PENANG SANGAM HIGH SCHOOL

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LESSON NOTES

WEEK 21

Year/Level: 13A/B　　　　　　　　　　　　**Subject:** Chemistry

Strand 3	**Reactions**
Sub Strand 3.3	**Aqueous Chemistry**
Content Learning Outcome	By the end of this lesson students should be able: * Explain the significance of the magnitude of the equilibrium constant *K*c * Use *K*c to calculate an equilibrium concentration of species involved in an equilibrium reaction

Le Chatelier's Principle

States that if a system is in equilibrium is subjected to stress (conc., pressure, temp and catalyst) behave in such a way as to oppose the stress.
Stress: concentration, temperature, volume and pressure.

Suppose you have the equilibrium between nitrogen, hydrogen and ammonia

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H° = -92.2 \text{ kJ}$$

Stress		Effect on Equilibrium
Concentration	Increase in $[N_2(g)]$	Moves toward right
	Decrease in $[NH_3(g)]$	Moves toward right
Pressure	Increase	Moves toward right (least number of moles)
	Decrease	Moves toward left
Temperature	Increase	Moves toward left (Favors endothermic reactions)
	Decrease	Moves toward right (Favors exothermic reactions)
Catalyst		No effect

Note: another factor is volume, so apply Boyles law to work with this factor (pressure volume relationship)

Significance of the Magnitude of Kc

- When Kc is very large ($\geq 1 \times 10^{2}$) the reaction proceeds towards completion i.e., more than reactants at equilibrium.

- When Kc = 1, the concentration of products and reactants are nearly the same at equilibrium.

- When Kc is very small ($\leq 1 \times 10^{-2}$) then hardly any products are formed.

Note:

- Kc value only indicates the extent of the reaction but not the time taken to reach the equilibrium.

Example 1

What do the following K_c values indicate?

a. $H_{2(g)} + Br_{2(g)} \rightleftharpoons 2HBr_{(g)}$ $\quad K_c = 7.9 \times 10^{18}$

Solution

Reaction proceeds far towards completion.

b. $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$ $\quad K_c = 4.8 \times 10^{-31}$

Solution

Hardly any products are formed.

Example 2: Calculating Equilibrium Concentrations Using K_c

Consider the reaction equation:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

Calculate the $[NH_3]$ given that the $K_c = 9.0$; $[N_2] = 0.9$ mol L^{-1} and $[H_2] = 0.9$ mol L^{-1}.

$$K_c = \frac{[\text{Products}]}{[\text{Reactants}]} = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{[x]^2}{[0.3][0.9]^3}$$

$$9.0 = \frac{[x]^2}{0.22}$$

Since $K_c = 9.0$

$$9.0 \times 0.22 = [x]^2$$

$$1.97 = [x]^2$$

$$\sqrt{1.97} = x$$

$$1.40 \text{ mol } L^{-1} = x$$

Therefore, $[NH_3]$ is 1.40 mol L^{-1}

Exercise

1. Which of the following two reactions would tend to proceed furthest to completion when they reach equilibrium?

a. $2HBr_{(g)} \rightleftharpoons H_{2(g)} + Br_{2(g)}$ $K_c = 7.0x10^{-20}$

b. $Si_{(s)} + O_{2(g)} \rightleftharpoons SiO_{2(s)}$ $K_c = 2.0x10^{142}$

c. $C_2H_{4(g)} + H_{2(g)} \rightleftharpoons C_2H_{6(g)}$ $K_c = 1.2x10^{1}$

(hint: refer to significance of magnitude of Kc)

2. At 55°C the Kc For the following reaction is:
$2NO_{2\ (g)} \rightleftharpoons N_2O_{4\ (g)}$ is 1.17mol/L

   a. Write the equilibrium expression for the reaction.
   b. Calculate the concentration of $N_2O_{4\ (g)}$ present in equilibrium with 0.05mol of $NO_{2(g)}$ in a one litre container.

(Hint: at **2 moles** its 1.17mol/L, what will be the conc. at **0.05 moles**?)

Refer to Year 13 Chemistry Text book for additional questions: pg. 158 (Q 1-5)