaction mixture at equilibrium? \_\_\_\_\_  
 If not, in which direction will the reaction proceed to attain equilibrium?  
 \_\_\_\_\_

D(10). Calculate  $K_p$  for the reaction



at 400 K using your answer from part A.

E(20). For chemical equation (1)

$$K_p = \left( \frac{m_{\text{H}_2} m_{\text{I}_2}}{m_{\text{HI}}^2} \right)^{(3/2)} \left( \frac{\sigma_{\text{HI}}^2}{\sigma_{\text{H}_2} \sigma_{\text{I}_2}} \right) \left( \frac{\theta_{\text{rot,HI}}^2}{\theta_{\text{rot,H}_2} \theta_{\text{rot,I}_2}} \right) \left( \frac{(1 - e^{-\theta_{\text{vib,HI}}})^2}{(1 - e^{-\theta_{\text{vib,H}_2}})(1 - e^{-\theta_{\text{vib,I}_2}})} \right) e^{(D_{0,\text{H}_2} + D_{0,\text{I}_2} - 2D_{0,\text{HI}})/RT}$$

Use the following data to evaluate  $K_p$  at 400 K.

	HI(g)	H <sub>2</sub> (g)	I <sub>2</sub> (g)
$\theta_{\text{vib}}/\text{(K)}$	3266	6215	308
$\theta_{\text{rot}}/\text{(K)}$	9.25	85.3	0.0537
$D_0/\text{(kJ mol}^{-1}\text{)}$	294.7	432.1	148.8

2(15). Compare the values of the average kinetic energies of the H<sub>2</sub> and I<sub>2</sub> molecules in the reaction mixture described by chemical equation (1).

Compare the values of the root-mean-square speeds of the H<sub>2</sub> and I<sub>2</sub> molecules in the reaction mixture described by chemical equation (1).

3(10). If the temperature of a gas is doubled, by how much is the average speed of the molecules increased?

4(25). The distribution function for speed is

$$G(u) = 4\pi \left( \frac{m}{2\pi k_{\text{B}} T} \right)^{3/2} e^{-mu^2/2k_{\text{B}}T} u^2$$

Determine the ratio of  $G(u)_{T_2} / G(u)_{T_1}$  where  $T_2 = 2T_1$  and  $u = 2u_{\text{rms}}$  measured at  $T_1$ .