CHEMISTRY   **9746/02**

Paper 2 Structured   **23 September 2009**

                                       1 hour 30 minutes

Candidates answer on the Question Paper

Additional Materials: Answer Paper
                             Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class 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.
A Data Booklet is provided.

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	
1	9
2	16
3	8
4	10
5	13
6	4
Total	60

This document consists of **15** printed pages and 1 blank page.

[Turn over

Answer **all** questions.

1 **(a)** *The use of the Data Booklet is relevant to this question.*

Nitrogen dioxide disproportionates in acidic solution to nitrous acid and nitrate ions.

(i) Write a balanced equation for the disproportionation reaction. [1]

(ii) Use the data below and any other relevant data in the Data Booklet to determine if this disproportionation reaction would actually occur under standard conditions

$NO_2 + H^+ + e \quad \square \quad HNO_2$ $\qquad E^\theta = +1.10$ V [2]
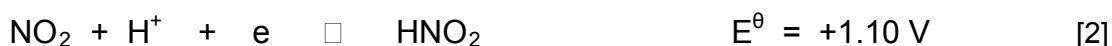
(b) A 0.360 g sample of gaseous aluminium chloride takes up a volume of 52 cm^3 at a temperature of 200°C and a pressure of 1.02 x 10^5 Pa.

(i) Under what conditions of temperature and pressure would you expect the behaviour of gaseous aluminium chloride to be most like that of an ideal gas? [1]

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(ii) Calculate the Mr of the vapour at this temperature. [2]

(c) Compounds of aluminium have many important uses industrially. For example in the Haber process, Al_2O_3 are mixed with iron catalyst to enhance efficiency of the iron catalyst.

Ammonia is manufactured in the Haber process according to the equation:

N_2 (g) + $3H_2$ (g) $\rightleftharpoons$ $2NH_3$ (g) ΔH = -92 kJmol^{-1}
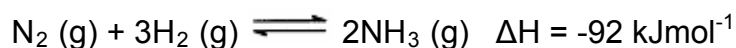
(i) Write an expression for K_p for this reaction [1]

(ii) When a 1:3 mixture of N_2 and H_2 was allowed to reach equilibrium at 200 atm and 500°C, the partial pressure of NH_3 was found to be 40 atm. Use the expression in c) (i) to calculate the value for K_p. [2]

[Total:9]

2 (a) $CH_2=CHCO_2H$ (l) $+$ H_2(g) $\longrightarrow$ $CH_3CH_2CO_2H$ (l) $\Delta H = -380$ kJ mol^{-1}

compound A
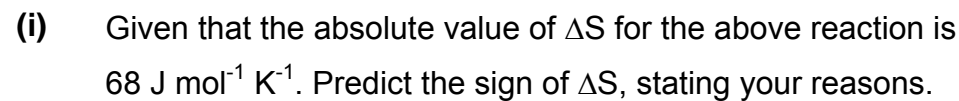
(i) Given that the absolute value of ΔS for the above reaction is
68 J mol^{-1} K^{-1}. Predict the sign of ΔS, stating your reasons. [2]

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(ii) Hence determine the temperature for the reaction to be non-spontaneous. [2]

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(iii) With the aid of an energy cycle, calculate the enthalpy change of combustion of compound A by using the data provided.

Data

ΔH_f (H_2O) = -286 kJ mol^{-1}

ΔH_c (CH_3CH_2COOH) = -1450 kJ mol^{-1} [3]

(b) Copper is an important metal used extensively in pipes and electrical wires. It can be made extremely pure and corrodes very slowly.

(i) Copper corrodes in moist air to first give a thin layer of copper(II) oxide and this process happens much more slowly than the rusting of iron to form the iron(III) oxides. With the use of relevant data from the *Data Booklet*, explain this difference. [2]

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(ii) Another possible oxidation state that copper can have is +1, such as in copper(I) sulphate, Cu_2SO_4. When this sulphate is added to water, blue solution of copper(II) sulphate and pink deposit of copper metal forms. Write a balanced equation for this process and using relevant data from the *Data Booklet*, show that this reaction is feasible. [2]

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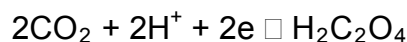..

(iii) A copper metal plate was dipped into an aqueous solution of 1.0 mol dm^{-3} copper(II) sulphate solution and this half-cell was connected via a salt bridge, to the following half-cell,

$$2CO_2 + 2H^+ + 2e \rightleftharpoons H_2C_2O_4$$

The **overall cell e.m.f** was found to be +0.83 V and the size of the copper plate *increased* after some time.

Give the cell notation and hence, calculate the reduction potential, E^θ (CO_2 / $H_2C_2O_4$) [2]

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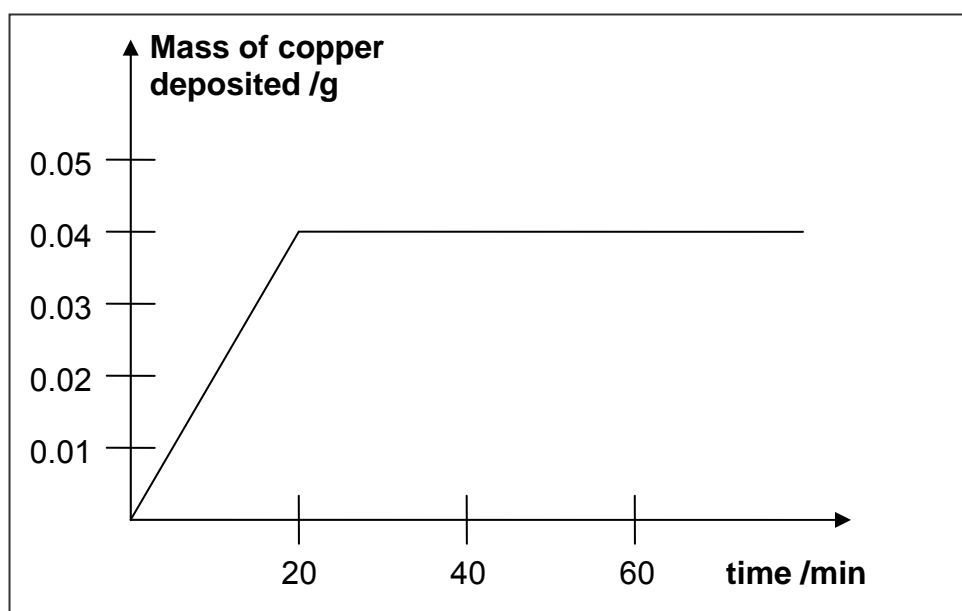..

(c) To obtain a pure metal, electrolysis can be conducted using an aqueous copper(II) sulphate solution and copper electrodes. The results of the experiment are shown below in the graph.

(i) Write balanced half-equations, with state symbols, for the reactions at the anode and the cathode. [1]

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(ii) Calculate the current used during electrolysis. [1]

(iii) It is not always possible to accurately predict the electrode reactions that occur during electrolysis. Suggest a reason for this. [1]

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[Total:16]

3 **(a)** Aluminium(III) oxide and phosphorous(V) chloride differ in their behaviour with water.

**(i)** Write equations (if any) for each of the behaviour. [2]

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(ii) Explain these differences in terms of the different structures and types of chemical bonding in the compounds. [2]

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(iii) State the pH of any solution formed in water. [1]

(b) In each of the following reactions, describe the way in which the oxide of the named element is reacting and discuss whether its behaviour is what you would expect from the position of the element in the Periodic Table:

(i)   Silicon: $MgO + SiO_2 \rightarrow MgSiO_3$
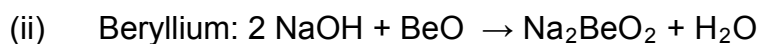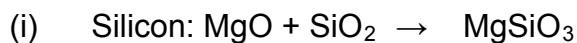
(ii)   Beryllium: $2\,NaOH + BeO \rightarrow Na_2BeO_2 + H_2O$ [3]

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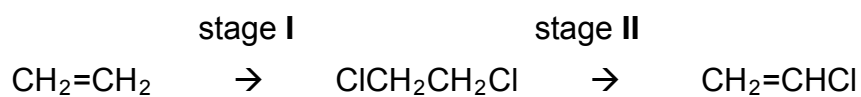
[Total: 8]

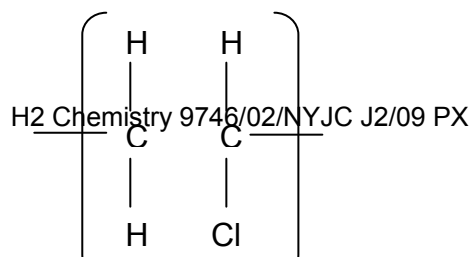**4**   Chloroethene is the monomer from which the polymer PVC (polyvinylchloride) is produced.

stage **I**   stage **II**

$$CH_2=CH_2 \quad \rightarrow \quad ClCH_2CH_2Cl \quad \rightarrow \quad CH_2=CHCl$$

(a) Suggest reagents and conditions for stages **I** and **II**.   [2]

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(b) Describe the mechanism of stage **I**.   [3]

(c) A repeat unit of PVC is shown below

[1]

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Suggest a reason why PVC might break down when exposed to concentrated aqueous sodium hydroxide whereas poly(ethene) does not.

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(d) It was suggested that the intermediate, $ClCH_2CH_2Cl$ used in the production of PVC be formed from ethane instead.

(i) Discuss if this will be a good alternative to the method used in stage I in (a). [1]

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(ii) A student proposed that one of the propagation steps in the mechanism when $ClCH_2CH_2Cl$ is formed from ethane to be:

$$CH_3CH_3 \; + \; Cl\gamma \; \longrightarrow \; CH_3CH_2Cl \; + \; H\gamma \qquad [3]$$
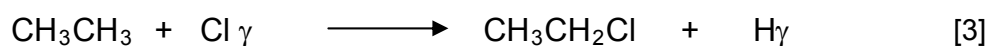
Using relevant bond energy values from the *Data Booklet*, explain why this is incorrect as compared to the actual step.

[Total: 10]

5   Ascorbic acid, also known as vitamin C is required for the synthesis of collagen in humans. A vitamin C deficient diet leads to a disease called scurvy. Ascorbic acid is known to be water soluble and is commonly used as food additives.
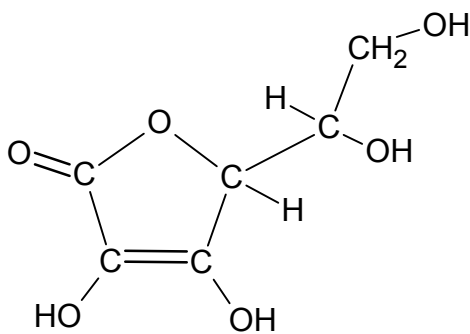
Ascorbic Acid

(a)   State the functional group(s) present in the ascorbic acid compound.   [2]

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(b)   Explain in terms of structure and bonding, why Ascorbic Acid is water soluble.   [2]

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(c)   Write an ionic equation to illustrate the acidity of ascorbic acid in water and explain how the stability of the conjugate base gives rise to its acidity.   [3]

(d)   The ascorbic acid molecule was reacted with acidified potassium dichromate (VI) followed by 2,4-dinitrophenylhydrazine.

Draw the structural formula of the product formed.   [2]

The building block for ascorbic acid is the glucose molecule. The following synthetic pathway was proposed:
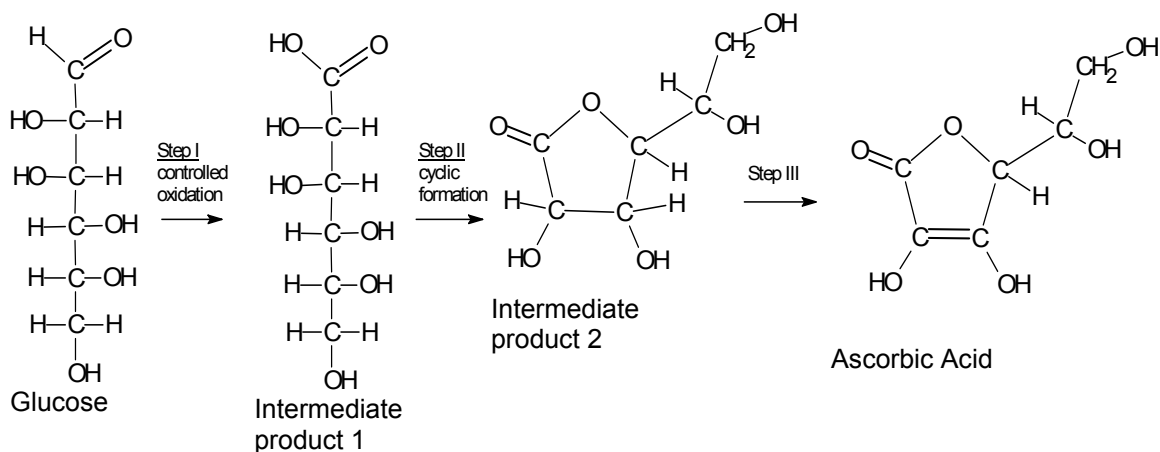
(i) State the type of reaction found in **step II** and hence <u>**circle**</u> the functional group(s) present in the <u>intermediate product 1</u> that is/are involved in the reaction**.** [3]

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(ii) State the type of reaction present in **Step III** [1]

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[Total: 13]

6 Aspirin, also known as acetylsalicylic acid is often used as an analgesic (pain-remover) to relieve minor aches and pains. It is readily absorbed from the intestines since it diffuses rapidly into the tissues.
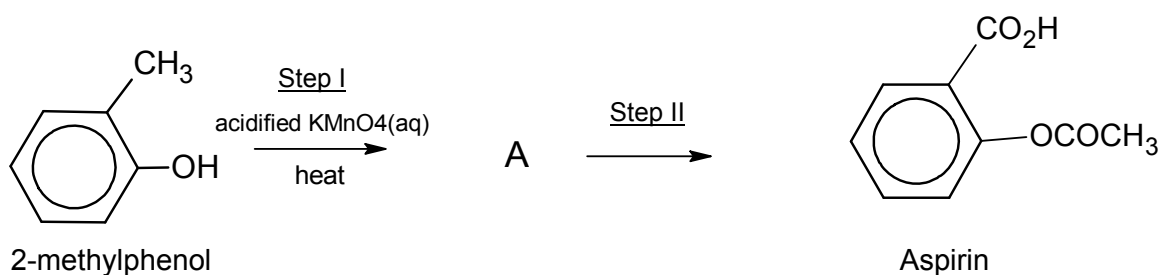
the structure is image
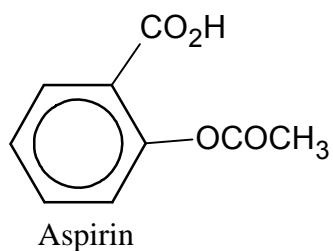
The molecule is hydrolysed by acids in the stomach.

(a) Draw the structural formulae of the hydrolysis products. [2]

Aspirin can be synthesised from 2-methylphenol via the following steps:

2-methylphenol

(b) Draw the structural formula of the intermediate **A** [1]

[Turn Over

(c) For step II, draw the displayed formula of the reagent and give the
necessary conditions that will allow intermediate A to react **<u>completely</u>**. [1]

Reagent	Conditions

[Total: 4]