The Meaning of Equilibrium Constants

$aA + bB \Leftrightarrow cC + dD$ $\qquad K_c = \dfrac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$

1. Provides Information on Reaction Completeness

    - Kc is very large: the reaction proceeds completely or almost completely to the right (irreversible reaction)
    - Kc is very small: the reaction proceeds completely or almost completely to the left

2. Predicting the Direction of Reaction

    By calculating the reaction quotient (Qc) whose formula is the same as Kc.

    - Qc < Kc: reaction goes to the right
    - Qc > Kc: reaction goes to the left
    - Qc = Kc: equilibrium state

Degree of Dissociation

The degree of dissociation (α) is the ratio between the number of moles of the substance that decomposes (reacts) to the number of moles initially.

$$\alpha = \frac{\text{moles of dissolved substance}}{\text{the initial moles of substance}}$$

Value range of α: $0 \leq \alpha \leq 1$

- $\alpha = 0 \longrightarrow$ undissociated substance
- $0 < \alpha < 1 \longrightarrow$ partially dissociated substance
- $\alpha = 1 \longrightarrow$ completely dissociated substance

04.It is known that the equilibrium constant data at a certain temperature for the following reactions:

$NO_{(g)} + \frac{1}{2} O_{2(g)} \Leftrightarrow NO_{2(g)}$ $K_c = a$

$2\ NO_{2(g)} \Leftrightarrow N_2O_{4(g)}$ $K_c = b$

Determine the K_c value for the reaction:

$N_2O_{4(g)} \Leftrightarrow 2\ NO_{(g)} + O_{2(g)}$

at that temperature in a and b.

Ans:

$N_2O_{4(g)} \Leftrightarrow 2\ NO_{2(g)}$ $K_c = \frac{1}{b}$

$2NO_{2(g)} \Leftrightarrow 2\ NO_{(g)} + O_{2(g)}$ $K_c = \frac{1}{a^2}$

$N_2O_{4(g)} \Leftrightarrow 2\ NO_{(g)} + O_{2(g)}$

$$K_c = \frac{1}{b} . \frac{1}{a^2} = \frac{1}{a^2 . b}$$

05.It is known that the equilibrium constant data at a certain temperature for the following reactions:

$XZ_2 + Y \Leftrightarrow XY + Z_2$ $K_c = 16$

$\frac{1}{2} XZ_2 + AZ_2 \Leftrightarrow \frac{1}{2} XA_2 + \frac{3}{2} Z_2$ $K_c = 2$

$AB + Z_2 \Leftrightarrow AZ_2 + B$ $K_c = 4\sqrt{2}$

$B_2Y \Leftrightarrow 2B + Y$ $K_c = 8$

Determine the K_c value for the reaction:

$XY + 2AB \Leftrightarrow XA_2 + B_2Y$

at that temperature.

Ans:

$XY + Z_2 \Leftrightarrow XZ_2 + Y$ $\quad K_c = \frac{1}{16}$

$2\,AB + 2\,Z_2 \Leftrightarrow 2\,AZ_2 + 2\,B$ $\quad K_c = (4\sqrt{2})^2 = 32$

$XZ_2 + 2\,AZ_2 \Leftrightarrow XA_2 + 3\,Z_2$ $\quad K_c = 2^2 = 4$

$2B + Y \Leftrightarrow B_2Y$ $\quad K_c = \frac{1}{8}$

$XY + 2\,AB \Leftrightarrow XA_2 + B_2Y$ $\quad K_c = \frac{1}{16} \cdot 32 \cdot 4 \cdot \frac{1}{8} = 1$

$K_c = 1$

06. The K_c value for the reaction:

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

at a certain temperature is 49. At that temperature, an experiment was carried out by mixing 2 mol H_2, 2 mol I_2, and 4 mol HI in a 10L chamber.

a. Is the mixture balanced? Explain.
b. If not, in which direction will the reaction proceed spontaneously?
c. Determine the number of moles of each gas at equilibrium.

Since the overall reaction is obtained by adding the two individual reactions, then the overall reaction equilibrium constant is the product of the two individual K values:

$K = K_1 . K_2 = 1278$

The equilibrium concentrations of the reactants and products is determined as follows:

	$C_6H_{12}O_{6(aq)}$	+	$ATP_{(aq)}$	$\Leftrightarrow$	$ADP_{(aq)}$	+	$F6P_{(aq)}$
I	$1,2 \times 10^{-6}$		1×10^{-4}		1×10^{-2}		-
C	-x	~	-x	~	+x	~	+x
E	$1,2 \times 10^{-6} - x$		$1 \times 10^{-4} - x$		$1 \times 10^{-2} + x$		x

$$K = \frac{[ADP][F6P]}{[C_6H_{12}O_6][ATP]}$$

$$1278 = \frac{(1x10^{-2} + x)(x)}{(1,2x10^{-6} - x)(1x10^{-4} - x)} = \frac{1x10^{-2}x + x^2}{1,2x10^{-10} - 1,012x10^{-4}x + x^2}$$

Expanding and rearranging the above equation yields the following second order polynomial: $1277x^2 - 0,1393x + 1,534 \times 10^{-7} = 0$

Using the quadratic equation to solve for x, we obtain two roots: $x = 1,113 \times 10^{-6}$ and $1,080 \times 10^{-4}$. Only the first one make physical sense, because it is less than the initial value of $C_6H_{12}O_6$. Therefore, $[F6P]_{eq} = 1,113 \times 10^{-6}$.

During a fever, the body generates heat. Since the net reaction above is exothermic, Le Chatelier's principle would force the equilibrium to the left, **reducing the amount of F6P generated.**