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

CHEMISTRY **9701/06**

Paper 6 Options

May/June 2003

1 hour

Additional Materials: Answer paper
Data Booklet

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.

This document consists of **8** printed pages.

MML 3328 5/02 S471

[Turn over

BIOCHEMISTRY

If you attempt this option, answer **both** questions on the paper provided.

1 **(a)** Explain briefly how enzymes work. [3]

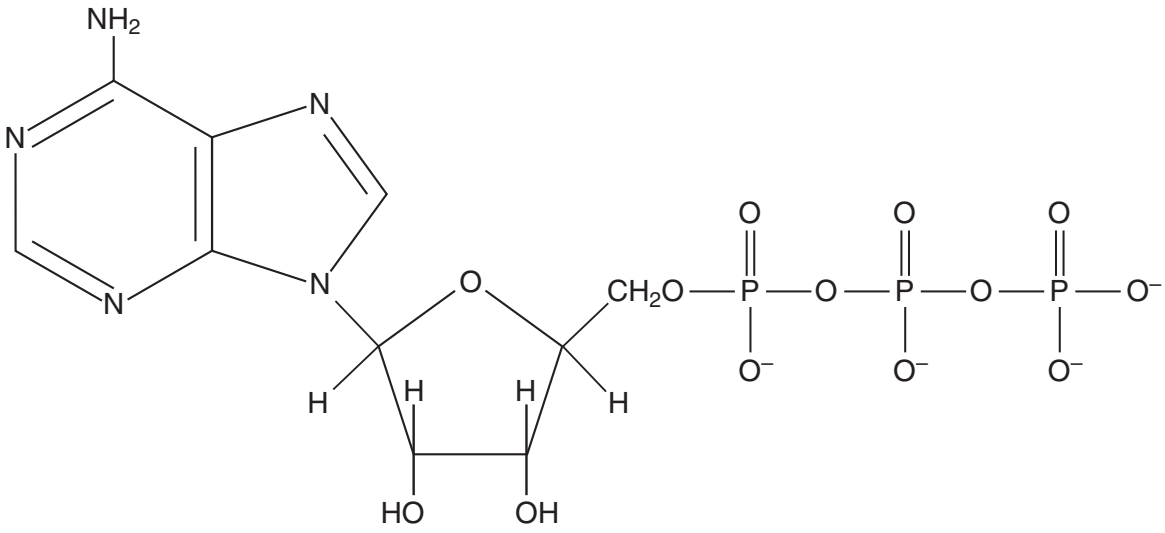
(b) Describe, using sketch graphs, how the rate of an enzyme-catalysed reaction varies with increasing substrate concentration [S].

Draw, on the same axes, **three** sketch graphs of rate against [S] for 1 unit, $^1/_2$ unit and $^1/_4$ unit of enzyme concentration. Label each sketch.

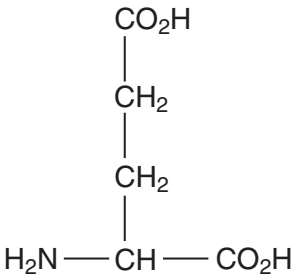
Your sketches should show how (i) V_{max}, and (ii) K_m are affected by the different enzyme concentrations. [7]

2 Each of the five structures **A** to **E** below represents an important biochemical compound.

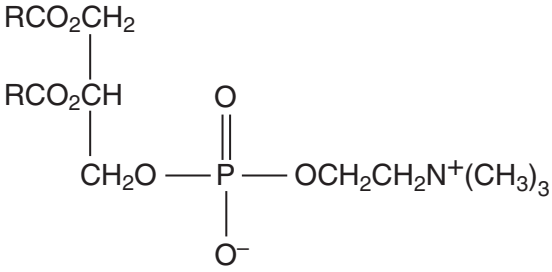
A



B



C



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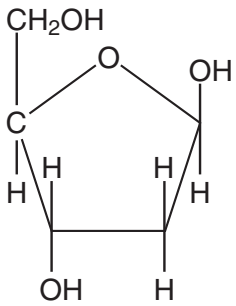
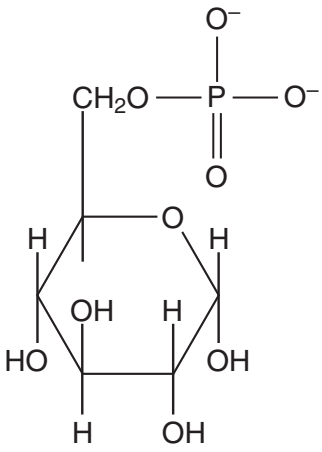


E



Identify as accurately as you can the class of compound to which each belongs, and refer briefly to its role in living organisms. [10]

ENVIRONMENTAL CHEMISTRY

If you attempt this option, answer **both** questions on the paper provided.

3 A village in the North East of England called Quaking Houses is situated near an old coal-mining tip. During the early 1990s the villagers became concerned by the pollution found in their local stream. This consisted of very acidic water containing high concentrations of aluminium ions, iron(III) ions and sulphate ions These are typical products of the run-off from old mining tips.

An innovative scheme was introduced to reduce the pollution. The contaminated water was first passed through organic compost wetlands. As a result, the sulphate ions were converted into sulphide ions, which were precipitated as iron(III) sulphide. The water then became more alkaline and precipitation of aluminium ions occurred. This caused the pH of the water to fall, and so the water was passed through limestone beds to neutralise it.

Although it was initially feared that the use of organic compost wetlands might raise the BOD of the water to unacceptable levels, this proved to be only a short-term problem and the purity of the stream was greatly improved.

(a) Explain how hydrated aluminium ions make water acidic. [3]

(b) **(i)** What kind of conditions did the organic compost wetlands provide?

(ii) Explain how the conversion of sulphate ions to sulphide ions makes the water more alkaline.

(iii) Suggest how the aluminium ions become precipitated, and why this lowers the pH of the water.

(iv) Write an equation to show how limestone beds neutralise the water.

[5]

(c) Suggest why the use of organic compost wetlands might cause the BOD of the water to rise. [2]

4 Much research has been focused on the causes of the 'hole' that has appeared in the Antarctic ozone layer. It is likely that this is caused by the release of chlorine free radicals formed as the winter clouds disperse with the onset of the polar spring.

During the lengthy winter period, the clouds have accumulated hydrogen chloride and the compound $ClONO_2$, obtained from the reaction of ClO free radicals and NO_2. In the spring, the temperature rises as the sunlight intensity increases and $ClONO_2$ reacts with HCl to form chlorine molecules.

(a) Describe, in detail, the processes which maintain the ozone layer in the unpolluted stratosphere. [5]

(b) Explain how the formation of chlorine gas in the polar spring leads to a substantial destruction of the ozone layer. [3]

(c) The gas NO_2 can have a role in limiting the destruction of the ozone layer. Explain how this is possible. [2]

PHASE EQUILIBRIA

If you attempt this option, answer **both** questions on the paper provided.

5 Tin and bismuth form a eutectic system. The freezing points of liquid tin-bismuth mixtures are as follows.

% of tin (by mass)	0	20	30	60	70	80	100
f.p. / °C	271	208	176	168	185	200	232

(a) **(i)** On graph paper, draw the eutectic diagram for this system. Label the axes and also the areas of the diagram.

(ii) What is the eutectic temperature and the composition of the eutectic?

[5]

(b) A mixture of 90% by mass of tin and 10% by mass of bismuth at 250 °C is allowed to cool.

Sketch a cooling curve for this mixture, indicating the temperatures at which phase changes occur. Label each section of the cooling curve. [4]

(c) State **one** application of eutectic systems. [1]

6 **(a)** **(i)** Outline and explain the technique of gas/liquid chromatography.

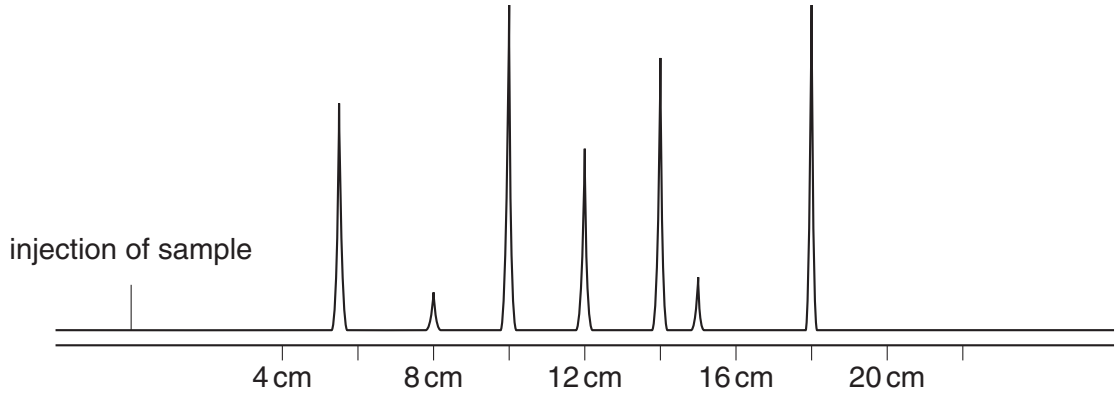
(ii) Name the process that is involved in this type of separation.

[4]

(b) The retention times of some organic liquids on a gas/liquid chromatogram run at a certain temperature are given below.

Compound	Retention time / s	Compound	Retention time / s
methanol	6	propanone	11
ethanol	24	butanone	20
propan-1-ol	36	pentan-2-one	26
propan-2-ol	30	pentan-3-one	28
		cyclohexanone	33

A mixture of liquids was injected, under the same conditions, on to the same column and the following trace was obtained.



(i) Given that the paper in the recorder moves at 0.5 cm s^{-1}, what compounds can you identify in the mixture?
[Not all the peaks can be identified.]

(ii) Suggest a suitable temperature range for the chromatographic analysis of the organic compounds in the table.

(iii) Suggest the chemical nature of the stationary phase. Explain your answer in terms of the intermolecular bonds present in the organic compounds.

[6]

SPECTROSCOPY

If you attempt this option, answer **both** questions on the paper provided.

7 **(a)** Explain why the complex $[Cu(H_2O)_6]^{2+}$ is coloured and why the complex $[Zn(H_2O)_6]^{2+}$ has no colour. [5]

(b) For each of the compounds shown below, identify the various electronic transitions which bring about absorptions in the uv/visible region of the spectrum.

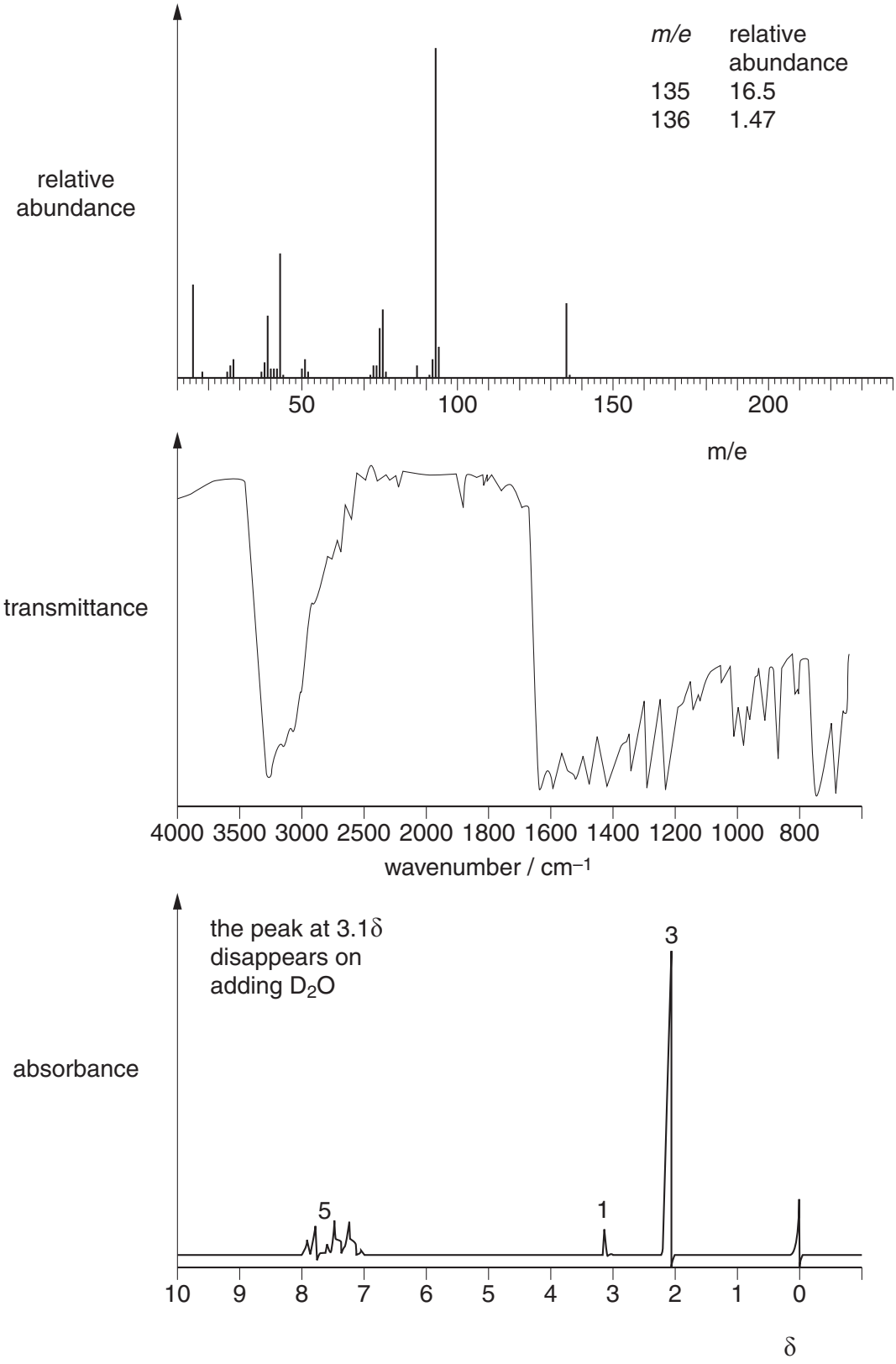
(i) $C_6H_5NO_2$

(ii) CH_3NH_2

(iii) $CH_3CH{=}CH_2$

[5]

8 The spectra shown below were obtained from compound **Q**, which contains the elements carbon, hydrogen, nitrogen and oxygen.



(a) Consider the nmr, mass and ir spectra in turn. Explain what information each spectrum gives about the structure of **Q**. [8]

(b) Use your answers to **(a)** to suggest what functional groups are present in **Q** and hence give a possible structure for the compound. [2]

TRANSITION ELEMENTS

If you attempt this option, answer **both** questions on the paper provided.

9 **(a)** Describe in outline the use of carbon monoxide in the industrial production of pure nickel. [4]

(b) Describe and explain **one** large scale use of nickel. [2]

(c) Nickel exhibits both 4-fold and 6-fold co-ordination in its complexes. Both of the following complexes can exist in two isomeric forms.

Draw structural formulae to show the shapes of these isomers, and describe the type of isomerism shown.

$[Ni(H_2O)_4(NH_3)_2]Cl_2$ $Ni(NH_3)_2Cl_2$ [4]

10 **(a)** Briefly explain why complexes of Cu(II) are coloured whereas complexes of Cu(I) are colourless, despite the fact that the d-orbitals are split into two energy levels in both series of complexes. [1]

(b) Cu(I) ions are unstable in aqueous solution, readily undergoing disproportionation.

(i) What do you understand by the term *disproportionation*?

(ii) Write an ionic equation showing the disproportionation of $Cu^+(aq)$ ions, and choose relevant $E^\ominus$ values from the Data Booklet to calculate $E^\ominus_{cell}$ for the reaction. [3]

(c) Cu(I) is stable in insoluble salts and in some complexes. Use this fact to explain the following observations, writing equations for all reactions.

(i) The addition of KI(aq) to $CuSO_4(aq)$ produces a white precipitate and a brown solution. The solution turns colourless when aqueous sodium thiosulphate is added.

(ii) On boiling with copper foil, the colour of a solution of $CuCl_2$ in dilute hydrochloric acid changes from blue to colourless. After filtering off the excess copper metal and diluting the solution with water, a white precipitate is formed, which contains 35.9% of chlorine by mass. [6]