RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATION II

CANDIDATE NAME

CLASS | 6 |

CENTRE NUMBER | S | | | |

INDEX NUMBER | | | | |

H2 CHEMISTRY 9647/02

Paper 2 Structured Questions

13 September 2016

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

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 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.

Answer **all** questions 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.

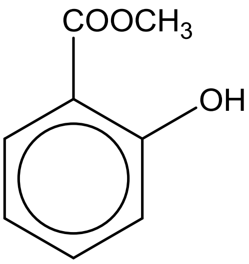
For Examiner's Use								
Paper 2								
Question Number	**1**	**2**	**3**	**4**	**5**	**6**		**Total (Paper 2)**
Marks	12	13	8	9	16	14		72
Paper 1		40		**Paper 3**		80	**Total**	192

This document consists of **18** printed pages and **2** blank pages.

1 Planning (P)

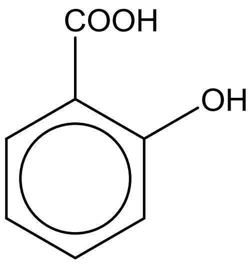
Salicylic acid is known for its ability to ease aches and pains as well as reduce fevers. Its analgesic and anti-inflammatory properties makes it one of the most important medications needed in a basic health system, placing it on the World Health Organisation Model List of Essential Medicines.

It can be synthesised via the alkaline hydrolysis of methyl salicylate, followed by acidification.



methyl salicylate

(M_r = 152)



salicylic acid

(M_r = 138)

Methyl salicylate is a liquid with a density of 1.174 g cm^{-3}.

Aqueous sodium hydroxide used for the hydrolysis has a concentration of 6.0 mol dm^{-3}.

Like most organic reactions, the yield of this reaction is less than 100%. Using the procedure described below, a typical yield of pure salicylic acid is 60%.

Methyl salicylate is mixed with aqueous sodium hydroxide in a molar ratio of 1:2. The reaction is heated under reflux conditions for around 30 minutes to form a di-sodium salicylate salt.

When the reaction mixture has cooled down, concentrated hydrochloric acid is added until in excess to cause the crude salicylic acid to precipitate. This process is highly exothermic.

The crude salicylic acid is then purified by recrystallisation from water.

(a) Using the information given above:

(i) write a balanced equation for the formation of the di-sodium salicylate salt;

[1]

(ii) calculate the volumes of methyl salicylate and aqueous sodium hydroxide you would use to prepare 10 g of pure salicylic acid, showing your working.

[2]

(b) Write a plan for the preparation of 10 g of pure salicylic acid.

In your plan, you should:

- draw a diagram of the assembled apparatus you would use when heating the reaction mixture;
- give a full description of the procedures, including the capacities of the apparatus involved, you would use to prepare and purify the salicylic acid;
- explain how you would minimise a potential safety hazard.

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.... **[9]**

[Total: 12]

2 Sodium azide is a chemical found in car safety airbags. When the car undergoes a head-on collision, a series of chemical reactions occur in the gas generator chamber. The first reaction produces nitrogen gas to fill the airbag. The equation for the reaction is shown below:

$$NaN_3(s) \rightarrow Na(s) + \frac{3}{2}N_2(g) \qquad \Delta H < 0$$

(a) The volume of a fully inflated airbag is 60 dm^3.

Calculate the mass of NaN_3 needed to fill such an airbag to an internal pressure of 150 kPa at 300 °C.

[2]

(b) **(i)** Given that $\Delta S_r = S(\text{products}) - S(\text{reactants})$ and the following information, calculate ΔS for the above reaction.

Molar entropy of $NaN_3(s)$	70.5 J mol^{-1} K^{-1}
Molar entropy of Na(s)	51.3 J mol^{-1} K^{-1}
Molar entropy of $N_2(g)$	191.6 J mol^{-1} K^{-1}

[1]

(ii) Explain why the reaction is feasible at all temperatures.

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(iii) Suggest why the reaction in fact occurs only at temperatures above 300 °C.

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(c) Sodium metal formed in the above reaction is very reactive and is made to react with potassium nitrate present in the airbag, forming sodium oxide as one of the products.

(i) Explain what is meant by the lattice energy of sodium oxide.

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(ii) Using the information given below and relevant information from the Data Booklet, construct an energy level diagram to calculate the lattice energy of sodium oxide.

Enthalpy change of formation of sodium oxide = –416 kJ mol^{-1}

Enthalpy change of atomisation of sodium = +107 kJ mol^{-1}

Sum of 1st and 2nd electron affinity of oxygen = +702 kJ mol^{-1}

[3]

(iii) Given that the 1st electron affinity of oxygen is –142 kJ mol^{-1}, calculate the 2nd electron affinity of oxygen and explain the significance of its sign.

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(d) A working airbag should become fully inflated within 0.04 s of the initial collision. At this point, it is actually unsafe for the driver's body to hit the inflated airbag due to the high internal pressure (150 kPa). The airbag is hence designed to deflate immediately such that by the time the driver's body hit the airbag, usually 2 s after the initial collision, the internal pressure of the airbag would have dropped to 101 kPa, providing a softer cushioning for the driver.

An airbag at a safety test has a depressurisation rate of 23 kPa s^{-1}.

Explain if this airbag is safe for use, showing relevant calculations.

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[Total: 13]

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3 **(a)** What do you understand by the term standard electrode potential?

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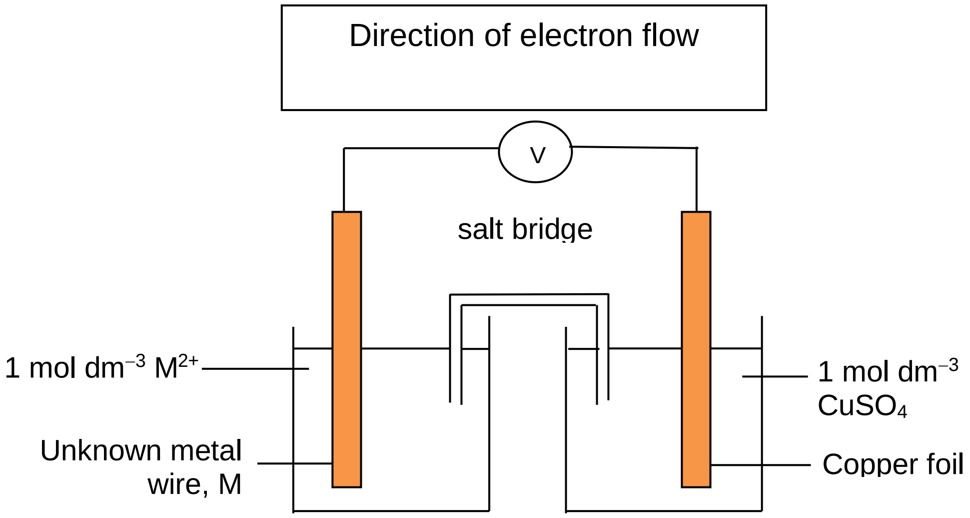
(b) The following cell was set up between a copper electrode and an unknown metal electrode $M^{2+}(aq)/M(s)$. The standard cell potential was found to be 0.76 V, and the copper foil was connected to the positive end of the voltmeter.



(i) Use the Data Booklet to calculate the standard electrode potential of the $M^{2+}(aq)/M(s)$ system.

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.... **[1]**

(ii) Draw an arrow in the box above to show the direction of electron flow through the voltmeter. **[1]**

(iii) Predict the outcomes of the following situations. Describe what you will see and write ionic equations, with state symbols, for any reactions that occur.

I A rod of metal M is dipped into a solution of 1 mol dm^{-3} $CuSO_4$.

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II Dilute sulfuric acid is added into a beaker containing a powdered sample of metal M.

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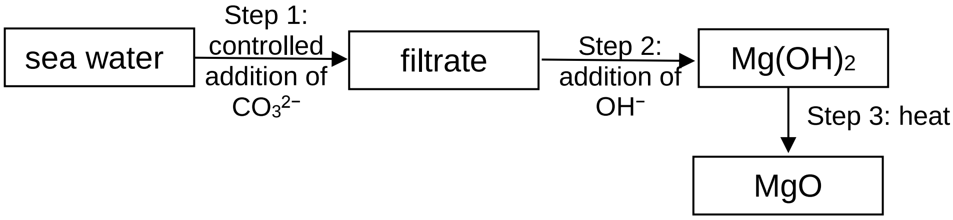
[Total: 8]

4 The four most abundant salts in sea-water are as follows.

Salt	kg per m^3
Sodium chloride	27.5
Magnesium chloride	6.75
Magnesium sulfate	5.625
Calcium sulfate	1.80

Magnesium oxide is obtained from sea-water by the following steps.



The relevant numerical values of the solubility products are given below.

Salt	K_{sp}
Sodium carbonate	-
Calcium carbonate	5.0×10^{-9}
Magnesium carbonate	1.0×10^{-5}
Magnesium hydroxide	1.5×10^{-11}
Calcium hydroxide	7.9×10^{-6}

(a) Explain why the addition of carbonate ions in Step 1 is necessary and has to be controlled.

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.... **[2]**

(b) Suggest why the Ksp value of sodium carbonate is not provided.

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(c) Using the reaction scheme above, Barny used 1 dm^3 of sea water to extract magnesium oxide.

(i) Calculate the concentration of Mg^{2+} in sea water.

[2]

(ii) Barny chose a pH of 9.5 to carry out the extraction of $Mg(OH)_2$.

Calculate the maximum mass of **magnesium oxide** that can be obtained at pH 9.5.

You may assume that negligible volumes of CO_3^{2-} and OH^- were used.

[3]

(iii) Suggest how Barny can modify his experiment to improve on the yield of MgO?

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[1]

[Total: 9]

5 **(a)** In the periodic table, elements can exhibit either single or variable oxidation states. One example of an element which can exhibit variable oxidation state is manganese, Mn, while aluminium, A*l* is an example of an element which cannot exhibit variable oxidation state.

(i) Draw a dot and cross diagram for aluminium chloride, $AlCl_3$.

[1]

(ii) In the vapour state, the M_r of aluminium chloride was found to be 267. However, when aluminium chloride is in the solid state, its M_r was found to be 133.5.

With the aid of suitable diagram, explain this behaviour exhibited by aluminium chloride and the type of bonding involved.

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.... **[3]**

(b) Manganese is often found in minerals in combination with iron and is a metal with important industrial metal alloy uses, particularly in stainless steels. Manganese is found in various black minerals known as pyrolusite. Pyrolusite consists mainly of manganese(IV) oxide. Manganese(IV) oxide is the most common starting material for the production of compounds of manganese in other oxidation states.

Manganese(IV) oxide undergoes a 2-step reaction to produce **Y** and **Z**.

$$MnO_2 \xrightarrow[\textbf{I}]{\text{Oxidation in alkaline medium}} MnO_4^{2-} \underset{\textbf{II}}{\overset{\text{Hot water / alkaline medium}}{\rightleftharpoons}} \text{Brown black solid } \mathbf{Y} \text{ in a purple solution containing } \mathbf{Z}$$

(i) Define the term *transition element*.

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(ii) Write the electronic configuration of Mn.

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(iii) Explain why manganese can exhibit variable oxidation state.

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(iv) The brown black solid **Y** contains 63.8% by mass of manganese and 36.2% by mass oxygen.

Determine the empirical formula of **Y**.

[1]

(v) Suggest the identity of **Z** and state the type of reaction that occurs at step **II**.

Hence, construct a balanced equation for the reaction.

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(vi) With reference to your answer in **(v)**, suggest how bubbling carbon dioxide gas into the hot solution of MnO_4^{2-} increases the yield of **Y** and **Z**.

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(c) Manganese(II) carbonate, $MnCO_3$, undergoes thermal decomposition in a similar way to a Group II carbonate.

$MnCO_3$ decomposes at 200 °C while $CaCO_3$ decomposes at 840 °C.

(i) Write an equation, with state symbols, for the thermal decomposition of $MnCO_3$.

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(ii) Explain why $MnCO_3$ decompose at a lower temperature than $CaCO_3$.

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[Total: 16]

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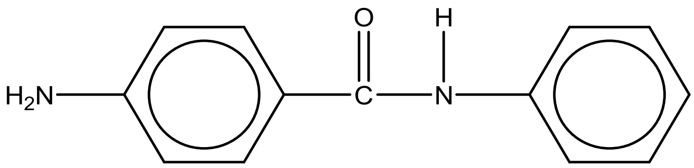
6 **(a)** 4-Amino-N-phenylbenzamide, the structure of which is drawn below, is used in the treatment of epilepsy.



4-amino-N-phenylbenzamide

(i) 4-Amino-N-phenylbenzamide is hydrolysed by warm aqueous sodium hydroxide. Draw the displayed formulae of the two hydrolysis products below.

A	**B**

[2]

(ii) Which of the two hydrolysis product **A** & **B** is a liquid?

.... **[1]**

(iii) When the other product is carefully neutralised with an aqueous mineral acid to pH 7, **C** is obtained.

Draw the structure of **C**.

[1]

(iv) Upon evaporation of all the solvent from the solution of **C**, a white solid is obtained.

Suggest a physical property of the solid.

.... **[1]**

(b) State the reagents and conditions required for the conversion of benzene into phenylamine in two steps. In your answer, identify the structure of the intermediate.

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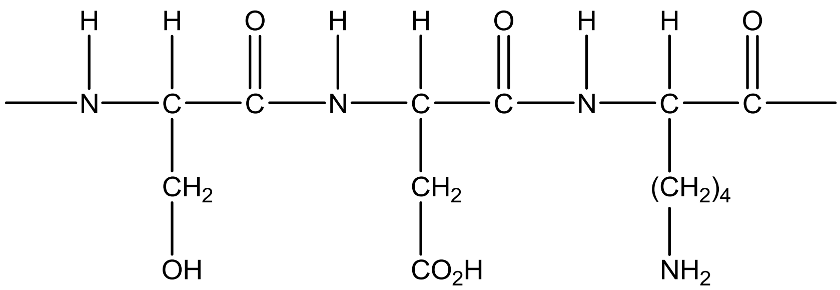
(c) The following structure shows part of a protein molecule.



(i) Using suitable diagrams, describe **two** interactions that the protein fragment above can exhibit in its tertiary structure

[3]

(ii) In solution, amino acids exist as zwitterions. Choose one of the amino acids that can be hydrolysed from the protein molecule above to illustrate what is meant by this term.

[1]

(iii) Amino acids act as buffers in solution. By means of equations, show how your chosen amino acid can act as a buffer when:

(I) dilute hydrochloric acid is added to its solution;

[1]

(II) dilute sodium hydroxide is added to its solution.

[1]

[Total: 14]

– End of Paper –