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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

1182281800

CHEMISTRY **9701/21**

Paper 2 Structured Questions AS Core **May/June 2012**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
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.
DO **NOT** WRITE IN 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.

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.

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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 Oxides are compounds which usually contain oxygen combined with one other element.

Oxides are classified as follows.

acidic alkaline amphoteric basic

(a) **Using these terms only**, complete the table to describe the oxides of the elements of the third period of the Periodic Table sodium to sulfur.

Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_2	Cl_2O_7
						acidic

[4]

(b) Give the names of **two** elements from sodium to chlorine which form more than one oxide.

..... and ..... [1]

(c) Sodium reacts with water.

(i) Describe, as fully as you can, what you would see when a piece of sodium is reacted with water.

.....

.....

.....

(ii) Write an equation for the reaction of sodium with water.

.....

[4]

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(d) Sulfur dioxide is present in small, but significant, amounts in the Earth's atmosphere.

(i) State **one** way by which sulfur dioxide enters the atmosphere.

.....

(ii) Give the formula of another sulfur compound which is formed in the atmosphere from sulfur dioxide.

.....

(iii) What are the environmental consequences of the compound you have identified in **(ii)**?

.....

[3]

(e) Sulfur dioxide is used as a food preservative.
What property of sulfur dioxide enables it to act in this way?

..... [1]

(f) Another sulfur compound which is present in the Earth's atmosphere is carbonyl sulfide, OCS. The sequence of atoms in the molecule is oxygen-carbon-sulfur and the molecule is **not** cyclic.

(i) Draw a 'dot-and-cross' diagram of the OCS molecule.
Show outer electrons only.

(ii) Suggest a value for the O – C – S bond angle.

.....

[2]

[Total: 15]

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2 Ammonium sulfate, $(NH_4)_2SO_4$, is widely used as a fertiliser.

In order to determine its percentage purity, a sample of ammonium sulfate fertiliser was analysed by reacting a known amount with an excess of NaOH(aq) and then titrating the unreacted NaOH with dilute HC*l*.

(a) Ammonium sulfate reacts with NaOH in a 1 : 2 ratio.
Complete and balance the equation for this reaction.

$$(NH_4)_2SO_4 + 2NaOH \rightarrow .....NH_3 + ... + ...$$

[2]

(b) A 5.00 g sample of a fertiliser containing $(NH_4)_2SO_4$ was warmed with 50.0 cm^3 (an excess) of 2.00 mol dm^{-3} NaOH.

When all of the ammonia had been driven off, the solution was cooled.

The remaining NaOH was then titrated with 1.00 mol dm^{-3} HC*l* and 31.2 cm^3 were required for neutralisation.

(i) Write a balanced equation for the reaction between NaOH and HC*l*.

.....

(ii) Calculate the amount, in moles, of HC*l* in 31.2 cm^3 of 1.00 mol dm^{-3} HC*l*.

(iii) Calculate the amount, in moles, of NaOH in 50.0 cm^3 of 2.00 mol dm^{-3} NaOH.

(iv) Use your answers to **(i)**, **(ii)** and **(iii)** to calculate the amount, in moles, of NaOH used up in the reaction with $(NH_4)_2SO_4$.

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(v) Use your answer to **(iv)** and the equation in **(a)** to calculate the amount, in moles, of $(NH_4)_2SO_4$ that reacted with NaOH.

(vi) Use your answer to **(v)** to calculate the mass of $(NH_4)_2SO_4$ that reacted with NaOH.

(vii) Hence, calculate the percentage purity of the ammonium sulfate fertiliser.

[7]

[Total: 9]

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3 Methanol, CH_3OH, is considered to be a possible alternative to fossil fuels, particularly for use in vehicles.

Methanol can be produced from fossil fuels and from agricultural waste. It can also be synthesised from carbon dioxide and hydrogen.

(a) Define, with the aid of an equation which includes state symbols, the standard enthalpy change of formation of carbon dioxide.

equation .....

definition .....

.....

..... [3]

(b) Relevant $\Delta H_f^\ominus$ values for the reaction that synthesises methanol are given in the table.

compound	$\Delta H_f^\ominus$ / kJ mol^{-1}
$CO_2(g)$	–394
$CH_3OH(g)$	–201
$H_2O(g)$	–242

(i) Use these values to calculate $\Delta H_{reaction}^\ominus$ for this synthesis of methanol.

Include a sign in your answer.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

$\Delta H_{reaction}^\ominus$ = ...kJ mol^{-1}

(ii) Suggest **one** possible environmental advantage of this reaction. Explain your answer.

.....

.....

[5]

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(c) The synthesis of methanol is carried out at about 500 K with a pressure of between 40 and 100 atmospheres (between 4×10^6 Pa and 10×10^7 Pa) and using a catalyst. The use of such conditions will affect both the rate of reaction and the equilibrium yield.

In the spaces below, explain the effects of higher temperature, higher pressure, and the use of a catalyst on the **equilibrium yield** of methanol.

higher temperature

effect .....

explanation .....

.....

higher pressure

effect .....

explanation .....

.....

use of catalyst

effect .....

explanation .....

.....

[6]

[Total: 14]

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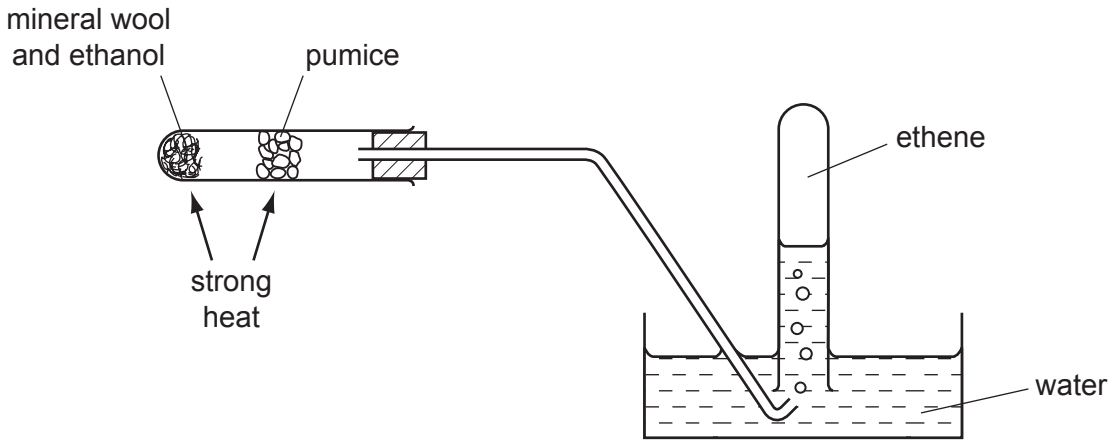
4 One method of preparing ethene in a school or college laboratory is from ethanol by using the apparatus shown below.



(a) (i) Write a balanced equation for this reaction.

.....

(ii) What *type of reaction* is this?

.....

(iii) Give the chemical name of a reagent other than pumice that could be used to carry out this reaction. It is not necessary to use the same apparatus.

.....

[3]

(b) Ethene is bubbled into two separate test-tubes, one containing aqueous hydrogen bromide and the other containing cold, dilute acidified potassium manganate(VII).

In **each** case, describe any colour changes you would see and give the structural formula of the organic product.

	aqueous hydrogen bromide	cold, dilute acidified potassium manganate(VII)
colour at start		
colour after reaction		
structural formula of organic product		

[4]

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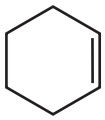
(c) Cyclohexene has the following structural formula.



(i) What is the molecular formula of cyclohexene?

.....

(ii) Draw the structural formula of the compound formed when cyclohexene is reacted with bromine.

(iii) State as fully as you can what *type of reaction* this is.

.....

(iv) Draw the structural formula of the compound formed when cyclohexene is reacted with hot concentrated acidified potassium manganate(VII).

[5]

[Total: 12]

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[Turn over

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5 Organic compounds which contain oxygen may contain alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. The functional groups may be identified by their reactions with specific reagents.

Compound **X** has the empirical formula CH_2O and M_r of 90.

(a) There is no reaction when **X** is treated with $NaHCO_3$.

What functional group does this test show to be **not** present in **X**?

..... [1]

(b) When 0.600 g of **X** is reacted with an excess of Na, 160 cm^3 of H_2, measured at room temperature and pressure, is produced.

(i) What functional group does this reaction show to be present in **X**?

.....

(ii) Use the data to calculate the amount, in moles, of hydrogen **atoms** produced from 0.600 g of **X**.

(iii) Hence, show that each molecule of **X** contains **two** of the functional groups you have given in **(i)**.

[4]

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(c) When **X** is warmed with Fehling's reagent, a brick red precipitate is formed. Treatment of **X** with 2,4-dinitrophenylhydrazine reagent produces an orange solid.

(i) What functional group do these reactions show to be present in **X**? Draw the displayed formula of this functional group.

(ii) Use your answers to **(b)(i)**, **(b)(ii)** and **(c)(i)** to deduce the structural formula of **X**.

(iii) What is the structural formula of the organic product of the reaction of **X** with Fehling's reagent?

[3]

(d) Compound **X** can be both oxidised and reduced.

(i) Give the structural formula of the compound formed when **X** is reacted with $NaBH_4$ under suitable conditions.

(ii) Give the structural formula of the compound formed when **X** is heated under reflux with acidified $K_2Cr_2O_7$.

[2]

[Total: 10]

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