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**RIVER VALLEY HIGH SCHOOL**  
**YEAR 6 Preliminary Examination II**

CANDIDATE NAME

CLASS 

6	
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CENTRE NUMBER 

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INDEX NUMBER 

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## H1 CHEMISTRY

**8872/02**

Paper 2

15 Sep 2014

2 hours

Candidates answer Section A on the Question Paper.

Additional Materials: Data Booklet, graph paper, writing papers

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### READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

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

Do not use staples, paper clips, highlighters, glue or correction fluid.

#### Section A

Answer all the questions.

#### Section B

Answer two questions on separate answer paper.

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.

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

For Examiner's Use	
Section A	
B5	
B6	
B7	
Total	

**Section A (40 marks)**

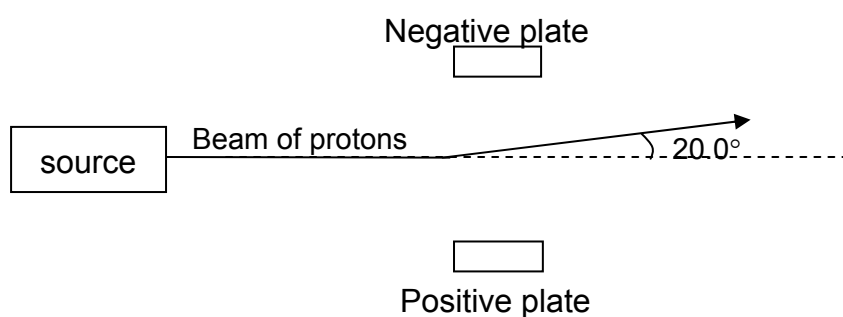
Answer all the questions in the space provided.

- 1 (a) Complete the table below.

Particle	Electric charge	Mass number	Number of		
			Protons	Electrons	Neutrons
<b>R</b>	0	31	15	15	16
<b>S</b>	-1	81	35	36	46

[2]

- (b) A beam of protons, subjected to an electric field, is found to be deflected by
- $20.0^\circ$
- .



A beam of particle **S**, travelling at the same speed, is also subjected to the same electric field shown above.

Determine the angle of deflection for the beam of particle **S** and state the direction of deflection.

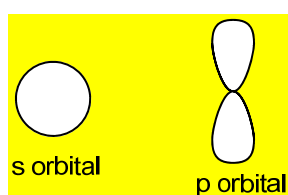
Direction of deflection: Towards ..... plate

[2]

$$\text{angle of deflection} = \left(\frac{20}{1}\right) \times \left(\frac{1}{81}\right) = 0.247^\circ$$

towards the positive plate .

- (c) Draw diagrams to show the shapes of orbitals in the valence shell of particle
- R**
- . Label each type of orbitals drawn.



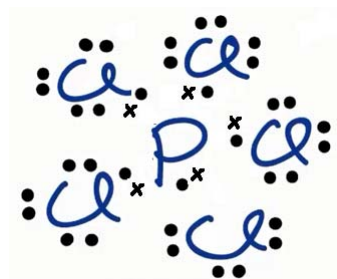
[2]

- (d) A sample of **R** in elemental form was heated with dry chlorine gas for some time. Two stable chlorides, with +3 and +5 oxidation states for **R**, were formed.

Both stable chlorides dissolved readily to water to form a solution which turned universal indicator red.

- (i) Identify the chloride with +5 oxidation state. Draw a dot-and-cross diagram for this chloride.

Stable chloride with +5 oxidation state: .....



- (ii) Explain why it is possible for **R** to form a chloride with a +5 oxidation state

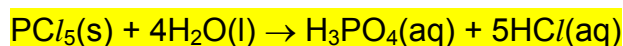
.....  
 .....

Phosphorus has energetically accessible vacant 3d orbitals to expand its octet structure (i.e. accommodate more than 8 electrons in its outermost shell)

- (ii) Write a balanced chemical equation, with state symbols, to illustrate the reaction for any one of the chlorides in water.

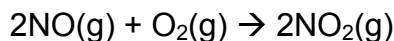
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[4]



[Total: 10]

- 2 (a) One reaction which occurs in air polluted with nitrogen oxides is shown below.



Several experiments were carried out at 700 °C to find the relationship between the initial concentration of NO and O<sub>2</sub>, and the initial rate of formation of NO<sub>2</sub>.

The results of the rate studies on this reaction are shown below.

Experiment	Initial concentration/ mol dm <sup>-3</sup>		Initial rate of formation of NO <sub>2</sub> /mol dm <sup>-3</sup> s <sup>-1</sup>
	[NO]	[O <sub>2</sub> ]	
1	0.001	0.002	$1.40 \times 10^{-5}$
2	0.002	0.003	$6.30 \times 10^{-5}$
3	0.003	0.003	$9.45 \times 10^{-5}$

- (i) Use the data provided to determine the order of the reaction with respect to

1. Nitrogen monoxide

Compare experiment 2 and 3 where [O<sub>2</sub>] is kept constant.

$$\frac{6.30 \times 10^{-5}}{9.45 \times 10^{-5}} = \left( \frac{0.002}{0.003} \right)^m$$

$$m = 1 = \text{order of reaction with respect to NO}$$

2. Oxygen

Compare experiment 1 and 2.

$$\frac{1.40 \times 10^{-5}}{6.30 \times 10^{-5}} = \left( \frac{0.001}{0.002} \right) \left( \frac{0.002}{0.003} \right)^n$$

$$n = 2 = \text{order of reaction with respect to O}_2$$

- (ii) Use your answers from (a)(i) to write a rate equation for the reaction.

$$\text{Rate} = k[\text{NO}][\text{O}_2]^2$$

- (iii) Determine a value for the rate constant and state its units.

$$1.40 \times 10^{-5} = k (0.001)(0.002)^2$$

$$k = 3500 \text{ mol}^{-2} \text{ dm}^6 \text{ s}^{-1}$$

[5]

- (b) Rate studies for the same reaction were conducted at 1000 °C to find out whether the order of reaction changes with temperature.

In this series of rate studies, the concentration of NO was monitored over a period of time.

The table below provides the ratio of first two successive half-lives obtained from two concentration– time graphs.

Graph	Initial concentration / mol dm <sup>-3</sup>		ratio of successive t <sub>1/2</sub>	
	[NO]	[O <sub>2</sub> ]	First t <sub>1/2</sub>	Second t <sub>1/2</sub>
1	0.0001	0.0001	1	3
2	0.0001	0.0040	1	1

- (i) Using the data above, deduce which graph will be suitable to be used to determine the order of reaction with respect to NO. Give reasons for your choice.

.....  
 .....  
 .....  
 .....

Graph 2. Oxygen is in large **excess**/ [O<sub>2</sub>] >> [NO].

Since [O<sub>2</sub>] remains **relatively constant** the rate of reaction only **depends on [NO]/ independent of [O<sub>2</sub>]** .

- (ii) Assume graph 2 is correct and the reaction follows the same rate equation derived in (a)(ii).

Use the following information to determine the rate constant for the same reaction at 1000 °C.

initial rate for Graph 2 =  $6.70 \times 10^{-3}$  mol dm<sup>-3</sup> s<sup>-1</sup>

t<sub>1/2</sub> = 10.8s

Rate = k[NO][O<sub>2</sub>]<sup>2</sup>

= k'[NO] where k' = k[O<sub>2</sub>]<sup>2</sup>

t<sub>1/2</sub> =  $\frac{\ln 2}{k[O_2]^2} = \frac{\ln 2}{k(0.0040)^2}$

k = 4011 mol<sup>-2</sup> dm<sup>6</sup> s<sup>-1</sup>

[Total: 8]

- 3 (a) State and explain how the acidities of ethanoic acid and propan-1-ol compare with each other. [3]

Ethanoic acid is more acidic than propan-1-ol

Comparing ethanoic acid and propan-1-ol, ethanoate anion is more stable than the propoxide anion as the negative charge is delocalised over the  $\text{COO}^-$  group.

On the other hand, the electron-donating propyl group intensifies the negative charge on oxygen of propoxide anion, making the anion less stable.

- (b) Compare and explain the difference in reactivity of chlorobenzene and chloroethane. [2]

Chlorobenzene is less reactive than chloroethane.

A lone pair in the p orbital of the chlorine atom is delocalised into the  $\pi$  electron cloud of the benzene ring. This strengthens the C-X bond.

Hence, the chlorine atom in chlorobenzene is more difficult to be substituted compared to a chlorine atom in an chloroethane.

- (c) Describe and explain the trend in boiling point from fluoroethane to iodoethane. [3]

The boiling point increases from fluoroethane to iodoethane.[1m]

As the size of the halogen atom increases, the number of electrons in the molecule increases and the electron cloud of the molecule become increasingly more polarisable. Hence, the van der Waals' forces between the molecules become increasingly stronger and require an increasing amount of energy to overcome. Therefore boiling point increases.

- (e) Compare and explain the difference in temperature required in bromination of benzene and methylbenzene. [2]

Methylbenzene requires a lower temperature as compared to benzene. Methylbenzene is more reactive due the presence of the methyl group

which has an electron-donating effect. Electron-donating groups increase the electron density on the benzene ring, making the ring more susceptible to electrophilic attack as well as stabilising the arenium ion. Therefore, temperature required is lower.

**[Total : 10]**

- 4 The food we eat is broken down, or metabolised, in stages by enzymes. The overall change in energy during metabolism is the same as the enthalpy change of combustion. The main difference is that combustion is usually a one-step process.

This means if glucose ( $C_6H_{12}O_6$ ) is converted to carbon dioxide and water, the total enthalpy change is  $-2801 \text{ kJ mol}^{-1}$ . This is regardless of whether glucose is burnt or metabolised in our bodies.

Food labels are useful references for consumers who want to estimate their energy consumption. The amount of energy in the food is often expressed in kilocalorie (i.e. 1000 calorie) on food labels. 1 calorie is defined as the amount of energy needed to raise 1 g of water by  $1^\circ\text{C}$ .

In the laboratory, the amount of energy present in food can be found by burning a fixed mass of food, and use the energy released to warm a fixed mass of water.

The respiratory quotient (RQ) can be used for understanding organism metabolism.

$$RQ = \frac{V_C}{V_O}$$

where  $V_C$  = volume of  $CO_2$  produced by a living organism

$V_O$  = volume of  $O_2$  consumed by the same living organism

When different sources of energy are metabolised, the volumes of carbon dioxide produced and oxygen consumed are different. This gives rise to different RQ values. Determining the RQ value is a convenient way to gain information about the source of energy a living organism is using.

The table below gives the RQ values for common types of energy source.

Energy source	Average RQ value
Carbohydrates	1.0
proteins	0.9
Fats	0.7

- (a) Define enthalpy change of combustion.

.....  
 .....

[1]

Enthalpy change when one mole of the substance is completely burnt in oxygen.



- (b) Half a teaspoon of glucose has a mass of 2.00 g. It is burnt as fuel to heat up 500 g of water.

The specific heat capacity of water is  $4.184 \text{ J g}^{-1} \text{ }^{\circ}\text{C}^{-1}$ .

- (i) Calculate the expected rise in the temperature of water.

$$\text{Molar mass of glucose} = 180 \text{ g mol}^{-1}$$

$$\text{Energy released} = \frac{2.00}{180} \times 2801 = 31.1 \text{ kJ}$$

$$31.1 \times 1000 = 500 \times 4.184 \times \Delta T$$

$$\Delta T = 14.9 \text{ }^{\circ}\text{C}$$

- (ii) Suggest why the actual temperature rise recorded is lower than expected.

Incomplete combustion or heat lost to the surrounding

- (iii) Express the amount of energy in 2.00g of glucose in term of kilocalorie.

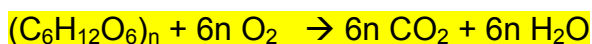
$$1 \text{ calorie} = 4.184 \text{ J g}^{-1} \text{ }^{\circ}\text{C}^{-1}$$

$$\text{Amount of energy} = \frac{31.1 \times 1000}{4.184} = 7433 \text{ cal}$$

$$= 7.43 \text{ kcal}$$

[4]

- (c) Write a balanced equation for the combustion of carbohydrate,  $(\text{C}_6\text{H}_{12}\text{O}_6)_n$ . Hence, show that the respiratory quotient, RQ, for carbohydrates is equal to 1.



volume ratio = mole ratio for measurement of gases volumes under same temperature and pressure

$$\text{Therefore, RQ} = \frac{6n}{6n} = 1$$

[2]

- (d) 1.00 g of a food sample with high energy content is burnt completely in  $1.00 \text{ dm}^3$  of excess oxygen gas. After cooling to room temperature and pressure, the volume of gaseous mixture was  $0.943 \text{ dm}^3$ . A further reduction of  $0.810 \text{ dm}^3$  was observed when the residual gas was passed through aqueous calcium hydroxide.

- (i) Calculate the respiratory quotient, RQ, for the food sample if it is completely metabolised in the body.

$$V_{\text{CO}_2} = 0.810 \text{ dm}^3$$

$$0.943 = V_{\text{CO}_2} + V_{\text{O}_2 \text{ excess}}$$

$$V_{\text{O}_2 \text{ excess}} = 0.943 - 0.810 = 0.133 \text{ dm}^3$$

$$\text{RQ} = \frac{0.810}{1.00 - 0.133} = 0.934$$

- (ii) The 1.00 g food sample contains 80% carbohydrates by mass. Calculate the volume of oxygen, measured at room temperature and pressure, required for complete combustion of the carbohydrates in the food sample.



Amount of C = amount of CO<sub>2</sub> produced

= amount of C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> unit × 6

$$= \frac{0.8}{180} \times 6 = 0.0267 \text{ mol}$$

V<sub>CO<sub>2</sub> produced</sub> = V<sub>O<sub>2</sub> required</sub>

$$= 0.0267 \times 24.0$$

$$= 0.640 \text{ dm}^3 \text{ at rtp}$$

- (iii) Show, by means of calculation, that the RQ value for metabolising the remaining 20% of food sample is 0.75.

$$\text{RQ} = \frac{V_{\text{CO}_2 \text{ from 20\%}}}{V_{\text{O}_2 \text{ required}}} = \frac{0.810 - 0.640}{1 - 0.640 - 0.133} = 0.75$$

[5]

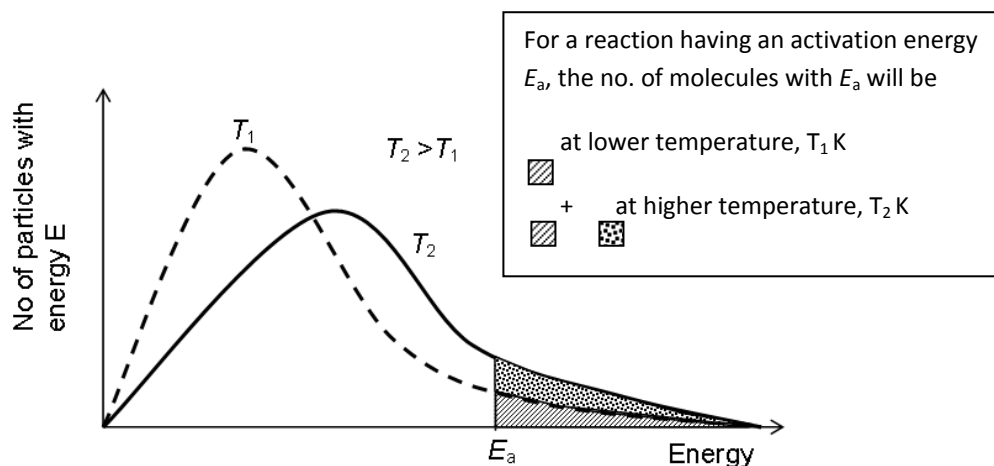
[Total: 12]

## Section B (40 marks)

Answer all the questions in this section on separate answer paper.

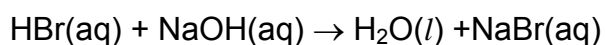
5. (a) Describe and explain in molecular terms, how the rate of a chemical reaction is affected by a change in temperature. You should include a Boltzmann distribution in your answer.

[3]



An increase in temperature increases the average energy of the reacting particles. The number of particles with energy equal to or greater than the activation energy increases. This leads to an increase in the number of effective collisions, hence rate of reaction increases.

- (b) (i) Suggest reasons why reaction I below must be heated for some time for it to occur, whereas reaction II takes place almost instantaneously at room temperature.



[4]

In reaction I, heating is required to break the C-Br bond present in bromopropane before nucleophilic substitution by  $\text{OH}^-$  can occur.

However, in reaction II, HBr is acidic. HBr and NaOH undergo an acid-base reaction. Therefore, it takes place instantaneously at room temperature.

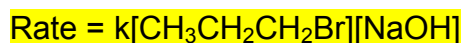
- (ii) How would the rate of reaction of  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}(l)$  and  $\text{NaOH}(aq)$  compare to that of reaction I? Explain your answer.

The rate of reaction will be slower. This is because C-Cl is stronger/higher bond energy than C-Br.

- (c) Reaction I is a second order reaction. Both  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$  and  $\text{NaOH}$  are first order.

[3]

- (i) Suggest a rate equation for this reaction

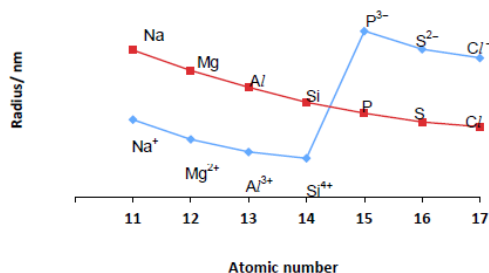


- (ii) Estimate the effect on the rate of this reaction of diluting solution with an equal volume of solvent

The rate of reaction will decrease by 4 times. Or the rate of reaction will be  $\frac{1}{4}$  of the original reaction.

- (d) (i) Sketch the ionic radii curve with respect to the atomic radii for elements from Na to Cl. Explain your graph.

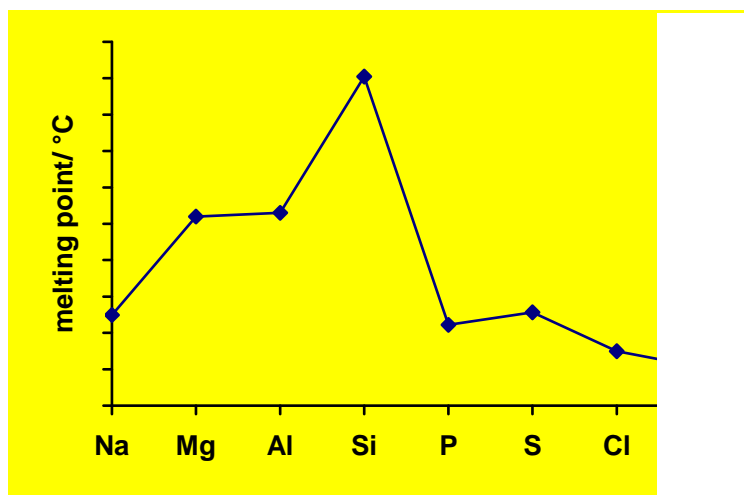
[10]



The radii of cations are smaller than the radii of corresponding atoms. Atoms lose their valence electrons to form cations. As a result, the cations formed have one less quantum shell of electrons.

The radii of anions are larger than the radii of corresponding atoms. In forming the anions, electrons are added to the outermost quantum shell of the atoms. As a result, there is greater electron-electron repulsion in the outermost quantum shell of the anions formed.

- (ii) Sketch a graph of the melting point from Na to Cl. Explain your graph.



Na, Mg and Al have higher melting points as they all have giant metallic structures and a larger amount of energy is required to overcome the strong electrostatic attraction between the positively-charged metal cations and delocalised valence electrons.

Si has the highest melting point as it has a giant covalent structure and a large amount of energy is required to overcome the strong covalent bonds between the Si atoms.

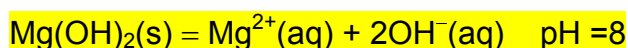
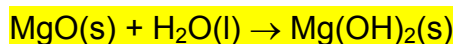
The P to Cl have lower melting points as they all have simple covalent structures. Less energy is required to overcome the weaker van der Waals' forces between the molecules.

(iii) Write an equation and state the pH for the reaction of the following compounds with water.

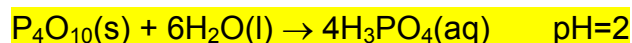
1. MgO

2.  $\text{Al}_2\text{O}_3$

3.  $\text{P}_4\text{O}_{10}$

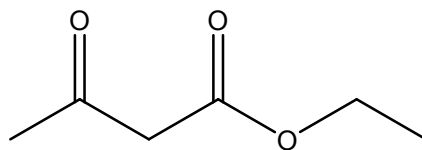


$\text{Al}_2\text{O}_3\text{(s)}$  is insoluble in water pH=7



[Total: 20 ]

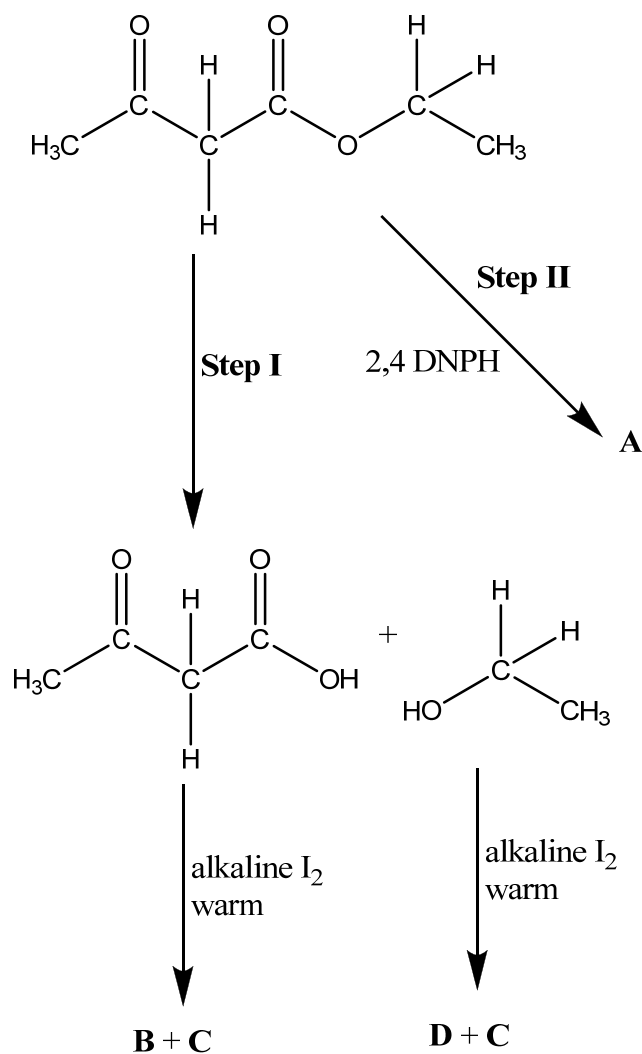
6. (a)  $\beta$ -Keto ester is a molecule which contains a ketone on the  $\beta$  carbon of an ester. Ethyl acetoacetate is a typical example of a  $\beta$ -keto ester. It has the following structure as shown below:



Ethyl acetoacetate

Ethyl acetoacetate can be formed from  $\text{CH}_3\text{CH}_2\text{OH}$  and  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{OH}$ .

Ethyl acetoacetate can undergo a series of reactions as shown below.



- (i) State the reagents and conditions for step I.

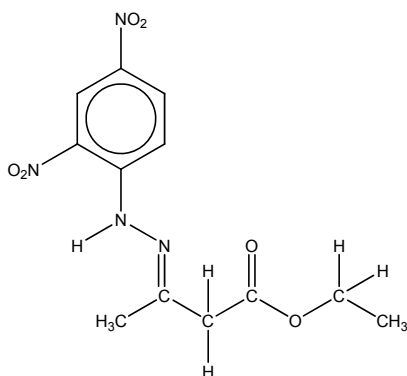
Dilute hydrochloric acid/sulfuric acid, heat under reflux

- (ii) State the type of reaction in Step I and Step II.

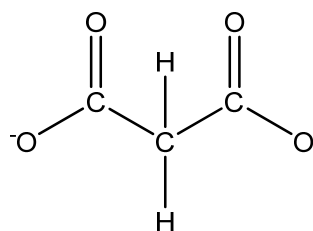
Step I : acidic hydrolysis

Step II : condensation reaction

- (iii) Draw the structures of the organic products of **A** to **D**.



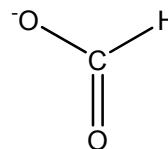
**A**



**B**



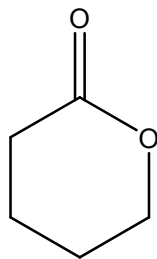
**C**



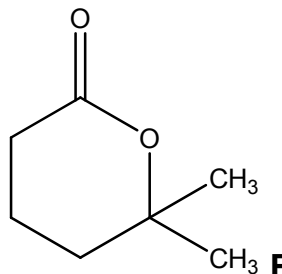
**D**

For the following pair of compounds, describe one simple chemical test which would enable you to distinguish between them.

- (b) (i)



**A**

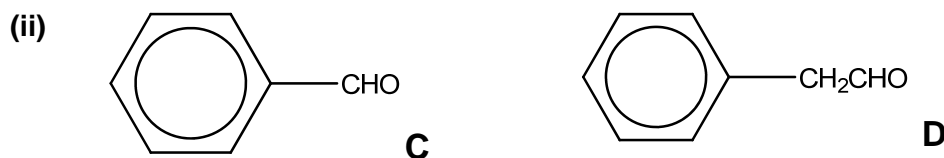


**B**

[4]

Chemical Test : acidified  $\text{KMnO}_4$ , heat under reflux

Observation : **A** will decolourise acidified  $\text{KMnO}_4$  while purple colour remains in **B**



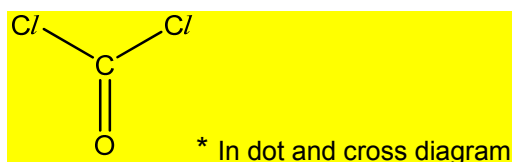
Chemical Test : Fehling's solution, heat

Observation : Brick red ppt is observed in **D** but no brick red ppt is observed in **C**

- (c) Carbonyl chloride, also commonly known as phosgene, is a chemical weapon used as a toxic gas used during World War II. In carbonyl chloride, the carbon atom is in the centre of the molecule and is attached to both chlorine atom and to the oxygen atom.

[6]

- (i) Draw a 'dot-and-cross' diagram of the phosgene molecule.

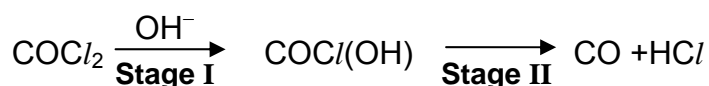


- (ii) Give the shape and bond angle of the molecule.

Bond angle :  $120^\circ$

Shape : Trigonal Planar

- (iii) Phosgene reacts with NaOH(aq). It is suggested that the reaction occurs in two stages.



What type of reaction occurred at Stage I and II.

Stage I : Substitution

Stage II : Elimination

- (iv) Phosgene can be converted into urea,  $\text{CO(NH}_2)_2$ , with the production of ammonium salt as the other product.

Name the reagent that is used for this conversion and hence write an equation for the conversion.

Reagent :  $\text{NH}_3$

Equation :  $\text{COCl}_2 + 4 \text{NH}_3 \rightarrow \text{CO(NH}_2)_2 + 2 \text{NH}_4\text{Cl}$



- (d) Carbonyl fluoride and carbonyl bromide are similar to phosgene. The boiling points of carbonyl fluoride and carbonyl bromide are as shown.

Molecule	Boiling Point / °C
COF <sub>2</sub>	-84.57
COBr <sub>2</sub>	64.5

[3]

- (i) Using the above data, deduce the boiling point of phosgene. Explain your answer.

$$-84.57^{\circ}\text{C} < \text{boiling point of phosgene} < 25^{\circ}\text{C}$$

The  $M_r$  of phosgene is between that of COF<sub>2</sub> and COBr<sub>2</sub>, hence strength of Van der Waals forces of attractions between phosgene molecules will be stronger than that of COF<sub>2</sub> molecules but weaker than that of COBr<sub>2</sub> molecules. Hence the boiling point is 8.3°C. (actual value)

- (ii) Give the physical appearance of carbonyl bromide under standard condition.

Liquid

[Total: 20 ]

- 7 (a) Ammonium hydrogen sulfide is a crystalline solid that decomposes as follows:



2.00g of NH<sub>4</sub>HS is placed in a 2 dm<sup>3</sup> evacuated vessel at 25°C. When equilibrium is attained, 0.631 g of solid NH<sub>4</sub>HS is found to remain in the vessel.

[5]

- (i) Write the  $K_c$  expression for the decomposition of NH<sub>4</sub>HS and calculate its numerical value at 25°C.

$$[\text{NH}_3] = [\text{H}_2\text{S}] = \frac{\left( \frac{2.00 - 0.631}{14.0 + 5.0 + 32.1} \right)}{2} = 0.0134 \text{ mol dm}^{-3}$$

$$K_c = [\text{NH}_3][\text{H}_2\text{S}]$$

$$= (0.0134)(0.0134)$$

$$= 1.79 \times 10^{-4} \text{ mol}^2 \text{ dm}^{-6}$$

- (ii) Explain whether the following changes will give rise to a different the equilibrium concentration of ammonia.

I Adding solid  $\text{NH}_4\text{HS}$

II Reducing the volume of reaction vessel

I Addition of solid does not disrupt the equilibrium system. The **equilibrium position does not change** and the partial pressure of ammonia remained **unchanged**.

II Reducing the volume of reaction vessel **increase the concentration of  $\text{NH}_3$  (and  $\text{H}_2\text{S}$ ) in the closed system temporarily**. The equilibrium position will **shift to the left to reduce  $[\text{NH}_3]$  to  $0.0134 \text{ mol dm}^{-3}$  again so as to keep  $K_c$  constant**.

- (b) Ammonia can be used to make aniline, an organic compound that is used in the dye industry as a precursor to indigo, the blue dye for jeans. Aniline is monobasic. An aqueous solution containing  $0.270 \text{ mol dm}^{-3}$  of aniline has a pH of 9.01.

[5]

- (i) Show, with the aids of calculation, that aniline is a weak base.

$$\text{pOH} = 14 - 9.01 = 4.99$$

$$[\text{OH}^-] = 10^{-4.99} = 1.02 \times 10^{-5} \text{ mol dm}^{-3} \ll 0.270 \text{ mol dm}^{-3}$$

Aniline dissociates only partially, therefore it is a weak base.

- (ii) Aniline can be used to form an alkaline buffer. For the buffer to work at maximum buffering capacity, the concentration of aniline and its salt must be equal.

$1.00 \text{ mol dm}^{-3}$  of sulfuric acid solution is added slowly to  $500 \text{ cm}^3$  of  $0.270 \text{ mol dm}^{-3}$  aniline solution. Calculate the volume of sulfuric acid that has to be added to form a buffer at maximum buffering capacity.

$$n_{\text{aniline reacted}} = n_{\text{aniline salt}}$$

$$= \frac{1}{2} \times 0.500 \times 0.270 = 0.0675 \text{ mol dm}^{-3}$$

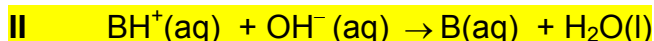
$$n_{\text{sulfuric required}} = 0.0675 \div 2 = 0.03375 \text{ mol}$$

$$\text{Volume of sulfuric acid} = 0.03375 \div 1 = 0.0338 \text{ dm}^3$$

- (iv) Using B to represent aniline and  $\text{BH}^+$  represent cation of aniline salt, write ionic equations to show how this solution reacts with

I added  $\text{H}^+$  (aq) ions,

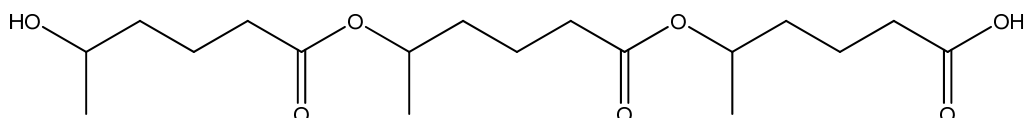
II added  $\text{OH}^-$  (aq) ions.



(c) Organic compound **A** has the molecular formula of  $\text{C}_6\text{H}_{11}\text{Br}$ .

Heating compound **A** in a mixture containing ethanol and aqueous sodium hydroxide, produces compound **B**,  $\text{C}_6\text{H}_{10}$ . Compound **B** decolourises hot acidified potassium manganate(VII) to produce compound **C**,  $\text{C}_6\text{H}_{10}\text{O}_3$ . No decolourisation is observed if compound **A** is used instead.

Compound **C** reacts with sodium borohydride to form compound **D**,  $\text{C}_6\text{H}_{12}\text{O}_3$ . Heating compound **D** with concentrated sulfuric acid produces several products. Compound **E**,  $\text{C}_6\text{H}_{10}\text{O}_2$  is one of these products and the diagram below shows another.



Use the information above to deduce the structural formulae for **A**, **B**, **C**, **D** and **E**, explaining your reasoning.

[10]

Organic compound **A** has the molecular formula of  $\text{C}_6\text{H}_{11}\text{Br}$ .

**A** is either cyclic or contains an alkene functional group.

Heating compound **A** in a mixture containing ethanol and aqueous sodium hydroxide, produces compound **B**,  $\text{C}_6\text{H}_{10}$ .

**A** undergoes elimination to give **B**.

→ **B** is an alkene.

Compound **B** decolourises hot acidified potassium manganate(VII) to produce compound **C**,  $\text{C}_6\text{H}_{10}\text{O}_3$ .

**B** undergoes (vigorous) oxidation to give **C**.

**C** has same number of carbon as **B**.

→ **B** is not a terminal alkene.

→ **B** is a cycloalkene

**C** the oxidised product of cycloalkene has 3 oxygen atoms

→ **C** has both a carboxyl and a ketone functional group.

No decolourisation (of  $\text{KMnO}_4$ ) is observed if compound **A** is used instead.

**A** is not oxidised. Since **A** is  $\text{C}_6\text{H}_{11}\text{Br}$

→ **A** is not an alkene but a

cyclic compound.

Compound **C** reacts with sodium borohydride to form compound **D**,  $C_6H_{12}O_3$ .

**C** is reduced to form **D**.

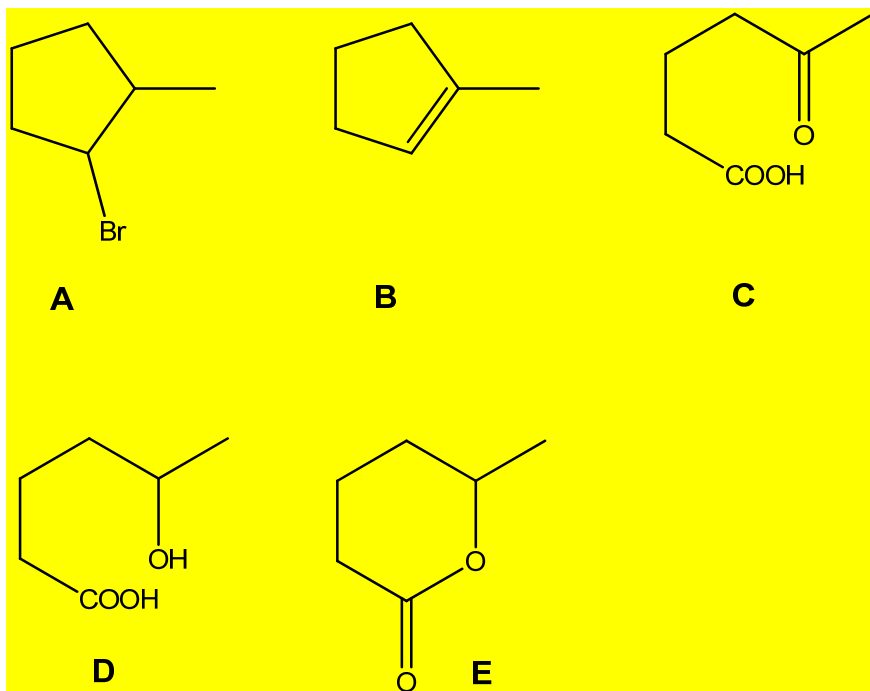
→ **C** is a ketone (carbonyl)

→ **D** is a secondary alcohol.

Heating compound **D** with concentrated sulfuric acid produces several products.

**D** undergoes condensation to give **E** and other products.

→ **E** is an (cyclic) ester



[Total: 20]

~ END OF PAPER~