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

CHEMISTRY **9701/06**

Paper 6 Options

October/November 2006

1 hour

Additional Materials: Answer Paper
Data Booklet

READ THESE INSTRUCTIONS FIRST

If you have been given an Answer Booklet, follow the Instructions on the front cover of the Booklet.
Write your Centre number, candidate number and name 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.

Answer **both** questions on **two** of the Options.
A Data Booklet is provided,

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.

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

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UNIVERSITY of CAMBRIDGE
International Examinations

[Turn over

BIOCHEMISTRY

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

1 Thiomersal is a mercury-containing substance that has been added to vaccines to prevent bacterial and fungal contamination. The vaccine that protects against the smallpox virus contains thiomersal. Viruses consist of DNA or RNA wrapped in a protein coat.

(a) (i) By using a simple block diagram draw two repeat units of a strand of DNA.

(ii) Explain briefly the role of m-RNA.

(iii) Give **two** differences between DNA and RNA.

[6]

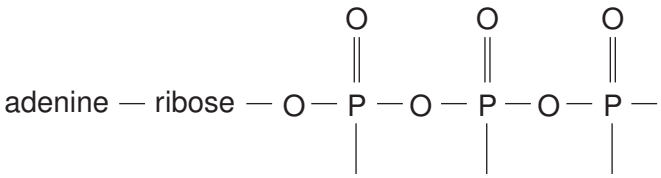
(b) (i) What is meant by the term *tertiary structure* as applied to proteins?
Describe the bonding by which a tertiary structure is stabilised.

(ii) Suggest how the heavy metal mercury in thiomersal may disrupt the tertiary structure of a protein.

[4]

2 The nucleotide adenosine triphosphate, ATP, is the universal source of energy for biological systems. The hydrolysis of ATP results in a large release of energy and the formation of either adenosine diphosphate, ADP, or adenosine monophosphate, AMP.

(a) (i) Copy and complete the structure of adenosine triphosphate.



(ii) Explain why the conversion of ATP to ADP releases a large amount of energy.

(iii) Write an equation to represent the hydrolysis of ATP to ADP.

(iv) Suggest which process forms ATP in the body.

(v) Give **one** way in which the body uses the energy released from the hydrolysis of ATP.

[6]

(b) Explain what is meant by *active transport*. Briefly describe **one** common example of active transport. [4]

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ENVIRONMENTAL CHEMISTRY

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

3 Ozone in the stratosphere reduces the intensity of harmful ultraviolet radiation at the Earth's surface.

(a) Ozone is made in the stratosphere when oxygen atoms react with oxygen molecules.

$$O(g) + O_2(g) \longrightarrow O_3(g)$$

This reaction is first order with respect to both oxygen atoms and oxygen molecules. The rate constant, k, for the reaction is $3.9 \cdot 10^5$ mol^{-1} dm^3 s^{-1}.
The concentration of oxygen atoms in the stratosphere is $3.0 \cdot 10^{-14}$ mol dm^{-3} and of oxygen molecules is $1.3 \cdot 10^{-4}$ mol dm^{-3}.

(i) Calculate the rate of ozone formation, giving units.

(ii) Describe, with the aid of equations, **two** sources of oxygen atoms in the stratosphere. [4]

(b) Describe how chlorofluorocarbons reduce the concentration of ozone in the stratosphere and explain why ozone depletion by chlorofluorocarbons will still be a problem in the year 2100 even with a total ban on their use. [3]

(c) Describe **two other** ways in which the concentration of ozone in the stratosphere is decreased and explain why the concentration of ozone in unpolluted stratosphere remains fairly constant. [3]

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4 The typical composition of solid domestic waste in an urban area in 2004 is shown in the table.

type of solid waste	percentage by mass
glass	9
metals	8
organic waste including waste food	22
paper	38
plastics	9
textiles	2
other	12

(a) Suggest why in 1950 the percentage of plastics in urban waste was much lower. [1]

(b) Many of the solid wastes listed in the table could be recycled. Outline some of the advantages and disadvantages of recycling some of the materials in solid waste. [3]

(c) Solid waste can be disposed of either by using land-fill sites or by incineration.

(i) Describe some of the problems of disposing of solid waste by incineration.

(ii) Explain how land-fill sites filled with solid urban waste can produce gases such as methane and hydrogen sulphide.

[6]

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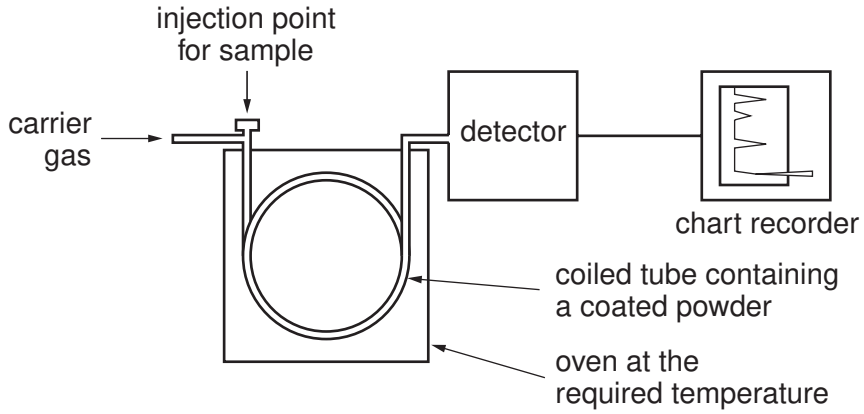
PHASE EQUILIBRIA

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

5 The diagram below represents an apparatus used for gas-liquid chromatography.



(a) **(i)** Explain simply how the apparatus works.

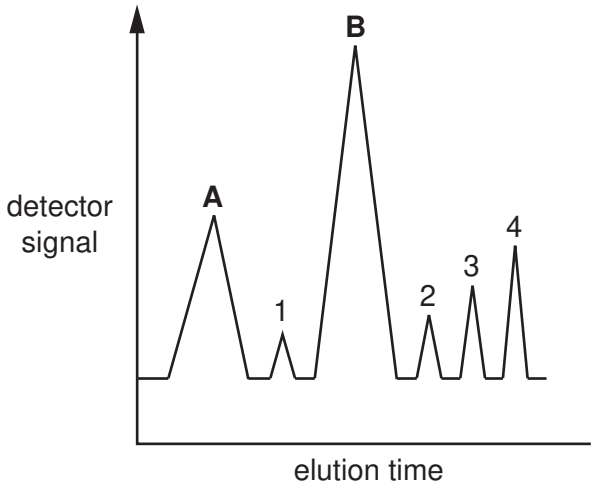
(ii) Suggest what might be used as the carrier gas.

[5]

(b) Police and forensic scientists use gas-liquid chromatography to detect small quantities of organic materials. Suggest **two** materials which might be investigated using this technique.

[2]

(c) Industrial alcohol may be manufactured by the fermentation of an aqueous solution of molasses, followed by distillation. The gas chromatogram of the distillate is shown below.



The small peaks 1, 2, 3 and 4 are due to propan-1-ol, ethyl ethanoate, methanol and ethanal, respectively.

(i) Suggest the identification of the two major peaks **A** and **B**.

(ii) State the direction of the 'elution time' along the horizontal axis.
Suggest an explanation for the order of elution.

[3]

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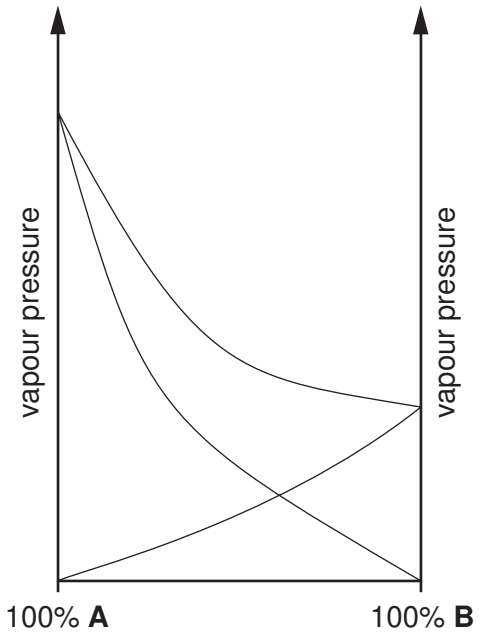
6 **(a)** The following diagram shows, for different mixtures of liquids **A** and **B**, the partial vapour pressures of the two components and the total vapour pressure of the mixture.



Explain how and why this mixture deviates from Raoult's law. [3]

(b) What is meant by the term *azeotrope*, and what features of a mixture cause an azeotrope to form? [2]

(c) The table below gives information about hydrogen chloride, water and the azeotrope formed by them. The azeotrope boils at 108.5 °C.

substance	**boiling point / °C**	**azeotrope composition / % by mass**
hydrogen chloride	85.0	20.2
water	100.0	79.8

Use this information to construct a liquid-vapour diagram. Use your diagram to show that it is impossible to separate completely a mixture of these two compounds by distillation. [5]

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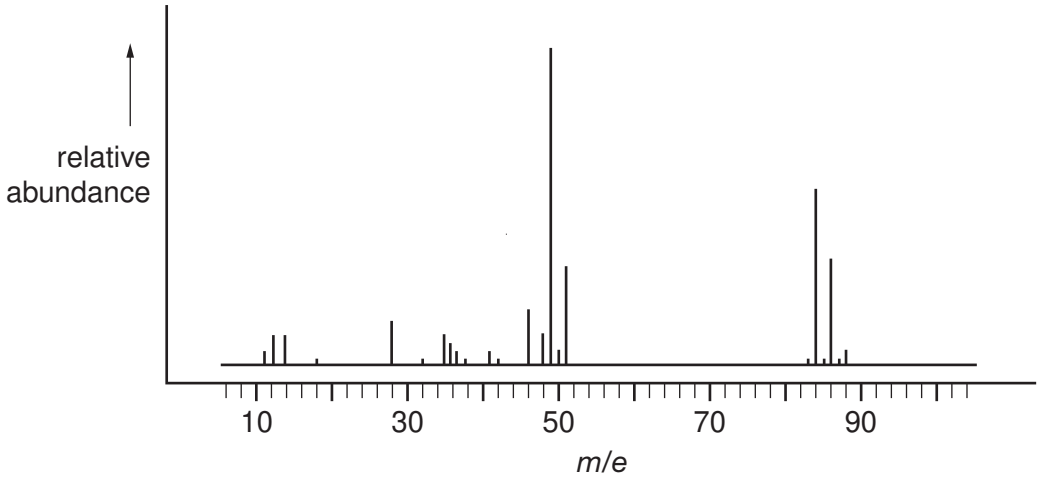
SPECTROSCOPY

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

7 The mass spectrum of the gaseous compound **A**, $C_xH_yCl_z$, is shown below.



m/e	%
M	51.00
M+1	0.55
M+2	35.80
M+4	5.60

(a) **(i)** Account for the existence of the three peaks at 84, 86 and 88.

(ii) Explain the ratio of the abundances of the peaks at 49 and 51.

(iii) Identify compound **A**.

[4]

(b) Why is the relative abundance of the M+1 peak very small? [1]

(c) The peak at *m/e* 28 is due to contamination. Suggest the identity of the contaminant and where it might have come from. [2]

(d) What would be the effect on the relative heights of the M, M+2 and M+4 peaks if the chlorine in the compound were replaced by bromine? [3]

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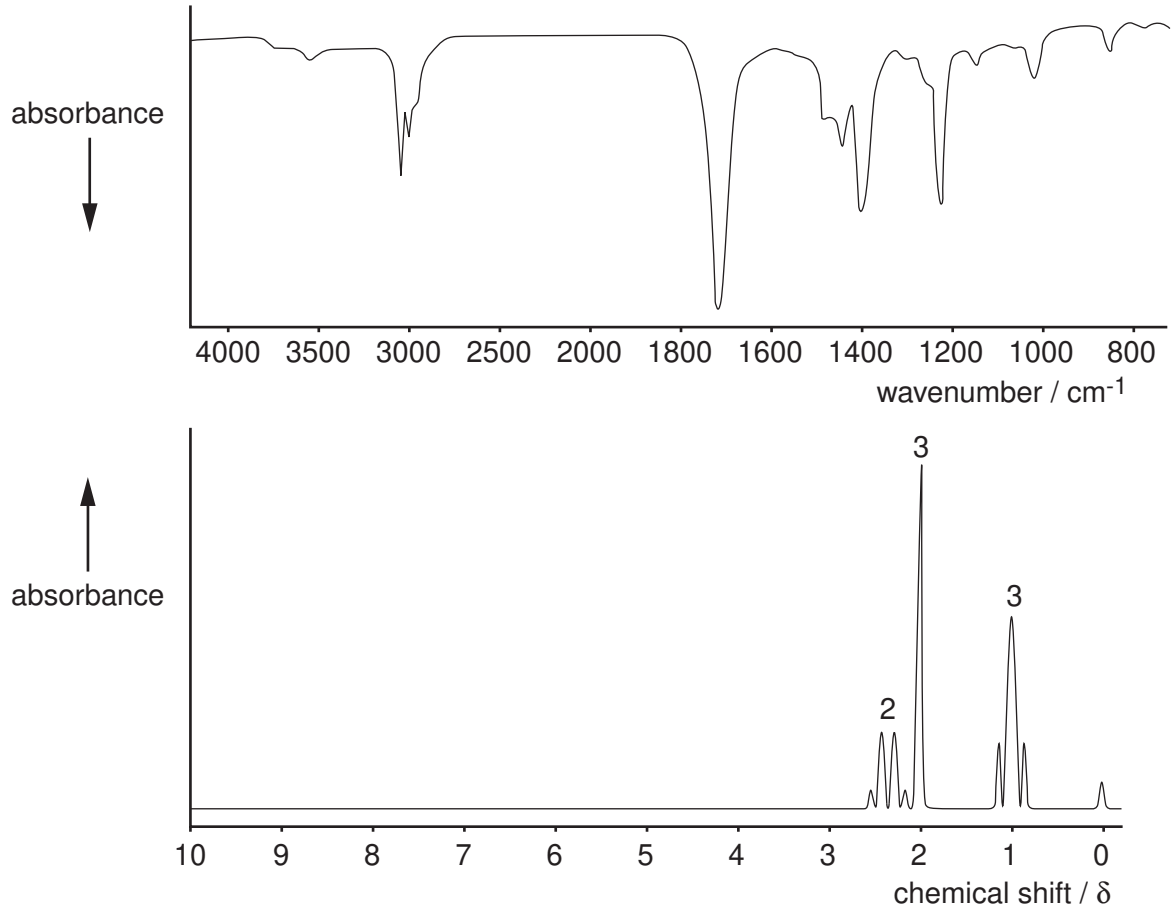
[Turn over

8 **(a)** While working on an organic synthesis, a student isolated a compound **E**.
Mass spectrometry revealed that **E** had an M_r of 72. From this the student proposed that **E** could be either C_5H_{12} or C_4H_8O.

Explain clearly how **uv/visible spectroscopy** could be used to distinguish between these two possible compounds. [3]

(b) The i.r. and n.m.r. spectra below were obtained from **E**.

Deduce a possible structural formula for **E**, indicating clearly the evidence you have used from each spectrum.



[7]

TRANSITION ELEMENTS

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

9 **(a)** **(i)** State the colour of, and the oxidation state of, manganese in the ion MnO_4^{2-}.

(ii) List **three** other common oxidation states of manganese.

(iii) Suggest a reaction you could use to prepare the MnO_4^{2-} ion.

[3]

(b) Explain the following observations using relevant $E^{\ominus}$ values from the *Data Booklet*, and ideas of the relative stabilities of complexes in the presence of different ligands.

(i) Solutions containing $Fe^{2+}(aq)$ **slowly** oxidise to $Fe^{3+}(aq)$ in air.

(ii) The precipitate formed when aqueous sodium hydroxide is added to a solution containing $Fe^{2+}(aq)$ **rapidly** turns brown in air.

[4]

(c) A 6.95 g sample of $FeSO_4.7H_2O$ was dissolved in water and the volume of solution made up to 250 cm^3. The solution was stored in an open container for some time and suffered partial oxidation. On titration of a 25.0 cm^3 portion of the partially oxidised solution with 0.020 mol dm^{-3} $KMnO_4$, it was found that 20.5 cm^3 of oxidant were required to reach the end-point.

Calculate the percentage of Fe^{2+} ions that had been oxidised. [3]

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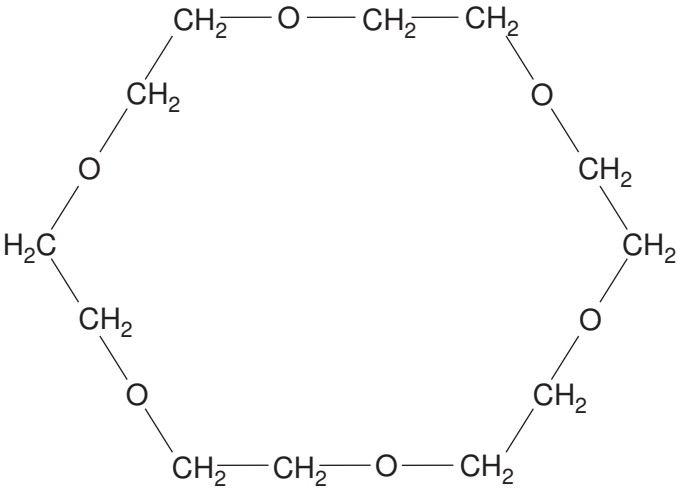
10 (a) (i) State **one** alloy that contains nickel, and give its use.

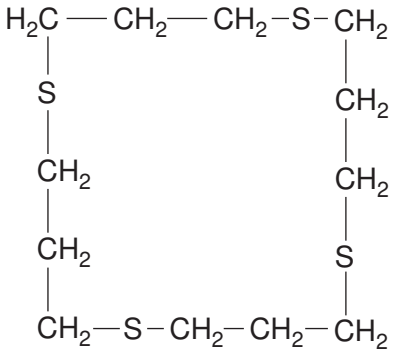
(ii) State an example of an industrially important reaction that uses nickel as a catalyst.

[2]

(b) The 'crown ether' **A** and the 'crown thioether' **B** are polydentate ligands that are used to remove harmful metals from the environment.



A



B

Compound **A** complexes with ions of metals on the left of the Periodic Table, and can be used to extract radioactive strontium ions from groundwater. (Complexes formed by the ions of Group II metals are similar to the complexes formed by transition metal ions.)

Compound **B** complexes well with ions of metals that are towards the right of the Periodic Table, and can be used to extract nickel, copper and lead ions from solutions of industrial waste.

(i) Explain what is meant by a *polydentate ligand*.

(ii) What features of **both** compound **A** and compound **B** make them suitable to act as ligands?

(iii) Suggest the co-ordination number in, and the shape of, the complex formed between **A** and Sr^{2+} ions.

(iv) Suggest the co-ordination number in, and the shape of, the complex formed between **B** and Ni^{2+} ions.

[6]

(c) The complex $[Ni(R_3P)_2Br_2]$ can exist in two isomeric forms. Draw structural formulae to show the shapes of these isomers, and describe the type of isomerism shown. [The R group is an organic group such as methyl, $–CH_3$.] [2]

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