# RIVER VALLEY HIGH SCHOOL
## JC 2 PRELIMINARY EXAMINATION

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | |
| CLASS | 2 | 0 | J | | | | | |
| CENTRE NUMBER | S | | | | | INDEX NUMBER | | |

# H1 CHEMISTRY 8873/02

Paper 2 Structured Questions

**15 Sep 2021**

**2 hours**

Additional Materials: Data Booklet

**READ THESE INSTRUCTIONS FIRST.**

**DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.**

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section **A**
Answer **all** questions in the space provided.

Section **B**
Answer **one** question in the space provided.

A Data Booklet is provided. Do NOT write anything on it.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Paper 1 | /30 |
| Paper 2 | |
| 1 | /9 |
| 2 | /7 |
| 3 | /6 |
| 4 | /5 |
| 5 | /18 |
| 6 | /15 |
| 7 | /20 |
| 8 | /20 |
| s.f. | |
| units | |
| Paper 2 | /80 |
| Total | /110 |

This paper consists of **20** printed pages.

## Section A (60 marks)

Answer all the questions in this section.

**1** **(a)** **(i)** Describe the reactions, if any, of the chlorides $MgCl_2$ and $PCl_5$ with water. Write equations for all reactions that occur, and suggest the pH of the resulting solutions. Relate the reactivity of these chlorides to their structure and bonding.

……

……

……

……

……

……

……

……

……

……

……

……

…… **[3]**

**(ii)** Carbon is in the same group as silicon. Suggest and explain if $CCl_4$ will react with water.

……

…… **[1]**

**(b)** Phosphorus exist as $^{31}P$, $^{32}P$ and $^{33}P$ isotopes. $^{31}P$ is the most stable isotopes.

**(i)** Define the term *isotopes*.

……

…… **[1]**

**(ii)** $^{31}P$ can react with chlorine to form phosphorus chloride. Phosphorus in phosphorus chloride can exhibit variable oxidation states. Based on your knowledge in periodicity, state the two common oxidation states of phosphorus in phosphorus chloride

……

**[1]**

**(iii)** Phosphorus can exist as cations or anions.

The angle of deflection for a beam of $^{31}P^{+}$ ions in an electric field is 6°. Calculate the angle of deflection for a beam of $^{33}P^{3-}$ ions in the same electric field and show in the diagram below, Fig 1, how a beam of $^{33}P^{3-}$ ions will deflect in the electric field.

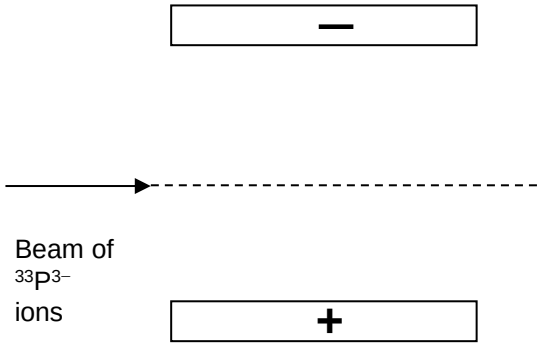



**Fig. 1**

**[2]**

**(iv)** $^{32}P$ is unstable and decays rapidly to another element. During the decay, a neutron is converted to a proton with the release of an electron, forming a charged ion.

Write an equation to show the reaction.

……

**[1]**

**[Total : 9]**

**2** **(a)** Propanoic acid is a weak acid and can be used to make a *buffer solution*.

**(i)** State the difference between a weak acid and a strong acid.

……

……

…… **[1]**

**(ii)** Explain what is meant by the term *buffer solution*.

……

……

…… **[1]**

**(iii)** The hydrogencarbonate ion, $HCO_3^-$, is part of the buffer in the blood. Write an equation showing how $HCO_3^-$ reacts with acid in the blood.

…… **[1]**

**(iv)** After consuming food or drink containing sugar, the pH in the mouth can drop from pH 6.8 to a pH of approximately 4.8 as the sugar is broken down into lactic acid. In time, hydrogencarbonate ions in saliva restore the pH to its original value.

Define pH and calculate the $H^+$ ion concentration in the mouth at pH 4.8.

……

……

……

……

……

…… **[2]**

**(b)** Write an equation for the reaction between propanoic acid and sodium hydroxide. Label the conjugate acid and the conjugate base in your equation.

……

…… **[2]**

**[Total: 7]**

**3** When 40 $cm^3$ of a gaseous organic compound, $C_xH_yO$, underwent complete combustion with an excess of oxygen, the total volume reduced by 130 $cm^3$. A further contraction of 200 $cm^3$ took place when the residual gas was passed through aqueous sodium hydroxide. All volumes were measured at 25 °C and 1 atm.

**(a)** Write a balanced equation for the complete combustion of $C_xH_yO$.

……..... **[1]**

**(b)** State the function of NaOH(aq).

……..... **[1]**

**(c)** **(i)** State the volume of $CO_2$ produced in this reaction

……..... **[1]**

**(ii)** Hence, determine the values of ***x*** and ***y***.

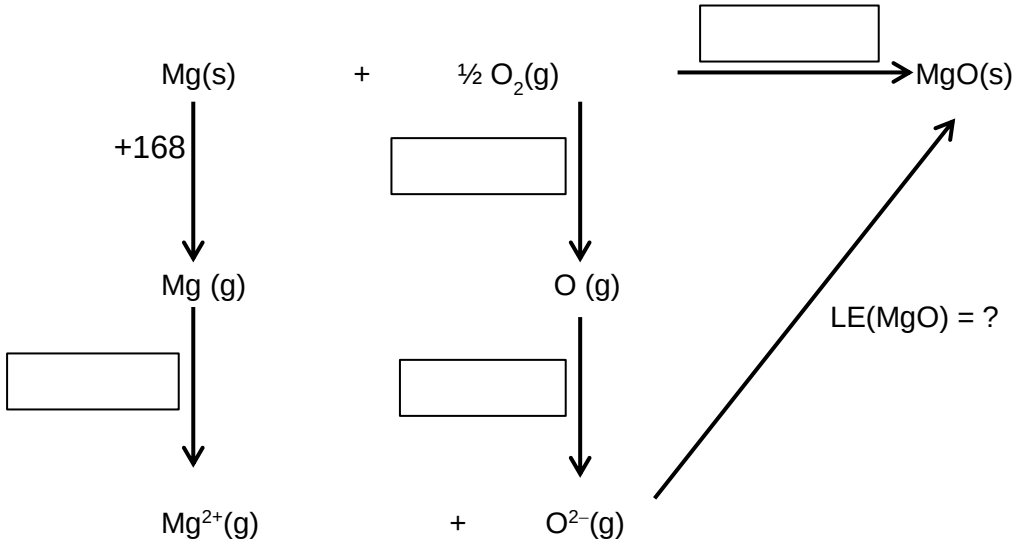
**[3]**

**[Total: 6]**

**4** Magnesium oxide is available for purchase without a prescription. It is added to dietary supplements as well as over-the-counter medications used to treat constipation, indigestion, and headaches.

**(a)** Using the given Born-Haber cycle for the formation of MgO(s), the following data given as well as data from the *Data Booklet*, calculate the lattice energy of MgO(s).

| | |
|---|---|
| sum of 1st and 2nd electron affinity of oxygen | +702 kJ mol$^{-1}$ |
| enthalpy change of formation of magnesium oxide | –602 kJ mol$^{-1}$ |




**[2]**

**(b)** Predict and explain how the lattice energy of $Mg_3N_2$ will differ as compared to MgO.

……

……

……

……

……

……

…… **[3]**

**[Total: 5]**

**5** Chemists use ideas of collisions and rates of reaction to help them be more efficient when manufacturing chemicals on a large scale. One such process is the Haber process for the production of ammonia. The enthalpy change of the reaction is `46 kJ per mole of ammonia.

**(a) (i)** Write an equation to show the chemical reaction that happens in the Haber process.

……..... **[1]**

**(ii)** Define the term *heterogeneous catalyst*.

……..... 

……..... 

……..... **[1]**

**(iii)** Name the catalyst used in the Haber process.

……..... **[1]**

**(iv)** State the conditions used in the Haber process.

……..... **[1]**

**(v)** Describe and explain what would happen to the yield of the desired product if

I the temperature is increased,

……..

……..

……..

II more hydrogen is added to the reaction vessel.

……..

……..

…….. **[2]**

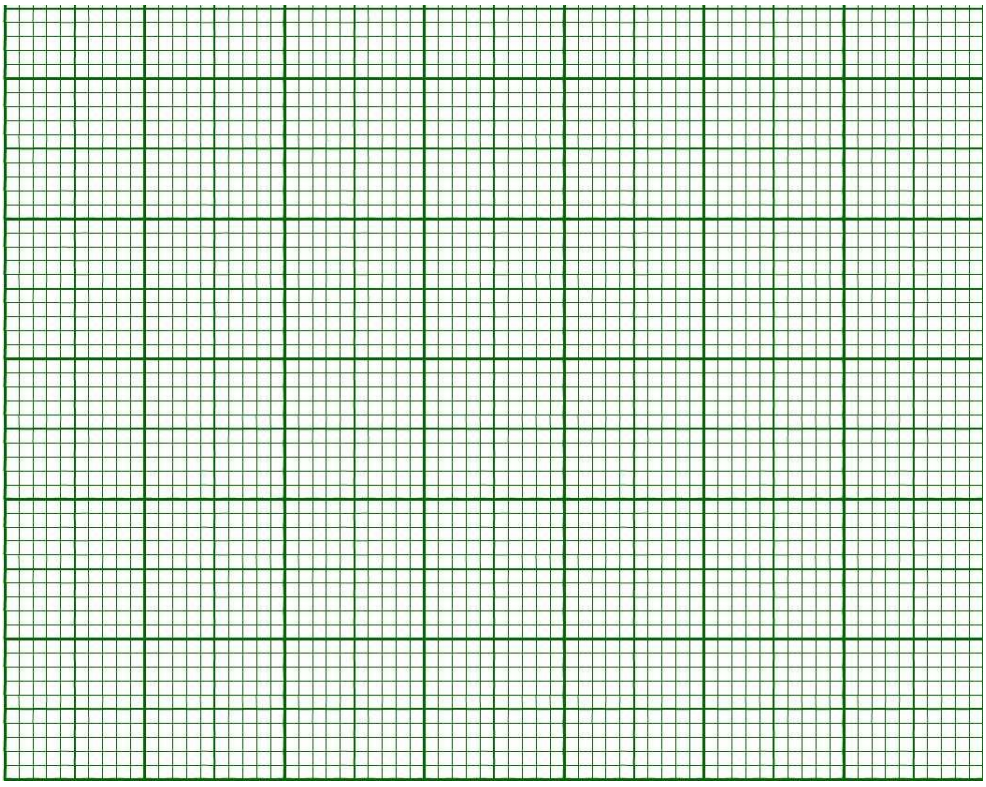
**(b)** Ammonia is oxidised by air to nitric acid in the presence of a platinum/rhodium catalyst. There are several stages to the reaction. The following equation is a summary of the overall process.

$$NH_3(g) + 2O_2(g) \rightarrow HNO_3(l) + H_2O(l) \quad \Delta H = -409 \text{ kJ mol}^{-1}$$

The rate of reaction was measured at different times and the results are shown in the table below:

| $[NH_3]$ / mol dm$^{-3}$ | 2.20 | 2.00 | 1.80 | 1.50 | 1.25 | 0.80 |
|---|---|---|---|---|---|---|
| Rate / $10^{-4}$ mol dm$^{-3}$ s$^{-1}$ | 22.7 | 21.1 | 18.9 | 15.7 | 13.1 | 8.3 |

**(i)** Plot a graph of rate against $[NH_3]$ in the space below.



**[3]**

**(ii)** Use your graph to find the order of the reaction with respect to $NH_3$

……

…… **[1]**

**(iii)** The order of reaction with respect to oxygen is zero. Write an expression for the rate equation.

…… **[1]**

**(iv)** Calculate the rate constant, giving its units.

**[2]**

**(v)** Sketch the shape of the graph of $[NH_3]$ against time.

**[2]**

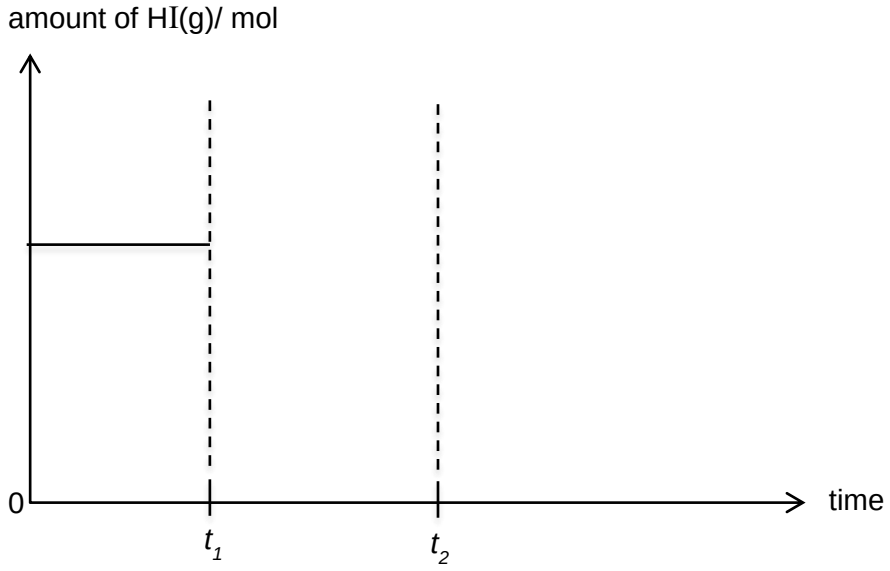
**(c)** Hydrogen reacts with iodine reversibly. The reaction is allowed to reach an equilibrium.

$$H_2(g) + I_2(g) \ll 2HI(g) \quad \Delta H = +26.5 \text{ kJ mol}^{-1}$$

Using Le Chatelier's Principle, show on the graph the effect of:

I. increasing the temperature at time $t_1$,
II. removing some HI(g) at time $t_2$

on this equilibrium.




**[3]**

**[Total: 18]**

**6** Super-absorbent polymers commonly known as hydrogel have the ability to absorb 200-300 times their own mass of water. Hydrogel is used in baby diapers and exists as small crystals of hydrogel at the core of the diaper. It absorbs the urine and swells up. Hydrogel has high water retention, enabling the baby to stay dry.

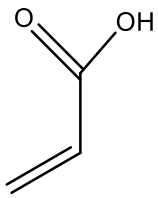
A diaper is known to be effective if the swelling capacity is greater than 6000%. The swelling capacity is calculated by the following formula.

$$\text{swelling capacity} = \frac{m_2 - m_1}{m_1} \times 100\%$$

$m_1$ : mass in grams, of hydrogel before swelling
$m_2$ : mass, in grams, of hydrogel after swelling

In a particular brand of diaper, Momocool, 3.97g of dried hydrogel is found in a piece of baby diaper. Typically, a baby passes 55.0 $cm^3$ of urine each time and a piece of diaper can hold 220.0 $cm^3$ of urine.

The hydrogel used in baby diapers is known as sodium polyacrylate. These polymers are commonly made by the polymerisation of monomer **A** mixed with sodium hydroxide in the presence of an initiator.




Monomer **A**

**(a) (i)** Given that the density of a baby's urine is 1.003 g $cm^{-3}$, calculate the swelling capacity of the diaper.

**[2]**

**(ii)** Based on the calculation in **(i)**, state if Momocool is a good brand of diapers. Explain your answer.

……

**[1]**

**(b) (i)** Give the IUPAC name of monomer **A**.

……

**[1]**

**(ii)** State the type of polymerisation involved in the formation of hydrogels.

…… **[1]**

**(iii)** Draw the structure of two repeat units of the polymer formed by the above method from monomer **A** when mixed with NaOH.

**[1]**

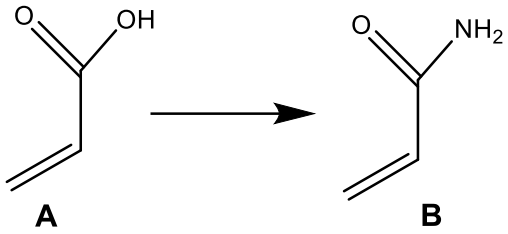
**(iv)** With the help of a diagram, explain how the hydrogel can absorb large quantities of water.

……

……

…… **[3]**

**(c)** Monomer **A** can be converted into monomer **B**, which can be polymerised to form a super-adsorbent polymer.




**A** **B**

**(i)** Name the functional groups in monomer **A** and **B**.

…… **[3]**

**(ii)** Identify the other product that is formed when monomer **A** is converted to monomer **B**.

…… **[1]**

**(iii)** State the reagents and conditions necessary to reform monomer **A** from monomer **B**.

…… **[1]**

**(iv)** State the reagents and conditions need to convert monomer **A** to propanoic acid.

…… **[1]**

**[Total: 15]**

## Section B (20 marks)

Answer **one** question from this section in the spaces provided.

**7 (a)** Electrical conductivity varies greatly across period 3 from Na to C*l*. Sketch a graph to show how their electrical conductivity differs, and explain this variation in terms of structure and bonding.

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

…… **[5]**

**(b)** Ferromanganese is an alloy added to steels to improve their mechanical properties. A 15g sample of ferromanganese was dissolved in 250cm$^3$ of dilute sulfuric acid to give an solution containing iron(II) sulfate and manganese(II) sulfate. 25.0 cm$^3$ of the resulting solution required 20.0 cm$^3$ of 0.0360 mol dm$^{-3}$ potassium manganate(VII) for complete reaction.

**(i)** By using the *Data Booklet*, write the oxidation and reduction half-equations for the reaction between the resulting solution and potassium manganate(VII).

……

…… **[1]**

**(ii)** Hence or otherwise, construct an equation for the reaction.

……..……...

……..…….. **[1]**

**(iii)** Calculate the percentage by mass of iron in ferromanganese.

**[3]**

**(c)** Propanol can be converted from propene or propanone as shown below.

$CH_3CH{=}CH_2 \xrightarrow{\text{step I}} CH_3CHBrCH_3 \xrightarrow{\text{step II}} CH_3CH(OH)CH_3 \xleftarrow{\text{step III}} CH_3COCH_3$

**(i)** With the aid of a diagram, describe the bonding in C^C bond in propene.

……..……...

……..……...

……..……....

……..……...

……..……... **[3]**

**(ii)** State the types of reaction for step **I** and step **III**.

……

…… **[2]**

**(iii)** State the reagents and conditions needed for step **III**

…… **[1]**

**(iv)** State and explain how the rate of reaction for step **II** changes when 2-bromopropane is replaced by 2-iodopropane.

……

……

……

…… **[2]**

**(v)** A student was given an unlabelled bottle and was told that it contains either a pure sample of propanone or a pure sample of propanol. Describe a chemical test, with appropriate observations, which would confirm the identity of the compound in the bottle.

……

……

…… **[2]**

**[Total: 20]**

**8 (a)** Pure samples of ethanol and propanoic acid are mixed, and an equilibrium is established, as shown,

$$C_2H_5OH(l) + CH_3CH_2COOH(l) \ll CH_3CH_2COOC_2H_5(l) + H_2O(l)$$

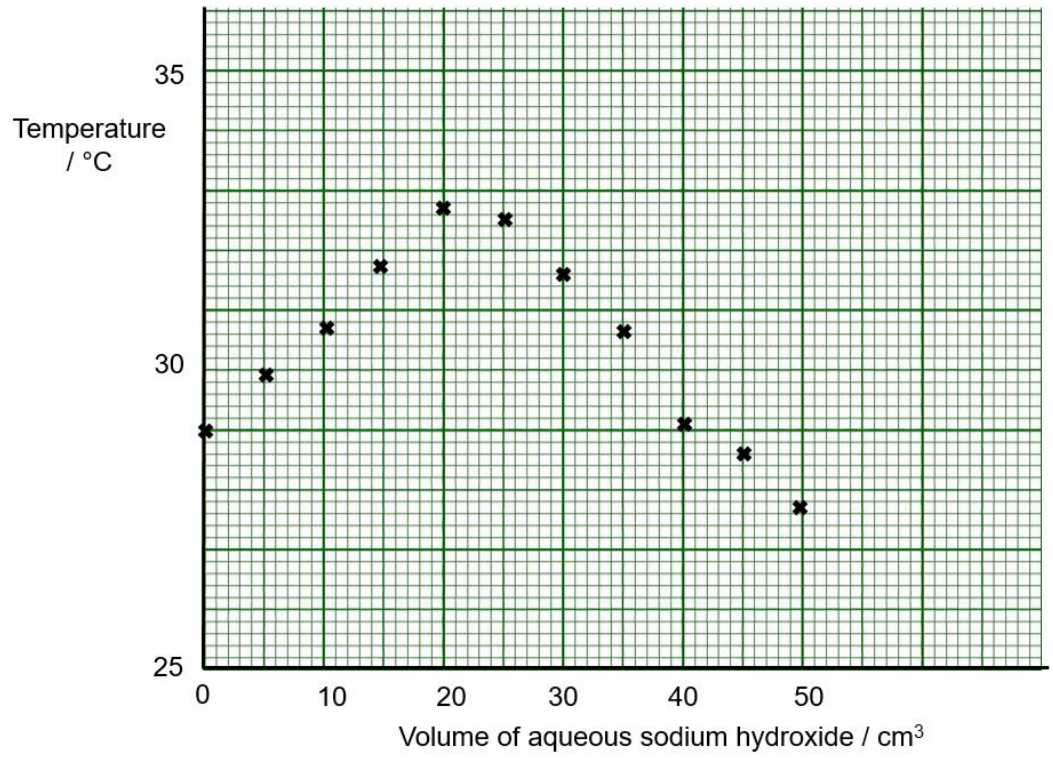
Holmes prepared a mixture containing 0.0300 mol of propanoic acid, 0.161 mol of ethanol and 0.150 mol of water. He added 0.00600 mol of concentrated sulfuric acid, $H_2SO_4$, to the mixture as a catalyst. The total volume of the reaction mixture was 90 $cm^3$.

The reaction mixture was closed and sealed and left at a constant temperature of 25 °C for 5 days so that an equilibrium can be established.

The reaction mixture was transferred to a polystyrene cup and quickly titrated with 1.50 mol $dm^{-3}$ aqueous NaOH. The initial temperature of the reaction mixture before the addition of NaOH was added is measured and recorded.

5.0 $cm^3$ portions of aqueous NaOH were added to the polystyrene cup. The temperature of the solution in the cup was measured after each addition. The maximum temperature occured when complete neutralisation has been achieved.

The results are shown in the graph below.




**(i)** By drawing two separate straight lines of best fit, determine the maximum temperature rise, $\Delta T_{max}$, of the titration. Show your working. **[2]**

**(ii)** Describe and explain the significance of:

**I.** the straight line of best fit before the maximum temperature

**II.** the straight line of best fit after the maximum temperature as more aqueous NaOH is added.

……..……..

……..……..

……..……..

……..……..

……..……..

……..……..

……..……..

……..…….. **[3]**

**(iii)** By showing evidence on the graph, determine the volume of sodium hydroxide, $V_{NaOH}$, required for neutralisation.

……..…….. **[1]**

**(iv)** Calculate the amount of NaOH required for complete neutralisation.

**[1]**

**(v)** Calculate the amount of NaOH that react with $H_2SO_4$.

**[1]**

**(vi)** Construct a balanced equation for the reaction of propanoic acid with NaOH.

……..…….. **[1]**

**(vi)** Assuming that the specific heat capacity of the reaction mixture is 4.18 J $g^{-1}$ $K^{-1}$ and density of the solution is 1.00 g $cm^{-3}$, calculate the energy, in kJ, evolved during the reaction.

**[1]**

**(vii)** Calculate the enthalpy change of neutralisation, in kJ $mol^{-1}$.

**[2]**

**(b) (i)** Using your answers from **a(iv)** and **a(v)**, calculate the amount of propanoic acid present at equilibrium.

**[1]**

**(ii)** Define *dynamic equilibrium.*

……..……..

……..……..

……..…….. **[1]**

**(iii)** Use the information given and the answer from **b(i)**, complete the table below. **[2]**

| | $C_2H_5OH$ | $CH_3CH_2COOH$ | $CH_3CH_2COOC_2H_5$ | $H_2O$ |
|---|---|---|---|---|
| Initial amount / mol | | | | |
| Equilibrium amount / mol | | | | |

**(iv)** Write an expression for the equilibrium constant, $K_c$.

……..……..

……..…….. **[1]**

**(iv)** Calculate the numerical value of $K_c$.

**[1]**

**(c)** Draw the structure of ethanol and state the bond angle about the carbon atoms.

**[2]**

**[Total: 20]**