Chemical Equilibria

⇒ **Reversible Reactions**

→ it is a process where reactants form products and simultaneously the products form back the reactants.

⇒ **Dynamic Equilibrium**

→ In a closed system, a reversible reaction reaches dynamic equilibrium when the forward and backward reactions occur at the same rate and the concentrations of both reactants and products remain unchanged.

⇒ **Factors affecting equilibrium**

→ Concentration

→ if concentration of L.H.S is increased, the equilibrium shifts to right and vice versa.

Ex. $N_2 + 3H_2 \rightleftharpoons 2NH_3$

→ Pressure (only when compounds are in gaseous state)

- → increase in pressure favors side with less no. of moles.
- → decrease in pressure favors side with more no. of moles.

Ex. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

4 moles → 2 moles

so if pressure ↑ equilibrium shifts to right
and if pressure ↓ equilibrium shifts to left

→ Temperature

- → as temperature increases it favors the endothermic side
- → as temperature decreases it favors the exothermic side

⇒ Equilibrium Constant K_c

Ex. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

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

[ ] means concentration of compound.

to find concentration use $c = \frac{n}{v}$

if $K_c > 1$ then products are more likely to be formed

if $K_c < 1$ then reactants are more likely to be formed

→ Temp affects the value of K_c

→ Pure solids and liquids dont have concentration so it is not included in the expression. only (g) and (aq) are included.

Ex. $aA(s) + bB(aq) \rightleftharpoons cC(aq) + dD(aq)$

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

we will not write A because it is in solid state.

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⇒ Equilibrium constant K_p

ex.	$N_2(g)$	+ $3H_2(g)$	$\rightleftharpoons$ $2NH_3(g)$
mol ratio	1	3	2
mol fraction	$\frac{1}{6}$	$\frac{3}{6}$	$\frac{2}{6}$
partial pressure	$\frac{1}{6} \times P$	$\frac{3}{6} \times P$	$\frac{2}{6} \times P$

Note: P = total pressure

Note: p = partial pressure

$$K_p = \frac{(pNH_3)^2}{(pH_2)^3 \times p\{N_2\}}$$

→ only can be found in gas state reactions.
→ only temperature affects the value of K_p

⇒ Questions

Q1] $2MgO(s) + 2Cl_2(g) \rightleftharpoons 2MgCl_2(s) + O_2(g)$

State 2 features of a reaction that is in dynamic equilibrium

→ Rate of forward reaction is equal to rate of backward reaction
→ concentration of reactants and products are constant

the equilibrium constant $K_p = \frac{pO_2}{p^2Cl_2}$

At 1.0×10^5 Pa and 500K, 70% of $Cl_2(g)$ has reacted

calculate K_p and state its units

	$2Cl_2$	$\rightleftharpoons$ O_2
I	x	0
F	$0.3x$	$0.35x$

2 : 1
$1Cl_2$ gives $\frac{1}{2}O_2$
so 70% Cl_2 gives $\frac{1}{2}O_2$ = 35%

$0.3 + 0.35$
$= 0.65$

mole fraction of $Cl_2 = \frac{0.3}{0.65}$

mole fraction of $O_2 = \frac{0.35}{0.65}$

$pCl_2 = \frac{0.3}{0.65} \times 1.0 \times 10^5$

$pO_2 = \frac{0.35}{0.65} \times 1.0 \times 10^5$

$$K_p = \frac{(0.35/0.65) \times 1 \times 10^5}{\left(\frac{0.3}{0.65}\right)^2 \times 1 \times 10^5} \rightarrow 2.53 \times 10^{-5}\ Pa^{-1}$$

Q2. $4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(g)$

when 1.6 mol of HCl are mixed with 0.5 mol of O_2 at 400°C.
0.600 mol of Cl_2 and 0.600 mol of H_2O are formed
the total pressure inside the container is 1.5×10^5 Pa

→ Calculate the amounts in mol of HCl and O_2 in the equilibrium mixture

	$4HCl$ +	$O_2(g)$ ⇌	$2Cl_2(g)$ +	$2H_2O(g)$
I	1.6	0.5	0	0
F	0.4	0.2	0.6	0.6

HCl = 0.400 mol
O_2 = 0.2 mol

→ Calculate the mole fraction and hence the partial pressure of Cl_2

total = 1.8

M_f of $Cl_2 = \frac{0.6}{1.8} = \frac{1}{3}$

partial pressure of $Cl_2 = \frac{1}{3} \times 1.5 \times 10^5$
= 50000 Pa

⇒ Acid-base equilibria

- → acid is a proton donor (H^+)
- → base is a proton acceptor (H^+)
- → strong acid and base dissociate fully
- → weak acid and base dissociate partially
- → an amphoteric substance can be both acidic and alkaline ex. H_2O

→ Conjugate base and acid → conjugate acid base pair.

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

- CH_3COOH → Acid → it can donate H^+
- H_2O → base → accepting H^+
- CH_3COO^- → conjugate base → after donating it needs H^+, so it can gain H^+ so base
- H_3O^+ → conjugate acid → because after recieving H^+, now it can donate

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

NH_3	H_2O	NH_4^+	OH^-
base	acid	conjugate acid	conjugate base

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