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 dm^3 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.

	N_2 +	$3H_2$ ⇌	$2NH_3$
Initial moles	2	3	0
Eqm moles	1.6	?	?

The equation says that for every 2 moles of NH_3 formed, 1 mole of N_2 and 3 moles of H_2 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 N_2, start with 2 moles, x moles used up (one lot of N_2 in equation)
For H_2, start with 3 moles, 3x moles used up (three lots of H_2 in equation)
For NH_3, start with 0 moles, 2x moles formed (2 lots of NH_3 in equation)

	N_2 +	$3H_2$ ⇌	$2NH_3$
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 H_2 at equilibrium is, therefore, 1.8 and moles of NH_3 at equilibrium is 0.8

	N_2 +	$3H_2$ ⇌	$2NH_3$
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:

$$aA + bB \rightleftharpoons cC + dD$$

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 dm^3)

- 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 +	$3H_2$ ⇌	$2NH_3$
Initial moles	2	3	0
Eqm moles	1.6	1.8	0.8
Eqm moles	2-x	3-3x	2x
Conc	1.6/2	1.8/2	0.8/2
(mol dm^{-3})	= 0.8	=0.9	=0.4

K_c = $[NH_3]^2/[N_2][H_2]^3$
= $0.4^2/(0.8 \times 0.9^3)$
= 0.274

Units = $(mol\ dm^{-3})^2/mol\ dm^{-3} \times (mol\ dm^{-3})^3$
= $1/(mol\ dm^{-3})^2$
= $mol^{-2}\ dm^6$

3) <u>Other points</u>

- 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