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

CHEMISTRY **9701/06**

Paper 6 Options

May/June 2006

1 hour

Additional Materials: Answer Booklet/Paper
Data Booklet

READ THESE INSTRUCTIONS FIRST

If you have been given a 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.
You may use a calculator.

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.

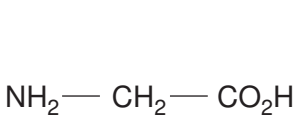
This document consists of **6** printed pages and **2** blank pages.

© UCLES 2006

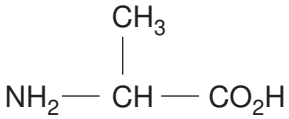
BIOCHEMISTRY

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

1 Spider silk is a natural structural protein, which belongs to the same group as collagen and keratin. It contains a high proportion of the amino acids glycine and alanine.



glycine



alanine

(a) **(i)** Draw the structure of the tripeptide Gly-Ala-Gly, showing the displayed structure of the peptide linkages.

(ii) What type of reaction takes place during the formation of a peptide?

[4]

The flexibility of spider silk is due to the glycine-rich regions in the structure.

(b) **(i)** Explain why glycine-rich regions of the protein structure give rise to its flexibility.

(ii) Silk is hydrophobic. Explain the meaning of the term *hydrophobic*.
What gives silk this property?

[4]

(c) Spider silk is considered to be a crystalline structure and has properties similar to nylon and *Kevlar*.

(i) Explain why silk and nylon have similar properties.

(ii) If spider silk could be manufactured industrially, suggest a possible use.

[2]

2 Deep-sea divers may experience 'nitrogen narcosis' during a dive. At sea level, nitrogen is inert and dissolves in the blood. As a diver goes deeper underwater, the partial pressure of nitrogen increases and more nitrogen dissolves in the blood. As a consequence, nitrogen can diffuse into the phospholipid bilayer.

(a) Draw a diagram of a phospholipid bilayer. State the nature of the intermolecular forces acting at **each** end of a phospholipid in a bilayer. [3]

(b) Nitrogen collects in the alkyl part of the lipid bilayer.

(i) How would the nitrogen interact with this section of the lipid bilayer?

(ii) Suggest what effect a high nitrogen concentration might have on the lipid bilayer.

[3]

(c) The high nitrogen concentration impairs the conduction of nerve impulses. Nerve impulses rely upon movement of Na^+ and K^+ into and out of the cell.

Describe how Na^+ and K^+ move into and out of cells such as nerve cells, with reference to the parts of the cell and the molecules involved. [4]

© UCLES 2006

ENVIRONMENTAL CHEMISTRY

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

3 Two of the characteristics of drinking water are that it must be free from
- disease-causing organisms,
- harmful or toxic chemicals.

(a) Describe, with the aid of an equation, how chlorine helps to remove disease-causing organisms from water. [2]

(b) Explain why chlorinated organic compounds may be found in drinking water. [1]

(c) River water is often polluted by phosphates that have come from detergents or fertilisers.

(i) Explain why phosphates are added to detergents.

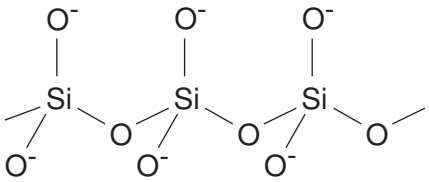
(ii) Describe the effect of excess phosphates in river water.

(iii) River water containing phosphates is a source of drinking water.
During the water purification process the phosphates can be removed by reaction with an excess of aluminium ions.

A 1000 dm^3 sample of river water is mixed with an excess of aluminium ions and a precipitate of mass 488 g is obtained.
Assuming all the phosphate exists as $PO_4^{3-}(aq)$ write an equation showing the formation of this precipitate. Calculate the concentration, in mol dm^{-3}, of phosphate ions in the river water sample. [7]

4 Soil is a mixture of decomposing organic material and inorganic compounds such as silicates or aluminosilicates.

The diagram shows the silicate repeat unit of a clay.



(a) **(i)** An aluminosilicate has one aluminium atom substituted for a silicon atom in the repeat unit shown above. Give the formula for the repeat unit of the aluminosilicate.

(ii) Suggest, with reference to silicates and aluminosilicates, how electrical neutrality is achieved.

[3]

(b) The pH of soil is controlled by both clays and organic material such as humus.

(i) Explain how clays can help to maintain soil acidity.

(ii) Explain how humus can help to maintain soil acidity. Assume that humus behaves as a carboxylic acid, RCO_2H.

[4]

(c) Farmers often use lime to reduce the acidity of soil.
Explain how lime reduces the acidity of soil and explain the limitations or disadvantages of liming acidic soil. [3]

© UCLES 2006

[Turn over

PHASE EQUILIBRIA

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

5 **(a)** **(i)** State Raoult's Law.

(ii) The vapour pressures of hexane and octane at a certain temperature are 48 kPa and 36 kPa respectively. Calculate the vapour pressure at the same temperature of a mixture of the two liquids with a mole fraction of 0.30 of hexane.

(iii) State what assumption you have made in this calculation, and explain why the assumption is reasonable in this case.

[5]

(b) Propanone and trichloromethane form a mixture with a negative deviation from Raoult's Law, which has a minimum vapour pressure at a mole fraction of 0.50.

(i) Explain why this pair of liquids produces a negative deviation.

(ii) Suggest why the minimum occurs at a mole fraction of 0.50.

[2]

(c) A sample of liquid of 0.25 mole fraction trichloromethane and 0.75 mole fraction propanone is distilled using a fractionating column.
Describe, with reasons, the sequence of the composition of the distillate obtained when the above mixture is distilled. [3]

6 **(a)** The triple point of carbon dioxide is 216.6 K and 5.11 atm. Solid carbon dioxide is more dense than liquid carbon dioxide.

Use this information to sketch and label the phase diagram of carbon dioxide. [5]

(b) Use the phase diagram you have drawn to comment on or explain the following observations about liquid carbon dioxide as present in some fire extinguishers.

(i) At 25 °C, the pressure inside an unopened fire extinguisher is over 60 atm.

(ii) When the nozzle is opened, the carbon dioxide is seen to form a finely-divided, white, powdery solid.

[4]

(c) How does the phase diagram for carbon dioxide differ from that of water? [1]

© UCLES 2006

SPECTROSCOPY

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

7 **(a)** Carbon dioxide has the displayed formula O=C=O. Predict the number of absorptions you would expect in an infra-red spectrum of carbon dioxide and identify the reason for each absorption. [3]

(b) An organic compound $C_4H_5O_2N$ is known to have **two** functional groups. These groups are responsible for absorptions at 1710 cm^{-1}, 2260 cm^{-1} and a broad peak at 2800 cm^{-1} in the infra-red spectrum of this compound.

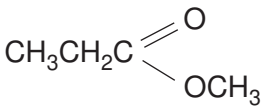
(i) Identify the bond responsible for each of these absorptions.

(ii) Suggest a possible structure for the compound.

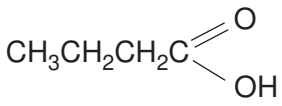
[4]

(c) Another spectroscopic technique could be used to confirm the proposed structure. Name a possible technique and briefly describe the evidence you would expect it to provide. [3]

8 A compound **E** is known to have either structure **I** or structure **II** as shown below.



I



II

E was investigated by using infra-red spectroscopy and nuclear magnetic resonance spectroscopy.

(a) The infra-red spectrum of **E** showed strong peaks at 1740 and 1200 cm^{-1}. Indicate which structure this suggests for **E**, outlining your reasoning. [2]

(b) **(i)** The nuclear magnetic resonance spectrum of **E** includes a triplet of peaks and a quartet of peaks. Indicate which groups of protons in the molecule are responsible for each of these multiple peaks, and outline how the splitting patterns arise.

(ii) The nuclear magnetic resonance spectrum of **E** shows one other peak. Suggest the chemical shift and the splitting pattern of this peak.

(iii) Describe and explain how the addition of deuterium oxide to a sample of **E** could be used to distinguish between the two structures shown.

[6]

(c) The mass spectra of compounds **I** and **II** are different. Give **two** differences in these spectra. [2]

© UCLES 2006

TRANSITION ELEMENTS

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

9 **(a)** **(i)** Stainless steel is widely used to make cutlery. Suggest a suitable percentage by mass of chromium to use in stainless steel.

(ii) Suggest an explanation of how the addition of chromium to iron makes it "stainless", i.e. reduces its susceptibility to corrosion.

[3]

(b) Compound **A** is a red liquid containing the following percentages by mass.
Cr, 33.6%; O, 20.6%; C*l*, 45.8%.

(i) Calculate the empirical formula of **A** and state the oxidation number of chromium in it.

(ii) When dissolved in water, compound **A** produces an orange, acidic solution that gives a white precipitate when $AgNO_3$(aq) is added.
On adding NaOH(aq) to a solution of **A** in water, the orange solution turns yellow.

Explain these observations, giving equations where appropriate.

[7]

10 *Use of the Data Booklet is relevant to this question.*

(a) Explain why transition element complexes are often coloured. [3]

(b) Suggest explanations for the following colour changes, writing equations where appropriate.

(i) The addition of KSCN(aq) to Fe^{3+}(aq) produces a deep blood-red colouration, which disappears when NaF(aq) is added.

(ii) The addition of SO_2(aq) to an acidified solution of ammonium vanadate(V), NH_4VO_3, produces a bright blue solution, which turns green when Sn^{2+}(aq) is added.

[7]

© UCLES 2006

BLANK PAGE

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

University of Cambridge International Examinations is part of the University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.