PENANG SANGAM HIGH SCHOOL

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LESSON NOTES

WEEK 20

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: • Write equilibrium constant expressions (*K*c) for systems at equilibrium • Use *K*c expression to calculate the value of *K*c value of a reaction

Equilibrium Constant

For any general chemical equation:

e.g.

$$aA + bB \rightarrow cC + dD$$

The mass action expression or equilibrium expression is:

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Q- Reaction quotient or mass action expression

[ ] – concentration

At dynamic equilibrium and constant temperature:

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

K_c – Equilibrium constant

K_C = [Products] / [Reactants]

Example:

Write the equilibrium constant expression for the following reaction using molar concentrations.

Solution:

$$2PCl_3(aq) + O_2(g) \rightleftharpoons 2POCl_3(g)$$

$$K_c = \frac{[POCl_3]^2}{[PCl_3]^2[O_2]}$$

Use a pencil and see carefully how I've labelled everything using arrow. Follow that

Note:

- K_c for the reverse reaction at the same temperature is the reciprocal (opposite) of the K_c for the forward reaction.
- Pure solids and pure liquids do not appear in equilibrium expressions.

Example:

$H_{2\,(g)} + I_{2(g)} \longrightarrow 2HI_{(g)}$ $K_C = 48.7$ at 45.8°C

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$K_C = \frac{[HI]^2}{[I_2]\,[H_2]}$ 48.7 at 45.8°C

forward reaction

look at both Kc; see what happened??

For the reverse reaction:

$2HI_{(g)} \longrightarrow H_{2\,(g)} + I_{2(g)}$

backward reaction

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$K_C = \frac{[I_2]\,[H_2]}{[HI]^2}$ = 1/48.7 AT 45.8°

Kc reverse= 1/Kc forward

☆ Kc value is specific at specific temperature, i.e. if temperature changes, the Kc also changes.

Example:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H° = -92.2$ kJ Kc = $6.8\text{x } 10^5$ at 25°C

For the forward reaction:

$Kc = \frac{[NH_3]^2}{[N_2]\,[H_2]^3}$

The forward reaction is exothermic, therefore an increase in temperature would favour the formation of N_2 and H_2 and a decrease in NH_3 which leads to a decrease in the Kc value.

Summary:

If ΔH is positive, reaction is endothermic, then:

- *K*c increases as temperature increases.
- *K*c decreases as temperature decreases.

If ΔH is negative, reaction is exothermic, then:

- *K*c decreases as temperature increases.
- *K*c increases as temperature decreases.

Exercise

1. Write the **equilibrium constant expression** for the following reactions using molar concentrations?

a.) $2H_2O\,(l) \rightleftharpoons H_3O^+\,(aq) + OH^-\,(aq)$
b.) $2SO_3\,(g) \rightleftharpoons 2SO_2\,(g) + O_2\,(g)$
c.) $N_2H_4\,(g) + 2O_2\,(g) \rightleftharpoons 2NO(g) + 2H_2O(g)$
d.) $N_2H_4\,(g) + 6H_2O_2\,(g) \rightleftharpoons 2NO_2\,(g) + 8H_2O(g)$
e.) $2PCl_3\,(aq) + O_2\,(g) \rightleftharpoons 2POCl_3\,(g)$
f.) $4PCl_3\,(g) \rightleftharpoons P_4\,(g) + 6Cl_2\,(g)$

2. Write an equation given the Kc:

$$Kc = \frac{[P_4]\,[Cl_2]^6}{[PCl_3]^4}$$