Name:		Class:	

ST ANDREW'S JUNIOR COLLEGE

JC2 Preliminary Examinations

Chemistry
Higher 2

Paper 2

9647/02
19 September 2011
2 hours

Candidates answer in the spaces provided on the question paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in dark blue or black pen.

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.

You are reminded of the need for good English and clear presentation in your answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use:

Question	Marks
1	
2	
3	
4	
5	
Total	

1. Planning (P)

FA 1 is a solution of sulphuric acid, H_2SO_4, of concentration approximately 1 mol dm^{-3}.

FA 2 is a solution of 1.50 mol dm^{-3} sodium hydroxide, NaOH

When sulphuric acid neutralises sodium hydroxide, water is produced.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

The neutralisation process is exothermic, that is, gives out heat, and the amount of heat produced changes with the amount of water produced. From the temperature rise in various experiments, the actual concentration of H_2SO_4 in **FA 1** can be determined.

(a) Calculate the approximate temperature rise, Δ**T**, when 10 cm^3 of **FA 1** and 40 cm^3 of **FA 2** were mixed. In your calculations, you are to assume

specific heat capacity of the mixture = 4.18 J cm^{-3} K^{-1}

standard enthalpy change of neutralisation (per mole of water) = – 57.4 kJ mol^{-1}

Δ**T**: .....

[3]

(b) Fill in the table below, the approximate temperature rise when various volumes of **FA 1** and **FA 2** were mixed. In each case, the total volume of mixture is 50 cm^3.

Volume of **FA 1** / cm^3	10	20	30	40
Volume of **FA 2** / cm^3	40	30	20	10
Temperature rise, Δ**T** / ^oC				

[2]

1. (c) With the help of **(b)**, describe the steps you would carry out to determine the exact concentration of H_2SO_4 in **FA 1**.

[3]

(d) Identify one source of error in your procedure and explain how you would minimise the error.

……..

……..

……..

[2]

(e) From the graph of temperature rise against volume of **FA 1**, show how you would treat the data in order to determine the actual concentration of H_2SO_4 in **FA 1**.

[2]

[Total: 12]

2. The preparation of iodo-compounds can be prepared from alcohols and phosphorus tri-iodide, PI_3. However, PI_3 are not readily available. Hence, it is generated *in situ* from red phosphorus and iodine. The following equations and steps show how iodoethane can be prepared.

$$2P + 3I_2 \longrightarrow 2PI_3 \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

$$3CH_3CH_2OH + PI_3 \longrightarrow 3CH_3CH_2I + H_3PO_3$$

(a) 2.5 g of red phosphorus was placed in a 250 cm^3 round-bottomed flask, followed by 25 cm^3 of ethanol. 25 g of powdered iodine was added to the contents of the flask in small quantities of about 3 - 4 g at a time, allowing about two minutes between consecutive additions. When all the iodine has been added, the product was allowed to stand for 10 minutes.

(i) Explain why powdered iodine was used instead of large crystals

……

……

(ii) Suggest why iodine was added in small quantities.

……

(iii) Give a possible reason why it is necessary for the mixture to stand for 10 minutes.

……

[4]

(b) After standing for 10 minutes, the flask was then heated in a water bath for 1 hour. After heating, the flask was fitted with a reflux condenser and distillation was carried out. The distillate obtained consisted of iodoethane, ethanol, phosphorus acid and a small amount of ether, $CH_3CH_2OCH_2CH_3$.

(i) With the aid of an equation, explain the formation of the ether in the distillate.

……

……

2 (b) (ii) When the distillate was allowed to stand, a small amount of iodine was formed. Using data from the *Data Booklet*, explain the formation of iodine in the distillate.

……

……

……

[5]

(c) The distillate was then transferred to a separating funnel. An equal volume of sodium carbonate solution was added and the mixture was well shaken. The lower layer of iodoethane was collected and the upper aqueous layer was discarded.

The iodoethane was transferred back to the separating funnel. An equal volume of water was added and the solution was mixed well. The lower iodoethane layer was collected into a small conical flask. A few granules of anhydrous calcium chloride were added and the conical flask was swirled until the liquid is clear.

Iodoethane was filtered into a 50 cm^3 round-bottomed flask, and was distilled. The distillate was collected between 68°C – 73°C. This process was repeated until the temperature was fixed to 71°C.

(i) State the purpose of adding sodium carbonate solution in the separating funnel.

……

(ii) State the purpose of adding water in the separating funnel.

……

(iii) Suggest another compound that can be used in place of anhydrous calcium chloride.

……

(iv) Explain why distillation was repeated until the temperature was fixed at 71°C.

……

[4]

2. (d) In a separate experiment, water was added using a thistle funnel to a conical flask containing excess PI_3. The mixture was heated and violet fumes were seen. A similar experiment was done for PCl_3 and white fumes were seen instead.

(i) Using VSEPR theory, explain why the bond angle of PCl_3 is smaller than PI_3.

……

……

(ii) Given that PI_3 reacts similarly as PCl_3 with water, write the equation for the reaction between PI_3 and water.

……

(iii) PI_3 and PCl_3 produce different colour fumes for their separate reactions with water when heated. Explain.

……

……

……

……

[7]

[Total: 20]

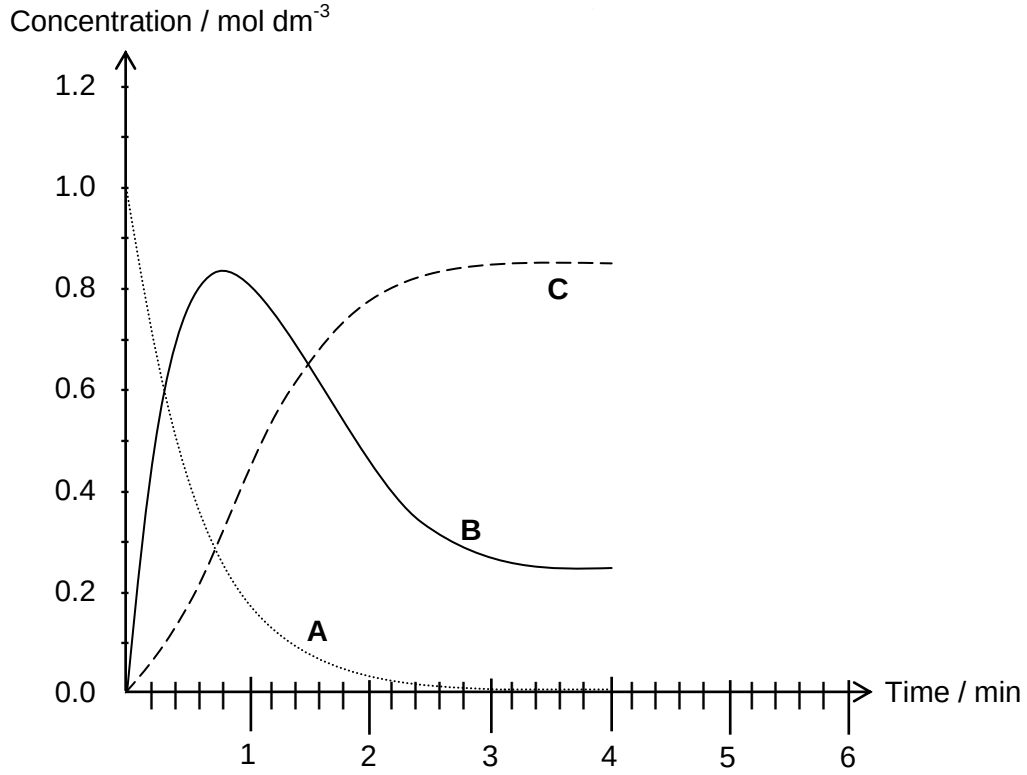
3. In a reaction where compound **A** is converted to compound **C**, the following mechanism was proposed.

Step 1: **A** (g) $\longrightarrow$ **B** (g)

Step 2: **B** (g) $\rightleftharpoons$ **C** (g)

Overall: **A** (g) $\longrightarrow$ **C** (g) $\quad \Delta H < 0$

To investigate the rate of the reaction, various concentrations were monitored over time and the following graph was obtained.



(a) (i) Using the graph of formation of **B** and **C** above, comment on the relative rate of the 2 steps proposed in the reaction mechanism.

……

……

(ii) Hence, determine which step is the rate determining step of the reaction.

……

3. (a) (iii) Using the graph above, show that the reaction is first order with respect to compound **A**.

……

……...

(iv) Draw an energy profile diagram of the reaction.

[8]

(b) At t = 4 min, **B** and **C** are at equilibrium. Show on the graph on **page 7** with proper labelling, the change in the composition of **B** and **C** when argon gas is added at the 4^{th} minute followed by increasing the concentration of **C** by 0.20 mol dm^{-3} at the 5^{th} minute.

[2]

[Total: 10]

4. The Nickel-Iron battery is a common type of rechargeable battery. It uses nickel (III) oxide-hydroxide (NiOOH) and iron as electrodes with potassium hydroxide as the electrolyte. During discharge, aqueous nickel (II) hydroxide and iron (II) hydroxide are produced with an overall e.m.f of 1.2 V.

(a) **(i)** Deduce the half equation at each electrode.

Nickel(III) oxide-hydroxide:……

Iron: ……..

(ii) Hence, deduce the flow of electrons in the battery during discharge.

……

When the iron half-cell of this battery is connected to the Standard Hydrogen Electrode, a reading of +0.55 V was obtained from the voltmeter.

(iii) Determine the standard electrode potential of the nickel(III) oxide-hydroxide half-cell of the battery.

……**V**

State and explain what happens to the overall e.m.f when the following changes are done:

(iv) a small amount of acid was added to the nickel(III) oxide-hydroxide half-cell.

……..

……...

(v) the volume of the aqueous potassium hydroxide used in the iron half-cell was increased.

……..

……...

[8]

4. (b) The Nickel-Iron battery needs to be charged once 95% by mass of both solid electrodes are used up.

(i) Write the equation for the charging of the Nickel-Iron battery.

……

(ii) The phrase "Can be charged in 2 hours!" is written on the packaging of these batteries. If the original mass of the iron electrode is 3.0 g, what is the minimum current that needs to be applied for the phrase on the packaging to be fulfilled?

……**A**

(iii) Hence, determine the original mass of nickel(III) oxide-hydroxide in the battery.

……**g**

(iv) All Nickel-Iron batteries are made in such a way to accommodate 'gassing', a process where gas is produced when the battery is being charged.

Using relevant data from the *Data Booklet*, explain why there is 'gassing' at the nickel(III) oxide-hydroxide electrode.

……

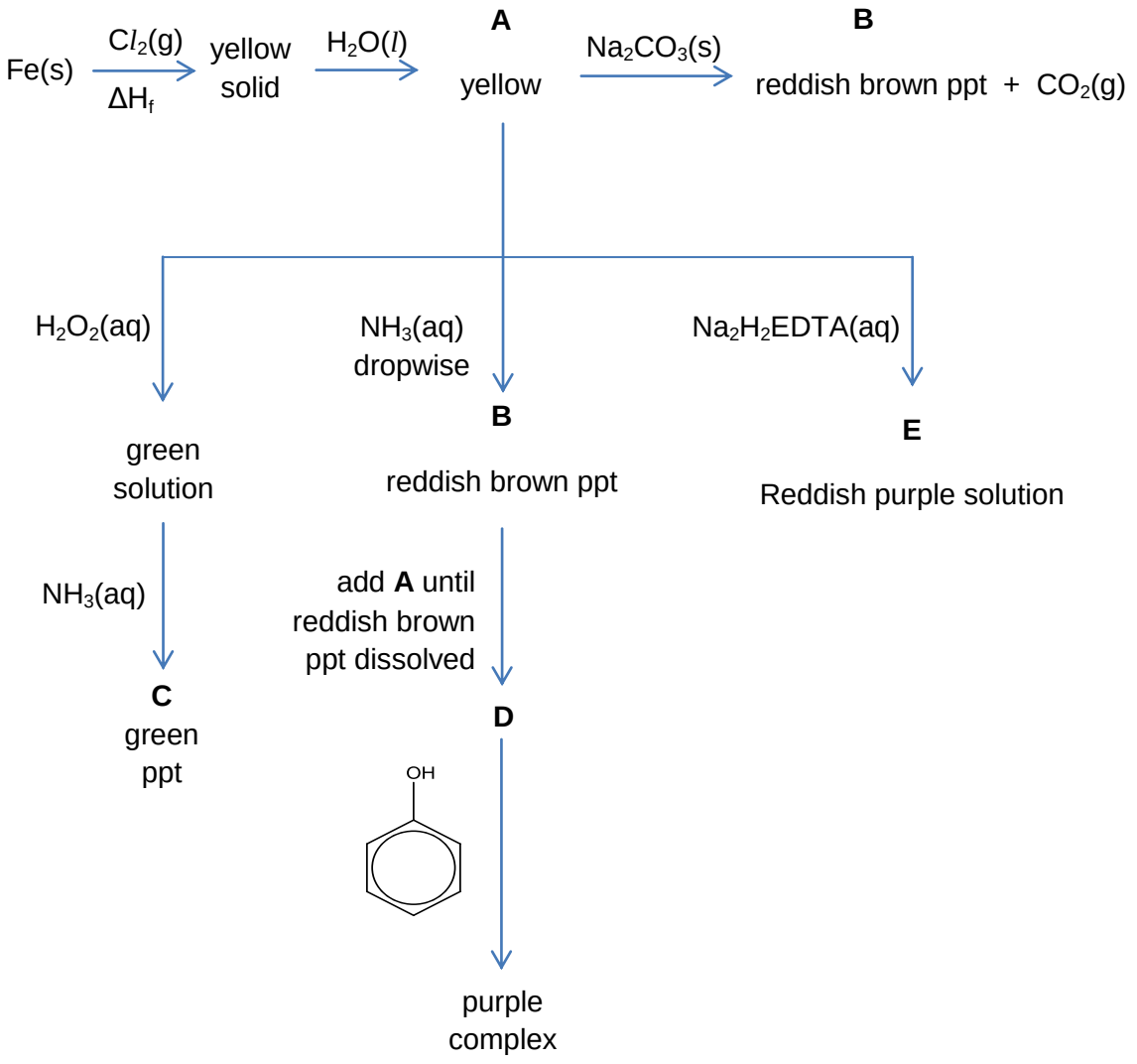
……

……

[7]

[Total: 15]

5. Iron is the fourth most common element in the Earth's crust. Its abundance has led to its common use in many industrial processes, whether as a raw material or catalyst. The following reaction scheme shows the chemistry of iron and some iron-containing species in aqueous solution.



(a) **(i)** Give the equation between iron and chlorine in the formation of the yellow solid.

……

(ii) State the electronic configuration of iron in the yellow solution **A**.

……

5. (a) (iii) With the aid of 2 suitable equations, show that CO_2 is produced when Na_2CO_3 is added to the yellow solution **A**.

……..

……..

(iv) Identify the following iron-containing species.

A : ……

B : ……

C : ……

D : ……

(v) Identify the type of reaction when Na_2H_2EDTA (aq) is added to the yellow solution **A**. Hence, state the formula of **E**, the reddish purple solution.

……

……

[10]

(b) The yellow solid obtained from the reaction between iron and chlorine is often used as a catalyst in the reaction between chlorine and benzene to generate the electrophile, Cl^+.

However, for the same reaction to take place with iodine, the yellow solid cannot be used. Instead, salts of copper(II) ions are used. In the process, copper(I) ions are formed as well.

(i) Write a balanced equation between iodine and the copper(II) ions and state the type of reaction taking place.

……

……

5. (b) (ii) Hence, state and outline the type of mechanism between iodine and benzene

[5]

[Total: 15]

-THE END-