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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

* 1 9 5 9 0 0 4 3 4 0 *

CHEMISTRY **9701/02**

Paper 2 Structured Questions AS Core **October/November 2007**

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.

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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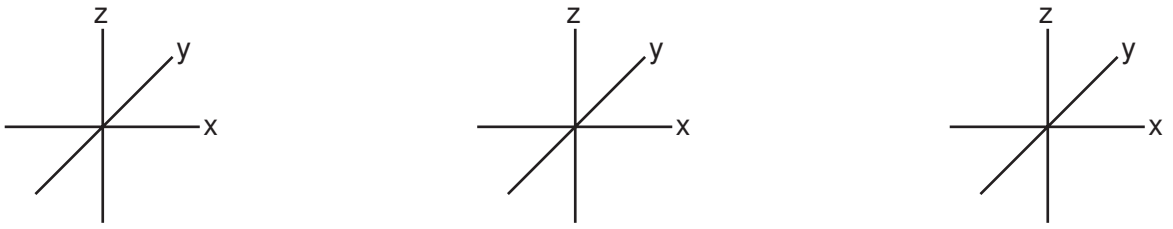
For Examiner's Use

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

1 This question is about the bonding of covalent compounds.

(a) On the axes below, sketch the shapes of a 1s, a 2s, and a $2p_x$ orbital.



1s 2s $2p_x$

[3]

(b) Covalent bonding occurs when two atoms share a pair of electrons. Covalent bonding may also be described in terms of orbital overlap with the formation of σ bonds.

(i) How are the two atoms in a covalent bond held together? In your answer, state which particles are attracted to one another and the nature of the force of attraction.

.....

.....

(ii) Draw sketches to show orbital overlap that produces the σ bonding in the H_2 **and** HC*l* molecules.

H_2	HC*l*

[4]

(c) The bond in the HC*l* molecule is said to be 'polar'.

(i) What is meant by the term *bond polarity*?

.....

(ii) Explain why the HC*l* molecule is polar.

.....

.....

[2]

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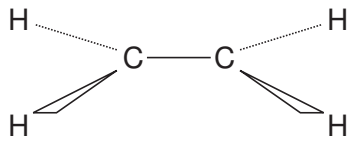
(d) The bonding in ethene may be described as a mixture of σ and π bonding.

Each carbon atom in ethene forms three σ bonds as shown below.



On the diagram, sketch the π bond that is also present in ethene. [1]

(e) Carbon, hydrogen and ethene each burn exothermically in an excess of air.

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H_c^{\ominus} = -393.7\,kJ\,mol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\quad \Delta H_c^{\ominus} = -285.9\,kJ\,mol^{-1}$

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$ $\quad \Delta H_c^{\ominus} = -1411.0\,kJ\,mol^{-1}$

Use the data to calculate the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, in $kJ\,mol^{-1}$, of ethene at 298 K.

$2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$

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

[Total: 13]

2 This question concerns the chlorides of the elements sodium to phosphorus of the third period of the Periodic Table.
The melting points of these chlorides are given below.

compound	sodium chloride	magnesium chloride	aluminium chloride	silicon tetrachloride	phosphorus(V) chloride
melting point/K	1081	987	451*	203	435

*sublimes at 451 K

(a) Give the equation, with state symbols, for the reaction of phosphorus with chlorine to form phosphorus(V) chloride, PCl_5.

.....[2]

(b) Suggest, in terms of the structure and bonding, explanations for the following.
You should draw diagrams where you think they will help your answer.

(i) the high melting point of sodium chloride

(ii) the low melting point of silicon tetrachloride

[4]

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(c) Write an equation for the reaction of silicon tetrachloride with water.

.....[1]

(d) What is the pH of the solution formed when **each** of the following compounds is dissolved in water?

NaC*l* .....

PCl_5 ..... [2]

(e) When solid aluminium chloride is heated above 451 K, a vapour is formed which has M_r = 267.
When this vapour is heated above 1100 K, the vapour has M_r = 133.5.

(i) What are the molecular formulae of these two forms of aluminium chloride?

at 460 K ..... at 1150 K .....

(ii) Draw a 'dot-and-cross' diagram of the form of aluminium chloride that exists at the **higher** temperature.

(iii) Draw a displayed formula of the form of aluminium chloride that exists at the **lower** temperature. Indicate clearly the different types of bonds present.

[5]

[Total: 14]

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3 The elements phosphorus, sulphur, and chlorine are regarded as having simple molecular structures.

(a) What are the molecular formulae of **each** of these three elements?

phosphorus .....

sulphur .....

chlorine ..... [3]

(b) **(i)** Place the three elements in order of their melting points **with the highest first**.

highest ..... lowest

(ii) Suggest an explanation for the order you have given in **(i)**.

.....

.....

.....[3]

(c) Sulphur and chlorine can be reacted together to form disulphur dichloride, S_2Cl_2.

Disulphur dichloride, S_2Cl_2, is decomposed by water forming sulphur and a mixture of hydrochloric acid and sulphurous acid.

When 2.7 g of S_2Cl_2 is reacted with an excess of water, 0.96 g of sulphur, S, is produced.

(i) What is the amount, in moles, of S_2Cl_2 present in 2.7 g?

(ii) What is the amount, in moles, of S produced from 1.0 mol of S_2Cl_2?

(iii) Construct a balanced equation for the reaction of S_2Cl_2 with water.

.....

[4]

(d) The reaction between S_2Cl_2 and water is a redox reaction.

Which product has been formed by oxidation and which by reduction?

product formed by oxidation .....

product formed by reduction ..... [2]

[Total: 12]

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4 The molecular formula of a compound states the number of atoms of each element that are present in one molecule. It contains no information about the structure of the molecule. Hydrocarbons with the molecular formula C_5H_{10} may be branched chain, straight chain or cyclic.

(a) Draw a displayed formula of C_5H_{10} as a branched chain hydrocarbon.

[1]

Pent-2-ene is one straight chain hydrocarbon with formula C_5H_{10}.

(b) Pent-2-ene exhibits *cis-trans* isomerism. Draw and label the structural formulae of the two *cis-trans* isomers of pent-2-ene.

[2]

(c) In the spaces below draw the structural formulae of **two** alcohols which would **each** produce pent-2-ene on dehydration.

[2]

(d) One of these alcohols exhibits optical isomerism. Draw the structural formulae of the two isomers of this alcohol. Your structures should clearly indicate the three-dimensional nature of the structures.

[2]

(e) Pent-2-ene decolourises aqueous bromine. Suggest the structural formula of an isomer of C_5H_{10} which does **not** decolourise aqueous bromine.

[1]

(f) Pent-2-ene can be polymerised. Draw a section of the polymer chain produced showing **two** repeat units.

[1]

[Total: 9]

5 Ethanoic acid, CH_3CO_2H, is formed as vinegar by the bacterial oxidation of ethanol present in wine and other solutions.

$$CH_3CH_2OH + 2[O] \rightarrow CH_3CO_2H + H_2O$$

Ethanoic acid can also be formed in the laboratory by the oxidation of ethanol.

(a) (i) What oxidising agent is used for this laboratory reaction?

.....

(ii) What colour change would be observed?

from ..... to .....

[2]

When ethanoic acid is prepared in this way in the laboratory, the reagents are heated under reflux for some time before the ethanoic acid is separated.

(b) (i) Why is the reaction carried out by heating under reflux?

.....

.....

(ii) What would be the main organic compound formed if, instead of heating under reflux, the reagents were heated together and the products immediately distilled off?

.....

[2]

(c) Ethanoic acid is manufactured from methanol, CH_3OH, by reacting it with carbon monoxide in the presence of a catalyst containing rhodium metal and iodide ions.

$$CH_3OH + CO \rightarrow CH_3CO_2H$$

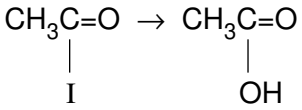
The reaction proceeds in a number of stages.

(i) One stage in this process is the reaction of methanol with hydrogen iodide.

What organic compound is formed in this reaction?

.....

(ii) A later stage involves the conversion of an intermediate compound.



What type of reaction is this?

.....

[2]

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(d) Methanol can be converted into ethanoic acid in the laboratory in a three-stage process.

$$CH_3OH \xrightarrow{\text{step I}} CH_3I \xrightarrow{\text{step II}} CH_3CN \xrightarrow{\text{step III}} CH_3CO_2H$$

What reagent(s) and conditions are used in each step of the conversion?

step I

reagent(s) .....

conditions .....

step II

reagent(s) .....

conditions .....

step III

reagent(s) .....

conditions .....

[6]

[Total: 12]

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