RIVER VALLEY HIGH SCHOOL

YEAR 6 Preliminary Examination II

CANDIDATE NAME								
CLASS	6							
CENTRE NUMBER	S					INDEX NUMBER				

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

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)

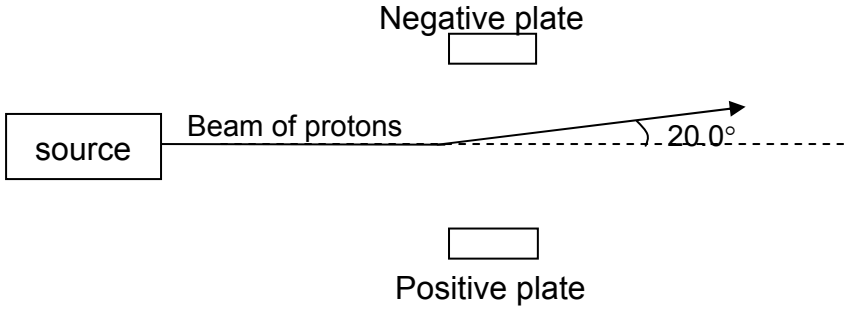
Answer all the questions in the space provided.

1 **(a)** Complete the table below.

Particle	Electric charge	Mass number	Number of		
			Protons	Electrons	Neutrons
R	0			15	16
S	−1	81		36	

[2]

(b) A beam of protons, subjected to an electric field, is found to be deflected by 20.0°.



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. **[2]**

Direction of deflection: Towards …….. 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. **[4]**

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

Chloride with +5 oxidation state: ……..

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

……

……

……

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

……

[Total: 10]

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

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

Several experiments were carried out at 700 °C to find the relationship between the initial concentration of NO and O_2, and the initial rate of formation of NO_2.

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

Experiment	Initial concentration/ mol dm^{-3}		Initial rate of formation of NO_2 /mol dm^{-3} s^{-1}
	[NO]	[O_2]	
1	0.001	0.002	1.40×10^{-5}
2	0.002	0.003	6.30×10^{-5}
3	0.003	0.003	9.45×10^{-5}

[5]

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

1. Nitrogen monoxide

2. Oxygen

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

……

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

(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^{-3}		ratio of successive $t_{½}$	
	[NO]	$[O_2]$	First $t_{½}$	Second $t_{½}$
1	0.0001	0.0001	1	3
2	0.0001	0.0040	1	1

[3]

(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.

……

……

……

……

(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 = 6.70×10^{-3} mol dm^{-3} s^{-1}

$t_{½}$ = 10.8s

[Total: 8]

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

……

……

……

……

……

……

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

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……

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

……

……

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

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[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 kJ mol^{-1}. This is regardless of whether glucose is burnt in air 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 °C.

In the laboratory, the amount of energy presence 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]**

……

……

(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 J g^{-1} °C^{-1}. **[4]**

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

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

……..

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

(c) Write a balanced equation for the combustion of carbohydrate, $(C_6H_{12}O_6)_n$. Hence, show that the respiratory quotient, RQ, for carbohydrates is equal to 1. **[2]**

……..

(d) 1.00 g of a food sample with high energy content is burnt completely in 1.00 dm^3 of excess oxygen gas. After cooling to room temperature and pressure, the volume of gaseous mixture was 0.943 dm^3. A further reduction of 0.810 dm^3 was observed when the residual gas was passed through aqueous calcium hydroxide. **[5]**

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

(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.

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

[Total: 12]

Section B (40 marks)

Answer 2 out of 3 questions in this section on separate answer paper.

Begin each question on a fresh piece of paper.

5. **(a)** Describe and explain in molecular terms, how the rate of a chemical reaction is affected by a change in temperature. You may include a diagram in your answer. **[3]**

(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.

$CH_3CH_2CH_2Br(l) + NaOH(aq) \rightarrow CH_3CH_2CH_2OH(aq) + NaBr(aq)$ **I**

$HBr(aq) + NaOH(aq) \rightarrow H_2O(l) + NaBr(aq)$ **II** **[4]**

(ii) How would the rate of reaction of $CH_3CH_2CH_2Cl$ (l) and NaOH(aq) compare to that of reaction **I** ? Explain your answer.

(c) Reaction **I** is a second order reaction. Both $CH_3CH_2CH_2Br$ and 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

(d) **(i)** Sketch the ionic radii curve with respect to the atomic radii for elements from Na to C*l*. Explain your graph **[10]**

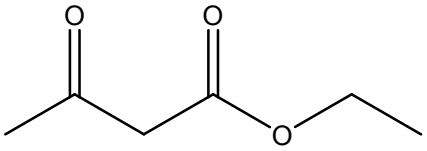
(ii) Sketch a graph of the melting point from Na to C*l*. Explain your graph.

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

1. MgO
2. Al_2O_3
3. P_4O_{10}

[Total: 20]

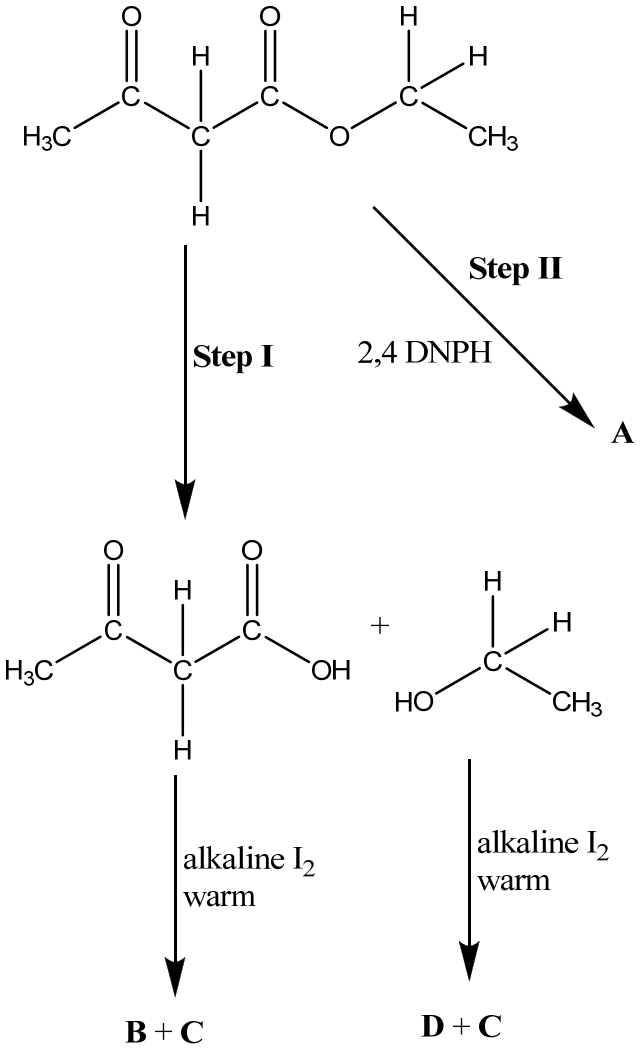
6. **(a)** β-Keto ester is a molecule which contains a ketone on the β carbon of an ester. Ethyl acetoacetate is a typical example of a β-keto ester. It has the following structure as shown below:



Ethyl acetoacetate

Ethyl acetoacetate can be formed from CH_3CH_2OH and $CH_3CH(OH)CH_2CH_2OH$.

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



[7]

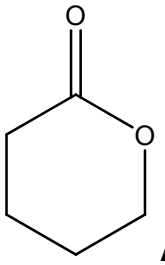
(i) State the reagents and conditions for step **I**.

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

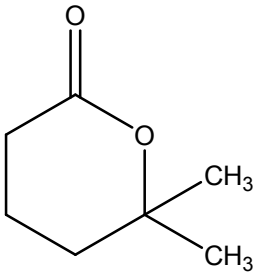
(iii) Draw the structures of the organic products of **A** to **D**.

(b) For the following pair of compounds, describe one simple chemical test which would enable you to distinguish between them. **[4]**

(i)

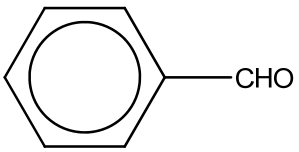


A

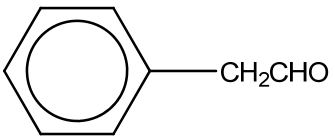


B

(ii)



C



D

(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

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

$$COCl_2 \xrightarrow[\textbf{Stage I}]{OH^-} COCl(OH) \xrightarrow[\textbf{Stage II}]{} CO + HCl$$

What type of reaction occurred at Stage **I** and **II**.

(iv) Phosgene can be converted into urea, $CO(NH_2)_2$, 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.

(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_2	−84.57
$COBr_2$	64.5

[3]

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

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

[Total: 20]

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

$$NH_4HS(s) = NH_3(g) + H_2S(g)$$

2.00g of NH_4HS is placed in a 2 dm^3 evacuated vessel at 25°C. When equilibrium is attained, 0.631 g of solid NH_4HS is found to remain in the vessel. **[5]**

(i) Write the K_c expression for the decomposition of NH_4HS and calculate its numerical value at 25°C.

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

I Adding solid NH_4HS

II Reducing the volume of reaction vessel

(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 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.

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

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

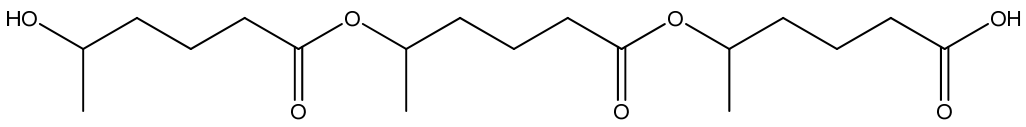
I added H^+ (aq) ions,

II added OH^- (aq) ions.

(c) Organic compound **A** has the molecular formula of $C_6H_{11}Br$.

Heating compound **A** in a mixture containing ethanol and aqueous sodium hydroxide, produces compound **B**, C_6H_{10}. Compound **B** decolourises hot acidified potassium manganate(VII) to produce compound **C**, $C_6H_{10}O_3$. No decolourisation is observed if compound **A** is used instead.

Compound **C** reacts with sodium borohydride to form compound **D**, $C_6H_{12}O_3$. Heating compound **D** with concentrated sulfuric acid produces several products. Compound **E**, $C_6H_{10}O_2$ 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]**

[Total: 20]

~ END OF PAPER~