

PENANG SANGAM HIGH SCHOOL

P.O.BOX 44, RAKIRAKI

LESSON NOTES

WEEK 21

Year/Level: 13A/B

Subject: Chemistry

|                                 |   |
|---------------------------------|---|
| <b>Strand 3</b>                 | <b>Reactions</b>  |
| <b>Sub Strand 3.3</b>           | <b>Aqueous Chemistry</b>  |
| <b>Content Learning Outcome</b> | By the end of this lesson students should be able: <ul style="list-style-type: none"><li>* Explain the significance of the magnitude of the equilibrium constant <math>K_c</math></li><li>* Use <math>K_c</math> to calculate an equilibrium concentration of species involved in an equilibrium reaction</li></ul> |

Le Chatelier's Principle

States that if a system 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



|                      | Stress                                | Effect on Equilibrium                            |
|----------------------|---------------------------------------|--|
| <b>Concentration</b> | Increase in $[\text{N}_2(\text{g})]$  | Moves toward right                               |
|                      | Decrease in $[\text{NH}_3(\text{g})]$ | Moves toward right                               |
| <b>Pressure</b>      | Increase                              | Moves toward right (least number of moles)       |
|                      | Decrease                              | Moves toward left                                |
| <b>Temperature</b>   | Increase                              | Moves toward left (Favors endothermic reactions) |
|                      | Decrease                              | Moves toward right (Favors exothermic reactions) |
| <b>Catalyst</b>      | No effect                             |  |

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

### Significance of the Magnitude of $K_c$

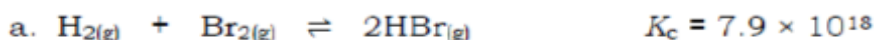
- ★ When  $K_c$  is very large ( $\geq 1 \times 10^2$ ) the reaction proceeds towards completion i.e., more than reactants at equilibrium.
- ★ When  $K_c = 1$ , the concentration of products and reactants are nearly the same at equilibrium.
- ★ When  $K_c$  is very small ( $\leq 1 \times 10^{-2}$ ) then hardly any products are formed.

#### Note:

- ★  $K_c$  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?



#### **Solution**

Reaction proceeds far towards completion.



#### **Solution**

Hardly any products are formed.

#### **Example 2: Calculating Equilibrium Concentrations Using $K_c$**

Consider the reaction equation:



Calculate the  $[\text{NH}_3]$  given that the  $K_c = 9.0$ ;  $[\text{N}_2] = 0.9 \text{ mol L}^{-1}$  and  $[\text{H}_2] = 0.9 \text{ mol L}^{-1}$ .

$$K_c = \frac{[\text{Products}]}{[\text{Reactants}]} = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} = \frac{[x]^2}{[0.3][0.9]^3}$$

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

Since  $K_c = 9.0$

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

$$1.97 = [x]^2$$

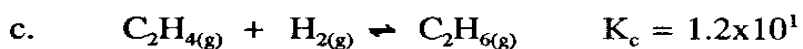
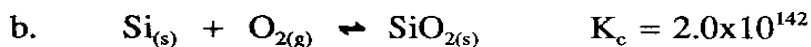
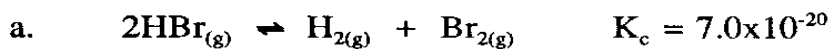
$$\sqrt{1.97} = x$$

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

**Therefore,  $[\text{NH}_3]$  is  $1.40 \text{ mol L}^{-1}$**

### Exercise

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



(hint: refer to significance of magnitude of  $K_c$ )

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2. At 55°C the  $K_c$  For the following reaction is:



- a. Write the equilibrium expression for the reaction.  
b. Calculate the concentration of  $\text{N}_2\text{O}_4(g)$  present in equilibrium with 0.05mol of  $\text{NO}_2(g)$  in a one litre container.

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

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