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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

* 8 5 2 2 4 4 3 8 7 8 *

CHEMISTRY **9701/02**

Paper 2 AS Structured Questions **May/June 2008**

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 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.
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 GREY AREAS BETWEEN THE PAGES.

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1	
2	
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Total	

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

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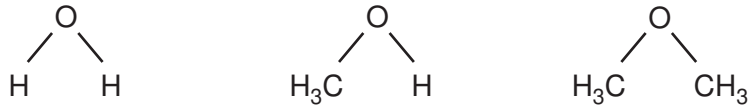
Answer **all** the questions in the spaces provided.

For Examiner's Use

1 The structural formulae of water, methanol and methoxymethane, CH_3OCH_3, are given below.



(a) (i) How many lone pairs of electrons are there around the oxygen atom in methoxymethane?

.....

(ii) Suggest the size of the C–O–C bond angle in methoxymethane.

.....

[2]

The physical properties of a covalent compound, such as its melting point, boiling point, vapour pressure, or solubility, are related to the strength of attractive forces between the molecules of that compound.

These relatively weak attractive forces are called intermolecular forces. They differ in their strength and include the following.

A interactions involving permanent dipoles

B interactions involving temporary or induced dipoles

C hydrogen bonds

(b) By using the letters **A**, **B**, or **C**, state the **strongest** intermolecular force present in **each** of the following compounds.
For each compound, write the answer on the dotted line.

ethanal	CH_3CHO	.....
ethanol	CH_3CH_2OH	.....
methoxymethane	CH_3OCH_3	.....
2-methylpropane	$(CH_3)_2CHCH_3$	.....

[4]

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(c) Methanol and water are completely soluble in each other.

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(i) Which intermolecular force exists between methanol molecules and water molecules that makes these two liquids soluble in each other?

.....

(ii) Draw a diagram that clearly shows this intermolecular force. Your diagram should show any lone pairs or dipoles present on either molecule that you consider to be important.

[4]

(d) When equal volumes of ethoxyethane, $C_2H_5OC_2H_5$, and water are mixed, shaken, and then allowed to stand, two layers are formed.

Suggest why ethoxyethane does not fully dissolve in water. Explain your answer.

.....

.....

.....

.....[2]

[Total: 12]

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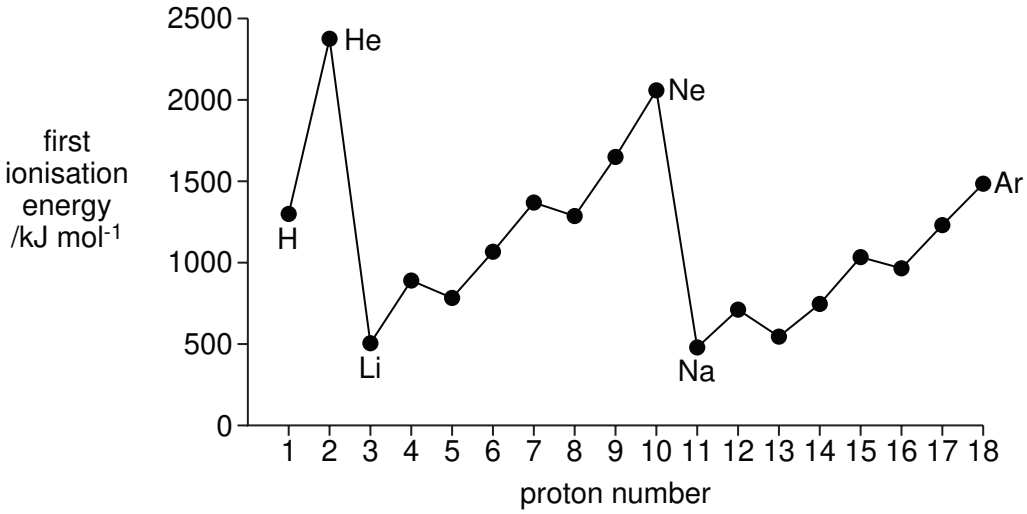
2 The Periodic Table we currently use is derived directly from that proposed by Mendeleev in 1869 after he had noticed patterns in the chemical properties of the elements he had studied.

The diagram below shows the first ionisation energies of the first 18 elements of the Periodic Table as we know it today.



(a) Give the equation, including state symbols, for the first ionisation energy of fluorine.

.....[2]

(b) Explain why there is a general increase in first ionisation energies from sodium to argon.

.....

.....

.....

.....[3]

(c) **(i)** Explain why the first ionisation energy of aluminium is less than that of magnesium.

.....

.....

.....

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(ii) Explain why the first ionisation energy of sulphur is less than that of phosphorus.

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.....

.....

.....
[4]

The table below refers to the elements sodium to sulphur and is incomplete.

element	Na	Mg	A*l*	Si	P	S
melting point		high				
conductivity		high				

(d) **(i)** Complete the 'melting point' row by using **only** the words 'high' **or** 'low'.

(ii) Complete the 'conductivity' row by using **only** the words 'high', 'moderate' **or** 'low'.
[5]

(e) When Mendeleev published his Periodic Table, the elements helium, neon and argon were not included.

Suggest a reason for this.

.....

.....[1]

[Total: 15]

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[Turn over

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3 When hydrocarbons such as petrol or paraffin wax are burned in an excess of air in a laboratory, carbon dioxide and water are the only products.
When petrol is burned in a car engine, nitrogen monoxide, NO, is also formed.

(a) Explain how NO is formed in an internal combustion engine but not formed when a small sample of petrol is burnt in an evaporating basin.

.....

.....

.....[2]

The engines of modern motor cars have exhaust systems which are fitted with catalytic converters in order to reduce atmospheric pollution from substances such as NO.

(b) (i) State **three more** pollutants, other than CO_2 and H_2O, that are present in the exhaust gases of a car engine.

..... and ..... and .....

(ii) What is the active material present in the catalytic converter?

.....

(iii) Write **one** balanced equation to show how NO is removed from the exhaust gases of a car engine by a catalytic converter.

.....
[4]

NO is also formed when nitrosyl chloride, NOC*l*, dissociates according to the following equation.

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

Different amounts of the three gases were placed in a closed container and allowed to come to equilibrium at 230 °C. The experiment was repeated at 465 °C.

The equilibrium concentrations of the three gases at each temperature are given in the table below.

	concentration / mol dm^{-3}		
temperature / °C	NOC*l*	NO	Cl_2
230	2.33×10^{-3}	1.46×10^{-3}	1.15×10^{-2}
465	3.68×10^{-4}	7.63×10^{-3}	2.14×10^{-4}

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(c) **(i)** Write the expression for the equilibrium constant, K_c, for this reaction. Give the units.

(ii) Calculate the value of K_c at each of the temperatures given.

230 °C

465 °C

(iii) Is the forward reaction endothermic or exothermic? Explain your answer.

.....

.....

[5]

(d) The temperature of the equilibrium was then altered so that the equilibrium concentrations of NOC*l* and NO were the same as each other.

What will be the effect on the equilibrium concentration of NOC*l* when the following changes are carried out on this new equilibrium? In each case, explain your answer.

(i) The pressure of the system is halved at constant temperature.

.....

.....

(ii) A mixture of NOC*l*(g) and NO(g) containing equal numbers of moles of each gas is introduced into the container at constant temperature.

.....

.....

[4]

[Total: 15]

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4 Two types of isomerism found in organic compounds are structural isomerism and *cis-trans* isomerism.

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(a) Draw displayed formulae for

(i) **two** structural isomers of $C_2H_4Br_2$,

D	**E**

(ii) the *cis*- and the *trans*- isomers of $C_2H_2Br_2$.

cis	*trans*

[4]

(b) **(i)** The *cis*- isomer of $C_2H_2Br_2$ can be converted into **one** of the structural isomers of $C_2H_4Br_2$. State the reagent(s) and conditions you would use to do this.

.....

.....

(ii) Which of your structural isomers, **D** or **E**, would be formed? Explain your answer.

isomer formed is .....

reason .....

[3]

[Total: 7]

5 Ethanedial (glyoxal) is used in the production of fabrics which have permanent creases.

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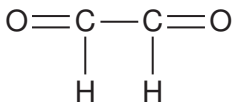

ethanedial

Ethanedial undergoes many of the reactions of aldehydes.

(a) Ethanedial reacts with Tollens' reagent.

(i) What would you see if you carried out this reaction?

.....

(ii) What is the structural formula of the organic compound formed?

[2]

(b) Ethanedial reacts with hydrogen cyanide, HCN, to give compound **F**.

(i) What is the structural formula of **F**?

(ii) What type of reaction is this?

.....

(iii) What is the structural formula of the compound formed when **F** is heated with an aqueous mineral acid such as dilute sulphuric acid?

[3]

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(c) Ethanedial can be oxidised and reduced.

(i) What is the structural formula of the organic compound formed when ethanedial is heated under reflux with an excess of acidified potassium dichromate(VI)?

(ii) What is the structural formula of the compound formed when ethanedial is reduced?

(iii) What reagent would be used for this reduction?

.....

[3]

(d) When ethanedial is reacted with NaOH and the product treated with a mineral acid such as dilute sulphuric acid, the following reaction sequence takes place.

I $CHOCHO + NaOH \rightarrow HOCH_2CO_2Na$

II $HOCH_2CO_2Na + H^+ \rightarrow HOCH_2CO_2H + Na^+$

What type of reaction is the overall change?

.....[1]

(e) An isomer of ethanedial exists which reacts with sodium metal to give hydrogen.

Suggest the displayed formula of this isomer.

[2]

[Total: 11]

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