

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 Gibbs free energy.

The Gibbs free energy change of a reaction and the equilibrium constant can both be used to ensure 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 dm³ 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 K_c.

	$\text{CH}_3\text{CH}_2\text{OH}(\text{l}) + \text{CH}_3\text{COOH}(\text{l}) \rightleftharpoons \text{CH}_3\text{COOCH}_2\text{CH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$			
I:	2.0	2.0	0	0
C:	-x	-x	+x	+x
E:	2.0 - x	2.0 - x	x	x

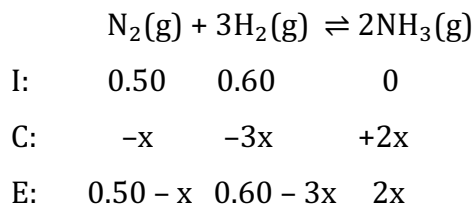
$$0.9 = 2.0 - x$$

$$x = 1.1$$

$$\begin{aligned} K_c &= \frac{[\text{CH}_3\text{COOCH}_2\text{CH}_3][\text{H}_2\text{O}]}{[\text{CH}_3\text{CH}_2\text{OH}][\text{CH}_3\text{COOH}]} \\ &= \frac{1.1^2}{(2.0 - 1.1)^2} \\ &= 1.49 \end{aligned}$$

➤ **Example 2**

In a Haber process, N₂ reacts with H₂ to produce NH₃ in the presence of catalyst Iron in the 2 dm³ container. The initial concentration of N₂ and H₂ are 0.50 mol dm⁻³ and 0.60 mol dm⁻³ respectively. It is found that 20% of N₂ is used when equilibrium is reached. Calculate the equilibrium constant for this reaction.



$$X = 0.5 \times 20\% = 0.1$$

$$\begin{aligned} K_c &= \frac{(2(0.1))^2}{(0.50 - 0.1)(0.60 - 3(0.1))^3} \\ &= 3.70 \text{ mol}^{-2} \text{ dm}^6 \end{aligned}$$

Question 1

The oxidation of NO to form NO₂ occurs during the formation of smog. When 0.8 mol of NO was reacted with 0.8 mol of O₂ in a 1.2 dm³ container at 450°C, 0.25 mol of NO₂ was found in the equilibrium mixture. Find the equilibrium constant for the reaction at this temperature.