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

15 September 2014

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 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.

Answer **all** questions in the space provided.
A Data Booklet is provided. Do NOT write anything on it.

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									
Paper 2									
Question Number	1	2	3	4	5				Total
Marks	/12	/16	/15	/15	/14				/72
Paper 1		/40		Paper 3		/80		Total	/192

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

1 Planning (P)

On a field trip to Bukit Timah Hill in Singapore, a new metal carbonate called rvium carbonate, $RvCO_3$, was discovered by Susie. It was found that the dissolving of rvium carbonate in water is endothermic, and that the salt is only slightly soluble. The solubility of rvium carbonate is approximately 0.25 mol dm^{-3} at the laboratory temperature.

You are to plan an experiment to determine the accurate values of both the solubility and enthalpy change of solution of rvium carbonate at the laboratory temperature.

This can be done by preparing a saturated solution of rvium carbonate and measuring the temperature change. The concentration of carbonate ions in the saturated solution can then be determined through volumetric analysis.

You may assume that you are provided with:

- Solid rvium carbonate, $RvCO_3$;
- Aqueous hydrochloric acid, HC*l*;
- Acid−base indicators;
- The apparatus and chemicals normally found in a school or college laboratory.

(a) Write the balanced equation for the reaction between rvium carbonate and hydrochloric acid.

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..... **[1]**

(b) Draw a well-labelled diagram to show the experimental set-up you would use to determine the temperature change during the preparation of the saturated rvium carbonate solution.

[2]

(c) Using the information given above, you are required to write a plan to determine the solubility and enthalpy change of solution of rvium carbonate.

You plan should include details of:

- the preparation of a saturated rvium carbonate solution
- the measurement of the temperature change during the dissolution process
- the intended concentration of the standard hydrochloric acid solution to be used
- the titration of the saturated rvium carbonate solution with the standard hydrochloric acid solution

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(d) Assume that the temperature drop during the preparation of **V** cm^3 of saturated rvium carbonate solution was **ΔT** °C. When a 25.0 cm^3 sample of the saturated rvium carbonate solution was titrated against a standard hydrochloric acid solution of **C** mol dm^{-3}, the average titre was **W** cm^3.

Outline how you would use these results to determine the

(i) solubility, in mol dm^{-3}, of rvium carbonate;

(ii) enthalpy change of solution, ΔH_{soln}, for rvium carbonate.

[3]

[Total: 12]

2 The halogens are a group of elements found in Group VII of the periodic table.

(a) Bromine was discovered in the 1820s by Antoine-Jérôme Balard and is commonly used in halogen lamps. The halogen lamp has a tungsten filament similar to standard incandescent lamps. However, in addition, the halogen lamp contains a small amount of bromine gas in the bulb that slows down the thinning of the tungsten filament, increasing the lamp's lifetime.

When the halogen lamp is switched on, all the bromine molecules dissociate at the high temperatures and exist as single bromine atoms.

$$Br_2(g) \rightarrow 2Br(g)$$

The hot tungsten filament also evaporates and condenses on the relatively cool walls of the bulb, where it reacts with the bromine atoms to give gaseous tungsten bromide, WBr_4.

$$W(s) + 4Br(g) \rightleftharpoons WBr_4(g)$$

(i) A halogen lamp was constructed using a 50 cm^3 bulb containing 0.107 g of $Br_2(g)$. When the halogen lamp was switched on, the temperature at the walls of the bulb reached 900 K and the equilibrium gas density was measured to be 0.003 g cm^{-3}.

Calculate the number of moles of Br(g) produced initially when the halogen lamp was switched on.

(ii) Calculate the number of moles of Br(g) and $WBr_4(g)$ that were present at equilibrium at 900 K.

(iii) Calculate the equilibrium partial pressures of Br(g) and $WBr_4(g)$.

Hence, calculate the value for K_p for the reaction between tungsten and bromine atoms at 900 K, giving the units in terms of Pa^{-3}.

(iv) Near the tungsten filament, where the temperature is about 2800 K, the K_p for the reaction between tungsten and bromine atoms has a smaller value of 1×10^{-16} Pa^{-3}.

Explain whether the forward or backward reaction is favoured near the tungsten filament.

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(v) In standard incandescent lamps, the hot tungsten filament that evaporates will collect on the walls of the bulb. As more and more tungsten evaporates, the filament starts to thin, reducing the lifespan of the incandescent lamp considerably.

Using your answer to **2(a)(iv)**, suggest how the addition of bromine gas into the bulb helps to slow down the thinning of the tungsten filament in halogen lamps.

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..... **[9]**

(b) Chlorine gas was first produced by Carl Wilhelm Scheele in 1774. It can be synthesised into phosphorus pentachloride, PCl_5, a colourless and moisture−sensitive solid.

(i) Write an equation for the reaction of phosphorus pentachloride with excess water.

Suggest the pH of the resultant solution.

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(ii) While the reaction between phosphorus pentachloride and water takes place vigorously at room temperature, nitrogen trichloride, NCl_3, is stable in the presence of water at room temperature.

Suggest why these two chlorides differ in their reactions with water.

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(iii) Phosphorus pentachloride can react with phosphorus pentaoxide to produce phosphoryl chloride.

$$6PCl_5(g) + P_4O_{10}(s) \rightarrow 10POCl_3(g)$$

Given the following data, construct an energy cycle and determine the enthalpy change of the reaction above.

$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g)$ $\quad \Delta H_r = -1226$ kJ mol^{-1}

$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$ $\quad \Delta H_r = -2967$ kJ mol^{-1}

$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$ $\quad \Delta H_r = -84.2$ kJ mol^{-1}

$PCl_3(g) + ½O_2(g) \rightarrow POCl_3(g)$ $\quad \Delta H_r = -286$ kJ mol^{-1}

[7]

[Total: 16]

3 Copper is a rare element that makes up only 6.8×10^{-3} percent of the Earth's crust by mass. It is used in alloys, electrical cables, plumbing pipes and coins.

Some properties of copper and its compounds are given below.

	Cu	CuO	$Cu(OH)_2$	$CuCO_3$
Melting point / °C	1085	1326	80 (decomposes)	200
Electrical conductivity in solid state	conductor	non-conductor	non-conductor	non-conductor
Solubility at 25 °C / mol dm^{-3}	-	negligible	1.77×10^{-7}	1.18×10^{-5}

(a) Explain, in terms of bonding and structure, the following observations.

(i) Copper has a higher melting point than calcium (melting point: 843 °C).

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(ii) Copper conducts electricity in solid state while CuO does not.

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(b) Copper(II) hydroxide, $Cu(OH)_2$, is a sparingly soluble salt.

(i) Write an expression for the solubility product, K_{sp}, of copper(II) hydroxide, and calculate its value at 25 °C.

(ii) State what is meant by the *common ion effect*.

Illustrate your answer by determining the solubility of copper(II) hydroxide in 0.050 mol dm^{-3} of NaOH at 25 °C.

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(iii) Describe the observations you would expect when excess aqueous ammonia is added to a solid sample of $Cu(OH)_2$.

Write an equation for any reaction that occurs.

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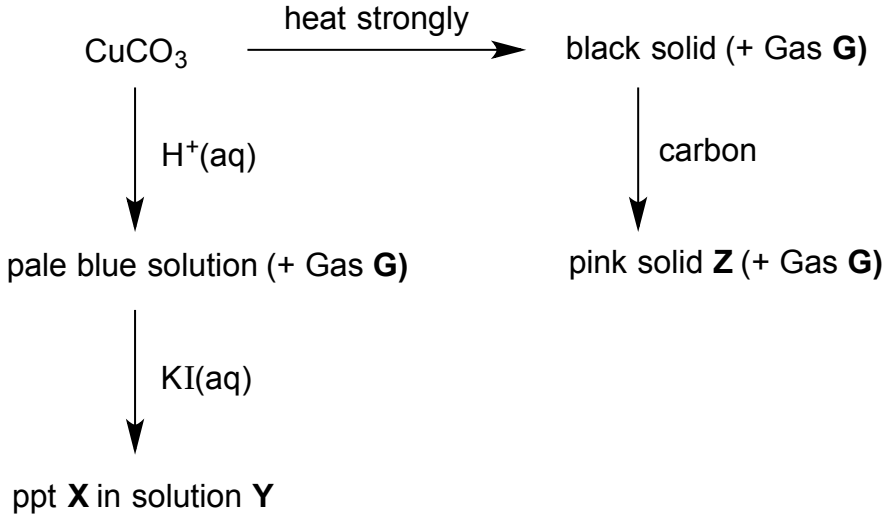
…… **[6]**

(c) Copper(II) carbonate, $CuCO_3$, undergoes the follow reactions.



The three gases evolved (Gas **G**) have the same identity.

(i) Suggest the identities of **X**, **Y** and **Z**, and the colours of **X** and **Y**.

Ppt **X**

Identity : …….....

Colour : ……...

Solution **Y**

Identity : ……....

Colour : ……...

Solid **Z**

Identity : ……....

(ii) Suggest the role of carbon in formation of solid **Z**.

…… **[4]**

(d) The Statue of Liberty is a landmark monument in New York and was a gift from France to the United States to mark her 100 years of independence. It is made of a copper alloy and has a distinct dull green coating, which consists of an equimolar mixture of $Cu(OH)_2$ and $CuCO_3$.

Copper reacts with moist air to form the dull green coating.

Given that three gases are involved in the reaction with copper, write an equation for the formation of the dull green coating.

…… **[1]**

[Total: 15]

4 Group II and Group VII elements are not found naturally in their elemental state. Many of these elements were first isolated by means of electrolysis.

(a) A major method of extracting magnesium is by electrolysis of molten magnesium chloride.

(i) Write the ion-electron half equations, including state symbols, for the reactions that would occur at the anode and cathode during the electrolysis of magnesium chloride.

Anode : …….

Cathode: …….

(ii) Calculate the current required to produced 20 tonnes of magnesium per day.

(1 tonne = 1000 kg)

[4]

(b) Seawater contains a significant quantity of magnesium ion. Seawater is treated with alkali to precipitate the magnesium in the form of magnesium hydroxide which is then heated to produce magnesium oxide. Magnesium oxide is then reacted with chlorine gas to produce solid magnesium chloride. Magnesium is isolated by electrolysing molten magnesium chloride.

The following table shows the three most common ions in seawater.

Species	% composition in seawater
chloride ion	1.94
sodium ion	1.08
magnesium ion	0.129

The following table shows melting points and boiling points for two magnesium compounds used industrially.

Compound	Melting point / °C	Boiling point / °C
magnesium oxide	2852	3600
magnesium chloride	714	1412

Using the information provided and quoting any relevant additional information from the *Data Booklet*, suggest an explanation for the following.

(i) A solid magnesium compound is isolated for electrolysis rather than directly electrolysing seawater to obtain magnesium.

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(ii) The magnesium oxide is converted to magnesium chloride before electrolysis.

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(c) A fireworks specialist was tasked by the National Day Parade organiser to design fireworks that showcased the colours of the Singapore flag. Suggest which Group II elements he should use in the fireworks and their corresponding colours.

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(d) Three separate experiments in which aqueous sodium chloride was electrolysed were performed. The experimental conditions are shown below.

Experiment	Conditions	Observations at anode
1	dilute aqueous sodium chloride 30 °C Solution is unstirred.	Colourless gas evolved.
2	concentrated aqueous sodium chloride 30 °C Solution is unstirred.	Greenish yellow gas evolved.
3	concentrated aqueous sodium chloride 70 °C Solution is stirred continuously.	No gas collected.

(i) Using relevant information from the *Data Booklet*, identify the gases evolved in experiments **1** and **2** and explain the difference in the observations between experiments **1** and **2**.

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(ii) Write an equation to account for the observation made in experiment **3**.

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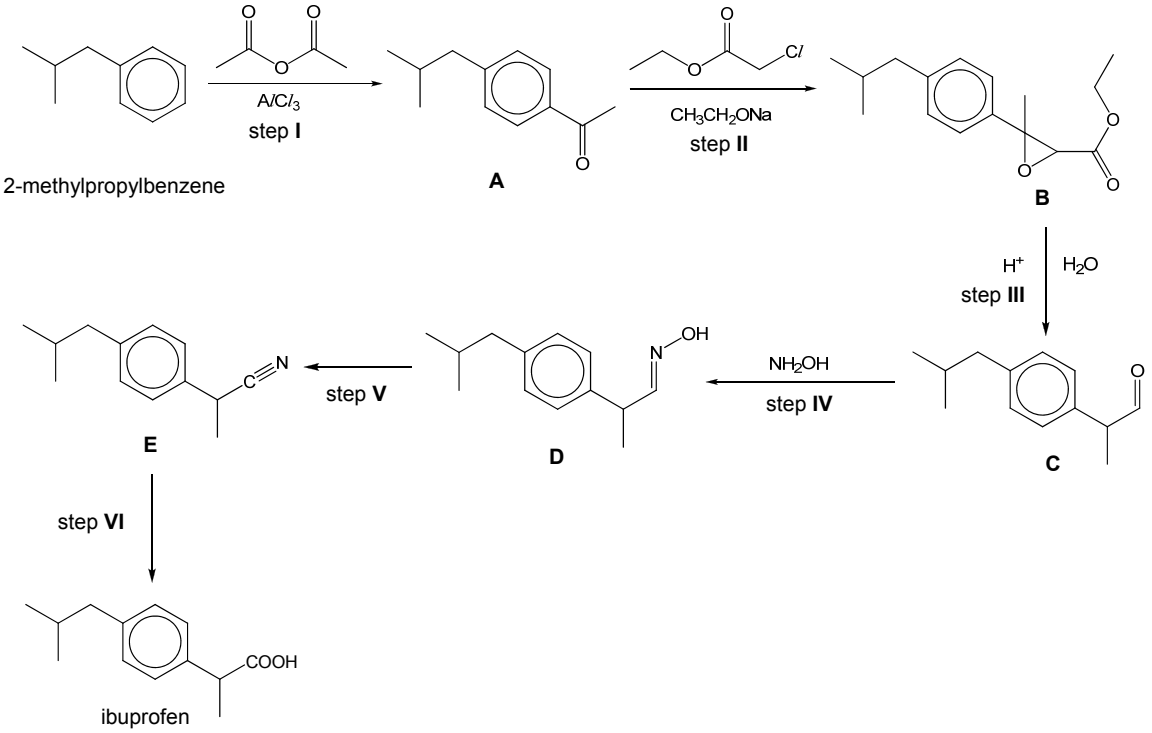
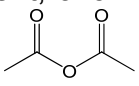
[Total: 15]

5 Ibuprofen is an over-the-counter remedy for mild to moderate pain and is sold under the brand name Nurofen. In the United Kingdom, ibuprofen was originally synthesised and first patented in 1961 by the research team in Boots Company. The starting material for the synthesis of ibuprofen is 2-methylpropylbenzene, which has a similar carbon skeleton to that of ibuprofen. The reaction scheme below shows Boots' synthesis of ibuprofen:



(a) Step **I** proceeds via an electrophilic substitution mechanism where the aluminium chloride acts as a Lewis acid catalyst. The aluminium atom is electron deficient, allowing it to accept a lone pair of electrons from the oxygen on the  molecule. The C–O bond breaks, generating the electrophile and another singly-charged anion as the only products.

(i) Draw the structure of the electrophile.

(ii) From the information given and your answer in **(i)**, suggest a balanced equation to illustrate the step involving the generation of the electrophile.

(iii) Describe the mechanism for the formation of intermediate **A** from 2-methylpropylbenzene, including curly arrows showing the movement of electrons, and all charges.

[4]

(b) The three-membered ring in intermediate **B** is known as an epoxide functional group.

State the hybridisation of the carbon atom in the epoxide ring and suggest why epoxides are highly reactive.

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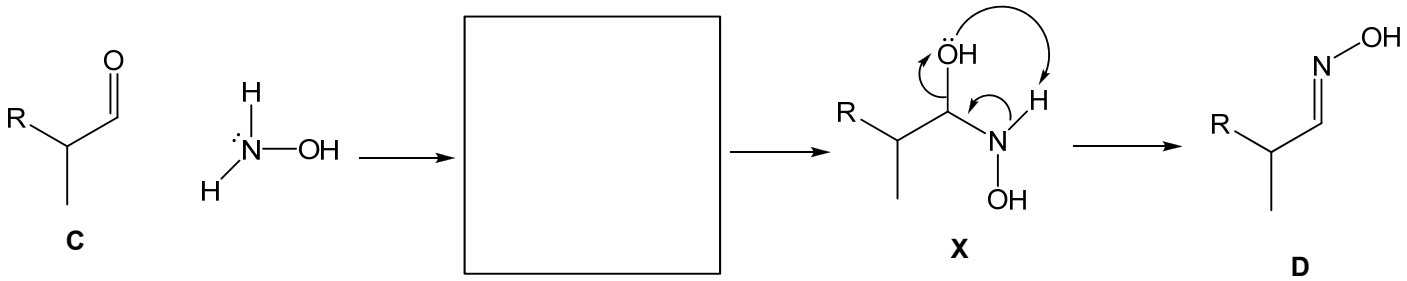
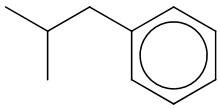
(c) The conversion of intermediate **C** to **D** in step **IV** involves the following sub-steps:

1. nucleophilic addition of NH_2OH to the carbonyl group in **C** to form a zwitterion

2. intramolecular transfer of proton, forming an O–H bond and breaking an N–H bond in the zwitterion to give intermediate **X**

Draw the zwitterion formed from the nucleophilic addition step in the box. Complete the reaction scheme below for sub-steps 1 and 2, using curly arrows to show movement of electrons and label all charges.



where R = 

[3]

(d) A dose of Nurofen contains more than just ibuprofen, the active ingredient. The science of blending other ingredients into the dose is known as formulation and Nurofen is available in a number of formulations. They include tablets to be taken orally or gels to be applied onto the skin. The oral variant is often formulated as the free acid or a lysine salt while the gel variant is often formulated with propan-2-ol.

(i) The ibuprofen in the lysine salt variant is found to be absorbed by the body nearly twice as quickly as the free acid variant.

Suggest why this is so.

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(ii) The gel variant is rubbed into painful parts of the body so that the active ingredient is applied directly to the site of pain. The inner layer of the skin consist mainly of polar molecules.

With reference to the polarities of ibuprofen and propan-2-ol, explain why ibuprofen is formulated with propan-2-ol instead of being applied directly on the skin as the free acid.

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……... **[3]**

(e) Describe a simple chemical test that can be used to distinguish between 2-methylpropylbenzene and ibuprofen.

State the observation for each compound.

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[Total: 14]

- End of Paper -