Introduction to Equilibrium

Equilibrium

- Chemical equilibrium – occurs when the ____________ & ____________ stop changing

- Equilibrium reactions are always denoted by _____

Equilibrium Expressions

- $aA + bB \rightleftarrows cC + dD$
- K_c =

- K_c = equilibrium constant
- [ ] = concentration in molarity

Equilibrium Expressions

- Write the equilibrium expressions for the following reactions…
- $2O_{3\ (g)} \rightleftarrows 3O_{2\ (g)}$

Equilibrium Expressions

- Write the equilibrium expressions for the following reactions…
- $H_{2\,(g)} + I_{2\,(g)} \rightleftarrows 2HI_{(g)}$

Equilibrium Expressions

- Write the equilibrium expressions for the following reactions…
- $FeO_{(s)} + H_{2\,(g)} \rightleftarrows Fe_{(s)} + H_2O_{(g)}$

Heterogeneous / Homogeneous

- The reaction is ____________ if all of the states are the same
- ____________ if any of the states are different

Look at the last 3 reactions

- Tell if they are heterogeneous or homogeneous
- $2O_{3\,(g)} \rightleftarrows 3O_{2\,(g)}$
- $H_{2\,(g)} + I_{2\,(g)} \rightleftarrows 2HI_{(g)}$
- $FeO_{(s)} + H_{2\,(g)} \rightleftarrows Fe_{(s)} + H_2O_{(g)}$

Equilibrium Constant in Terms of Pressure

- When the reactants & products are gases the k_{eq} will be in partial pressures not molarity
- K_p when using pressure
- aA + bB ⇄ cC + dD

Switching between k_c & k_p

- $K_p = k_c(RT)^{\Delta n}$
- R = 0.0821
- T = temperature in Kelvin
- Δn = change in moles
  (# moles products - # moles reactants)

Switching between k_c & k_p

- $N_{2\ (g)} + 3H_{2\ (g)} \rightleftarrows 2NH_{3\ (g)}$
- Calculate k_p at 300°C if k_c = 9.60

Magnitude of K_{eq}

- Will either be big or small
- Value of K_c will determine if the products or reactants are favored
- $CO + Cl_2 \rightleftarrows COCl_2$
- $Kc = \frac{[COCl_2]}{[CO][Cl_2]} = 4.57 \times 10^9$

Magnitude of K_{eq}

- K_c is greater than 1
- Therefore the [products] is greater than the [reactants]
- So products are favored
- $K_c > 1$ = products are favored
- $K_c < 1$ = reactants are favored

Magnitude of K_{eq}

- $N_{2\,(g)} + O_{2\,(g)} \rightleftarrows 2NO_{(g)}$
- $Kc = \frac{[NO]^2}{[N_2][O_2]} = 1 \times 10^{-30}$
- What is favored…products or reactants???

Direction of Equilibrium & k

- Equilibrium reactions occur in both directions
- $N_{2\,(g)} + 3H_{2\,(g)} \rightleftarrows 2NH_{3\,(g)}$
- $2NH_{3\,(g)} \rightleftarrows N_{2\,(g)} + 3H_{2\,(g)}$

Direction of Equilibrium & k

- $N_2O_4 \rightleftarrows 2NO_2$ kc = 0.212
- What is the kc of …
- $2NO_2 \rightleftarrows N_2O_4$

Calculating Equilibrium Constants

- A mixture of N_2 gas and H_2 gas produce NH_3 gas and are allowed to come to equilibrium at 472°C. The equilibrium mixture was analyzed and found to contain 0.1207 M H_2, 0.0402 M N_2, & 0.00272 M NH_3. Calculate K_c.

Calculating Equilibrium Constants

- $2NO_2Cl \rightleftarrows 2NO_2 + Cl_2$
- At equilibrium the
- $[NO_2Cl]$ = 0.00106 M
- $[NO_2]$ = 0.0108 M
- $[Cl_2]$ = 0.00538 M
- Calculate Kc

Calculating Equilibrium Constants

- $N_{2\ (g)} + 3H_{2\ (g)} \rightleftarrows 2NH_{3\ (g)}$
- Kp = 1.45×10^{-5}
- At equilibrium P_{H2} = 0.928 atm & P_{N2} = 0.432 atm. What is the P_{NH3}?

Calculating Equilibrium Constants

- $PCl_{5\ (g)} \rightleftarrows PCl_{3\ (g)} + Cl_{2\ (g)}$ Kp = 0.497
- At equilibrium P_{PCl5} = 0.860 atm, P_{PCl3} = 0.350 atm.
- Calculate P_{Cl2}