Topic 17 Equilibrium (HL)

Syllabus:

17.1 Equilibrium

Le Châtelier's principle for changes in concentration can be explained by the equilibrium law.

Calculate the equilibrium constant using the concentration data. (ICE method)

Calculate the equilibrium amount of compounds given the equilibrium constant. (ICE method)

The position of equilibrium corresponds to a maximum value of entropy and a minimum in the value of the Bibbs free energy.

The Gibbs free energy change of a reaction and the equilibrium constant can both be used to easure the position of an equilibrium reaction and are related by the equation, $\Delta G = -RT \ln K$

- **Example 1**

  The ester, ethyl ethanoate is produced by the esterification reaction between ethanol and ethanoic acid, water is the side product. 2.0 mol of ethanol and 2.0 mol of ethanoic acid are dissolved in solvent to produce 1 dm^3 solution and heated in the presence of sulphuric acid. It is found that 0.9 mol of each reactant remains when equilibrium is reached. Calculate the equilibrium constant Kc.

$$CH_3CH_2OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOCH_2CH_3(aq) + H_2O(l)$$

I:	2.0	2.0	0	0
C:	−x	−x	+x	+x
E:	2.0 − x	2.0 − x	x	x

$0.9 = 2.0 - x$

$x = 1.1$

$$Kc = \frac{[CH_3COOCH_2CH_2][H_2O]}{[CH_3CH_2OH][CH_3COOH]}$$

$$= \frac{1.1^2}{(2.0 - 1.1)^2}$$

$= 1.49$

➢ **Example 2**

In a Haber process, N_2 reacts with H_2 to produce NH_3 in the presence of catalyst Iron in the 2 dm^3 container. The initial concentration of N_2 and H_2 are 0.50 mol dm^{-3} and 0.60 mol dm^{-3} respectively. It is found that 20% of N_2 is used when equilibrium is reached. Calculate the equilibrium constant for this reaction.

	$N_2(g)$	+ $3H_2(g)$	$\rightleftharpoons 2NH_3(g)$
I:	0.50	0.60	0
C:	−x	−3x	+2x
E:	0.50 − x	0.60 − 3x	2x

X = 0.5 x 20% = 0.1

$$Kc = \frac{(2(0.1))^2}{(0.50-0.1)(0.60-3(0.1))^3}$$

$= 3.70\ mol^{-2}\ dm^6$

Question 1

The oxidation of NO to form NO_2 occurs during the formation of smog. When 0.8 mol of NO was reacted with 0.8 mol of O_2 in a 1.2 dm^3 container at 450°C, 0.25 mol of NO_2 was found in the equilibrium mixture. Find the equilibrium constant for the reaction at this temperature.