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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

0955802702

CHEMISTRY **9701/23**

Paper 2 Structured Questions AS Core **October/November 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

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.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE ON ANY BARCODES.

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.

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.

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1	
2	
3	
4	
5	
Total	

This document consists of **10** printed pages and **2** blank pages.

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

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1 The element magnesium, Mg, proton number 12, is a metal which is used in many alloys which are strong and light.

Magnesium has several naturally occurring isotopes.

(a) What is meant by the term *isotope*?

.....

.....

.....[2]

(b) Complete the table below for two of the isotopes of magnesium.

isotope	number of protons	number of neutrons	number of electrons
^{24}Mg			
^{26}Mg			

[2]

A sample of magnesium had the following isotopic composition:
^{24}Mg, 78.60%; ^{25}Mg, 10.11%; ^{26}Mg, 11.29%.

(c) Calculate the relative atomic mass, A_r, of magnesium in the sample.
Express your answer to an appropriate number of significant figures.

[2]

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Antimony, Sb, proton number 51, is another element which is used in alloys.

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Magnesium and antimony each react when heated separately in chlorine.

(d) Construct a balanced equation for the reaction between magnesium and chlorine.

.....[1]

When a 2.45 g sample of antimony was heated in chlorine under suitable conditions, 4.57 g of a chloride **A** were formed.

(e) (i) Calculate the amount, in moles, of antimony atoms that reacted.

(ii) Calculate the amount, in moles, of chlorine atoms that reacted.

(iii) Use your answers to **(i)** and **(ii)** to determine the empirical formula of **A**.

(iv) The empirical and molecular formulae of **A** are the same.

Construct a balanced equation for the reaction between antimony and chlorine.

.....[5]

(f) The chloride **A** melts at 73.4 °C while magnesium chloride melts at 714 °C.

(i) What type of bonding is present in magnesium chloride?

.....

(ii) Suggest what type of bonding is present in **A**.

.....[2]

[Total: 14]

2 Sulfur and its compounds are found in volcanoes, in organic matter and in minerals.
Sulfuric acid, an important industrial chemical, is manufactured from sulfur by the Contact process.
The Contact process may be considered to be a three-stage process in which sulfur is converted into sulfuric acid. Each stage consists of a single chemical reaction.

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(a) Write a balanced equation for **each** of these reactions **in the correct sequence**.
Where appropriate, use $\rightleftharpoons$ to indicate that the reaction is an equilibrium.

first reaction .....

second reaction .....

third reaction .....[4]

(b) Give **three** different operating conditions that are used in the **second** stage.

condition 1 .....

condition 2 .....

condition 3 .....[3]

(c) State **one** large scale use of sulfuric acid.

..... [1]

(d) Most of the sulfur that is used in the Contact process is recovered from sulfur compounds present in crude oil and natural gas by using the Claus process.

(i) In this process, about one third of the hydrogen sulfide, H_2S, present in the oil or gas, is converted into sulfur dioxide, SO_2.

Balance the equation for this reaction.

$$.....H_2S + ...O_2 \rightarrow .....SO_2 + ...H_2O$$

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(ii) The SO_2 formed is then reacted catalytically with the remaining H_2S, producing sulfur and water.

$$2H_2S + SO_2 \rightarrow 3S + 2H_2O$$

What are the oxidation numbers of each of the sulfur-containing substances in this reaction?

H_2S..... SO_2 ..... S .....

Which substance is reduced? Explain your answer.

substance .....

explanation .....[3]

The sulfur present in crude oil is removed in order to prevent the formation of sulfur dioxide when fuels such as petrol (gasoline) or diesel fuel are burned in internal combustion engines.
Other substances that may be present in the exhaust gases of motor vehicles include CO, CO_2, NO/NO_2, and unburnt hydrocarbons.

The emission of sulfur dioxide can produce 'acid rain'.

(e) (i) Outline, with the aid of equations, how acid rain is formed from the exhaust gases of motor vehicles.

.....

.....

.....

.....

(ii) State **one** environmental effect of acid rain.

.....[4]

(f) Sulfur dioxide is used to preserve dried fruits and vegetables.

What chemical property of SO_2 enables it to be used as a food preservative?

.....[1]

[Total: 16]

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3 Astronomers using modern spectroscopic techniques of various types have found evidence of many molecules, ions and free radicals in the dust clouds in Space. Many of the species concerned have also been produced in laboratories on Earth.

Two such species are the dicarbon monoxide molecule, C_2O, and the amino free radical, NH_2.

(a) (i) Dicarbon monoxide can be produced in a laboratory and analysis of it shows that the sequence of atoms in this molecule is carbon-carbon-oxygen and there are no unpaired electrons, but one of the atoms is only surrounded by six electrons.

Draw a 'dot-and-cross' diagram of C_2O and suggest the shape of the molecule.

shape .....

(ii) What is meant by the term *free radical*?

.....

.....

(iii) Explain why NH_2 is described as a 'free radical'.

.....

.....[5]

Two derivatives of ethene which have been detected in dust clouds in Space are acrylonitrile (2-propenenitrile), CH_2=CHCN, and vinyl alcohol (ethenol), CH_2=CHOH.

(b) Like ethene, acrylonitrile can be polymerised. The resulting polymer can be used to make carbon fibres.

(i) Draw the structural formula of the polymer made from acrylonitrile, showing **two** repeat units.

(ii) What type of polymerisation is this reaction?

.....[2]

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Vinyl alcohol cannot be polymerised in the same way as acrylonitrile because it will readily isomerise into another common organic compound, **Z**.

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(c) (i) Suggest the structural formula of the organic compound **Z**.

(ii) Suggest the structural formula of another isomer of vinyl alcohol which has a cyclic (ring) structure.

[2]

Acrolein (2-propenal), CH_2=CHCHO, has also been found in Space.

(d) Give the structural formulae of the organic compounds formed when acrolein is reacted separately with **each** of the following reagents.

reagent	product
Br_2 in an inert solvent	
NaCN + dilute H_2SO_4	
Tollens' reagent	
$NaBH_4$	

[4]

[Total: 13]

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4 Although few halogenoalkanes exist naturally, such compounds are important as intermediates in organic reactions and as solvents.

The bromoalkane **B** has the following composition by mass: C, 29.3%; H, 5.7%; Br, 65.0%. The relative molecular mass of **B** is 123.

(a) Calculate the molecular formula of **B**.

[3]

Halogenoalkanes such as bromoethane, C_2H_5Br, have two different reactions with sodium hydroxide, NaOH, depending on the conditions used.

(b) (i) When hot aqueous NaOH is used, the C_2H_5Br is hydrolysed to ethanol, C_2H_5OH.

Describe the mechanism of this reaction. In your answer, show any relevant charges, dipoles, lone pairs of electrons and movement of electron pairs by curly arrows.

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(ii) What will be formed when C_2H_5Br is reacted with NaOH under different conditions?

.....

(iii) What are the conditions used?

.....

(iv) What type of reaction is this?

.....[7]

When 1,4-dichlorobutane, $ClCH_2CH_2CH_2CH_2Cl$, is reacted with NaOH, two different reactions can occur, depending on the conditions used.

(c) (i) Draw the **displayed** formula of the product formed when 1,4-dichlorobutane is reacted with hot aqueous NaOH as in **(b)(i)**.

(ii) Draw the **skeletal** formula of the product formed when 1,4-dichlorobutane is reacted with NaOH in the way you have described in **(b)(ii)** and **(b)(iii)**.

[2]

[Total: 12]

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5 A student placed separate small samples of 1-chlorobutane, 1-bromobutane and, 1-iodobutane, in three separate test-tubes. To each test-tube, 1 cm^3 of ethanol was added, followed by 1 cm^3 of aqueous silver nitrate, $AgNO_3$. The tubes were then carefully shaken, placed in a test-tube rack and observed for 30 minutes.

A precipitate was formed in each test-tube but **not** at the same time; the fastest taking about two minutes to become opaque and the slowest about 20 minutes.

(a) What is the identity of the precipitate formed when 1-chlorobutane is used?

.....[1]

(b) What will be the colour of this precipitate?

.....[1]

(c) Which of the three halogenoalkanes will produce a precipitate in about two minutes?

.....[1]

(d) Use appropriate data from the *Data Booklet* to explain why this reaction takes place most quickly of the three.

.....

.....

.....[2]

[Total: 5]

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