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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

6547572065

CHEMISTRY **9701/22**

Paper 2 Structured Questions AS Core **October/November 2009**

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.

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.

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1 The elements carbon and silicon are both in Group IV of the Periodic Table.
Carbon is the second most abundant element by mass in the human body and silicon is the second most common element in the Earth's crust.

Carbon and silicon each form an oxide of general formula XO_2.
At room temperature, CO_2 is a gas while SiO_2 is a solid with a high melting point.

(a) Briefly explain, in terms of the chemical bonds and intermolecular forces present in **each** compound, why CO_2 is a gas and SiO_2 is a solid at room temperature.

.....

.....

.....

..... [3]

(b) Draw a simple diagram to show the structure of SiO_2. Your diagram should contain at least **two** silicon atoms **and** show clearly how many bonds each atom forms.

[2]

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CO_2 does not behave as an ideal gas.

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(c) (i) State the basic assumptions of the kinetic theory as applied to an ideal gas.

.....

.....

.....

.....

.....

.....

(ii) Suggest **one** reason why CO_2 does not behave as an ideal gas.

.....

[5]

Carbon exists in a number of forms, one of which is a conductor of electricity and one of which is a non-conductor of electricity. Silicon is the main component of most semi-conductors.

(d) Graphite is the form of carbon that is a conductor of electricity. Give a simple explanation for this property.

.....

..... [1]

When carbon and silicon(IV) oxide are heated together at about 2000 °C, silicon carbide, SiC, is formed. Silicon carbide is a hard material which is widely used as an abrasive and in ceramics.

(e) (i) Construct an equation for the reaction of carbon and silicon(IV) oxide.

.....

(ii) SiC has a similar structure to one of the common forms of carbon.
Which form is this? Give a reason for your answer.

form .....

reason .....

[2]

[Total: 13]

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2 The elements of the third period of the Periodic Table form chlorides of general formula ECl_x where *E* represents the element. These chlorides show a variation in oxidation number from sodium to sulfur.

(a) (i) Use the information given to complete the table below.

formula of chloride	NaCl	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_3	SCl_2
oxidation number of element in the chloride						

(ii) By considering the electron configurations of the elements, explain the variation in oxidation number in the chlorides from Na to Al and from Si to S.

Na to Al .....

.....

Si to S .....

.....

[5]

Sodium hydride, NaH, is a colourless crystalline solid which melts at 800 °C and has the same crystal structure as sodium chloride which has a melting point of 808 °C. When molten sodium chloride is electrolysed using graphite electrodes, a shiny deposit, **D**, forms on the cathode and a greenish-yellow gas is evolved from the anode. When molten sodium hydride is electrolysed, under suitable conditions using graphite electrodes, the same shiny deposit **D** is formed on the cathode and a colourless gas, **G**, is evolved from the anode.

(b) (i) Describe with the aid of a diagram the bonding in a sodium chloride crystal.

(ii) Suggest the type of bonding that is present in sodium hydride.

.....

(iii) What is the oxidation number of hydrogen in sodium hydride?

.....

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(iv) Draw a 'dot-and-cross' diagram for sodium hydride. Show outer electrons only.

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(v) The metals magnesium and aluminium form hydrides with formulae MgH_2 and AlH_3. The non-metals phosphorus and sulfur form hydrides with formulae PH_3 and H_2S.
By considering their positions in the Periodic Table, suggest oxidation numbers for these four elements in their hydrides.

compound	MgH_2	AlH_3	PH_3	H_2S
oxidation number of element in the hydride				

[8]

At room temperature, the chlorides of sodium, magnesium and aluminium are all solids which dissolve in water.
The hydrides of sodium, magnesium and aluminium are also solids which react with water with the rapid evolution of the **same** colourless gas **G** in each case.

(c) (i) What is the pH of the solutions formed when separate samples of sodium chloride, magnesium chloride, and aluminium chloride are dissolved in water?

chloride	sodium	magnesium	aluminium
pH			

(ii) Suggest an equation for the reaction between sodium hydride and water.

.....

(iii) Suggest a value for the pH of the solution formed in **(ii)**.

.....

[4]

At room temperature, the chlorides of silicon, phosphorus and sulfur are all low melting point solids or low boiling point liquids that can be seen to react with water.

(d) (i) Suggest what type of bonding is present in sulfur dichloride, SCl_2.

.....

(ii) Write a balanced equation for the reaction between the chloride of silicon, $SiCl_4$, and water.

..... [2]

[Total: 19]

3 One method of making 1-bromobutane in the laboratory is described below.

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Stage 1	Place 35 g of powdered sodium bromide, 30 cm^3 of water, and 25 cm^3 (20 g) of butan-1-ol, in a 250 cm^3 two necked flask fitted with a tap funnel and reflux condenser.
Stage 2	Concentrated sulfuric acid (25 cm^3) is then placed in the tap funnel and added drop by drop to the reagents in the flask, keeping the contents well shaken and cooled occasionally in an ice-water bath.

(a) The overall reaction may be considered to take place in two stages. In the first stage the inorganic reagents react together to form HBr. In the second stage, the organic reagent reacts with the HBr that is formed in the first stage.

Write an equation for **each** of these stages.

stage I .....

stage II ..... [2]

(b) In this preparation, by using the amounts given above, **one** of the reagents, sodium bromide or butan-1-ol, will be present in an excess.

Use your equations in **(a)** and the data above to determine, by calculation, which reagent is in an excess.

[2]

(c) In a laboratory preparation of 1-bromobutane, when 15.4 g of butan-1-ol was used, 22.5 g of 1-bromobutane was obtained after purification.

Calculate the yield of 1-bromobutane as a percentage of the theoretical maximum yield.

[2]

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(d) When the concentrated sulfuric acid is added to the reaction mixture (stage 2), unless the temperature is controlled carefully, the acid may react with either of the original reactants (sodium bromide or butan-1-ol) to give at least two by-products, one of which is inorganic and the other organic.

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What inorganic and organic by-products may be formed?

In **each** case, identify **one** by-product and state the role of the concentrated sulfuric acid in the formation of this by-product.

inorganic by-product .....

role of conc. H_2SO_4 .....

organic by-product .....

role of conc. H_2SO_4 ..... [4]

[Total: 10]

4 **(a)** Complete the following reaction scheme which starts with 1-bromobutane.
In **each empty** box, write the **structural formula** of the organic compound that would be formed.

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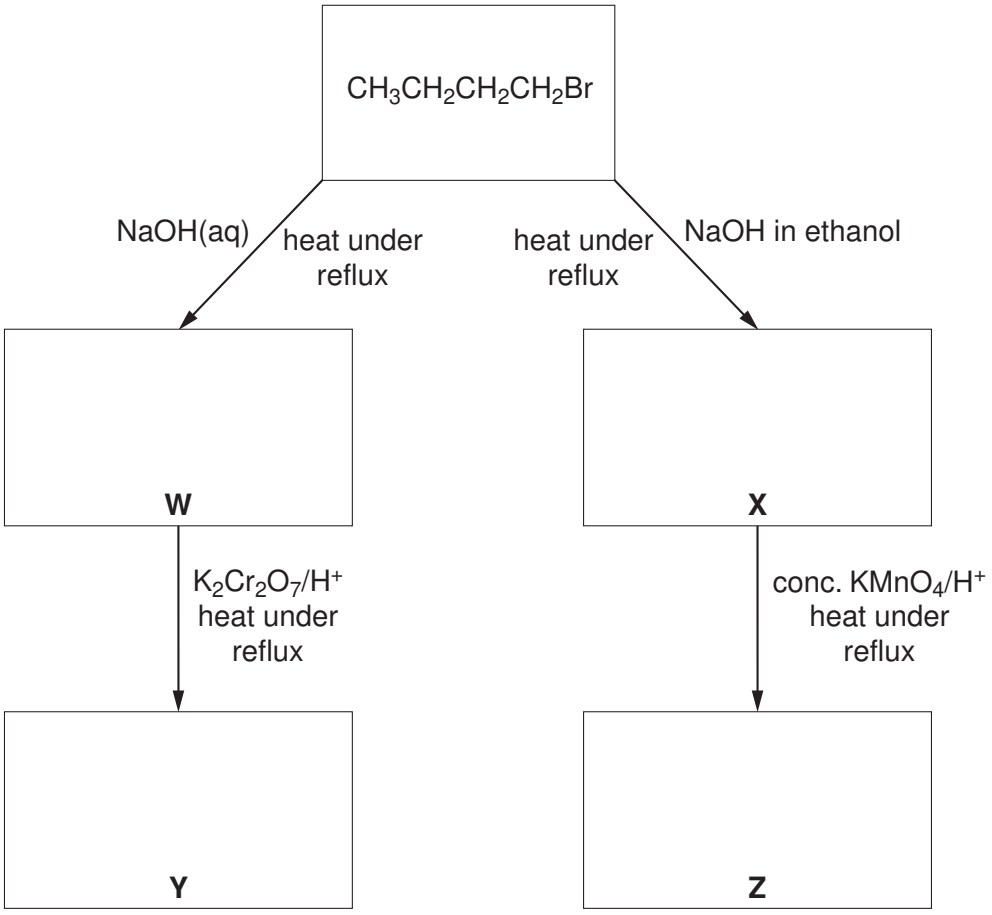

[4]

(b) One of the compounds **W**, **X**, **Y** or **Z** can be polymerised.

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(i) Identify this compound by its letter.

.....

(ii) Draw a section of the polymer chain formed by this compound.

Show **two** repeat units.

[2]

[Total: 6]

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5 The fermentation of starch or molasses using the bacterium *Clostridium acetobutylicum*, produces a mixture of propanone and butan-1-ol.

(a) Give the reagent(s) and state what would be observed when **one** test is carried out to confirm the presence of propanone in a mixture of propanone and butan-1-ol.

reagent(s) .....

observation ..... [2]

(b) What will be observed when a small piece of sodium metal is dropped into a dry sample of butan-1-ol? Write an equation for the reaction that takes place.

observation .....

equation ..... [2]

The molecular formula $C_5H_{12}O$ represents a number of alcohols.
Three alcohols with molecular formula $C_5H_{12}O$ are straight chain pentanols.

(c) Draw the following formulae.

(i) the **structural** formula of pentan-1-ol

(ii) the **displayed** formula of pentan-2-ol

(iii) the **skeletal** formula of pentan-3-ol

[3]

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When one of the three pentanols in **(c)** is dehydrated, alkenes with **two** different structural formulae are formed.

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(d) Identify this alcohol and give the structural formula of **each** alkene.

name of alcohol .....

alkene 1	alkene 2

[3]

A number of alcohols with molecular formula $C_5H_{12}O$ are branched chain compounds and may be considered as derivatives of butanol or propanol with alkyl side chains.

(e) **(i)** Draw the structural formula of the **derivative of propanol** that has the molecular formula $C_5H_{12}O$.

(ii) Draw the structural formula of the organic compound that will be present when the derivative of propanol you have given in **(i)** is heated under reflux with acidified potassium dichromate(VI).

[2]

[Total: 12]

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