UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY

Paper 2 Structured Questions AS Core

9701/02

May/June 2006

1 hour 15 minutes

Candidates answer on the Question Paper.
Additional Materials: Data Booklet

Candidate Name

Centre Number

Candidate Number

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number and candidate number on all the work you hand in.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.
You may use a calculator.
The number of marks is given in brackets [ ] at the end of each question or part question.
At the end of the examination, fasten all your work securely together.

DO NOT WRITE IN THE BARCODE.

DO NOT WRITE IN THE GREY AREAS BETWEEN THE PAGES.

For Examiner's Use	
1	
2	
3	
4	
5	
Total	

This document consists of **11** printed pages and **1** blank page.

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Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Mohr's salt is a pale green crystalline solid which is soluble in water. Mohr's salt is a 'double salt' which contains

two cations, one of which is Fe^{2+},

one anion which is SO_4^{2-},

and water of crystallisation.

(a) The identity of the second cation was determined by the following test.
Solid Mohr's salt was heated with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution.

(i) What is the gas?

.....

(ii) What is the formula of the second cation identified by this test?

.....

(iii) In this test, a grey/green solid residue was also formed.

Suggest a name **or** formula for this solid.

.....
[3]

(b) The identity of the anion present in Mohr's salt was confirmed by adding dilute hydrochloric acid followed by aqueous barium chloride to an aqueous solution of Mohr's salt. A white precipitate was formed.

Suggest the identity of the white precipitate.

.....[1]

(c) When a double salt such as Mohr's salt is made, the two individual salts are mixed together in a 1:1 molar ratio, dissolved in water and the solution crystallised.

(i) Give the formula of **each** of the two salts that would be mixed to make the double salt, Mohr's salt.

salt 1 .....

salt 2 .....

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(ii) Calculate the relative formula mass of **each** of the salts present in Mohr's salt.

For Examiner's Use

salt 1

relative formula mass of salt 1 .....

salt 2

relative formula mass of salt 2 .....

(iii) The crystals of the double salt contain water of crystallisation.

The relative formula mass of Mohr's salt is 392. Use your answers to **(ii)** to calculate the number of moles of water of crystallisation present in one mole of Mohr's salt.

[6]

[Total: 10]

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[Turn over

For Examiner's Use

2 The unsaturated hydrocarbon ethyne (acetylene), C_2H_2, is widely used in 'oxy-acetylene torches' for cutting and welding metals. In the torch, ethyne is burned in oxygen to produce a flame with a temperature of 3400 K.

(a) Ethyne is a linear molecule with a triple bond, C≡C, between the two carbon atoms.

Draw a 'dot-and-cross' diagram of an ethyne molecule.

[1]

(b) When used for cutting or welding, ethyne is transported in cylinders which contain the gas under pressure. A typical cylinder has a volume of 76 dm^3 and contains ethyne gas at 1515 kPa pressure at a temperature of 25 °C.

Use the general gas equation, $pV = nRT$, to calculate the amount, in moles, of ethyne in this cylinder.

[2]

(c) In some countries, ethyne is manufactured from calcium carbide, CaC_2, which is produced by heating quicklime and coke together at 2300 K.

$$CaO + 3C \longrightarrow CaC_2 + CO$$

When water is added to the CaC_2, calcium hydroxide, $Ca(OH)_2$, and ethyne, C_2H_2, are produced.

(i) Construct a balanced equation for the formation of ethyne from calcium carbide.

.....

(ii) Use this equation and your answer to part **(b)** to calculate the mass of CaC_2 which will react with an excess of water to produce enough ethyne to fill 100 cylinders of the gas.

[3]

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(d) The equation for the complete combustion of ethyne is given below.
Use appropriate bond energy data from the *Data Booklet* to calculate a value for the enthalpy change of combustion of ethyne.

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$$C_2H_2(g) + 5/2O_2(g) \longrightarrow 2CO_2(g) + H_2O(g)$$

[3]

(e) The value for the standard enthalpy change of combustion of ethyne is $-1300\,kJ\,mol^{-1}$.

(i) Define the term *standard enthalpy change of combustion*.

.....

.....

.....

(ii) Explain why your answer to **(d)** does not have the same value as the standard enthalpy change of combustion.

.....

.....
[3]

[Total: 12]

For Examiner's Use

3 This question is about the elements of Group VII, the halogens.

(a) Complete the following table.

halogen	colour	physical state at room temperature
chlorine		
bromine		
iodine		

[2]

(b) Concentrated sulphuric acid is added to separate solid samples of magnesium chloride, magnesium bromide, and magnesium iodide.

(i) Describe, in **each** case, **one** observation you would be able to make.

$MgCl_2$ .....

.....

$MgBr_2$ .....

.....

MgI_2 .....

.....

(ii) Give an equation for the reaction of concentrated sulphuric acid with magnesium chloride.

.....

[4]

(c) When dilute nitric acid and aqueous silver nitrate are added to a solution of a magnesium halide, MgX_2, a pale cream precipitate is formed.
This precipitate is soluble in concentrated aqueous ammonia but not soluble in dilute aqueous ammonia.

(i) What is the identity of the precipitate?

.....

(ii) Give an equation, with state symbols, for the reaction of the precipitate with concentrated aqueous ammonia.

.....

[3]

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(d) A hot glass rod is plunged into separate gas jars, one containing hydrogen chloride and one containing hydrogen iodide.

(i) For **each** gas, state what you would observe, if anything, and write an equation for any reaction that takes place.

HC*l* .....

.....

HI .....

.....

(ii) Explain your answer to **(i)** in terms of enthalpy changes.

.....

.....

.....

(iii) What is the role of the hot glass rod in any reaction that occurs?

.....

.....

[6]

[Total: 15]

For Examiner's Use

4 Compounds containing the allyl group, $CH_2=CHCH_2-$, have pungent smells and are found in onions and garlic.
Allyl alcohol, $CH_2=CHCH_2OH$, is a colourless liquid which is soluble in water.

(a) Allyl alcohol behaves as an alkene and as a primary alcohol.

Give the structural formula of the organic compound formed when allyl alcohol is

(i) reacted with Br_2,

(ii) heated under reflux with an acidified solution of $Cr_2O_7^{2-}$ ions.

[2]

(b) When allyl alcohol is reacted with MnO_2 at room temperature, propenal, $CH_2=CHCHO$ is formed.

What type of reaction is this?

.....[1]

(c) Allyl alcohol may be converted into propanal, CH_3CH_2CHO, by using a ruthenium(IV) catalyst in water.

$$CH_2=CHCH_2OH \xrightarrow{\text{ruthenium(IV) catalyst}} CH_3CH_2CHO$$

The reactant and the product are isomers.
What form of isomerism do they display?

.....[1]

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(d) Allyl alcohol can be converted into propanal in two steps **without** the use of a ruthenium(IV) catalyst.

$$CH_2{=}CHCH_2OH \xrightarrow{\text{step I}} CH_3CH_2CH_2OH \xrightarrow{\text{step II}} CH_3CH_2CHO$$

What reagents and conditions would be used for **each** step?

step I

reagent(s) .....

condition(s) .....

step II

reagent(s) .....

condition(s) .....[4]

(e) By considering your answers to **(b)** and **(d)**, suggest what is unusual about the single-step reaction in **(c)**.

.....

.....[1]

(f) Suggest the structural formula of the organic compound formed when allyl alcohol is

(i) reacted with cold, dilute MnO_4^- ions,

(ii) heated under reflux with acidified MnO_4^- ions.

[3]

[Total: 12]

For Examiner's Use

5 Many organic reactions are substitution reactions in which the number of carbon atoms in the organic compound is unchanged.

(a) What is meant by the term *substitution reaction*?

.....

.....[1]

(b) One example of a substitution reaction is the formation of an alcohol from a halogenoalkane.

(i) Write a balanced equation for the formation of ethanol from bromoethane.

.....

(ii) State the conditions for this reaction.

.....[2]

(c) In a few organic reactions, the product contains **one** more carbon atom than the starting material.

(i) Write the equation for a reaction in which the organic compound bromoethane, which contains **two** carbon atoms, is converted into an organic compound which contains **three** carbon atoms.

.....

(ii) State the conditions for this reaction.

.....[2]

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(d) Ethanol may be converted into propanoic acid in a three-stage process which uses ethanol as the only organic compound.

$$C_2H_5OH \xrightarrow{\text{step I}} \mathbf{K} \xrightarrow{\text{step II}} \mathbf{L} \xrightarrow{\text{step III}} C_2H_5CO_2H$$

(i) Give the structural formulae of the intermediate compounds **K** and **L**.

K .....

L .....

(ii) State the reagent(s) used and give the essential condition(s) for step I and for step III.

step I

reagent(s) .....

condition(s) .....

step III

reagent(s) .....

condition(s).....

[6]

[Total: 11]

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