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

CHEMISTRY **9701/06**

Paper 6 Options

May/June 2004

1 hour

Additional Materials: Answer paper
Data Booklet
Graph Paper (1 sheet)

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number and candidate number on the front of any work handed in.
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.
Write your answers on the separate answer paper provided.

Answer **all** questions on **two** of the Options.
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.
You may use a calculator.

This document consists of **9** printed pages and **3** blank pages.

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BIOCHEMISTRY

Answer **both** questions on the paper provided.

1 **(a)** Name and describe the **two** secondary structures of proteins, giving simplified diagrams and showing the bonding by which these structures are stabilised. [4]

(b) The tertiary structure of a protein is disrupted when the protein is denatured.

By referring to representative groups involved, explain which chemical bonds are affected in each of the following cases.

(i) Changing pH (in your answer refer to both high and low pH).

(ii) Adding heavy metal ions such as Ag^{+} or Cu^{2+}.

[5]

(c) Briefly describe and explain a common everyday example of the denaturing of a protein. [1]

2 **(a)** **(i)** Draw the displayed formula of a typical phosphoglyceride, using **R** as a general symbol for an alkyl group.

(ii) Explain why the hydrophilic part of the phospholipid is a zwitterion.

[4]

(b) **(i)** Describe, with the aid of a simple labelled diagram, the fluid mosaic structure of membranes.

(ii) Briefly explain the function of each part of the mosaic. In your answer, state the nature of the chemical interactions involved.

[6]

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ENVIRONMENTAL CHEMISTRY

Answer **both** questions on the paper provided.

3 **(a)** **(i)** Explain why carbon dioxide levels in the air increase at night compared to daytime.

(ii) Explain why carbon dioxide levels in the air increase in winter compared to summer. [2]

(b) **(i)** Carbon dioxide is one important 'greenhouse gas'. State **two** other gases that contribute to the 'greenhouse effect'.

(ii) Describe the role of these gases in the 'greenhouse effect'. [4]

(c) One possible method suggested for the disposal of waste carbon dioxide is to pump it into deep water in the oceans. Explain, using appropriate equations, how this might prevent the release of carbon dioxide into the atmosphere. [4]

4 **(a)** What feature gives clay soils their large water-holding capacity? [1]

(b) Air in sandy soils contains a higher concentration carbon dioxide than the atmosphere, whereas clay soils often contain more methane.

Explain these differences. [2]

(c) **(i)** Kaolinite is a 1:1 clay. Show by means of a labelled diagram the structure of kaolinite.

(ii) Explain why kaolinite does not produce large cracks during dry periods. [4]

(d) Soil pH is a very important factor in plant growth. Outline **two** factors that cause soil pH to be reduced, and **one** that causes it to increase. [3]

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[Turn over

PHASE EQUILIBRIA

Answer **both** questions on the paper provided.

5 **(a)** What is meant by the *molar enthalpy change of vaporisation*, ΔH_{vap}, of a liquid? [1]

(b) The table below provides data about cyclohexane and ethanol.

Substance	M_r	T_b / °C	ΔH_{vap} / kJ mol^{-1}
cyclohexane	84	81	35.7
ethanol	46	79	83.9

Use the data to explain the different intermolecular forces present in these two liquids. [2]

(c) The table below gives the boiling points, T_b, of mixtures of cyclohexane and ethanol.

mole fraction of cyclohexane	0.0	0.2	0.3	0.4	0.6	0.8	1.0
T_b / °C	79.0	67.5	66.7	67.5	69.5	74.3	81.0

(i) Draw on graph paper the boiling point/composition curve for these mixtures.

(ii) Determine the temperature and composition of the mixture at the azeotropic point.

[3]

(d) **(i)** Suggest a value for the molar enthalpy change of vaporisation for the azeotropic mixture. Explain how you obtained this value.

(ii) Explain the shape of the boiling point/composition curve.

You may use your knowledge of the two molecules involved, the data in the question, or your value from **(d)(i)**.

[4]

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6 **(a)** **(i)** Describe how proteins are hydrolysed so that they can be analysed by using electrophoresis.

(ii) With the aid of a diagram, describe the process of electrophoresis in the separation of peptides and amino acids.

(iii) Explain how peptides and amino acids are identified by this method.

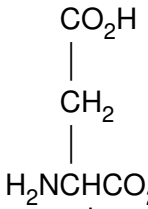
[7]

(b) Suggest and explain the relative movement during electrophoresis, at a pH of 7.0, of the following amino acids.

(i) $H_2NCH_2CO_2H$

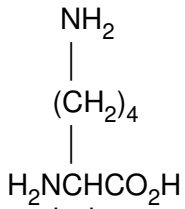
glycine

(ii)



aspartic acid

(iii)



lysine

[3]

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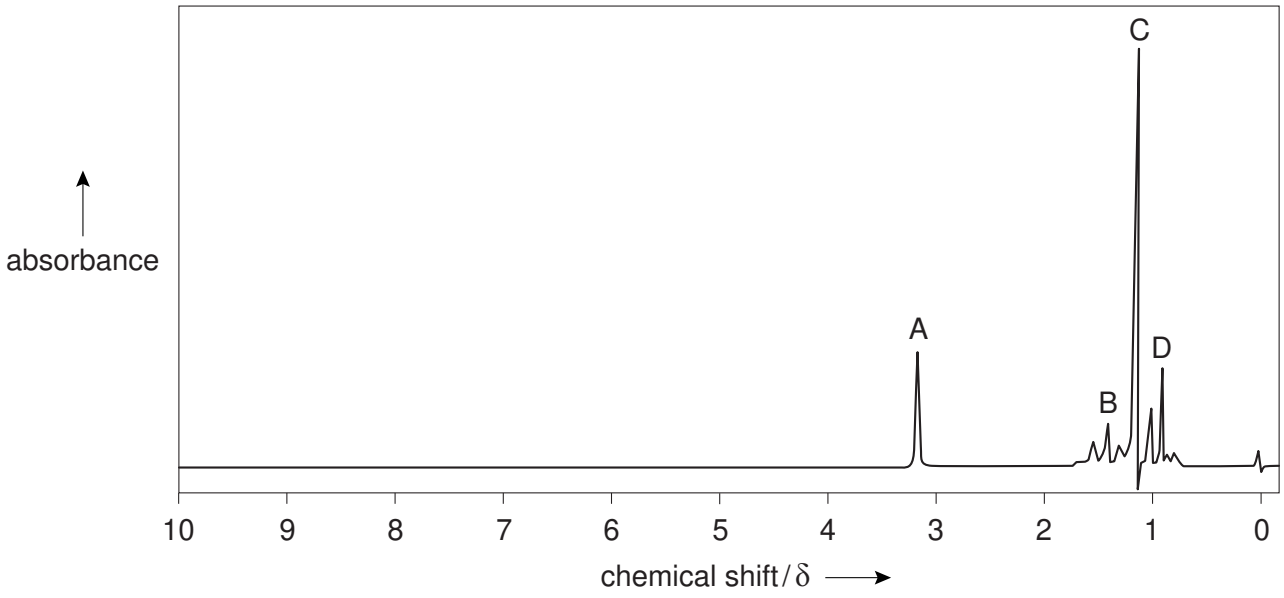
SPECTROSCOPY

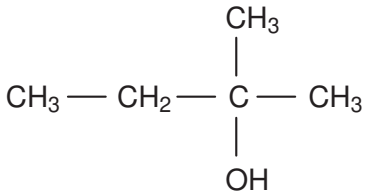
Answer **both** questions on the paper provided.

7 **(a)** Explain, in terms of electron transitions, the difference between the yellow colour of a sunflower, and the yellow colour of a sodium street light. [4]

(b) Study the nmr spectrum of the compound 2-methylbutan-2-ol below.



The structure of 2-methylbutan-2-ol is



(i) Identify which peak or group of peaks is produced by each type of proton in the molecule.

(ii) One of the peaks in the nmr spectrum disappears on the addition of a small amount of D_2O. Identify which peak this is, and state why it disappears.

[6]

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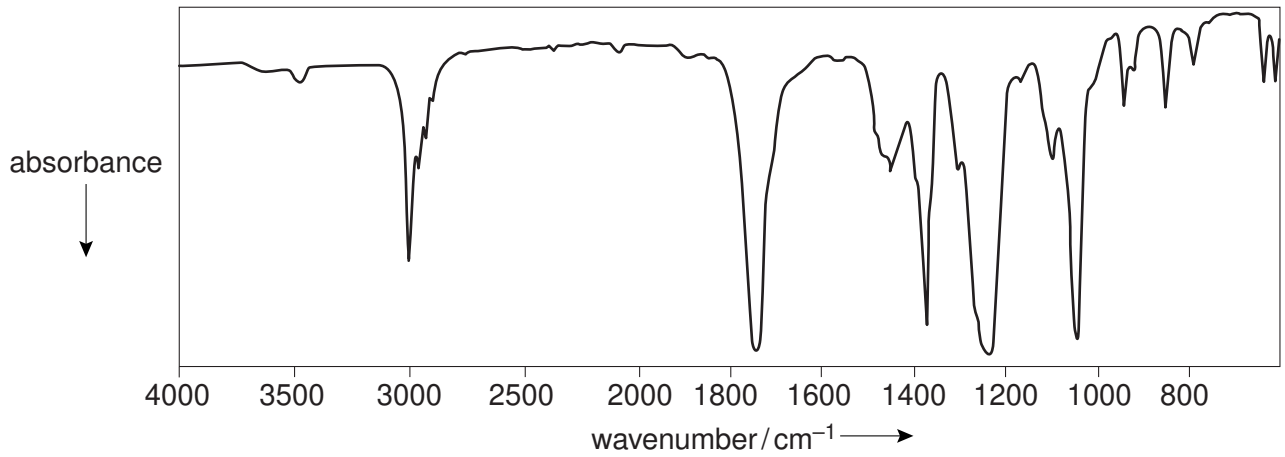
8 **(a)** The mass spectrum of a compound **A** contains a small peak at (M+1) together with a larger peak at (M+2). The M and (M+2) peaks are of equal height.

Explain the origins of these peaks. [3]

(b) Explain why a carbon monoxide molecule shows an absorption in the infra-red region of the spectrum, but a hydrogen molecule does not absorb. [2]

(c) **(i)** The infra-red spectrum shown was produced from compound **B** which contains carbon, hydrogen and oxygen only.



Identify the **two** absorptions, with their wavenumbers, which would allow you to suggest the identity of the functional group(s) present in compound **B**.

(ii) This molecule fragments to produce peaks at *m/e* 29 and *m/e* 43.

Suggest the identity of these fragments and hence that of compound **B**.

[5]

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[Turn over

TRANSITION ELEMENTS

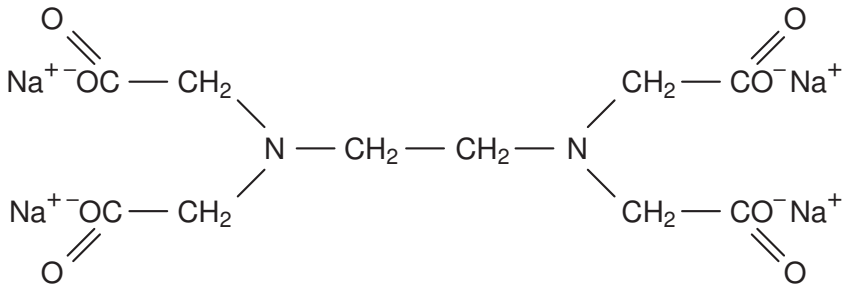
Answer **both** questions on the paper provided.

9 **(a)** What do you understand by the term *ligand*? [2]

(b) Choose **two** neutral molecules and **one** ion that can act as ligands.

Draw a diagram to show clearly how one of these ligands combines with a metal ion such as Cr^{3+}. [2]

(c) The salt tetrasodium ethylenediaminetetra-acetate, EDTA, is a polydentate ligand that forms six bonds to a metal.



EDTA

With many metal ions EDTA forms strong complexes that are usually very soluble; consequently it has been used to counteract the effects of poisoning by heavy metals such as cadmium. The complexed cadmium can then be excreted in urine.

One disadvantage of its therapeutic use is that it also forms soluble complexes with cations such as Ca^{2+} and Zn^{2+} that occur naturally in the body and which are essential for health.

(i) Copy the above formula of EDTA and circle six atoms that can form bonds to a metal ion.

(ii) Use the following data to explain how EDTA alleviates cadmium poisoning. Explain whether calcium or zinc ions might also be complexed at similar concentrations and suggest how these problems could be overcome.

$Ca^{2+} + edta^{4-} \rightarrow [Ca(edta)]^{2-} \quad K_c = 5 \times 10^{10}\,dm^3\,mol^{-1}$
$Cd^{2+} + edta^{4-} \rightarrow [Cd(edta)]^{2-} \quad K_c = 4 \times 10^{16}\,dm^3\,mol^{-1}$
$Zn^{2+} + edta^{4-} \rightarrow [Zn(edta)]^{2-} \quad K_c = 3 \times 10^{16}\,dm^3\,mol^{-1}$

[6]

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10 (a) Potassium manganate(VII) is manufactured from the ore *pyrolusite*, MnO_2, by the following method.

- The ore is dissolved in molten KOH and oxygen from the air is passed through the melt. A solution of potassium manganate(VI) is formed.
- The solution is diluted and electrolysed. Hydrogen is produced at the cathode, where the solution becomes more alkaline due to the formation of potassium hydroxide. A solution of potassium manganate(VII) is formed at the anode.

(i) What colour is a solution of potassium manganate(VI)?

(ii) What will be the colour change at the anode during the electrolysis?

(iii) Construct an equation for the production of potassium manganate(VI) from pyrolusite.

(iv) State the equation for the production of hydrogen at the cathode.

(v) Construct the overall equation for the electrolysis reaction.

[5]

(b) When a solution of potassium manganate(VI) is acidified, a disproportionation reaction occurs, Dark brown MnO_2 is precipitated and a solution of potassium manganate(VII) is formed. Suggest an equation for this reaction. [2]

(c) In neutral or alkaline solution, potassium manganate(VII) reacts with sodium sulphite in a 1:1 mole ratio to give a bright blue solution. Suggest the oxidation state of manganese in the final solution, suggest a formula for the blue compound and write an equation for the reaction.
$[SO_3^{2-} + 2OH^- - 2e^- \longrightarrow SO_4^{2-} + H_2O]$ [3]

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