Topic 1 – How far?
Revision Notes

1) Equilibrium quantities

- A reversible reaction reaches a position of dynamic equilibrium where both the forward and backward reactions are taking place at the same rate and concentrations of chemicals are constant
- At equilibrium there will always be a mixture of reactants and products
- The moles present at equilibrium can be worked out using the equation and the moles present at the start

Example 1

The hydrolysis of ethyl ethanoate is a reversible reaction. The equation for the equilibrium is shown below.

$$CH_3COOC_2H_5 + H_2O \quad CH_3COOH + C_2H_5OH$$

A student mixed together 8.0 mol ethyl ethanoate and 5.0 mol water. He also added a small amount of hydrochloric acid to catalyse the reaction.

The student left the mixture until it had reached equilibrium at constant temperature. He found that 2.0 mol of ethanoic acid had formed.

The information in the question is summarised in the table below.

Component	$CH_3COOC_2H_5$	H_2O	CH_3COOH	C_2H_5OH
Initial mol	8.0	5.0	0.0	0.0
Equilibrium mol			2.0	

The equation says that for every mole of CH_3COOH made, one mole of C_2H_5OH is made so the equilibrium moles of ethanol is also 2.0

The equation also says that for every mole of CH_3COOH made, one mole of $CH_3COOC_2H_5$ is used up so the equilibrium moles of ethyl ethanoate is initial moles - 2.0 = 6.0 mol

The equation also says that for every mole of CH_3COOH made, one mole of H_2O is used up so the equilibrium moles of water is initial moles - 2.0 = 3.0 mol

The completed table is as follows.

Component	$CH_3COOC_2H_5$	H_2O	CH_3COOH	C_2H_5OH
Initial mol	8.0	5.0	0.0	0.0
Equilibrium mol	6.0	3.0	2.0	2.0

Source: OCR Module 2816/01 June 2008 part question

2) The equilibrium constant, K_c

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

$$aA + bB \quad cC + dD$$

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

Example 1 continued

Writing the K_C expression for the equilibrium gives:

$$K_C = \frac{[CH_3COOH][C_2H_5OH]}{[CH_3COOC_2H_5][H_2O]}$$

Calculating equilibrium concentrations gives

Component	**$CH_3COOC_2H_5$**	**H_2O**	**CH_3COOH**	**C_2H_5OH**
Initial mol	8.0	5.0	0.0	0.0
Equilibrium mol	6.0	3.0	2.0	2.0
Equilibrium conc	6.0/V	3.0/V	2.0/V	2.0/V

$$K_C = \frac{[2.0/V][2.0/V]}{[6.0/V][3.0/V]}$$

$$= 4.0/18.0$$

$$= 0.22$$

$$\text{Units} = \frac{(\text{mol dm}^{-3})(\text{mol dm}^{-3})}{(\text{mol dm}^{-3})(\text{mol dm}^{-3})}$$

= no units (as they all cancel - this should be stated, not left blank)

Source: OCR Module 2816/01 June 2008 part question

3) Other points

- Changes in concentration and pressure have no effect on the numerical value of K_c
- The presence of a catalyst has 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
- A large value of K_c indicates a high theoretical yield of products as the equilibrium position is well to the right
- A small value of K_c or K_p means that the equilibrium position is well to the left and the yield of products is low
- Most organic reactions are in equilibrium (i.e. they are reversible)