RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATION

CANDIDATE NAME								
CLASS	6							
CENTRE NUMBER	S					INDEX NUMBER				

H2 CHEMISTRY 9647/02

Paper 2 Structured Questions **11 September 2012**

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	6	7	8	Total
Marks	12	7	7	6	10	9	13	8	72
Paper 1		40		Paper 3		80		Total	192

This document consists of **17** printed pages and **1** blank page.

1 Planning (P)

Calcium salts are used in many industrial processes. Calcium oxide is used in the production of cement while calcium nitrate is sometimes used to accelerate the setting of concrete.

Calcium oxide is a white hygroscopic solid. Calcium oxide can react with water and as such can cause severe irritation when in contact with skin, eyes or if inhaled.

Calcium nitrate is also a white hygroscopic solid. Calcium nitrate decomposes on heating to form the oxide, nitrogen dioxide and oxygen.

(a) Write a balanced equation, including state symbols, for the thermal decomposition of calcium nitrate.

……..... [1]

(b) Calculate the change in mass of the solid you would expect if 1.00 mol of calcium nitrate underwent thermal decomposition.

[1]

(c) A container of calcium nitrate was contaminated with calcium oxide. Design an experiment to determine the percentage purity of calcium nitrate by a gravimetric method. You are provided with about 2 g of the impure calcium nitrate.

(In gravimetric methods, the objective is to form a thermally stable solid so that the mass can be determined accurately for analysis.)

Your plan should include the following:

- A full description of the procedure.
- Details of how you would calculate the percentage purity from the measurements made.

[M_r of $Ca(NO_3)_2$ = 164]

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…… [8]

(d) State and explain clearly one precaution you would take to improve the accuracy of your results.

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…… [1]

(e) Identify one potential safety hazard in this experiment and state how you would minimise the risk.

……

…… [1]

[Total: 12]

2 Titanium(IV) oxide, TiO_2, is the naturally occurring oxide of titanium. It is the main ingredient in sunscreen lotion due to its high refractive index and strong UV-light absorbing capability.

(a) Using the following information as well as relevant data from the *Data Booklet*, draw a Born-Haber cycle for the formation of $TiO_2(s)$ and calculate the lattice energy of $TiO_2(s)$.

Standard enthalpy change of formation of $TiO_2(s)$	−945 kJ mol^{-1}
Standard enthalpy change of atomisation of Ti	+471 kJ mol^{-1}
1st electron affinity of oxygen	−142 kJ mol^{-1}
2nd electron affinity of oxygen	+844 kJ mol^{-1}

[3]

(b) Crude titanium(IV) oxide is purified via the Chloride process. In this two-step process, the crude ore (containing at least 70% titanium(IV) oxide) is first reacted with carbon and chlorine, represented by the equation shown below.

$$TiO_2(s) + C(s) + 2Cl_2(g) \rightarrow TiCl_4(l) + CO_2(g)$$

Standard enthalpy change of formation of $TiCl_4(l)$	−804 kJ mol^{-1}
Standard enthalpy change of formation of $CO_2(g)$	−394 kJ mol^{-1}
Standard molar entropy of $TiO_2(s)$	+49.9 J mol^{-1} K^{-1}
Standard molar entropy of C(s)	+5.7 J mol^{-1} K^{-1}
Standard molar entropy of $Cl_2(g)$	+223 J mol^{-1} K^{-1}
Standard molar entropy of $TiCl_4(l)$	+252 J mol^{-1} K^{-1}
Standard molar entropy of $CO_2(g)$	+214 J mol^{-1} K^{-1}

Using the above information, as well as relevant data from **(a)** and the *Data Booklet*, calculate, for the first step of the Chloride process,

(i) the standard enthalpy change of reaction,

(ii) the standard entropy change of reaction.

Note: $\Delta S^{\ominus} = \Sigma S^{\ominus}$(products) – $\Sigma S^{\ominus}$(reactants)

[2]

(c) Using your answers in **(b)**, determine if the first step of the Chloride process is spontaneous at 2000 K.

[1]

(d) The second step of the Chloride process involves the titanium(IV) chloride being distilled off and oxidised in a pure oxygen flame to give pure titanium(IV) oxide and chlorine gas.

Write an equation for the reaction in the second step.

……..... [1]

[Total: 7]

3 Neidong Forest Recreation National Park, located in the Wulai District in Taipei, has the highest concentration of anions in Taiwan due to the numerous waterfalls and lush forestation in the park. Anions are said to help boost the immune system, among other health benefits.

(a) Bromide ions are thought to be one of the anions present in abundance. The concentration of bromide ions in the river waters can be used as an estimate of the concentration of the ions in the park.

A 25.0 cm^3 sample of river water was collected and 50.0 cm^3 of 1.00 mol dm^{-3} $Pb(NO_3)_2$ was added. The precipitate formed was filtered off and 3.00 g of precipitate was collected. The filtrate can be regarded as a saturated solution of $PbBr_2$.

(i) Calculate the concentration of Pb^{2+} ions in the filtrate.

(ii) Write an expression for the solubility product, K_{sp}, of $PbBr_2$.

……

(iii) The numerical value for the K_{sp} of $PbBr_2$ is 3.9×10^{-5}. Determine the concentration of bromide ions in the sample of river water.

[5]

(b) Another anion, **W**, found in Neidong National Park can be formed when the oxide of a Period 3 element reacts with an alkali. When dilute nitric acid is added to a solution containing **W**, a colourless and pungent gas that turns acidified potassium dichromate(VI) from orange to green is evolved.

(i) Suggest an identity for anion **W**.

……

(ii) Write an equation for the formation of **W** from the reaction of a Period 3 oxide with an alkali.

…… [2]

[Total: 7]

4 The lead–acid accumulator is a storage battery used in cars because it can be recharged. It consists of a series of cells containing lead plate anodes, lead dioxide plate cathodes and an electrolyte of 6 mol dm^{-3} sulfuric acid.

When it is operating, the reactions that occur at the electrodes are

$Pb^{2+}(aq) + 2e^- = Pb(s)$ $\quad E^\ominus = -0.13$ V

$PbO_2(s) + 4H^+(aq) + 2e^- = Pb^{2+}(aq) + 2H_2O(l)$ $\quad E^\ominus = +1.47$ V

(a) Write the overall equation for the reaction during discharge and calculate the voltage delivered by the battery.

Equation: ……

[2]

(b) However, it is noted that the actual voltage is 2.0 V as compared to the value that you have calculated in **(a)**. Explain why the actual voltage differs from the calculated voltage.

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…… [2]

(c) Explain why the battery is rechargeable.

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…… [1]

(d) State **one** disadvantage of the lead-acid accumulator battery.

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…… [1]

[Total: 6]

5 This question is about the chemistry of halogens and halide ions.

(a) Aqueous bromine is decolourised when added to aqueous sodium thiosulfate. When excess of aqueous barium nitrate is added to the resulting solution, a white precipitate is observed. This precipitate is filtered off, leaving a colourless filtrate.

(i) Write a balanced ionic equation for the reaction between bromine and sodium thiosulfate.

……

(ii) To the colourless filtrate in **(i)**, aqueous silver nitrate is added, followed by concentrated ammonia solution.

Describe what is observed and write balanced equations for any reaction that occur.

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…… [4]

(b) In a separate experiment, aqueous bromine is added to aqueous potassium iodide. To the resulting mixture, an equal volume of an organic solvent is added.

What will be the colour of the organic layer? Write equations for any reactions that occur.

……

…… [2]

(c) Iodide ions react with peroxodisulfate ions in the presence of Fe^{3+} catalyst. The overall equation for the reaction is shown below.

$$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

(i) Fe^{3+} ions are added to lower the high activation energy so that the reaction can proceed at a higher rate. Explain why the activation energy is high for the reaction between the iodide and peroxodisulfate ions if no Fe^{3+} ions are added.

……

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……

(ii) With reference to the *Data Booklet*, suggest a mechanism for this reaction in the presence of Fe^{3+}.

[4]

[Total: 10]

6 Chromium is a hard grey metal which is widely used in the manufacture of stainless steel due to its good corrosion-resistant properties.

Calcium is a fairly soft, silvery grey metal which tarnishes quickly in air.

(a) The melting point of calcium is 843 °C while chromium melts at a much higher temperature of 1907 °C.

Explain this difference in terms of the type and strength of bonding in each metal.

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…… [3]

(b) Write the electronic configuration of chromium atoms and chromium(III) ions.

Cr ……

Cr^{3+}…… [2]

(c) When aqueous sodium hydroxide was added to aqueous chromium(III) nitrate, a blue-green precipitate was observed. Upon addition of excess aqueous sodium hydroxide, the precipitate dissolved to give a dark green complex.

When aqueous sodium carbonate was added to aqueous chromium(III) nitrate, effervescence was observed.

(i) State the formula of the blue-green precipitate.

……

(ii) Suggest a reason why effervescence was observed when aqueous sodium carbonate was added to aqueous chromium(III) nitrate.

……

……

(iii) Given that the formula of the soluble dark green complex is $Na_3CrO_6H_6$, state the formula of the complex ion formed.

……

(iv) Draw the structure of the complex ion.

[4]

[Total: 9]

7 Hydrocarbons are commonly used as combustible fuel sources as well as feed materials in the petrochemical industry.

(a) Describe a simple chemical test to distinguish between but-1-ene and but-2-ene. State clearly what would be observed with each compound.

……

……

……

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…… [2]

(b) But-2-ene is able to exist as 2 isomers.

(i) State the type of isomerism exhibited by but-2-ene.

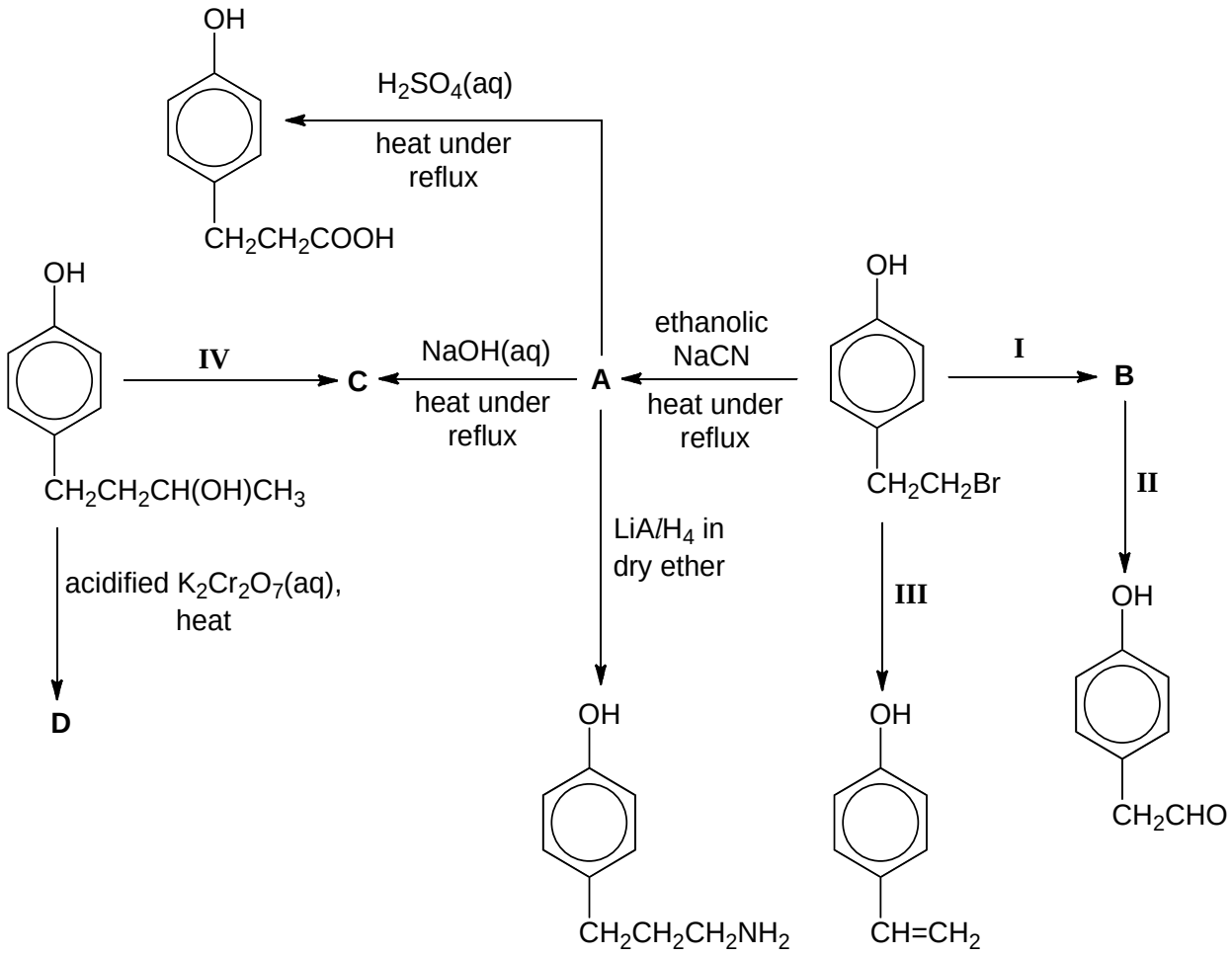
……

(ii) Draw the displayed structural formulae for the 2 isomers of but-2-ene.

[3]

(c) Benzene is an aromatic hydrocarbon present in many compounds.

A reaction scheme involving benzene derivatives is given below. Draw the structures of **A** to **D** and give the reagents and conditions for steps **I** to **IV**.



A:	**B:**
C:	**D:**

Step **I**: ……....

Step **II**: ……

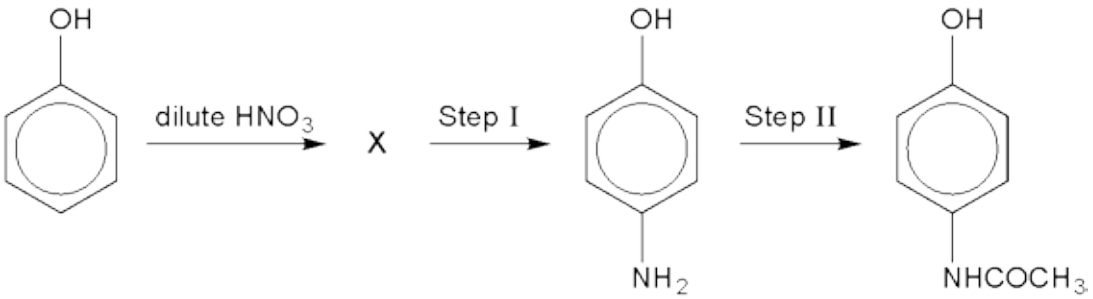
Step **III**: ……

Step **IV**: ……

[8]

[Total: 13]

8 Students often complain of headaches when faced with a tough problem they cannot solve. A very common over-the-counter drug to combat headaches is paracetamol. The synthesis of paracetamol is shown below:



Paracetamol

(a) Draw the structure of compound **X**.

[1]

(b) Step **I** is actually a two-stage process. State the reagents and conditions for the two stages.

Stage 1: ……

Stage 2: …… [2]

(c) Step **II** involves a condensation reaction. An organic side-product, **Y**, can be formed along with paracetamol.

(i) State the reagent for this step.

……

(ii) Suggest a structure for **Y**.

[2]

(d) Suggest the structures of all the organic products formed when paracetamol reacts with

(i) NaOH(aq) at room temperature

(ii) NaOH(aq) with heating

[3]

[Total: 8]