

Topic 2 – Equilibria Revision Notes

1) Equilibrium quantities

- The moles present at equilibrium can be worked out using simple algebra

Example 1

2 moles of nitrogen and 3 moles of hydrogen were reacted in a sealed vessel of volume 2 dm³ at a temperature of 700K. At equilibrium 1.6 moles of nitrogen remained. Calculate the moles of hydrogen and ammonia present in the equilibrium mixture.

	N₂	+	3H₂	⇌	2NH₃
Initial moles	2		3		0
Eqm moles	1.6		?		?

The equation says that for every 2 moles of NH₃ formed, 1 mole of N₂ and 3 moles of H₂ are used up. We can write expressions for the equilibrium moles in terms of x that will allow us to calculate the missing numbers of moles.

For N₂, start with 2 moles, x moles used up (one lot of N₂ in equation)

For H₂, start with 3 moles, 3x moles used up (three lots of H₂ in equation)

For NH₃, start with 0 moles, 2x moles formed (2 lots of NH₃ in equation)

	N₂	+	3H₂	⇌	2NH₃
Initial moles	2		3		0
Eqm moles	1.6		?		?
Eqm moles	2-x		3-3x		2x

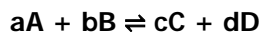
We know that 1.6 = 2-x, so x=0.4

Moles of H₂ at equilibrium is, therefore, 1.8 and moles of NH₃ at equilibrium is 0.8

	N₂	+	3H₂	⇌	2NH₃
Initial moles	2		3		0
Eqm moles	1.6		1.8		0.8
Eqm moles	2-x		3-3x		2x

2) The equilibrium constant, K_c

- An equilibrium constant can be defined in terms of concentrations for the following reaction:



where a = moles of A etc

- It can be shown that:

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

where [A] = concentration of A in mol dm⁻³ etc

- Once equilibrium moles are known they need to be converted into concentrations before being put into the K_c expression. Concentration = moles/volume (in dm³)

- If the volume is not known, use V to represent it and the V's will almost certainly cancel
- The units for the K_c can be determined by substituting and cancelling
- Continuing with **example 1**

	N_2	$+ 3\text{H}_2$	$\rightleftharpoons 2\text{NH}_3$
Initial moles	2	3	0
Eqm moles	1.6	1.8	0.8
Eqm moles	2-x	3-3x	2x
Conc (mol dm^{-3})	1.6/2 = 0.8	1.8/2 = 0.9	0.8/2 = 0.4

$$\begin{aligned}
 K_c &= \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} \\
 &= \frac{0.4^2}{(0.8 \times 0.9^3)} \\
 &= 0.274
 \end{aligned}$$

$$\begin{aligned}
 \text{Units} &= \frac{(\text{mol dm}^{-3})^2}{\text{mol dm}^{-3} \times (\text{mol dm}^{-3})^3} \\
 &= \frac{1}{(\text{mol dm}^{-3})^2} \\
 &= \text{mol}^{-2} \text{ dm}^6
 \end{aligned}$$

3) Other points

- Changes in concentration have no effect on the numerical value of K_c
- For an exothermic reaction, increasing the temperature decreases the magnitude of K_c . The equilibrium shifts in the endothermic or backward direction to remove the added heat
- For endothermic reactions, increasing the temperature increases the value of K_c . The equilibrium shifts in the endothermic or forward direction to remove the added heat
- Reducing the volume of the reaction vessel increases the pressure and may affect the position of equilibrium
- Increasing the volume of the reaction vessel decreases the pressure and may affect the position of equilibrium