Chemistry 192
Recitation Section Problems
January 29, 2018
Solutions

All the questions pertain to the gas-phase reaction at 298K

$$\mathrm{NO}_{2(g)} + \frac{1}{2}\mathrm{Cl}_{2(g)} \rightleftharpoons \mathrm{NO}_2\mathrm{Cl}_{(g)}$$

1. At equilibrium it is found that $[\mathrm{Cl}_2]$=2.74 M, $[\mathrm{NO}_2\mathrm{Cl}]$=1.31 M and $[\mathrm{NO}_2]$=0.531 M. Calculate the concentration equilibrium constant K_c for the reaction.
Answer:

$$K_c = \frac{[\mathrm{NO}_2\mathrm{Cl}]}{[\mathrm{NO}_2][\mathrm{Cl}_2]^{1/2}} = \frac{1.31}{(0.531)(2.74)^{1/2}} = 1.49$$

2. Under different equilibrium conditions it is found that $[\mathrm{NO}_2]$=2.00 M and $[\mathrm{NO}_2\mathrm{Cl}]$=3.35 M. Calculate the concentration of chlorine gas in the mixture.
Answer:

$$1.49 = \frac{3.35}{(2.00)[\mathrm{Cl}_2]^{1/2}}$$

$$[\mathrm{Cl}_2]^{1/2} = 1.12$$

$$[\mathrm{Cl}_2] = 1.26 \text{ M}$$

3. Determine K_c for the dissociation of $\mathrm{NO}_2\mathrm{Cl}_{(g)}$; i.e. the reaction

$$\mathrm{NO}_2\mathrm{Cl}_{(g)} \rightleftharpoons \mathrm{NO}_{2(g)} + \frac{1}{2}\mathrm{Cl}_{2(g)}$$

Answer:

$$K_c = \frac{1}{1.49} = 0.671$$

4. Calculate the pressure equilibrium constant, K_P for the dissociation of $\mathrm{NO}_2\mathrm{Cl}_{(g)}$ at 298K.
Answer:

$$K_P = K_c(RT)^{\Delta n_{gas}} = (0.671)[(0.08314)(298)]^{1/2} = 3.34$$

5. In a container of fixed volume, the degree of dissociation of $NO_2Cl_{(g)}$ at 298K is found to be $\alpha = 0.784$. Calculate the total pressure in the container.

Answer:

Let n_0 be the initial number of moles of NO_2Cl. Then

	n_{NO_2Cl}	n_{NO_2}	n_{Cl_2}
initial	n_0	0	0
change	-0.784n_0	0.784n_0	0.392n_0
equilibrium	0.216n_0	0.784n_0	0.392n_0

$$n_{tot} = 1.392 n_0$$

$$P_{NO_2Cl} = \chi_{NO_2Cl} P = \frac{0.216}{1.392} P$$

$$P_{NO_2} = \chi_{NO_2} P = \frac{0.784}{1.392} P$$

$$P_{Cl_2} = \chi_{Cl_2} P = \frac{0.392}{1.392} P$$

$$K_P = 3.34 = \frac{\left(\frac{0.784}{1.392}P\right)\left(\frac{0.392}{1.392}P\right)^{1/2}}{\left(\frac{0.216}{1.392}P\right)} = 1.93 P^{1/2}$$

$$P = 3.00 \text{ bar}$$

6. Calculate K_P for the reaction

$$2NO_2Cl_{(g)} \rightleftharpoons 2NO_{2(g)} + Cl_{2(g)}$$

Answer:

$$K_P = 3.34^2 = 11.2$$