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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

CHEMISTRY **9701/22**

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

For Examiner's Use	
1	
2	
3	
4	
5	
Total	

This document consists of **12** printed pages.

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

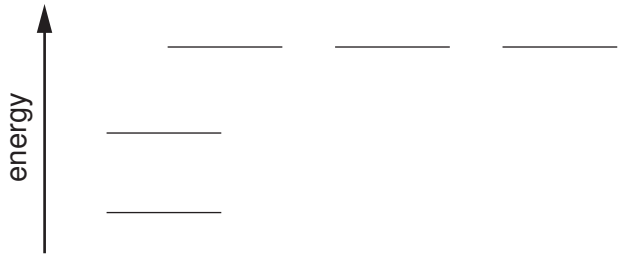
For Examiner's Use

1 In the 19th and 20th centuries, experimental results showed scientists that atoms consist of a positive, heavy nucleus which is surrounded by electrons.

Then in the 20th century, theoretical scientists explained how electrons are arranged in orbitals around atoms.

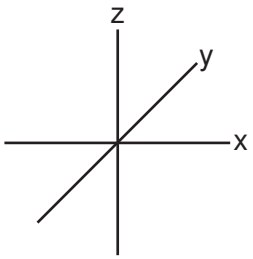
(a) The diagram below represents the energy levels of the orbitals present in atoms of the second period (Li to Ne).

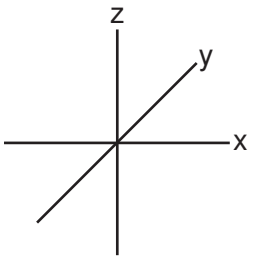
(i) Label the energy levels to indicate the principal quantum number **and** the type of orbital at each energy level.



(ii) On the axes below, draw a sketch diagram of **one** of each **different type (shape)** of orbital that is occupied by the electrons in a second-period element.

Label each type.





(iii) Complete the electronic configurations of nitrogen atoms and oxygen atoms on the energy level diagrams below.
Use arrows to represent electrons.

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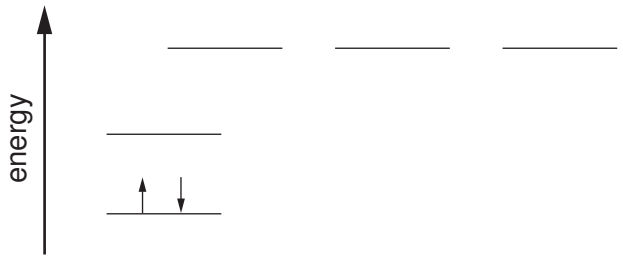
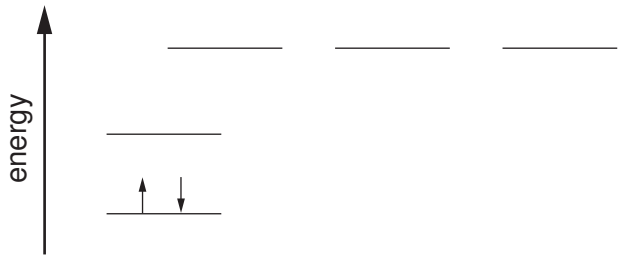


nitrogen



oxygen

[6]

(b) (i) Use the *Data Booklet* to state the value of the first ionisation energy of nitrogen and of oxygen.

N ..... kJ mol^{-1} O ..... kJ mol^{-1}

(ii) Explain, with reference to your answer to **(a)(iii)**, the relative values of these two ionisation energies.

.....

.....

.....

[3]

[Total: 9]

2 Copper, proton number 29, and argon, proton number 18, are elements which have different physical and chemical properties.
In the solid state, each element has the same face-centred cubic crystal structure which is shown below.

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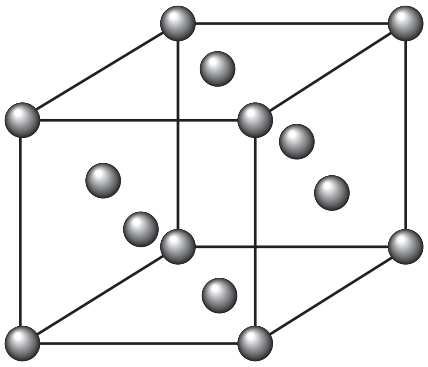

The particles present in such a crystal may be atoms, molecules, anions or cations. In the diagram above, the particles present are represented by ●.

(a) Which types of particle are present in the copper and argon crystals?
In each case, give their formula.

element	particle	formula
copper		
argon		

[2]

At room temperature, copper is a solid while argon is a gas.

(b) Explain these observations in terms of the forces present in **each** solid structure.

.....

.....

.....

.....

.....

..... [4]

Although copper is a relatively unreactive element, when it is heated to a high temperature in an excess of chlorine, copper(II) chloride is formed.

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When a mixture of argon and chlorine is heated to a high temperature, no reaction occurs.

(c) (i) How does chlorine behave in its reaction with copper?

.....

(ii) Suggest a reason for the lack of a reaction between argon and chlorine.

.....

..... [2]

The melting points of the noble gases neon to xenon are given below.

	Ne	Ar	Kr	Xe
melting point/K	25	84	116	161

(d) Explain why there is an increase in melting point from neon to xenon.

.....

.....

..... [2]

[Total: 10]

3 The table below gives data for some of the oxides of Period 3 elements.

For Examiner's Use

oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_6	SO_2
melting point/°C	1275	2827	2017	1607	24	–75
bonding						
structure						

(a) Complete the table by filling in

(i) the 'bonding' row by using **only** the words 'ionic' **or** 'covalent',

(ii) the 'structure' row by using **only** the words 'simple' **or** 'giant'.

[2]

(b) From the table of oxides above, suggest the formula of **one** oxide that is **completely** insoluble in water.

..... [1]

(c) Separate samples of Na_2O and SO_2 were added to water.

(i) For **each** oxide, write a balanced equation for its reaction with water and suggest a numerical value for the pH of the resulting solution.

Na_2O

equation .....

pH .....

SO_2

equation .....

pH .....

(ii) Construct a balanced equation for the reaction that occurs when a solution of Na_2O in water reacts with a solution of SO_2 in water.

.....

[5]

(d) Separate samples of the oxides MgO and SiO_2 are melted.
Each molten sample is then tested to see whether or not it conducts electricity.

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Suggest what would be the results in **each** case. Explain your answers.

MgO .....

.....

.....

SiO_2 .....

.....

.....

[4]

[Total: 12]

4 An organic compound, **E**, has the following composition by mass:
C, 48.7%; H, 8.1%; O, 43.2%.

(a) Calculate the empirical formula of **E**.

[2]

(b) When vaporised in a suitable apparatus, 0.130 g of **E** occupied a volume of 58.0 cm^3 at 127 °C and 1.00 × 10^5 N m^{-2}.

(i) Use the expression $pV = \frac{mRT}{M_r}$ to calculate M_r of **E**,

where m is the mass of **E**.

(ii) Hence calculate the molecular formula of **E**.

[4]

(c) Compound **F**, is an ester with the molecular formula $C_4H_8O_2$.

F is one of four isomers, **S**, **T**, **U**, and **V**, that are all esters.

In the boxes below, the structural formula of **S** is given.

Draw the structural formulae of the other **three** isomers of **F** that are esters.

$HCO_2CH(CH_3)_2$			
S	**T**	**U**	**V**

[3]

(d) When the ester **F** is hydrolysed, an alcohol **G** is produced.

(i) What reagent can be used to hydrolyse an ester to an alcohol?

.....

(ii) What other type of organic compound is produced at the same time?

.....

[2]

(e) On mild oxidation, the alcohol **G** gives a compound **H** which forms a silver mirror with Tollens' reagent.

(i) What functional group does the reaction with Tollens' reagent show to be present in compound **H**? Give the name of this group.

.....

(ii) What type of alcohol is **G**?

.....

(iii) What could be the structural formula of the alcohol **G**?

[3]

(f) **(i)** Which of the four isomers, **S**, **T**, **U**, or **V**, could **not** be **F**?

.....

(ii) Explain your answer.

.....

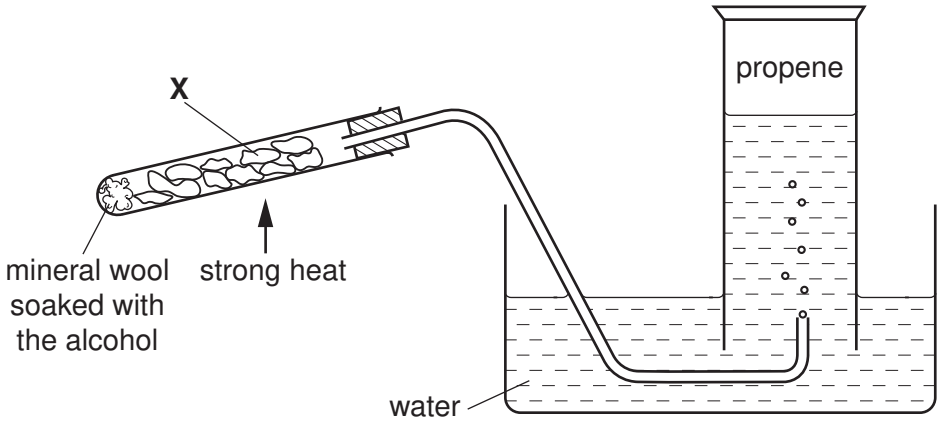
.....

[2]

[Total: 16]

5 Alkenes such as propene can be readily prepared from alcohols in a school or college laboratory by using the apparatus below.

For Examiner's Use



(a) (i) Give the **name** of an alcohol that can be used in this apparatus to prepare propene.

.....

(ii) Draw the **skeletal** formula of the alcohol you have named in **(i)**.

(iii) What type of reaction occurs in this case?

.....

[3]

(b) (i) During the reaction, the material **X** becomes black in colour.
Suggest the identity of the black substance and suggest how it is produced during the reaction.

.....

.....

.....

(ii) At the end of the experiment, when no more propene is being produced, the delivery tube is removed from the water before the apparatus is allowed to cool.

Suggest why this done.

.....

.....

.....

(iii) The material labelled **X** can be broken crockery, broken brick or pumice.

Give the chemical formula of a compound that is present in one of these materials.

.....

(iv) State another reagent that could be used to produce propene from an alcohol.

.....

[5]

(c) Give the structural formula of the organic product formed when propene reacts separately with **each** of the following substances.

(i) bromine

(ii) cold, dilute manganate(VII) ions

(iii) hot, concentrated manganate(VII) ions

[3]

[Turn over

For Examiner's Use

(d) Propene may be polymerised.

(i) What is the essential condition for such a polymerisation?

.....

(ii) The disposal of waste poly(propene) is very difficult.
Give **one** important reason for this.

.....

.....
[2]

[Total: 13]