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

**CHEMISTRY**

Paper 2 Structured Questions AS Core

**9701/02**
October/November 2004

**1 hour 15 minutes**

Candidates answer on the Question Paper.
Additional Materials:
Data Booklet

Candidate Name

Centre Number

Candidate Number

**READ THESE INSTRUCTIONS FIRST**

Write your name, Centre number and candidate number in the spaces provided at the top of this page.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
The number of marks is given in brackets [ ] at the end of each question or part question.
You may lose marks if you do not show your working or if you do not use appropriate units.

DO NOT WRITE IN THE BARCODE.

DO NOT WRITE IN THE GREY AREAS BETWEEN THE PAGES.

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given on this page.

Stick your personal label here, if provided.

| 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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**1** Hydrogen iodide dissociates into its elements according to the equation below.

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$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

**(a)** Write the expression for the equilibrium constant, $K_c$.

[1]

**(b)** At 120 °C the equilibrium mixture contains 1.47 mol dm$^{-3}$ of HI(g), 0.274 mol dm$^{-3}$ each of $H_2(g)$ and $I_2(g)$.

Calculate the value of $K_c$ for the equilibrium at 120 °C.

[1]

**(c)** Suggest and explain why it would be more difficult to determine $K_c$ for this equilibrium at room temperature.

.....

.....

.....

.....[2]

**(d)** **(i)** Explain how enthalpy changes, $\Delta H$ values, for covalent bonded molecules can be calculated from bond energies.

.....

.....

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**(ii)** Use bond energies from the *Data Booklet* to calculate $\Delta H$ for the following dissociation.

For Examiner's Use

$$2HI(g) \rightarrow H_2(g) + I_2(g)$$

[3]

**(e)** HI dissolved in water behaves as a strong acid.

**(i)** Explain what is meant by a ***strong*** *acid*.

.....

**(ii)** Complete the equation.

$$HI + H_2O \rightarrow \text{.....} + \text{.....}$$

**(iii)** Identify the conjugate base of HI in this equation.

.....[3]

[Total : 10]

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**2** The table below gives data on some oxides of elements in Period 3 of the Periodic Table.

*For Examiner's Use*

| oxide | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_4O_{10}$ | $SO_3$ |
|---|---|---|---|---|---|---|
| melting point / K | 1193 | 3125 | 2345 | 1883 | 853 | 290 |
| boiling point / K | 1548 | 3873 | 3253 | 2503 | – | 318 |

**(a)** Write an equation for the reaction of aluminium with oxygen to form aluminium oxide.

.....[1]

**(b)** Drawing diagrams where appropriate, suggest in terms of structure and bonding, explanations for the following.

**(i)** the high melting point and boiling point of $Al_2O_3$

**(ii)** the low boiling point of $SO_3$

**(iii)** the melting point of $SiO_2$ is much higher than that of $P_4O_{10}$

[7]

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**(c)** Water was added to each of the oxides in the table.

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Choosing a suitable oxide in each case, write an equation for the formation of

**(i)** an alkaline solution, .....

**(ii)** an acidic solution. .....[2]

[Total : 10]

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**3 (a) (i)** Describe, with the aid of a fully labelled diagram, the industrial electrolysis of brine (aqueous NaC*l*). State what the electrodes are made of and show clearly the inlet and the outlets.

**(ii)** Write equations for the reactions at each electrode, giving state symbols.

anode .....

cathode .....

**(iii)** Explain in terms of changes in oxidation number why redox processes take place at the electrodes.

anode .....

cathode .....

**(iv)** Name the chemical which is produced in solution by this electrolysis.

.....

**(v)** Suggest **two** large scale uses of this chemical.

.....

.....

[10]

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**(b)** Hydrochloric acid is manufactured by burning the hydrogen formed in this electrolysis in chlorine and dissolving the product in water.

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**(i)** Construct an equation for the burning of hydrogen in chlorine.

.....

**(ii)** When the product of **(i)** dissolves in water there is a change in bonding. Explain with the aid of an equation what change in bonding has occurred.

[2]

**(c)** Describe, with the aid of equations including state symbols, what happens when

**(i)** hydrochloric acid is added to aqueous silver nitrate,

.....

.....

**(ii)** an excess of aqueous ammonia is added to the resulting mixture.

.....

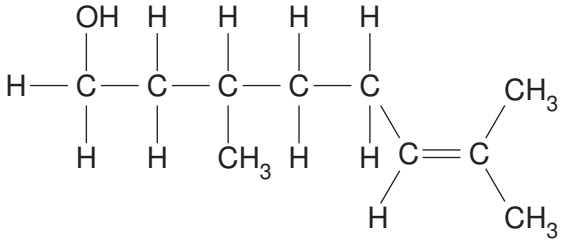
.....

.....[5]

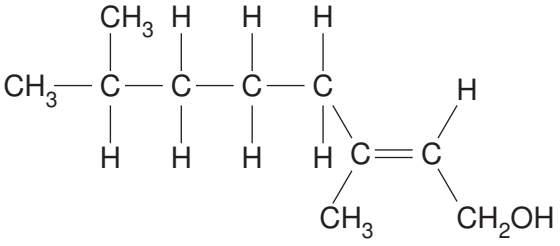
[Total : 17]

For Examiner's Use

**4** Some perfumes and scents of flowers and fruit contain compounds which are structural isomers. Two such examples are citronellol and geraniol.



citronellol



geraniol

**(a)** Confirm that citronellol and geraniol are isomers by calculating their molecular formula and their relative molecular mass, $M_r$.

**(i)** Molecular formula .....

**(ii)** $M_r$ .....[2]

**(b)** Name two functional groups present in **both** molecules.

**(i)** .....

**(ii)** .....[3]

Citronellol and geraniol also show stereo isomerism.

**(c)** On the diagram of the structure of citronellol above, draw a circle around a chiral carbon atom. [1]

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**(d)** **(i)** Draw the other *cis-trans* isomer of geraniol. [In parts **(d)** and **(f)** use R – to represent a part of the molecule.]

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**(ii)** Explain why geraniol has no optical isomers.

.....

.....[2]

**(e)** State what you would expect to see if citronellol was reacted with aqueous bromine.

.....

.....[1]

**(f)** Draw structures of the organic products when geraniol reacts with each of the following reagents.

**(i)** an excess of $H^+ / Cr_2O_7^{2-}$ under reflux

**(ii)** ethanoic acid in the presence of an acidic catalyst

**(iii)** hydrogen bromide, HBr

[4]

[Total : 13]

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**5** 2-Hydroxypropanoic acid (lactic acid), $CH_3CH(OH)CO_2H$, can be prepared in a two-stage synthesis from ethanal, $CH_3CHO$.

**(a)** In the first stage, ethanal reacts with hydrogen cyanide, HCN, in the presence of an NaCN catalyst to produce a cyanohydrin.

**(i)** Write an equation for the reaction of ethanal and HCN, giving the displayed formula of the product.

**(ii)** State what type of reaction this is.

.....

**(iii)** Describe the mechanism of this reaction.

[5]

**(b)** In the second stage, the product from **(a)** is converted into lactic acid.

**(i)** Write the equation for this stage.

.....

**(ii)** State what type of reaction this is.

.....[2]

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**(c)** In this synthesis 4.40 g of ethanal were used and at the end 5.40 g of lactic acid were obtained.

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Calculate the percentage yield of lactic acid.

[3]

[Total : 10]

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