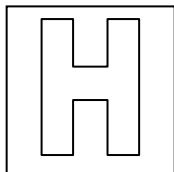


<b>Name:</b>	<b>Index No.:</b>	<b>CT Group: 13</b>
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PIONEER JUNIOR COLLEGE

2014 JC2 PRELIMINARY EXAMINATION  
HIGHER 1

**CHEMISTRY**  
**Paper 2**

**8872/02**

**23 September 2014**

Candidates answer **Section A** on the Question Paper

Additional Materials:      Data Booklet  
   Writing Paper

**2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name, index no and CT group on all the work you hand in.

Write in dark blue or black pen.

You may use a pencil for any diagrams, graphs or rough working.

**Section A**

Answer **all** questions.

**Section B**

Answer any **two** questions on separate writing paper. Begin each question in a fresh sheet of writing paper.

At the end of the examination, fasten all your work securely together.

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

FOR EXAMINER'S USE			
Section A		Section B	
1	/ 9	5	/ 20
2	/ 12	6	/ 20
3	/ 8	7	/ 20
4	/ 11	Penalty	s.f. / units
		<b>TOTAL</b>	<b>/ 80</b>

## Section A (40 marks)

Answer all questions in the spaces provided.

1 This question is about Period 3 elements and their compounds.

- (a) The electrical conductivity in  $\text{MS m}^{-1}$  (megasiemens per metre) at  $25^\circ\text{C}$  of four consecutive elements in Period 3 are given below.

Element	A	B	C	D
Conductivity/ $\text{MS m}^{-1}$	22	37	$1.0 \times 10^{-3}$	$1.0 \times 10^{-15}$

- (i) Based on the information above, identify the elements **A**, **B**, **C** and **D**.

**A** : magnesium

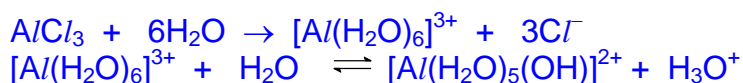
**B** : aluminium

**C**: silicon

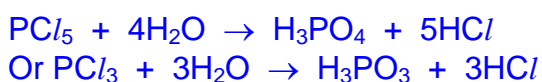
**D**: phosphorus

- (ii) Period 3 elements react with chlorine to form chlorides. Account for the difference in the pH values when chlorides of **B** and **D** are separately dissolved in water. Write equations to support your answer.

Since  $\text{Al}^{3+}$  has a high charge density, it hydrolyses in water to form an acidic solution at pH 3.

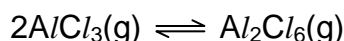


Since P has vacant d orbitals to accept lone pair of electrons from water, it undergoes complete hydrolysis in water completely to form strong acids of  $\text{HCl}$  and  $\text{H}_3\text{PO}_4$ , thus the solution formed is at pH 2.

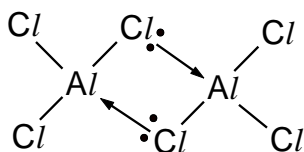


[6]

- (b) (i) In the vapour phase, an equilibrium is established between aluminium chloride and its dimer as follows:



With an aid of a diagram, explain how the dimer is formed.



The aluminium atom in  $\text{AlCl}_3$  has only 6 electrons surrounding it hence it is

electron-deficient. To complete the octet, the lone pair electrons from a chlorine atom in a neighbouring molecule would be donated via a dative bond, resulting in a dimer.

- (ii) At 180 °C, aluminium chloride,  $Al_2Cl_6$ , sublimes. Explain why it sublimes at a relatively low temperature?

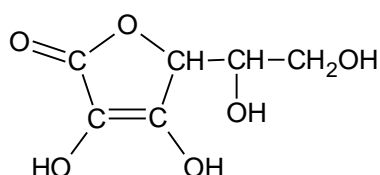
[3]

$Al_2Cl_6$  has simple molecular structure. The intermolecular forces of attraction (van der Waals') between the  $Al_2Cl_6$  molecules are weak.

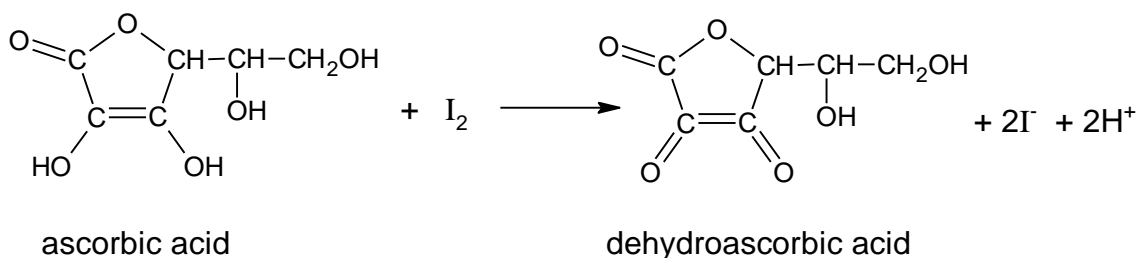
[Total: 9]

- 2 **Vitamin C**,  $C_6H_8O_6$ , also known as ascorbic acid, is a biological antioxidant. It is commonly found in bottled fruit juices and also available in tablet form.

**Vitamin C** ( $M_r = 176$ ) is a monobasic acid and has a  $pK_a$  of 4.10. It has the following structure :



- (a) To determine the concentration of ascorbic acid in bottled fruit juice, a titration with iodine solution is carried out. Iodine will oxidise ascorbic acid to form dehydroascorbic acid.



A brand of orange juice claims to have at least 5 g of **Vitamin C** in every one litre bottle of its orange juice. It was found that 25.0 cm<sup>3</sup> of the brand's orange juice required 15.00 cm<sup>3</sup> of 0.0500 mol dm<sup>-3</sup> iodine solution. Determine the concentration of **Vitamin C** in the orange juice and hence verify if the claim is likely to be true.

Vitamin C  $\equiv$  I<sub>2</sub>

Amount of Vitamin C in 25.0 cm<sup>3</sup> = 15.00 / 1000 x 0.0500 = 7.50 x 10<sup>-4</sup> mol

Concentration of Vitamin C = ( 7.50 x 10<sup>-4</sup> x 1000 ) / 25.0 = 0.030 mol dm<sup>-3</sup>

Mass of Vitamin C in 1 dm<sup>3</sup> = 0.030 x 176 = 5.28 g

The claim is likely to be true as it contains at least 5 g per litre bottle.

[3]

- (b) When a 500 mg tablet of **Vitamin C** is swallowed, it dissolves in the stomach before being absorbed into the bloodstream. The stomach may be assumed to contain  $1.0 \text{ dm}^3$  of  $0.10 \text{ mol dm}^{-3}$  hydrochloric acid.

- (i) Calculate the molar concentration of the **Vitamin C** tablet when it is dissolved upon entering the stomach.

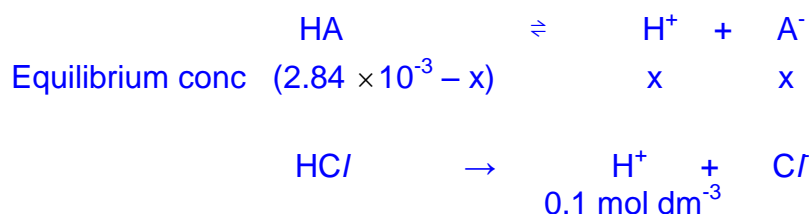
$$[\text{C}_6\text{H}_8\text{O}_6] = \frac{500 \times 10^{-3}}{176} \text{ mol dm}^{-3} \\ = 2.84 \times 10^{-3} \text{ mol dm}^{-3}$$

- (ii) In the presence of the strong acid, HCl, calculate the concentration of the  $\text{H}^+$  contributed by **Vitamin C** at equilibrium.

$$\text{p}K_a = -\log K_a = 4.10 \\ \therefore K_a = 10^{-4.10} = 7.94 \times 10^{-5}$$

Let  $[\text{H}^+]_{\text{eqm}}$  from the vitamin C =  $x \text{ mol dm}^{-3}$ .

Using HA for vitamin C :



Vitamin C is a weak acid, only partially ionises in solution,  $x$  is very small so that  $(2.84 \times 10^{-3} - x) \approx 2.84 \times 10^{-3} \text{ mol dm}^{-3}$  and  $(0.1 + x) \approx 0.1 \text{ mol dm}^{-3}$

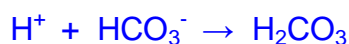
$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} = \frac{(x + 0.1)(x)}{2.84 \times 10^{-3} - x} \\ 7.94 \times 10^{-5} = \frac{(0.1)x}{2.84 \times 10^{-3}} \\ \therefore x = [\text{H}^+] = 2.25 \times 10^{-6} \text{ mol dm}^{-3}$$

- (iii) Hence, calculate the percentage of **Vitamin C** that has ionised in the stomach under these conditions.

$$\% \text{ of Vitamin C that has ionised} = \frac{2.25 \times 10^{-6}}{2.84 \times 10^{-3}} \times 100 \\ = 0.0792 \%$$

- (c) Blood has a pH of 7.35 and is saturated with a buffering system containing  $\text{H}_2\text{CO}_3$  and  $\text{HCO}_3^-$ .
- (i) Explain with an aid of an equation, how the buffering system minimises the changes in pH on the addition of either acid or alkali.

On addition of small amounts of  $\text{H}^+$ ,  $\text{HCO}_3^-$  reacts with it,



So, pH hardly changes.

OR

On addition of small amounts of  $\text{OH}^-$ ,  $\text{H}_2\text{CO}_3$  reacts with it,



So, pH hardly changes

- (ii) Explain how the extent of ionisation of **Vitamin C** changes as it moves from the stomach to the bloodstream.

Conditions in the blood stream are basic.

Increased ionisation as equilibrium position,

$(\text{C}_6\text{H}_8\text{O}_6 \rightleftharpoons \text{H}^+ + \text{C}_6\text{H}_7\text{O}_6^-)$  shifts right as the  $\text{H}^+$  is removed in the basic medium to form water.

[4]

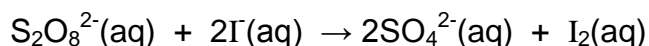
[Total: 12]

- 3 (a) Explain what is meant by the term *rate constant*.

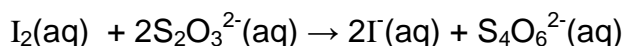
[1]

Rate constant is the proportionality constant in an experimentally determined rate equation. Its value depends on temperature and the presence of a catalyst.

- (b) The kinetics of the reaction between  $\text{I}^-$  and  $\text{S}_2\text{O}_8^{2-}$  can be investigated by varying the volume of the reactants used.



The two reactants are mixed in the presence of a known amount of  $\text{Na}_2\text{S}_2\text{O}_3$  and a little starch.  $\text{S}_2\text{O}_3^{2-}$  reacts immediately with the iodine produced.



When the  $\text{S}_2\text{O}_3^{2-}$  is used up, any further  $\text{I}_2$  formed reacts with starch and a deep blue colour appears.

The time taken for the appearance of the deep blue colour is then determined.

Experiment	Volume used / $\text{cm}^3$			Time, t / s	Relative initial rate of reaction
	1.0 mol $\text{dm}^{-3}$ KI	0.040 mol $\text{dm}^{-3}$ $\text{Na}_2\text{S}_2\text{O}_8$	$\text{H}_2\text{O}$		
1	10.0	5.0	25.0	170	0.00588 $\text{s}^{-1}$
2	15.0	5.0	20.0	113	0.00885 $\text{s}^{-1}$
3	15.0	10.0	15.0	56.5	0.0177 $\text{s}^{-1}$

- (i) Given that the rate  $\propto \frac{1}{t}$ , complete the last column in the table, stating the units for the relative initial rate.

Last column correctly calculated with units shown

- (ii) Determine the rate equation for the reaction between  $\text{I}^-$  and  $\text{S}_2\text{O}_8^{2-}$  and state the units of the rate constant.

Since total volume is kept constant,  $[\text{reactant}] \propto \text{volume of reactant used}$ .

$$\text{Let rate} = k[\text{I}]^x[\text{S}_2\text{O}_8^{2-}]^y$$

Comparing expt 1 and 2

$[\text{S}_2\text{O}_8^{2-}]$  kept constant, when  $[\text{I}^-]$  is increased to 1.5 times, rate is increased to 1.5 times. Thus, rate  $\propto [\text{I}^-]$  and reaction is first order w.r.t.  $\text{I}^-$

Comparing expt 2 and 3

$[\text{I}^-]$  kept constant, when  $[\text{S}_2\text{O}_8^{2-}]$  is doubled, rate is doubled. Thus, rate  $\propto [\text{S}_2\text{O}_8^{2-}]$  and reaction is first order w.r.t.  $\text{S}_2\text{O}_8^{2-}$

$$\text{rate} = k[\text{I}][\text{S}_2\text{O}_8^{2-}]$$

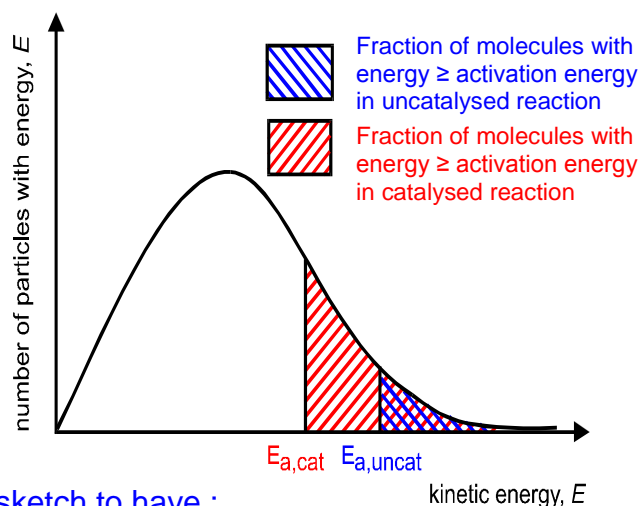
$$\text{units for } k : \text{mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$$

[4]

- (c) With the aid of a sketch of the Boltzmann distribution, explain how the presence of a

catalyst affects the rate of reaction.

[3]



Note: sketch to have :

- Axes labelled
- Activation energy ( $E_{a, \text{cat}}$  and  $E_{a, \text{uncat}}$ ) clearly marked
- Legend given

When a catalyst is used in a reaction, it provides an alternative reaction pathway with lower activation energy. There is an increase in the number of reacting particles with energy  $\geq E_a$  and the number of effective collisions per unit time [ $\frac{1}{2}$ ]. This gives rise to an increase in the rate of reaction.

[Total: 8]

- 4 (a) A monobasic organic acid, **W**, has the composition by mass: C, 40.0%; H, 6.7%; O, 53.3%.

- (i) Calculate the empirical formula of the acid.

Let the mass of the acid be 100 g

	C	H	O
Mass / g	40.0	6.7	53.3
Molar Mass / $\text{g mol}^{-1}$	12.0	1.0	16.0
Amount/ mol	3.333	6.7	3.331
Mole Ratio	1	2	1

Empirical formula acid is  $\text{CH}_2\text{O}....$

- (ii) 0.90 g of **W** is exactly neutralised by  $10.0 \text{ cm}^3$  of  $1.0 \text{ mol dm}^{-3}$  sodium hydroxide. Calculate the relative molecular mass of **W** and hence its molecular formula.

$$\begin{aligned} \text{Amount of sodium hydroxide used} &= 10/1000 \times 1 \\ &= 0.0100 \text{ mol} \end{aligned}$$

$$\text{Amount of acid reacted} = 0.0100 \text{ mol}$$

$$\begin{aligned} M_r \text{ of the acid} &= 0.90 / 0.01 \\ &= 90.0 \end{aligned}$$

Let molecular formula of **W** be  $(\text{CH}_2\text{O})_n$ .

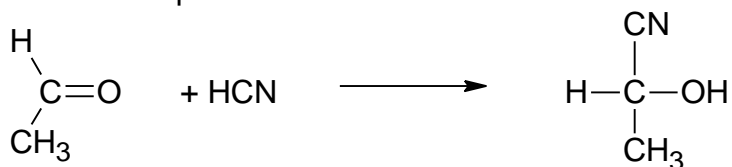
$$n[(12.0) + 2(1.0) + 16.0] = 90.0 \Rightarrow n = 3$$

Hence the molecular formula of **W** is  $\text{C}_3\text{H}_6\text{O}_3$

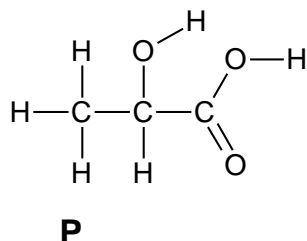
- (b) The **W** has two isomers, **P** and **Q**. Both the isomers can be obtained by two different routes. [3]

**P** is obtained by the hydrolysis of the product of the reaction between ethanal and hydrogen cyanide.

- (i) Write the equation for the reaction between ethanal and hydrogen cyanide.



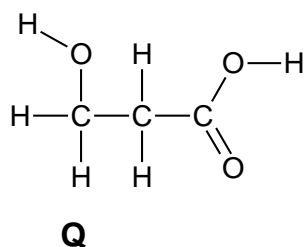
- (ii) Draw the full structural formula of **P**.



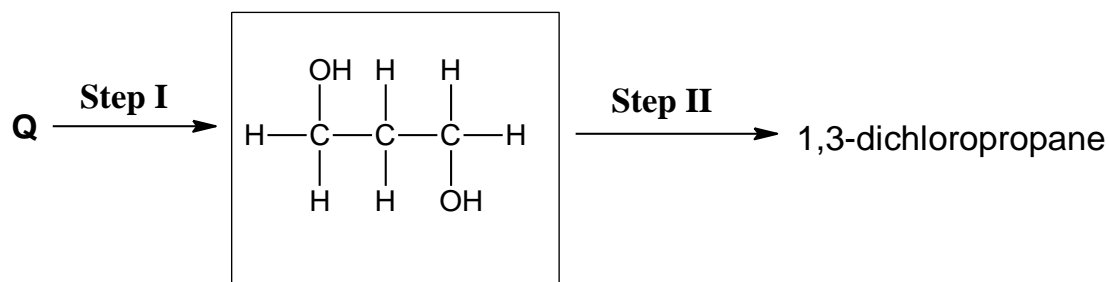
[2]

- (c) **Q** can be obtained by the hydrolysis of 3-chloropropanoic acid.

- (i) Draw the structural formula of **Q**.



- (ii) 1,3-dichloropropane can be synthesised from compound **Q** in two steps shown below.



State the reagents and conditions for Steps I and II. Draw the intermediate in the box provided above.



Step I :  $\text{LiAlH}_4$ , dry ether

Step II :  $\text{PCl}_5$ , r.t.p. /  $\text{PCl}_3$ , heat/  $\text{SOCl}_2$ , warm

- (d) Describe a simple chemical test to distinguish between **P** and **Q**. [3]

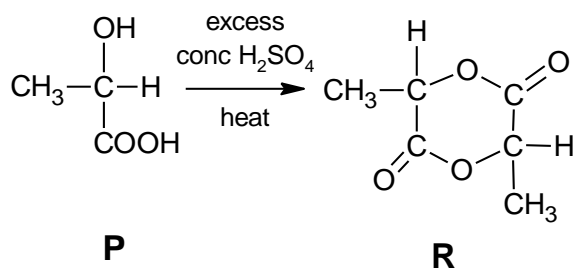
Add  $\text{I}_2(\text{aq})$ ,  $\text{NaOH}(\text{aq})$ , warm

**P** : Yellow precipitate of  $\text{CHI}_3$  produced.

**Q** : No yellow precipitate of  $\text{CHI}_3$  produced.

- (e) A cyclic di-ester, **R**, with the molecular formula of  $\text{C}_6\text{H}_8\text{O}_4$  can be made from **P** when subjected to hot excess concentrated sulfuric acid. [2]

Draw the structural formula of **R**.



[1]

[Total: 11]

**Section B (40 marks)**

Answer **two** questions from this section on separate answer paper.

- 5 (a) (i) Methanoic acid is a *weak acid*. What do you understand by the term in *italics*?

A weak acid is a proton donor that dissociates partially in an aqueous solution.

- (ii) The dissociation constant for methanoic acid,  $K_a = 1.6 \times 10^{-4} \text{ mol dm}^{-3}$ . Calculate the pH of a  $0.100 \text{ mol dm}^{-3}$  solution of methanoic acid.

$$K_a = \frac{[\text{HCOO}^-][\text{H}^+]}{[\text{HCOOH}]} = \frac{x^2}{0.100 - x}$$

Since  $x$  is very small,

$$K_a = \frac{[\text{HCOO}^-][\text{H}^+]}{[\text{HCOOH}]} = \frac{x^2}{0.100}$$

$$x = \sqrt{(0.100 \times 1.6 \times 10^{-4})} = 4.0 \times 10^{-3}$$

$$\text{pH} = 2.40$$

[3]

- (b)  $40.0 \text{ cm}^3$  of  $3.00 \text{ mol dm}^{-3}$  methanoic acid,  $\text{HCO}_2\text{H}$ , is added to  $60.0 \text{ cm}^3$  of  $1.40 \text{ mol dm}^{-3}$  potassium hydroxide in a polystyrene cup. The maximum temperature rise is recorded as  $8.5^\circ\text{C}$ .

[specific heat capacity of the solution is  $4.20 \text{ J g}^{-1} \text{ K}^{-1}$ ]

- (i) Define what is meant by the *standard enthalpy change of neutralisation*.

Standard enthalpy change of neutralisation ( $\Delta H_n^\ominus$ ) is the energy change / evolved when one mole of water is formed from the neutralisation between acid and alkali under standard conditions of 1 atm and 298K.

- (ii) Write a balanced chemical equation for the neutralisation of methanoic acid with potassium hydroxide.



- (iii) Given that the process was 80% efficient, calculate the standard enthalpy change of neutralisation for the reaction in (ii).

$$\text{No. of moles of } \text{HCO}_2\text{H} = 40/1000 \times 3 = 0.1200$$

$$\text{No. of moles of } \text{KOH} = 60/1000 \times 1.4 = 0.08400$$

$\Rightarrow$  KOH is the limiting reagent.

$$\begin{aligned}
 q &= mc\Delta T \\
 &= 100 \times 4.2 \times 8.5 \\
 &= 3570 \text{ J} \quad (80\% \text{ efficient})
 \end{aligned}$$

$$\begin{aligned}
 \text{Actual } q &= 3570/80 \times 100 \\
 &= 4462.5 \text{ J}
 \end{aligned}$$

$$\begin{aligned}
 \Delta H_n^\theta &= \frac{-q}{n_{\text{H}_2\text{O}}} \\
 &= -4462.5 / 0.084 \\
 &= -53125 \\
 &= \underline{-53100 \text{ J mol}^{-1}} \text{ or } \underline{-53.1 \text{ kJ mol}^{-1}}
 \end{aligned}$$

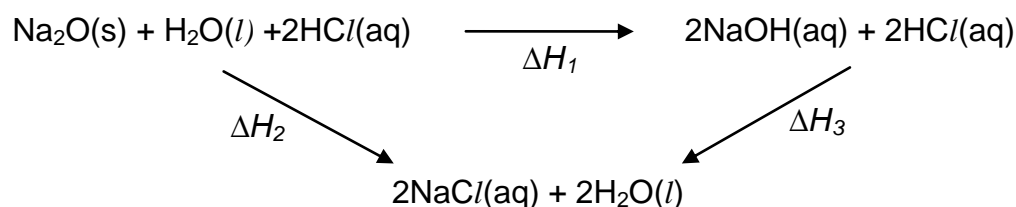
- (iv) How would you expect the enthalpy change calculated in (iii) to compare with the enthalpy change of neutralisation of nitric acid with potassium hydroxide? Explain your answer.

The enthalpy change of neutralisation involving HCOOH and KOH is less exothermic than enthalpy change of neutralisation involving HNO<sub>3</sub> and KOH.

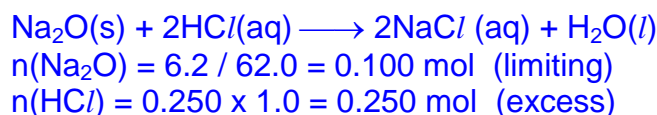
Some of the energy evolved from the neutralisation process is used to further dissociate the weak acid completely / to cause ionisation of the undissociated weak acid.

[7]

- (c) Enthalpy change of reaction 1,  $\Delta H_1$ , can be determined using enthalpy change of reaction 2,  $\Delta H_2$ , and enthalpy change of reaction 3,  $\Delta H_3$ , in the energy cycle below.



- (i)  $\Delta H_2$  can be calculated from the reaction between Na<sub>2</sub>O(s) and HCl(aq). When 6.2 g of Na<sub>2</sub>O(s) is dissolved in 250 cm<sup>3</sup> of 1.0 mol dm<sup>-3</sup> HCl(aq), the temperature of the solution rose by 17 °C. Calculate  $\Delta H_2$ .



$$\Delta H_2 = -(0.25 \times 4.18 \times 17) / 0.100 = -177.7 = -178 \text{ kJ mol}^{-1}$$

- (ii) The enthalpy change of neutralisation between NaOH(aq) and HCl(aq) is known to be  $-57.3 \text{ kJ mol}^{-1}$ . Hence calculate  $\Delta H_1$ .

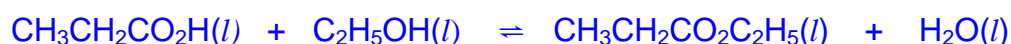
[3]

$$\begin{aligned}\Delta H_1 &= \Delta H_2 - \Delta H_3 = -177.7 - (-114.6) \\ &= -63.1 \text{ kJ mol}^{-1}\end{aligned}$$

- (d) Many fruit flavours and aromas that are used in the food industry are esters. The following is an account of the preparation of an ester, ethyl propanoate.

1. Using a measuring cylinder, place  $5 \text{ cm}^3$  of propanoic acid and an excess of ethanol in a dry round-bottomed flask.
2. Add  $0.5 \text{ cm}^3$  of concentrated sulfuric acid to the mixture. Add a few pieces of glass beads.
3. Fit a reflux condenser in the neck of the round-bottomed flask. Gently heat the mixture under reflux using an isomantle for about 30 minutes.
4. Cool the mixture and add  $25 \text{ cm}^3$  of aqueous sodium carbonate to it.
5. Separate the organic layer from the aqueous layer using a separating funnel.
6. Collect the organic layer and allow it to dry in contact with anhydrous magnesium sulfate.

- (i) Write an equation for the reaction between ethanol and propanoic acid



- (ii) What are the two roles of concentrated sulfuric acid in the experiment?

Concentrated  $\text{H}_2\text{SO}_4$  is a catalyst.

Concentrated  $\text{H}_2\text{SO}_4$  is a dehydrating agent. It removes  $\text{H}_2\text{O}$  and position of equilibrium shifts right generating more ester, thus increasing the yield.

- (iii) At the end of the experiment, only about 20% of the propanoic acid has reacted. Explain why this is so?

Esterification is a reversible reaction. Not all the reactants reacted when a state of equilibrium is reached.

- (iv) Suggest two reasons why ethanol, instead of propanoic acid, is added in excess.

Ethanol is volatile and is easily removed after the reaction.

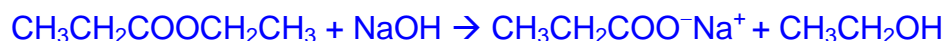
Some ethanol undergoes dehydration in the presence of conc. sulfuric acid to form alkene

Propanoic acid is corrosive.

- (v) Why is aqueous sodium carbonate added in step 4?

To remove the sulfuric acid / unreacted propanoic acid.

- (vi) Write an equation to show the hydrolysis of ethyl propanoate using aqueous sodium hydroxide.



[7]  
[Total: 20]

- 6 (a) Explain the following observations.

- (i)  $\text{I}_2$  is sparingly soluble in water but dissolves readily in tetrachloromethane.

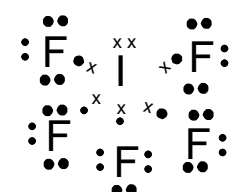
$\text{I}_2$  is non-polar and has weak van der Waals' forces of attraction between its molecules. The energy released from solute –solvent interaction of  $\text{I}_2$ -water is not sufficient to overcome the hydrogen bonds between water molecules. Hence,  $\text{I}_2$  is sparingly soluble in water. However, tetrachloromethane is non polar and  $\text{I}_2$  can form weak van der Waals' forces of attraction with  $\text{CCl}_4$ . The solute – solvent interaction is energetically similar making it soluble in  $\text{CCl}_4$ .

- (ii) The boiling points of the hydrogen halides show a trend.

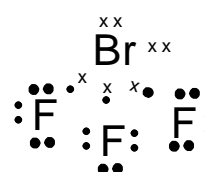
compound	boiling point/ °C
HCl	-84.2
HBr	-67.1
HI	-35.1

The compounds have simple molecular structure and are polar. Iodine atom is larger than the other two halogens. Hence, the no of electrons to be polarised in HI is higher than that of HBr and HCl. Hence, the van der Waals' forces of attraction is predominant in these compounds. The van der Waals' forces of attraction is the strongest in HI and weakest in HCl. More energy is needed to overcome the forces of attraction in HI and hence it has the highest boiling point.

- (b) Draw 'dot-and-cross' diagrams to show the bonding in  $\text{BrF}_3$  and  $\text{IF}_5$  and state their shapes. [4]  
[3]

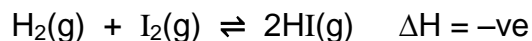


Square pyramidal



T-shaped

- (c) Hydrogen iodide can be made by heating together hydrogen gas and iodine vapour. The reaction takes place slowly and does not go to completion.



- (i) Write an expression for  $K_c$  and state its units.

$$K_c = \frac{[\text{HI}]^2}{[\text{H}_2] [\text{I}_2]}$$

No units.

- (ii) State and explain how the position of equilibrium might change if the above reaction is subjected to

I: increasing the pressure.

II: decreasing the temperature.

I: According to Le Chatelier's Principle, increasing pressure will cause the position of equilibrium to shift to the side with lesser no of moles of gases. However, both sides of the equation have same number of moles of gases. So there will no shift in the equilibrium position.

II: According to Le Chatelier's Principle, decreasing temperature will favour exothermic reaction. The forward reaction is exothermic. Hence, the equilibrium position will shift to the right.

- (iii) A mixture of 0.20 mol of hydrogen and 0.20 mol of iodine was placed in a 1 dm<sup>3</sup> flask and allowed to reach equilibrium at 650 K.

Calculate the amount, in moles, of each substance present in the equilibrium mixture at 650 K.

The numerical value of the equilibrium constant  $K_c$  at 650 K is 59.

	$\text{H}_2(\text{g})$	+	$\text{I}_2(\text{g})$	$\rightleftharpoons$	$2\text{HI}(\text{g})$
Initial amount / mol	0.200		0.200		0.00
$\Delta$ in amount / mol	-x		-x		+2x
Eqm amount / mol	0.200-x		0.200-x		+2x

$$K_c = \frac{[\text{HI}]^2}{[\text{H}_2] [\text{I}_2]}$$

$$59 = \frac{\left[\frac{2x}{1}\right]^2}{\left[\frac{0.200-x}{1}\right]^2}$$

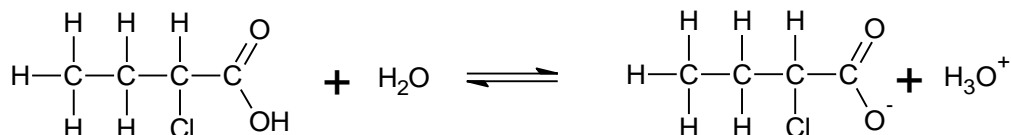
$$x = 0.1587$$

Amount of  $\text{H}_2 = \text{I}_2 = 0.0413$  mol ( for both  $\text{H}_2$  and  $\text{I}_2$ )

Amount of  $\text{HI} = 0.317$  mol

- (d) Compare and explain, the acidity of 2-chlorobutanoic acid and 2-bromobutanoic acid. [2]

2-chlorobutanoic acid is a stronger acid than 2-bromobutanoic acid. Cl is a stronger electron withdrawing group than Br, hence  $\text{CH}_3\text{CH}_2\text{CH}_2\text{C}/\text{CO}_2^-$  is more stable than  $\text{CH}_3\text{CH}_2\text{CH}_2\text{BrCO}_2^-$  as Cl will disperse the negative charge on the carboxylate anion more than Br and thus stabilising it more. With a more stable carboxylate anion, 2-chlorobutanoic dissociates to a greater extent.



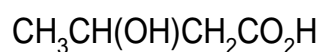
- (e) The blood plasma and urine of diabetes patients can contain large amounts of 'ketone bodies'. These include propanone, 3-oxobutanoic acid and 3-hydroxybutanoic acid.



propanone



3-oxobutanoic acid



3-hydroxybutanoic acid

Describe a simple chemical test to distinguish 3-oxobutanoic acid from

- (i) propanone,

Reagent and conditions : Add Na metal

Observation: Effervescence will be seen in 3-oxobutanoic acid and  $\text{H}_2$  will be produced which gives a "pop" sound with a lighted splint. Propanone will not produce any gas.

Reagent and conditions: Add  $\text{Na}_2\text{CO}_3(\text{aq})$

Observation: Effervescence will be seen in 3-oxobutanoic acid and  $\text{CO}_2$  will be produced which produces a white ppt in  $\text{Ca}(\text{OH})_2$ . Propanone will not produce any gas.

- (ii) 3-hydroxybutanoic acid

Reagent and conditions: 2,4-dinitrophenylhydrazine.

Observation: Orange precipitate is seen in 3-oxobutanoic acid and no orange precipitate seen for 3-hydroxybutanoic acid.

Reagent and conditions :  $\text{KMnO}_4$ ,  $\text{H}_2\text{SO}_4(\text{aq})$ , heat

Observation: Decolourisation of purple  $\text{KMnO}_4$  can be seen in 3-hydroxybutanoic acid but purple  $\text{KMnO}_4$  remains purple in 3-oxobutanoic acid

Reagent and Conditions :  $\text{K}_2\text{Cr}_2\text{O}_7$ ,  $\text{H}_2\text{SO}_4(\text{aq})$ , heat

Observation: Orange  $\text{K}_2\text{Cr}_2\text{O}_7$  turns green in 3-hydroxybutanoic acid but Orange  $\text{K}_2\text{Cr}_2\text{O}_7$  remains orange in 3-oxobutanoic acid

- 7 (a) Describe the relative masses and relative charges of the three sub-atomic particles within an atom. [2]

Particles	Relative Charge	Relative Mass
Electron (e)	-1	0
Proton (p)	+1	1
Neutron (n)	0	1

- (b) Predict with reasons, how the radius of  
(i) the fluoride ion, F<sup>-</sup>;

Fluoride ion has same number of electrons as neon atom however the nuclear charge for neon atom is higher than fluoride. The shielding effect is same for neon and fluoride ion. Thus, the radius of neon atom will be smaller than that of fluoride ion.

- (ii) the magnesium atom, Mg

Mg:  $1s^2 2s^2 2p^6 3s^2$

Ne:  $1s^2 2s^2 2p^6$

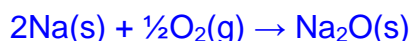
Mg has one extra quantum shell of electrons compared to neon atom hence the shielding effect in Mg will be higher than that of neon. Thus, Mg atom will have bigger radius than Ne atom.

compared with neon atom.

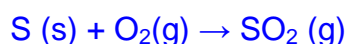
[4]

- (c) (i) Describe what you would see when sodium and sulfur are separately burnt in oxygen. Write equations for the reactions that occur.

Na burns in oxygen vigorously with a yellow flame, leaving behind a white residue of Na<sub>2</sub>O.

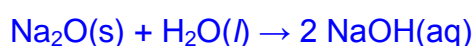


S or S<sub>8</sub> burns in oxygen with a blue flame to give a colourless pungent gas, SO<sub>2</sub>.



- (ii) The oxides of sodium and sulfur resulting from the reactions in (c)(i) both react with water. Write equations for these two reactions and describe the effect of the resulting solutions on Universal Indicator solution.

[4]



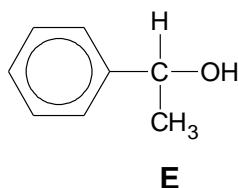
Colour of universal indicator solution: violet



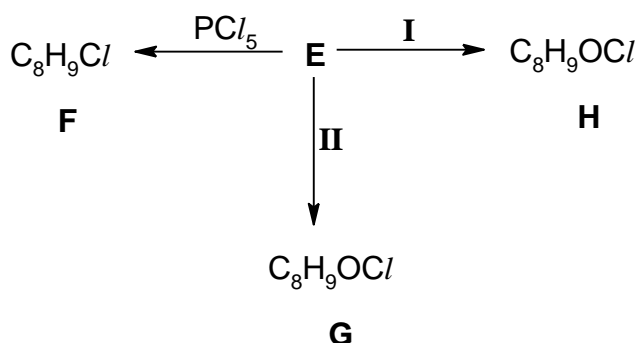
Colour of universal indicator solution: red



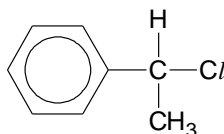
- (d) 1-phenylethanol, **E**, is an aromatic compound and its structure is shown below.



Depending on the reagents and conditions, compound **E** can react to form three compounds **F**, **G** and **H**.



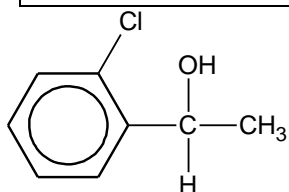
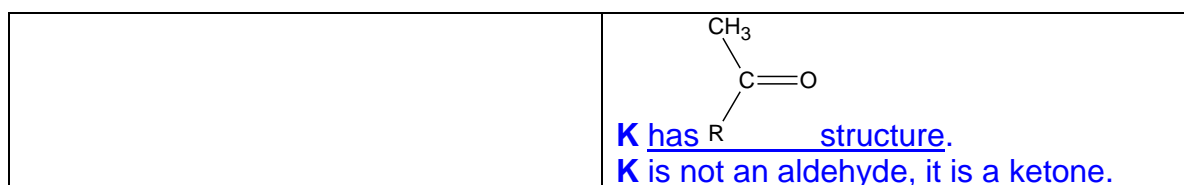
- (i) Suggest a structural formula for compound **F**.



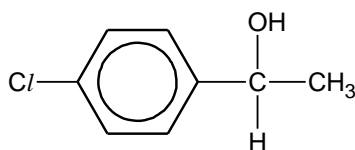
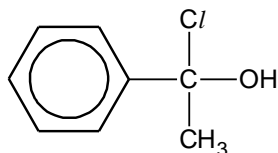
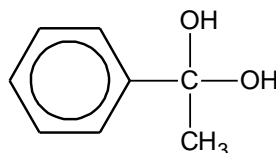
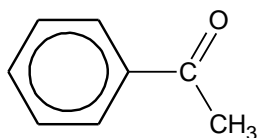
- (ii) When reacted with hot aqueous silver nitrate, compound **H** produces a white precipitate but compound **G** does not. Compound **H** reacts with NaOH(aq) to give **J**,  $\text{C}_8\text{H}_{10}\text{O}_2$  which immediately loses water to give **K**,  $\text{C}_8\text{H}_8\text{O}$ . Compound **K** reacts with 2,4-dinitrophenylhydrazine and with alkaline aqueous iodine but not with Fehling's solution.

Identify and draw the structural formulae of compounds **G**, **H**, **J** and **K**. Explain the chemistry of the reactions involved.

When reacted with hot aqueous silver nitrate, compound <b>H</b> produces white precipitate.	<u>Hydrolysis</u> reaction and white ppt is <u>AgCl</u> .
Compound <b>H</b> reacts with NaOH(aq) to give <b>J</b> , $\text{C}_8\text{H}_{10}\text{O}_2$ .	<b>H</b> undergoes <u>substitution</u> reaction. <b>J</b> has <u>two OH groups</u> attached to same C atom.
Compound <b>K</b> reacts with 2,4-dinitrophenylhydrazine and with alkaline aqueous iodine but not with Fehling's solution.	<b>K</b> undergo <u>condensation</u> reaction with 2,4-DNPH. <b>K</b> is either an <u>aldehyde or ketone</u> . <b>K</b> undergoes mild <u>oxidation reaction</u> with alkaline aqueous iodine.



or

**G****H****J****K**

(iii) Suggest the reagents and conditions for reaction **I** and **II**.

reagents and conditions for reaction **I** : limited  $\text{Cl}_2$ , uv light

reagents and conditions for reaction **II**:  $\text{Cl}_2$ , anhydrous  $\text{AlCl}_3$  in the dark.

[10]

[Total: 20]

**End of Paper**