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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

* 1 5 3 6 1 8 7 8 2 8 *

CHEMISTRY **9701/23**

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 Although the actual size of an atom cannot be measured exactly, it is possible to measure the distance between the nuclei of two atoms. For example, the 'covalent radius' of the C*l* atom is assumed to be half of the distance between the nuclei in a Cl_2 molecule. Similarly, the 'metallic radius' is half of the distance between two metal atoms in the crystal lattice of a metal. These two types of radius are generally known as 'atomic radii'.
The table below contains the resulting atomic radii for the elements of period three of the Periodic Table, Na to C*l*.

element	Na	Mg	A*l*	Si	P	S	C*l*
atomic radius / nm	0.186	0.160	0.143	0.117	0.110	0.104	0.099

(a) (i) Explain qualitatively this variation in atomic radius.

.....

.....

.....

.....

.....

(ii) Suggest why it is not possible to use the same type of measurement for argon, Ar.

.....

.....
[4]

(b) (i) Use the *Data Booklet* to complete the following table of radii of the cations and anions formed by some of the period three elements.

radius of cation / nm			radius of anion / nm		
Na^+	Mg^{2+}	Al^{3+}	P^{3-}	S^{2-}	Cl^-

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(ii) Explain the differences in size between the cations and the corresponding atoms.

.....

.....

.....

(iii) Explain the differences in size between the anions and the corresponding atoms.

.....

.....

.....

[5]

(c) Each of the elements Na to C*l* forms at least one oxide. Na_2O is an ionic oxide, SO_2 is a covalent oxide. Both oxides react with water.

(i) Write an equation for the reaction of **each** of these oxides with water.

Na_2O .....

SO_2 .....

(ii) What is the pH of the resulting solution in **each** case?

Na_2O ..... SO_2 .....

(iii) Write an equation for the reaction that occurs between the products of your reactions in **(i)**.

.....

[5]

[Total: 14]

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2 Washing soda is hydrated sodium carbonate, $Na_2CO_3.xH_2O$.

A student wished to determine the value of x by carrying out a titration, with the following results.

> 5.13 g of washing soda crystals were dissolved in water and the solution was made up to 250 cm^3 in a standard volumetric flask.
>
> 25.0 cm^3 of this solution reacted exactly with 35.8 cm^3 of 0.100 mol dm^{-3} hydrochloric acid and carbon dioxide was produced.

(a) (i) Write a balanced equation for the reaction between Na_2CO_3 and HC*l*.

.....

(ii) Calculate the amount, in moles, of HC*l* in the 35.8 cm^3 of solution used in the titration.

(iii) Use your answers to **(i)** and **(ii)** to calculate the amount, in moles, of Na_2CO_3 in the 25.0 cm^3 of solution used in the titration.

(iv) Use your answer to **(iii)** to calculate the amount, in moles, of Na_2CO_3 in the 250 cm^3 of solution in the standard volumetric flask.

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(v) Hence calculate the mass of Na_2CO_3 present in 5.13 g of washing soda crystals.

[6]

(b) Use your calculations in **(a)** to determine the value of x in $Na_2CO_3.xH_2O$.

[2]

[Total: 8]

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3 With the prospect that fossil fuels will become increasingly scarce in the future, many compounds are being considered for use in internal combustion engines. One of these is DME or dimethyl ether, CH_3OCH_3. DME is a gas which can be synthesised from methanol. Methanol can be obtained from biomass, such as plant waste from agriculture.

(a) Define, with the aid of an equation which includes state symbols, the standard enthalpy change of combustion, $\Delta H_c^{\ominus}$, for DME at 298 K.

equation .....

definition .....

.....

..... [3]

(b) DME may be synthesised from methanol. Relevant enthalpy changes of formation, $\Delta H_f^{\ominus}$, for this reaction are given in the table below.

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CH_3OH(l)$	–239
$CH_3OCH_3(g)$	–184
$H_2O(l)$	–286

Use these values to calculate $\Delta H_{reaction}^{\ominus}$ for the synthesis of DME, using the following equation. Include a sign in your answer.

$$2CH_3OH(l) \rightarrow CH_3OCH_3(g) + H_2O(l)$$

$\Delta H_{reaction}^{\ominus}$ = ... kJ mol^{-1}
[3]

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(c) DME and ethanol are isomers with the molecular formula C_2H_6O.

(i) Draw the displayed formula of DME and of ethanol.

DME	ethanol

(ii) What type of isomerism do DME and ethanol show?

.....

[2]

(d) DME is a gas at room temperature while ethanol is a liquid.

(i) Which intermolecular force exists between ethanol molecules, which causes ethanol to be a liquid at room temperature?

.....

(ii) Draw a diagram that clearly shows this intermolecular force.
Your diagram should show any lone pairs or dipoles present that you consider to be important. You should represent at least two molecules in your diagram.

[4]

[Total: 12]

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[Turn over

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4 But-2-ene, $CH_3CH{=}CHCH_3$, is an important compound which is obtained from the cracking of hydrocarbons present in crude oil.

(a) Give **two** different conditions under which long chain hydrocarbons may be cracked.

.....

.....

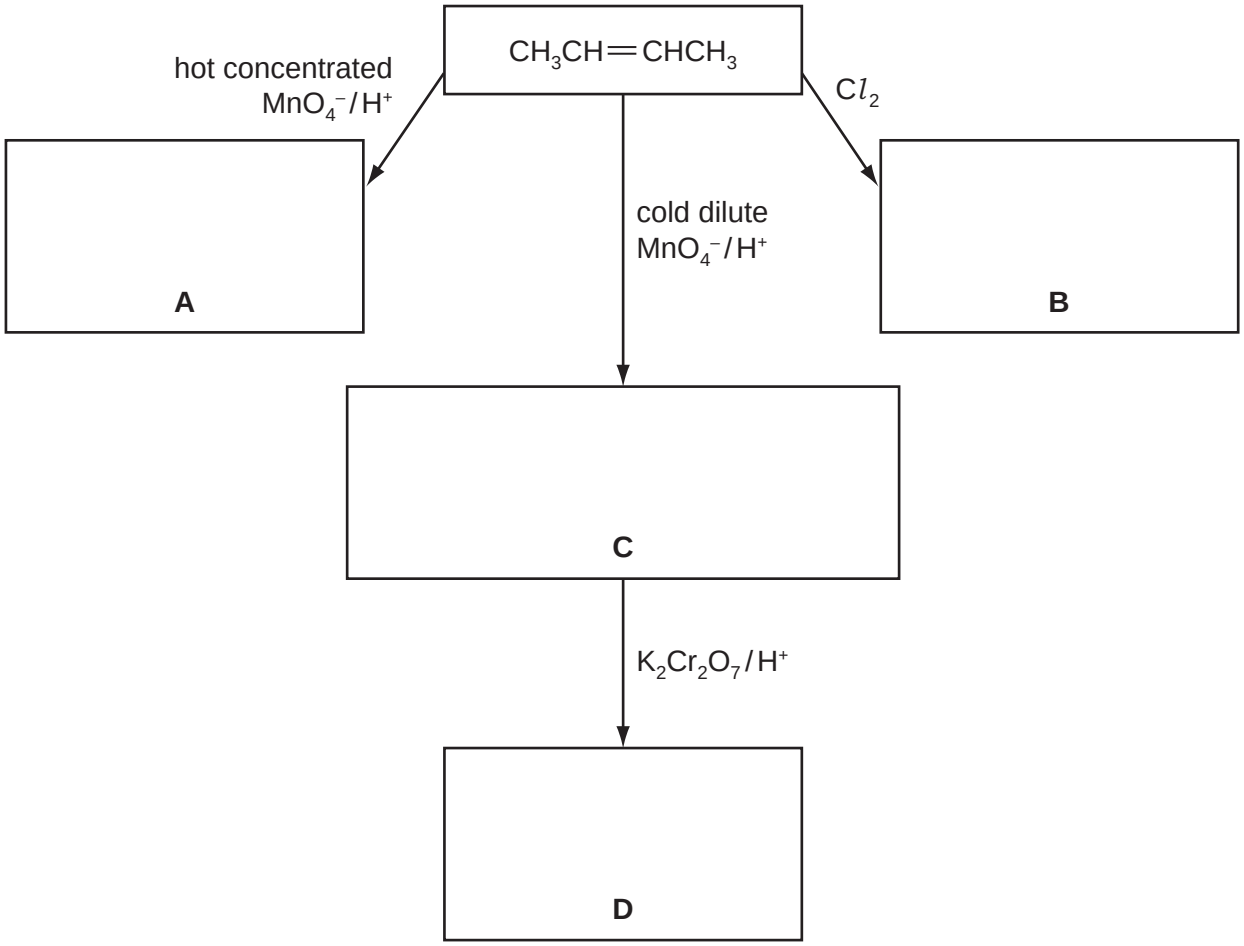
..... [2]

(b) Dodecane, $C_{12}H_{26}$, is a long chain hydrocarbon which is present in crude oil and which can be cracked to form but-2-ene and an alkane.

Write a balanced equation for this reaction.

..... [1]

(c) Some reactions of but-2-ene are shown below.
In the boxes below, give the **structural** formulae of the organic compounds **A** to **D**.



[4]

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(d) (i) Draw the **skeletal** formula of compound **D**.

(ii) By using the letters **A** to **D** as appropriate, identify those compounds which are chiral. If there are none, write 'none'.

.....

[3]

(e) But-2-ene can be polymerised to give poly(butene).

Draw the **structural** formula of a portion of the polymer chain in poly(butene) showing **two** repeat units.

[1]

(f) Compound **C** is a liquid which can be reacted with concentrated sulfuric acid to give a gas, **E**, which will decolourise aqueous bromine when passed through it.

(i) Suggest the **structural** formula of **E**.

(ii) Suggest the **structural** formula of the product of the reaction between **E** and an excess of bromine.

(iii) What *type of reaction* occurs between **E** and an excess of bromine?

.....

[3]

[Total: 14]

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[Turn over

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5 Many naturally occurring organic compounds contain oxygen. Such compounds may contain alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. These functional groups may be identified by their reactions with specific reagents.

Compound **F** is a white solid which has the molecular formula $C_3H_6O_3$.

Compound **F** is soluble in water. Addition of $NaHCO_3$ to this solution produces a colourless gas, **G**, which turns lime water milky.

(a) (i) What is the identity of the gas **G**?

.....

(ii) What functional group does this test show to be present in **F**?

.....

[2]

(b) When **F** is heated with concentrated sulfuric acid, a colourless liquid **H** is produced. When cold dilute acidified $KMnO_4$ is shaken with **H**, the solution becomes colourless.

(i) What *type of reaction* occurs when **H** is formed from **F**?

.....

(ii) Use your answers to **(a)(ii)** and **(b)(i)** to deduce the structural formula of the colourless liquid **H**.

[4]

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(c) Compound **F** will react with sodium.

Calculate the volume of H_2, measured at room temperature and pressure, which will be produced when 0.600 g of **F** is reacted with an excess of Na.

[4]

(d) There are two structural isomers of **F** that give the reactions described in **(a)** and **(b)**.

(i) Suggest two structural formulae for these isomers.

J	**K**

(ii) Isomers **J** and **K** can both be oxidised.
What will be produced when **each** of the isomers **J** and **K** is heated under reflux with acidified $K_2Cr_2O_7$?

product from **J**	product from **K**

[2]

[Total: 12]

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