CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT

A Level

Chemistry

Session: 1994 June
Type: Question paper
Code: 9250

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

General Certificate of Education Advanced Level

CHEMISTRY 9250/1

PAPER 1

Monday **6 JUNE 1994** Afternoon 2 hours 30 minutes

Additional materials:
Answer paper
Data booklet
Graph paper
Mathematical tables

TIME 2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer **eight** questions.

Answer **three** questions from Section A, **two** questions from Section B and **three** questions from Section C.

Write your answers on the separate answer paper provided.

Begin each answer on a fresh page.

If you use more than one sheet of paper, fasten the sheets together.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

A Data Booklet is provided.

Mathematical tables and graph paper are available.

Where relevant, the symbols for aluminium, chlorine and iodine are printed as: A*l*; C*l*; I; respectively.

This question paper consists of 6 printed pages and 2 blank pages.

Section A

Answer **three** questions in this section.

1 Describe the various forces responsible for keeping particles together in elements and compounds and their effects on physical properties, making use of the data below.

substance	*formula*	*molar mass* M_r	*m.p./*°C
neon	Ne	20	–248
argon	Ar	40	–189
water	H_2O	18	0
sodium fluoride	NaF	42	993
diamond	C	12	3550

[10]

2 Iodine and chlorine can react together to give a compound, **A**. The mass spectrum of **A** contains 12 peaks, of which the first three are at *m/e* values of 35, 37 and 127, and the last one is at an *m/e* value of 238.

(a) Predict the *m/e* values of **four** of the other peaks, giving the formula of the species responsible for each peak. [3]

(b) Suggest a molecular formula for compound **A**, and calculate the oxidation number and the percentage, by mass, of iodine in it. [2]

(c) When dissolved in an excess of aqueous potassium iodide, **A** liberates iodine quantitatively.

(i) Predict the equation for the reaction between **A** and potassium iodide.

(ii) What volume of 1.00 mol dm^{-3} sodium thiosulphate would be required to react with all the iodine liberated when 1.00 g of **A** reacts with an excess of aqueous potassium iodide? [3]

(d) Draw a dot-and-cross diagram showing the bonding in **A**, and draw a diagram of the shape of the molecule you would predict. [2]

3 The major acidic component of soured milk is lactic acid:

$$CH_3CH(OH)CO_2H$$

When 10.0 cm^3 of a solution of lactic acid was titrated against 0.050 mol dm^{-3} sodium hydroxide the following pH readings were obtained:

Volume of NaOH *added*/cm^3	pH
0	2.5
2	3.1
4	3.4
6	3.7
8	3.9
10	4.1
12	4.4
14	4.7
16	9.1
18	11.6
20	11.8

(a) Plot a graph of these results with pH on the y-axis and volume added on the x-axis. Comment on the shape of the curve before, at and after neutralisation. [4]

(b) Suggest an indicator, giving a reason for your choice. [2]

(c) Calculate the concentration of the lactic acid in the solution in

(i) mol dm^{-3};

(ii) g dm^{-3}. [2]

(d) Deduce the K_a value for lactic acid, giving your reasoning and the units. [2]

4 **(a)** Batteries for electric cars can be made with one electrode of zinc, and the other of carbon. During discharge, the zinc dissolves as ions, which migrate through the electrolyte to the carbon electrode, where they combine with oxygen from the air and water to form zinc hydroxide.

(i) Sketch a diagram of the above cell, showing which battery electrode provides electrons to the external circuit (i.e. the negative electrode). [2]

(ii) By choosing **two** suitable electrode processes from the *Data Booklet,* write the overall equation for the reaction that occurs during discharge.

Calculate the e.m.f. of one cell of the battery, assuming standard conditions. [3]

(iii) Suggest a suitable substance to use as an electrolyte. [1]

(b) A small petrol car needs about 3.6 x 10^4 kJ to travel 100 km.

What volume of petrol (C_8H_{18}) would it use during this journey, assuming that the engine efficiency was 20%?

[ΔH_c (C_8H_{18}) = –5470 kJ mol^{-1}; density of petrol = 0.66 g cm^{-3}] [4]

[Turn over

Section B

Answer **two** questions in this section.

5 **(a)** Outline the process by which chlorine is manufactured from brine. [2]

(b) Describe how chlorine reacts with

(i) hot, aqueous sodium hydroxide;

(ii) aqueous potassium bromide;

(iii) ethene.

In each case, describe what is seen, write an equation and identify the type of reaction occurring. [8]

6 **(a)** What oxidation numbers do the elements sodium to phosphorus show in their chlorides? Outline the reactions, if any, of these chlorides with water and relate these reactions to the bonding present. [5]

(b) Sulphur and chlorine can react together to form S_2Cl_2. When 1.00 g of this sulphur chloride reacted with water, 0.36 g of a yellow precipitate was formed, together with a solution containing a mixture of sulphurous acid, H_2SO_3, and hydrochloric acid.

(i) Use the above data to deduce the equation for the reaction between S_2Cl_2 and water. [3]

(ii) What volume of 1.00 mol dm^{-3} sodium hydroxide would be required to neutralise the final solution? [2]

7 **(a)** Nitrogen can be obtained in the laboratory by warming a mixture of ammonium chloride and sodium nitrite, $NaNO_2$. Steam is also produced and a solid is left.

(i) Suggest an identity for the solid and write a balanced equation for the reaction. [2]

(ii) Calculate the changes in oxidation numbers of the nitrogen atoms during this reaction. [2]

(iii) A similar reaction takes place when ammonium chloride is heated with sodium nitrate, $NaNO_3$, but this time the only different product is an oxide of nitrogen.

Suggest a formula for this oxide, and calculate the oxidation number of nitrogen in it. [2]

(b) One of the main uses of nitrogen compounds is for agricultural fertilisers.

(i) Name **two** compounds used in this way. [1]

(ii) Why is it sometimes necessary to apply nitrogen-based fertilisers several times during the growing season, whereas one application of a phosphate-based fertiliser is all that is likely to be needed? [1]

(iii) What are the environmental consequences of the over-use of nitrogen-based fertilisers? How do they arise? [2]

Section C

Answer **three** questions in this section.

8 **(a)** Draw a displayed/full structural formula of benzoyl chloride, C_6H_5COCl. How can it be made, starting from benzoic acid? [3]

(b) Describe **three** reactions of benzoyl chloride, giving reagents and products in each case. How and why does the reactivity of benzoyl chloride differ from that of (chloromethyl)benzene (benzyl chloride), $C_6H_5CH_2Cl$? [7]

9 **(a)** Explain the differences in solubility and melting point of the following substances as fully as you can.

substance	*formula*	*solubility in water*	*m.p. / °C*
phenylamine	$C_6H_5NH_2$	insoluble	–6
benzoic acid	$C_6H_5CO_2H$	sparingly soluble	121
phenylalanine	$C_6H_5CH(NH_2)CO_2H$	soluble	greater than 200 °C, with decomposition

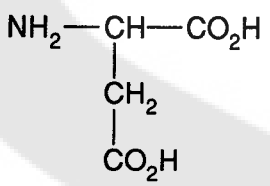
[6]

(b) Draw displayed/full structural formulae of the products of the reactions between phenylalanine and

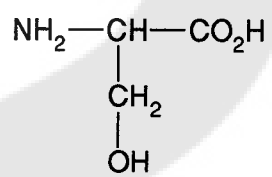
(i) NaOH(aq);

(ii) HCl(aq). [2]

(c) Two other amino acids are aspartic acid and serine:



aspartic acid



serine

Draw the structural formula of a dipeptide formed from these two amino acids, showing the ionic form in which it would exist at pH 12. [2]

10 **(a)** State the type of reaction undergone and give the structural formula of each of the organic products obtained when propan-2-ol reacts with the following reagents:

(i) HBr;

(ii) sodium metal;

(iii) alkaline aqueous iodine. [5]

(b) Alcohol **B** has esters which are responsible for the flavours of various fruits and has the molecular formula $C_5H_{12}O$. Reaction of **B** with acidified potassium dichromate(VI) produces a compound **C**, $C_5H_{10}O_2$. Heating **B** over Al_2O_3 produces **D**, C_5H_{10}. Vigorous oxidation of **D** forms 2-methylpropanoic acid as one of the products.

Suggest structures for **B, C** and **D** and explain the reactions involved. [5]

11 By the use of a suitable example of each mechanism, describe the similarities and differences between those reactions classified as electrophilic substitutions and those classified as electrophilic additions. You should include in your answer:

(a) the reagents used and their function;

(b) the reaction conditions used;

(c) the products formed;

(d) the mechanism of each reaction;

(e) how the structure of a molecule determines the mechanism. [10]

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

General Certificate of Education Advanced Level

CHEMISTRY 9250/2

PAPER 2 Option Topics

Friday **10 JUNE 1994** Afternoon 1 hour

Additional materials:
Answer paper
Data booklet
Graph paper
Mathematical tables

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer **four** questions.

Answer no more than **two** questions from any **one** section.

Write your answers on the separate answer paper provided.

If you use more than one sheet of paper, fasten the sheets together.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You should not attempt questions on Options for which you have not been prepared.

Mathematical tables and graph paper are available: a Data booklet is provided.

Where relevant, the symbols for aluminium, chlorine and iodine are printed as: Al; Cl; I; respectively.

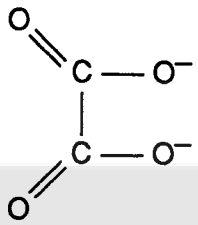
This question paper consists of 15 printed pages and 1 blank page.

FURTHER TRANSITION METAL CHEMISTRY

Not more than **two** *questions to be answered from this section.*

1 **(a)** **(i)** Explain what is meant by the *stoichiometry* of a transition metal complex.

(ii) Calculate the stoichiometry of the complex formed between iron and ethanedioate ions,



from the following data.

The potassium salt of the iron(III) ethanedioate complex has the following composition by mass:

K, 26.8%; Fe, 12.8%; C, 16.5%; O, 43.9% [4]

(b) Suggest the geometry of the above complex and explain what type of isomerism it could show. [3]

(c) When aqueous potassium thiocyanate, KSCN(aq), is added to a solution of the above complex, a red colour is observed. By contrast, when aqueous potassium thiocyanate is added to aqueous potassium hexacyanoferrate(III), no such red colour is formed.

Suggest an explanation for this difference. [3]

2 **(a)** Explain why transition elements often show variable oxidation states in their compounds, whereas other metals tend not to do so. [3]

(b) Use the *Data Booklet* to predict the reactions, if any, that occur when **acidified** solutions containing the following pairs of reagents listed in **(i)** to **(iii)** below are mixed.

Calculate the relevant overall $E^{\ominus}$ values, and state the change in oxidation number of any transition metal during any reaction.

(i) $MnO_4^-(aq)$ and $Br^-(aq)$

(ii) $Fe^{3+}(aq)$ and $Cl_2(aq)$

(iii) $VO_2^+(aq)$ and $Sn^{2+}(aq)$ [7]

3 **(a)** Explain why aqueous ions containing transition metals are coloured, whereas aqueous ions of other metals are usually colourless. [You may wish to use $[Cr(H_2O)_6]^{3+}$ and $[Al(H_2O)_6]^{3+}$ as examples.] [5]

(b) When an aqueous solution of the ligand *L* is mixed with an aqueous solution of a chromium salt, the following equilibrium is set up:

$$Cr^{3+}(aq) + 6L(aq) \rightleftharpoons [CrL_6]^{3+}(aq)$$

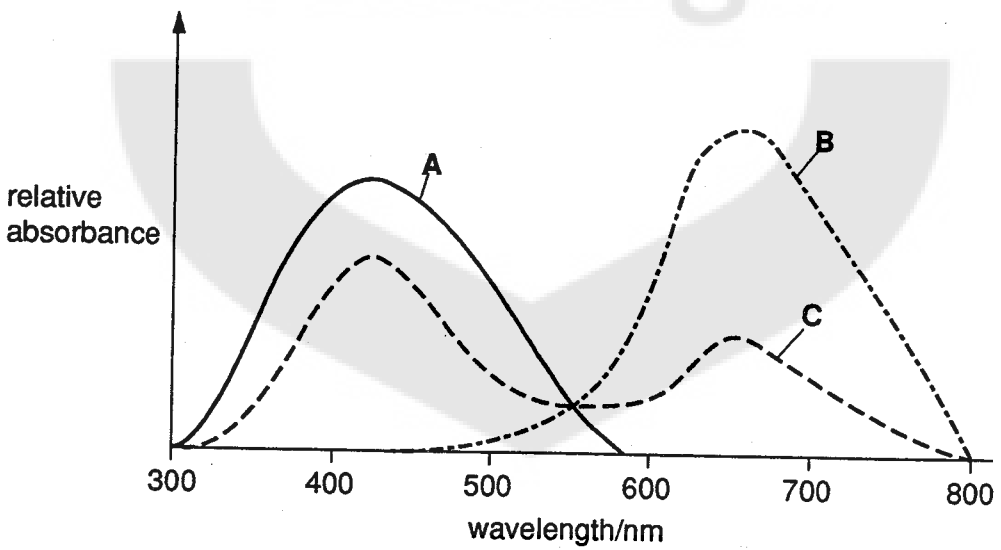
A similar equilibrium occurs with the ligand *J*, forming $[CrJ_6]^{3+}(aq)$.

The equilibrium constants for these reactions are both large and similar to each other, so that $[Cr^{3+}(aq)]$ in the solution is very small in the presence of the ligands.

Solutions **A**, **B** and **C** were made up by mixing 0.1 mol dm^{-3} solutions of Cr^{3+}, *L* and *J*. The table below gives the volumes of each used.

	volumes of 0.1 mol dm^{-3} solution / cm^3		
solution	$Cr^{3+}(aq)$	*L*	*J*
A	2	98	0
B	2	0	98
C	2	49	49

The visible absorption spectra of the three solutions **A**, **B** and **C** are shown below:



(i) What are the colours of solutions **A** and **B**?

(ii) The spectra show that the peak in the curve for solution **B** is at a longer wavelength than is the peak in the curve for solution **A**.

What deduction can be made from this fact about the size of the d-orbital splitting in the two complexes?

(iii) The absorbance of a solution at a particular wavelength is proportional to the concentration of the ion responsible for the absorption.

Use this information and the given absorption spectra to suggest and explain which ligand, *L* or *J*, forms the stronger bond with Cr^{3+}. [5]

[Turn over

PHASE EQUILIBRIA

Not more than **two** *questions to be answered from this section.*

4 Magnesium and calcium form an unusual two-component system in that these two elements form an intermetallic compound of composition 55.5% calcium and 44.5% magnesium, by mass. The formation of this compound also gives rise to two eutectic points for the system.

The temperatures at which liquid mixtures of the two metals begin to solidify are given below.

composition % Mg	0	10	20	25	30	44.5	60	70	80	85	90	100
temperature of first formation of solid from melt / °C	840	710	485	560	625	720	660	605	530	560	600	650

(a) Calculate the empirical formula of the intermetallic compound. [1]

(b) **(i)** Plot on graph paper the eutectic diagram of the magnesium/calcium system.

(ii) Record **on your graph** the values of the two eutectic points.

(iii) Use a rule to divide your diagram into areas and label each area. [9]

5 Nitric acid (b.p. 87 °C) and water form an azeotropic mixture of boiling point 122 °C and composition 65% by mass of nitric acid.

(a) Sketch the boiling point/composition curve for nitric acid and water, labelling both the vapour and the liquid curves. [3]

(b) State qualitatively what happens to the temperature and the composition of the residual mixture during the simple distillation of a nitric acid/water mixture containing initially 20% of nitric acid by mass. [3]

(c) **(i)** State *Raoult's Law.*

(ii) Suggest why there is a deviation from this law for the nitric acid/water system. [4]

6 **(a)** Outline the principle of chromatography. [3]

(b) **(i)** Draw a diagram of the apparatus used to separate a mixture by column chromatography. Describe how the separation is made. [4]

(ii) Name a mixture which could be separated by column chromatography and suggest what substances could be used for the stationary and mobile phases. [3]

BIOCHEMISTRY AND FOOD CHEMISTRY

Not more than **two** *questions to be answered from this section.*

7 Either BIOCHEMISTRY

Recent techniques have allowed DNA from various sources to be broken down by enzymes (called restriction endonucleases). These enzymes cut DNA molecules at specific places in the sequence of base pairs.

The various fragments that result from the enzyme action are separated by gel electrophoresis carried out in a buffer of pH7 and constant potential difference.

(a) Describe, using a block diagram, the structure of the nucleotides which make up nucleic acids. State briefly how these are arranged in DNA. [4]

(b) Describe how the enzyme functions in this example and state what sort of reaction occurs. [2]

(c) Explain, in terms of the structure of the nucleotide, why the DNA fragments move towards the positive electrode in the electrophoresis separation. [2]

(d) What factors determine how far the various DNA fragments move in the electrophoresis separation? [2]

Or FOOD CHEMISTRY

(a) Cadmium, lead and mercury are contaminant metals.

State how **two** of these may initially enter the food chain. [2]

(b) Explain how rancidity arises in food. Outline **two** methods of food preservation which attempt to minimise rancidity. [8]

[Turn over

8 Either BIOCHEMISTRY

Write an account of the biochemical composition and function of membranes. Illustrate the most important features involved, using diagrams or formulae as appropriate. [10]

Or FOOD CHEMISTRY

Fruit farmers are continually producing new varieties of citrus fruits. A coloured extract, **P**, was obtained from one of these fruits. The extract, **P**,was investigated to test the suitability of the fruit as a foodstuff.

I A sample of **P** was found to be completely insoluble in ethoxyethane.

II A second sample of **P** was tested with water and found to be partially soluble.

III The mixture in (II) was filtered and the residue was found to be readily soluble in hot dilute hydrochloric acid.

(a) **(i)** From the information given above, suggest **one** specific major food component apparently absent from **P.**

(ii) What other important group of food components is also absent from **P**? [2]

(b) Name the process you would use to investigate the colours of the extract and outline how the method could be used to determine the number of dyes present in the food material. [4]

(c) The water-insoluble portion of **P** was readily soluble in hot dilute hydrochloric acid and was thought to have reacted with it.

Name **two** major food components which would behave in this way and describe, with equations, how each of your stated components reacts with dilute hydrochloric acid. [4]

9 **Either** BIOCHEMISTRY

For each of the examples below, describe and explain the relevance of hydrogen bonding. In each case, draw clear diagrams of the bonds involved:

(a) the stabilisation of secondary structures of proteins; [5]

(b) the interaction of some R groups in amino acids; [2]

(c) the solubilities of monosaccharides and polysaccharides. [3]

Or FOOD CHEMISTRY

(a) Outline how a protein can be hydrolysed in the laboratory and describe how the component amino acids in the hydrolysate can be separated. [5]

(b) Of the amino acids obtained from proteins in the human diet, only eight are essential to adults.

Explain this statement and suggest why a healthy diet should contain protein from several different sources. [3]

(c) The white of an egg is about 88% water and 12% protein (by mass). When an egg is heated, the white undergoes obvious changes.

Name the process responsible for these changes and explain the structural changes which the food components undergo. [2]

SOIL CHEMISTRY

Not more than **two** *questions to be answered from this section.*

10 **(a)** Explain the factors which govern how strongly cations are held at cation exchange sites. Illustrate your answer by reference to aqueous potassium, calcium and magnesium ions. [5]

(b) When a 500 g sample of a soil with a cation exchange capacity of 10 was shaken with 100 cm^3 of 0.50 mol dm^{-3} aqueous magnesium sulphate, 80% of the exchange sites became occupied with magnesium ions.

Calculate the concentration of the aqueous magnesium sulphate after the adsorption had taken place. [5]

11 A deficiency of phosphorus may be noticed on plants by the development of yellow leaves and by a generally stunted growth.

(a) State and explain whether the newer or older leaves are likely to appear yellow. [3]

Analysis shows that each of the following soils contains reasonable amounts of phosphorus but plants grown on them show the deficiency symptoms indicated above.

Soil **A** has a good general composition but a pH of 4.

Soil **B** has a good general composition but a pH of 8.

Soil **C** is mostly of inorganic origin but contains some partly decomposed organic compost. It has a pH of 6.5

(b) In what ionic forms is the phosphorus present in soil solutions between pH4 and pH8? [2]

(c) For each of the soils **A, B** and **C**, suggest why a deficiency of phosphorus might be observed despite the apparently satisfactory reserves of the element within the soils. [4]

(d) An initial analysis of soil **B** indicated that it might be deficient in sulphate ion. The visual symptoms on the plant of such a deficiency might look somewhat similar to a lack of phosphorus.

In what essential respect, however, would the lack of sulphate be distinguishable from a lack of phosphate? [1]

12 A soil contains a component with an anion yielding the following analysis by mass: Si, 39%; O, 61%.

(a) Calculate the empirical formula of this anion and state its electrical charge. [3]

(b) Identify the anion and draw a section of its structure. [3]

(c) Use your diagram to explain how it will have the empirical formula calculated in **(a)**. [3]

(d) If this component were present in significant amounts within a soil sample, what would this suggest about the extent of weathering that had occurred? [1]

CHEMICAL ENGINEERING

Not more than **two** *questions to be answered from this section.*

13 Chemists in the research and development section of your company have developed a new reaction for producing cyclohexanol, a raw material used in the production of nylon.

$$C_6H_{12} + {}^1/_2O_2 \longrightarrow C_6H_{11}OH$$

The exothermic reaction takes place in the gas phase by passing the reactants at a pressure of 1.5 MPa and a temperature of 450 K over a ruthenium/palladium catalyst. This gives a conversion of about 12% for a single pass.

Outline **five** important factors you will need to investigate before deciding whether the process would be worth developing to pilot-plant stage. Explain the relevance of each of your stated factors. [10]

14 **(a)** Distillation is a common method of separating liquids in the industrial manufacture of many different chemicals. Distillation towers may be tens of metres tall and contain a series of plates. These plates control the passage of vapour up, and of liquid down, the tower in the separation process. Two types of plate are used, sieve plates or plates with bubble caps.

Explain, with the aid of a suitable diagram, how **one** of these types of plate works. [4]

(b) The table below shows the equilibrium mole fractions values of the benzene present in the liquid phase and vapour phase for different mixtures of benzene and methylbenzene.

Mole fraction of benzene	
In liquid	In vapour
0.10	0.20
0.20	0.37
0.30	0.49
0.40	0.61
0.50	0.71
0.60	0.78
0.70	0.85
0.80	0.90
0.90	0.95

Assuming an infinite reflux ratio, plot a suitable graph to find the number of theoretical plates required to produce a distillate containing at least 0.95 mole fraction of benzene from a mixture containing 0.30 mole fraction benzene and 0.70 mole fraction methylbenzene. [4]

(c) Distillation in industrial processes is sometimes carried out under reduced pressure.

(i) Describe, in general terms, the sort of materials for which distillation under reduced pressure might be used.

(ii) Explain briefly an advantage of using reduced pressure. [2]

15 **(a)** Describe briefly, with the aid of diagrams, how fluid flow may be measured in pipes by

either **(i)** an absolute displacement method;

or **(ii)** a hydrodynamic method. [2]

(b) Depending on the value of the Reynolds' number, a given liquid in a particular pipe may show either streamline or turbulent flow.

Show how the Reynolds' number may be derived and, hence, how the diameter of the pipe used affects the type of flow. [4]

(c) In one part of a petrochemical plant, 1,2-dimethylbenzene is produced. This liquid has a density of 880 kg m^{-3} and a viscosity of 0.0075 kg m^{-1} s^{-1} at 298 K.

(i) Calculate the maximum flow rate, in m s^{-1}, for streamline flow if the liquid is in a pipe with a diameter of 0.15 m.

(ii) What type of flow would you expect if the temperature was increased to about 400 K (other conditions being constant)? Explain your answer. [4]

POLYMERS

Not more than **two** *questions to be answered from this section.*

16 **(a)** **(i)** Describe the type of bonding which holds together the monomer units in a large polymer molecule.

(ii) Separate molecules or segments of a polymer chain are held together by secondary bonding.

Give **two** examples of secondary bonding found in polymer systems.

(iii) Give **two** physical properties of polymers which involve the making or breaking of secondary bonding. [5]

(b) **(i)** What is meant by the terms *thermosetting* and *thermoplastic* when applied to polymer systems?

(ii) Give **one** advantage and **one** disadvantage connected with the use of thermoplastics.

(iii) What is commonly the limiting factor in the use of thermosetting polymers? [5]

17 **(a)** Explain, with the use of equations, how initiators function in addition polymerisation reactions. [6]

(b) Explain why, in addition polymerisation, the reaction vessel is initially heated and then later cooled. [4]

18 **(a)** Thiokol A is a polysulphide rubber.

(i) Indicate how thiokol A can be prepared.

(ii) Polysulphide rubbers are mechanically inferior to natural rubber and more expensive. They do, however, have one important advantage compared with natural rubber.

What is this advantage and to what uses can a polysulphide rubber be put as a consequence? [4]

(b) **(i)** Draw a section, containing three repeat units, of the polymer formed by the partial hydrolysis and polymerisation of R_2SiCl_2.

(ii) It is not possible to vulcanise silicone rubbers.

How is an effect similar to vulcanisation brought about in these polymers?

(iii) What is the effect on the reaction during the formation of silicone rubber if R_3SiCl is added to the reaction mixture?

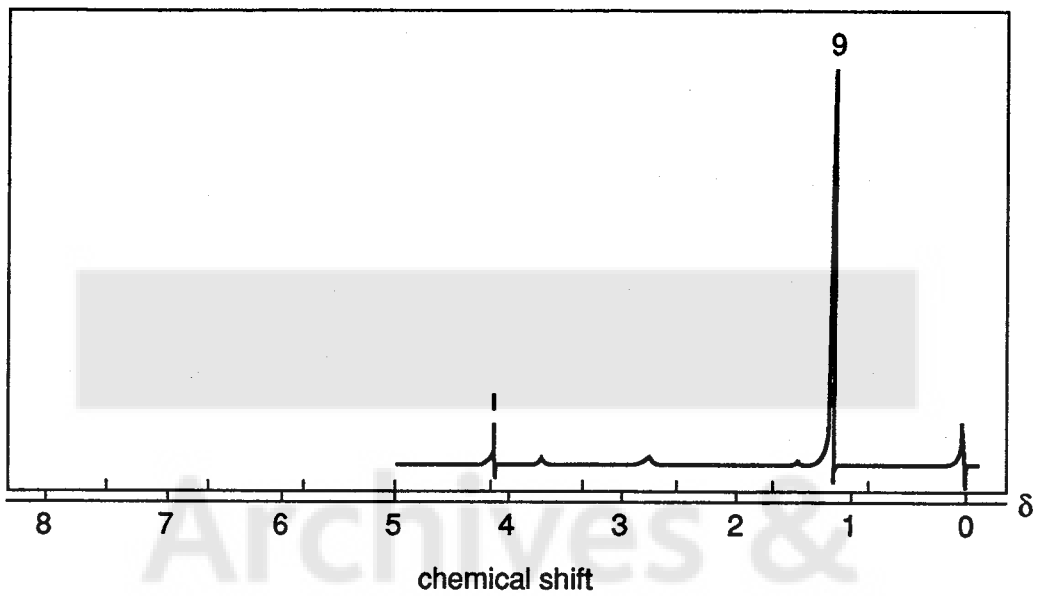
(iv) Why are silicones preferred over carbon chain polymers as electrical insulators for high temperature applications? [6]

[Turn over

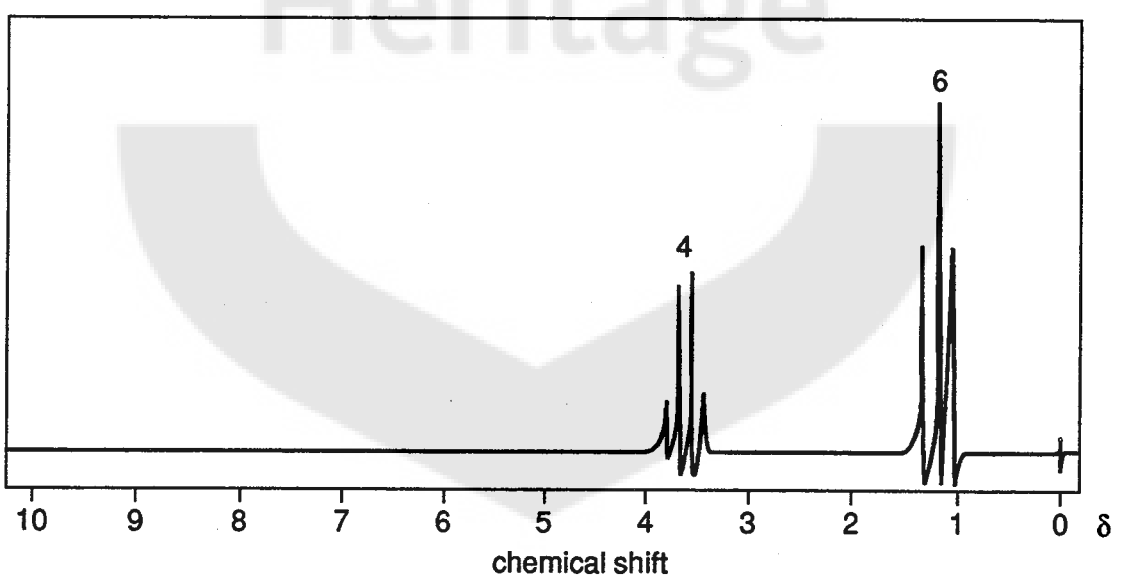
SPECTROSCOPY

Not more than **two** *questions to be answered from this section.*

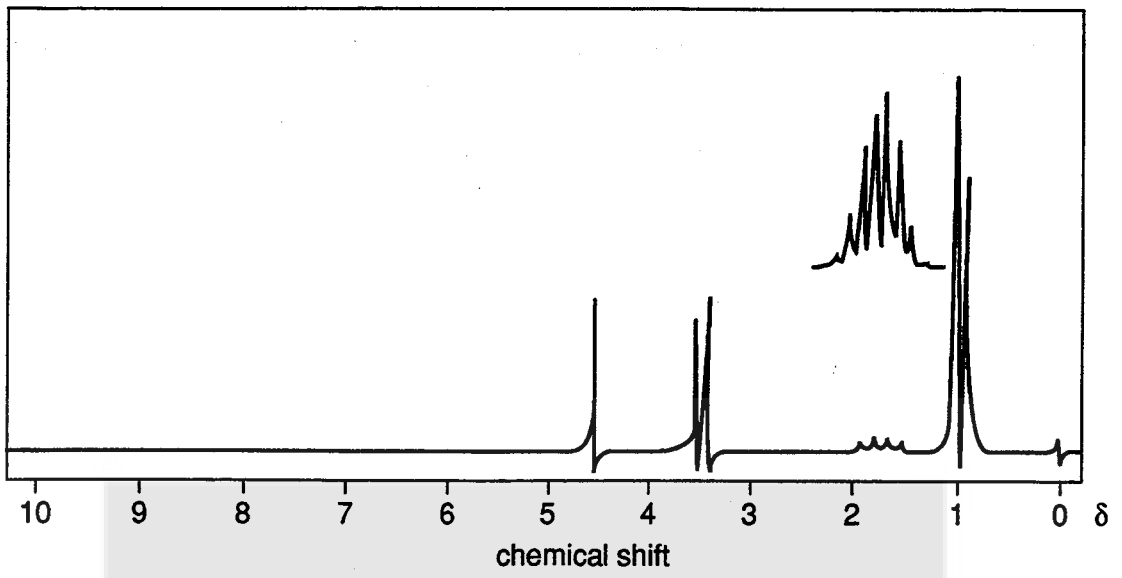
19 The following n.m.r. spectra were produced by three isomeric compounds of formula $C_4H_{10}O$.



Spectrum 1



Spectrum 2



Spectrum 3

By studying each spectrum in turn,

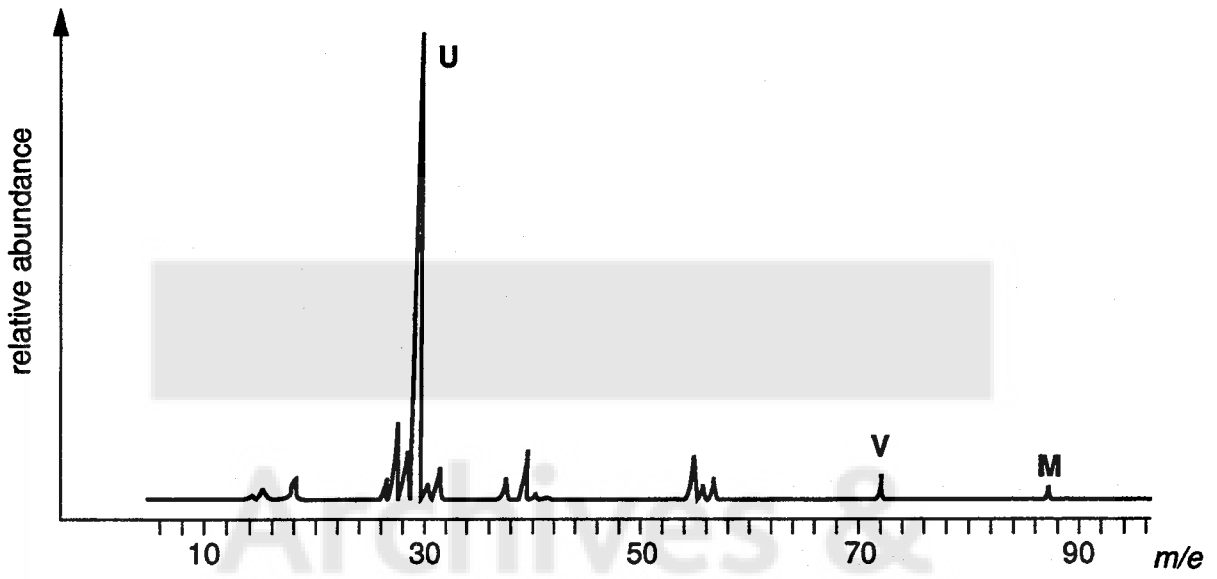
(a) describe the splitting pattern of each group of peaks; [3]

(b) identify the arrangement of hydrogen atoms responsible for each group; [4]

(c) draw the displayed (full structural) formula for each of the compounds. [3]

20 **(a)** Using the reaction between methanol and ethanoic acid as an example, outline the procedure you could use to determine which of the oxygen atoms present in the ester formed came from the methanol. [4]

(b) The mass spectrum shown below was obtained from compound **Q**, C_xH_yN.



(i) Use the information provided to determine the number of carbon atoms in the molecule and, hence, its empirical formula.

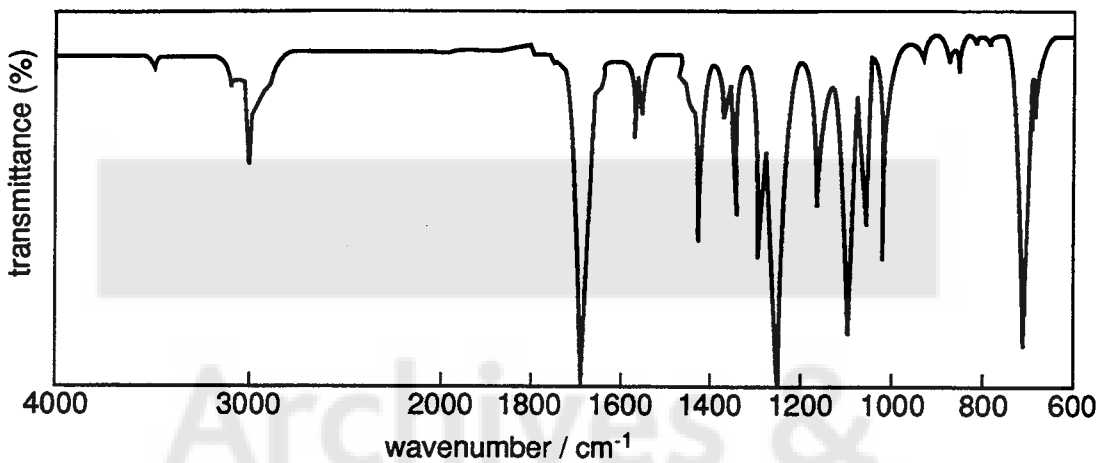
(ii) Identify the fragments responsible for peaks labelled **U** and **V** on the mass spectrum.

(iii) Draw a displayed (full structural) formula of **Q**. [6]

21 **(a)** By using hydrogen sulphide, H_2S, as an example, explain the origin of infra-red absorption in simple molecules. [2]

(b) Using diagrams, indicate the molecular vibrations in H_2S responsible for infra-red absorption. [3]

(c) Compound **S** has an M_r of 150, and contains three functional groups. The infra-red spectrum of **S** is given below.



(i) Identify each of the functional groups present and their absorption(s).

(ii) Suggest a structure for **S.** [5]

Centre Number	Candidate Number

Candidate Name _____

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

General Certificate of Education Advanced Level

CHEMISTRY 9250/3

PAPER 3

Thursday **23 JUNE 1994** Morning 1 hour

Candidates answer on the question paper.
Additional materials:
Data booklet
Mathematical tables

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
There are **five** questions in this paper.
Mathematical tables are available.
A Data Booklet is provided.
Where relevant, the symbols for aluminium, chlorine and iodine are printed as: Al; Cl; I; respectively.

FOR EXAMINER'S USE	
1	
2	
3	
4	
5	
TOTAL	

This question paper consists of 8 printed pages.

[Turn over

1 The first ionisation energies, in kJ mol^{-1}, of Group II and Group III elements are given below:

Group II		*Group III*		
Be	900	B	799	
Mg	736	Al	577	
Ca	590	Ga	577	
Sr	548	In	558	
Ba	502	Tl	589	[Tl = thallium]

(a) (i) Define, by means of an equation, what is meant by the *first ionisation energy* of an element.

..... [1]

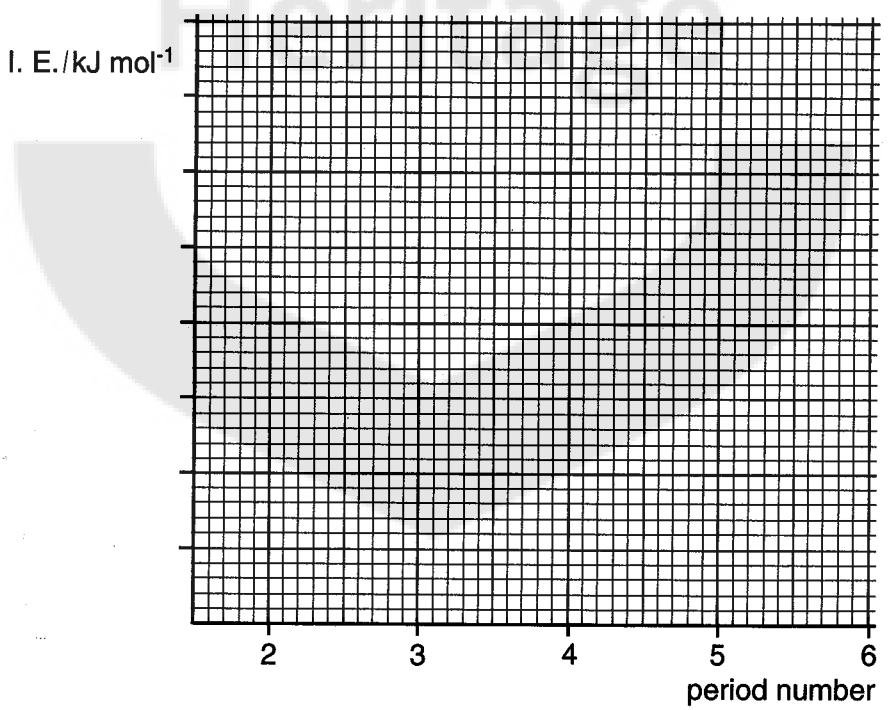
(ii) Explain why the first ionisation energies decrease in magnitude on descending Group II.

.....

.....

..... [1]

(b) (i) On the grid below, plot and label the two graphs of the variation of the first ionisation energies of these two groups of elements. Join the points of each group using a ruler.



[1]

(ii) Explain why the first ionisation energy of aluminium is *less* than that of magnesium.

.....

.....

..... [2]

(iii) Suggest why the first ionisation energy of thallium, T*l*, is *greater* than that of barium.

.....

.....

..... [1]

(c) Use the values of ionisation energies from the *Data Booklet* to explain why barium compounds are ionic but boron compounds are predominantly covalent.

.....

.....

.....

.....

.....

.....

.....[3]

[Total: 9]

2 **(a)** Write an expression for the solubility product of calcium hydroxide, $Ca(OH)_2$.

[1]

(b) A 20.0 cm^3 sample of saturated, aqueous calcium hydroxide required 18.2 cm^3 of 0.050 mol dm^{-3} hydrochloric acid for neutralisation.

Calculate

(i) the hydroxide ion concentration of the saturated solution,

[1]

(ii) the pH of the saturated solution,

[1]

(iii) a value for the solubility product of calcium hydroxide, stating the units.

[2]

(c) State a use of calcium hydroxide which depends on its solubility in water.

.....[1]

[Total: 6]

3 **(a)** Compare and contrast the properties of the Group IV chlorides by completing the table below.

	tetrachloromethane	silicon tetrachloride	lead(II) chloride
physical state at room temperature			
electrical conductivity when liquid			
effect of adding water at room temperature			
type of bonding			

[5]

(b) **(i)** Write an equation for **one** of the Group IV oxides reacting with a base.

.....

(ii) Write an equation for **one** of the Group IV oxides reacting with an acid.

.....[2]

(c) **(i)** Which Group IV metal forms divalent ions that readily decolourise acidified, aqueous potassium manganate(VII)?

.....

(ii) Use the redox half-equations in the *Data Booklet* to write a balanced equation for the reaction in **(c)(i)**.

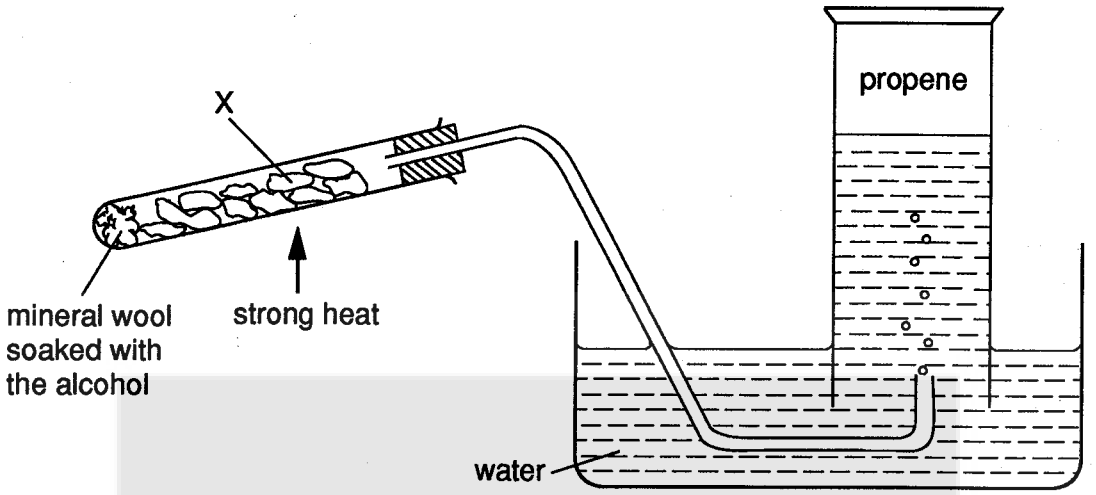
.....

.....[2]

[Total: 9]

[Turn over

4 Alkenes can be conveniently prepared in the laboratory by the dehydration of alcohols. The apparatus shown below can be used to prepare a sample of propene.



(a) **(i)** Give the full structural formula of an alcohol which can be used to prepare propene.

[1]

(ii) Write an equation for the dehydration of the alcohol you have quoted in **(a)(i)**.

.....[1]

(b) **(i)** The material **X** can be pumice or a ceramic such as broken brick or broken crockery.
Write the chemical name of a substance that might be present in one of these materials.

.....[1]

(ii) Suggest why **X** needs to be heated strongly.

.....

.....[1]

(iii) The material **X** becomes black in colour.
Suggest what substance is responsible for this black colour, and how it arises in the reaction.

.....

.....

.....[2]

(iv) At the end of the reaction, when no more propene comes over, the apparatus is left to cool with the delivery tube out of the water.

Suggest why this is done.

.....

.....

.....[1]

(c) (i) Write an equation for the reaction of propene with bromine.

.....

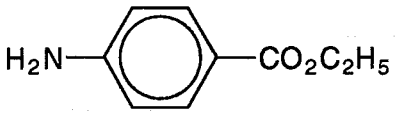
(ii) Write a formula representing poly(propene), giving at least two repeat units.

(iii) Give **one** use of poly(propene).

.....[3]

[Total: 10]

5 Benzocaine is a local anaesthetic used in sunburn ointments. Its formula is given below.

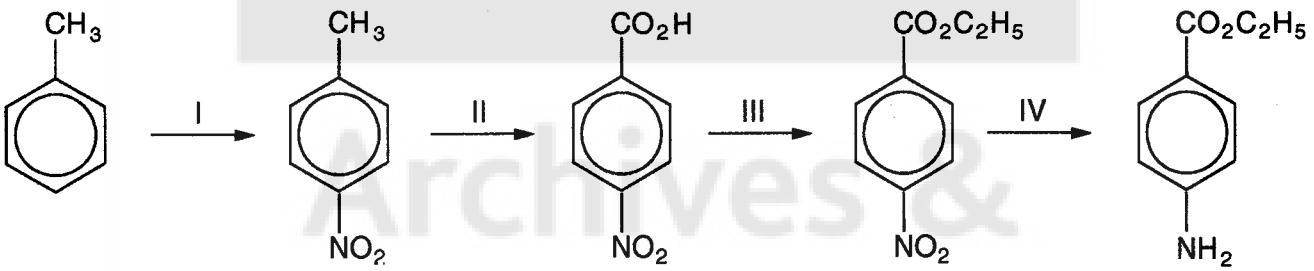


(a) State and explain whether benzocaine would be expected to be water-soluble or to be oil-soluble.

.....

.....[1]

(b) Benzocaine can be made by the following reaction scheme, starting from methylbenzene.



(i) State what reagents and conditions are used for each of the stages I to IV.

I .....

II .....

III .....

IV .....[4]

(ii) Write the structural formula of the isomer which is also formed in stage I.

[1]

[Total: 6]

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

General Certificate of Education Advanced Level

CHEMISTRY 9250/4

PAPER 4 Multiple Choice

Thursday **23 JUNE 1994** Morning 1 hour

Additional materials:
- Data booklet
- Mathematical tables
- Multiple Choice answer sheet
- Soft pencil (type B or HB is recommended)
- Soft clean eraser

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your name, Centre number and candidate number on the answer sheet in the spaces provided unless this has already been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate answer sheet.

Read very carefully the instructions on the answer sheet.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

A Data booklet is provided.

Mathematical tables are available.

Where relevant, the symbols for aluminium, chlorine and iodine are printed as: A*l*; C*l*; I; respectively.

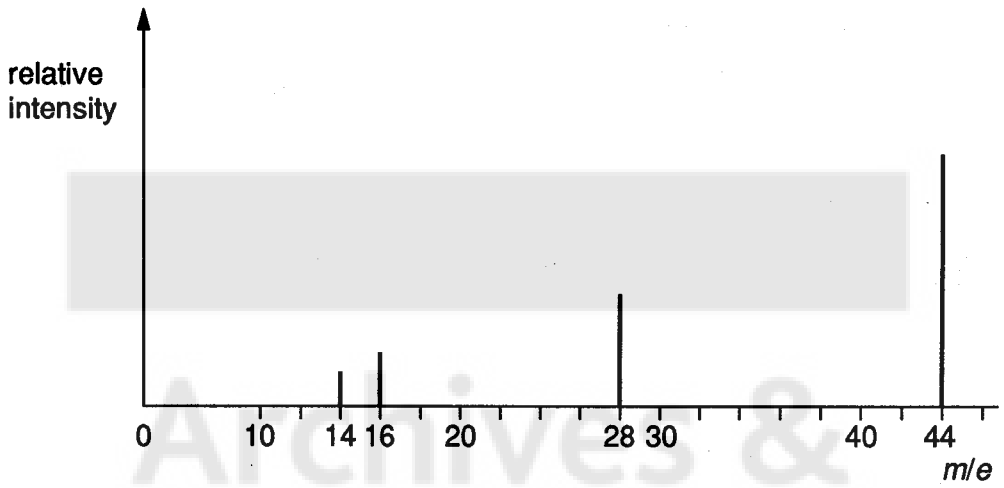
This question paper consists of 14 printed pages and 2 blank pages.

[Turn over

Section A

Four possible answers labelled **A**, **B**, **C** and **D** are given for each question. Choose the one which you consider to be correct.

1 A mass spectrum is shown below.



Which one of the following gives the complete mass spectrum illustrated?

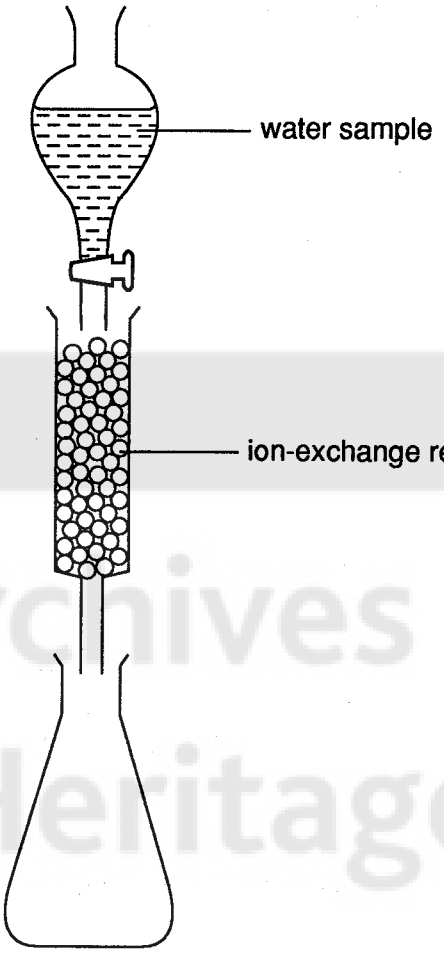
A CO_2

B C_3H_8

C N_2O

D a mixture of CH_4 and N_2

2 The hardness present in a water sample due to dissolved calcium ions can be determined by using an ion-exchange column as shown in the diagram.



A 50 cm^3 sample of a solution containing calcium sulphate was passed through the ion-exchange resin. The calcium ions in the sample were quantitatively exchanged by hydrogen ions. The sample collected in the flask required 25 cm^3 of 1.0×10^{-2} mol dm^{-3} potassium hydroxide for complete neutralisation.

What was the concentration of the calcium sulphate in the original sample?

A 2.5×10^{-3} mol dm^{-3}

B 1.0×10^{-2} mol dm^{-3}

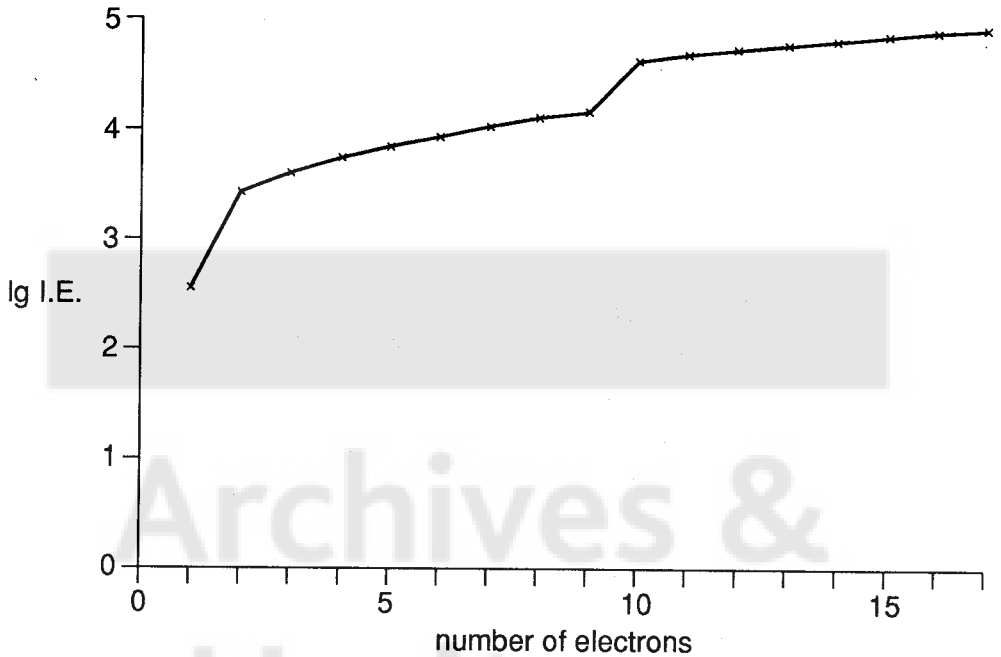
C 2.0×10^{-2} mol dm^{-3}

D 4.0×10^{-2} mol dm^{-3}

[Turn over

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

The graph shows the logarithm, lg, of the ionisation energies for the outermost seventeen electrons in an atom of an element **X**.



Which of the following could be **X**?

A argon **B** calcium **C** chlorine **D** potassium

4 Which of the following exerts the highest pressure?

A 1 mol of N_2 at 0 °C in 11.2 dm^3

B 1 mol of N_2 at 27 °C in 22.4 dm^3

C 1 mol of H_2O at 27 °C in 1 dm^3

D 1 mol of C_4H_{10} at its normal boiling point

5 Methane was burned in an incorrectly adjusted burner. The methane was converted into a mixture of carbon dioxide and carbon monoxide in the ratio of 99:1, together with water vapour.

What will be the volume of oxygen consumed when y dm^3 of methane is burned?

A $(2y - \frac{0.01y}{2})$ dm^3

B $(2y - 0.01y)$ dm^3

C $(y - \frac{0.01y}{2})$ dm^3

D $(y - 0.01y)$ dm^3

6 For which of the following ions is the enthalpy change of hydration likely to be the most exothermic?

	ion	*charge on ion*	*ionic radius*/nm
A		–1	0.181
B		+1	0.169
C		+2	0.065
D		+2	0.135

7 The elements radon (Rn), francium (Fr) and radium (Ra) are consecutive in the Periodic Table.
What is the order of their first ionisation energies?

	least endothermic ⟶		*most endothermic*
A	Fr	Ra	Rn
B	Fr	Rn	Ra
C	Ra	Fr	Rn
D	Rn	Ra	Fr

8 Which of the following molecules will **not** form a hydrogen bond with another of its own molecules?

A CH_3CHO **B** CH_3NH_2 **C** CH_3OH **D** NH_3

9 Which of the following molecules has **no** permanent dipole?

A CCl_2F_2 **B** $CHCl_3$ **C** C_2Cl_4 **D** C_2H_5Cl

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

How many electrons have to be removed to ionise 1.0×10^{-6} mol of Ne atoms to Ne^+ ions in a neon advertising tube?

A $\dfrac{6.02 \times 10^{23}}{1.0 \times 10^{-6}}$

B $1.0 \times 10^{-6} \times 6.02 \times 10^{23}$

C $\dfrac{1.0 \times 10^{-6} \times 6.02 \times 10^{23}}{20.2}$

D $\dfrac{1.0 \times 10^{-6} \times 6.02 \times 10^{23}}{9.65 \times 10^{4}}$

11 Which statement about the effect of a catalyst on a reversible reaction is correct?

A It increases the equilibrium constant for the forward reaction.

B It increases the yield of product in an equilibrium.

C It increases the rate constant for both the forward reaction and the reverse reaction.

D It increases the rate constant for the forward reaction but not that of the reverse reaction.

12 A substance *P* changes by a first-order reaction to form the product *Q*, according to the equation

$$P \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} Q.$$

Which expression represents the rate of the forward reaction?
[k_1 = rate constant of the forward reaction; k_{-1} = rate constant of the reverse reaction.]

A k_1 **B** $\frac{k_1}{k_{-1}}$ **C** $k_1[P]$ **D** $\frac{k_1[P]}{k_{-1}[Q]}$

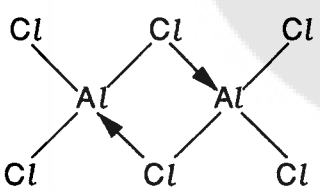
13 In which of the following pairs is the radius of the second atom greater than that of the first atom?

A Na, Mg **B** Sr, Ca **C** P, N **D** Cl, Br

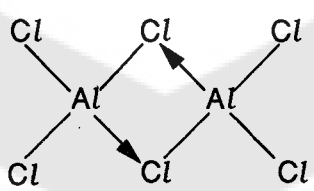
14 Aluminium chloride sublimes at 178 °C.

Which structure best represents the species in the vapour at this temperature?

A



B



C $Al^{\bullet} + 3\,Cl^{\bullet}$

D $Al^{3+}(Cl^{-})_3$

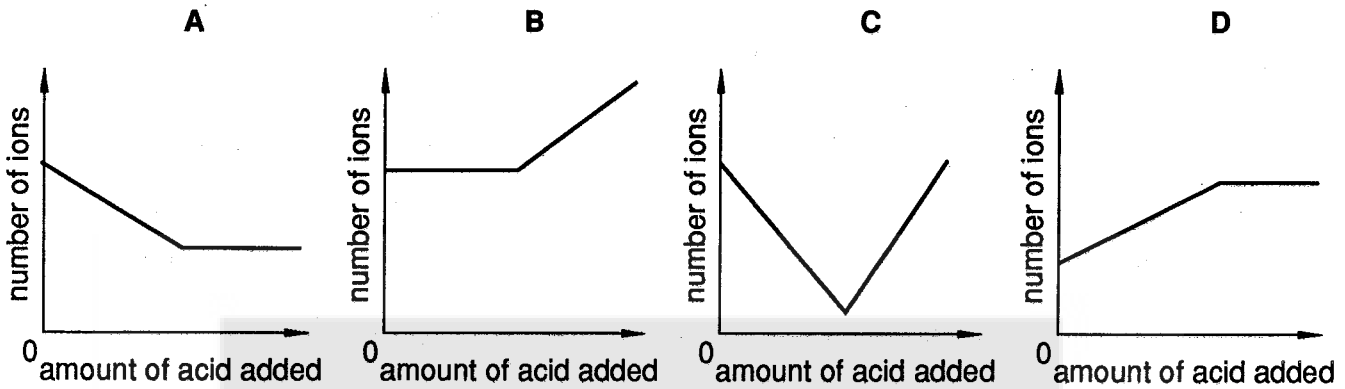
15 One mole of each of the following compounds is strongly heated with a Bunsen flame and any gas produced is collected at room temperature and pressure.

From which compound is 24 dm^3 of gas likely to be collected? (One mole of any gas occupies 24 dm^3 at room temperature and pressure.)

A $MgCl_2$ **B** $MgCO_3$ **C** $Mg(NO_3)_2$ **D** $Mg(OH)_2$

16 Dilute sulphuric acid was added to aqueous barium hydroxide until the acid was in excess.

Which graph shows the variation in the total number of ions in solution?



17 Nitrogen is frequently used as an inert atmosphere because it is an unreactive gas.

Which is the best explanation of this unreactivity?

A Its molecule contains a triple bond.

B The bond energy of the molecule is high (994 kJ mol^{-1}).

C The bond in its molecule is very short (0.110 nm).

D The three p orbitals of nitrogen are half-filled.

18 Which of the following compounds would give coloured fumes on warming with concentrated sulphuric acid?

A sodium bromide

B sodium carbonate

C sodium chloride

D sodium ethanoate

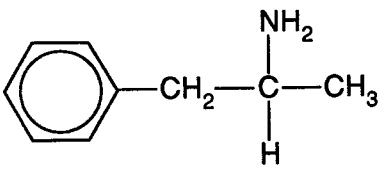
19 Letters written on paper using aqueous ammonium thiocyanate are invisible until turned blood-red by brushing the paper with aqueous iron(III) chloride. If the ammonium thiocyanate is first made alkaline, the letters are orange and less clear.

Which of the following substances, when formed on the paper in these reactions, best explains these observations?

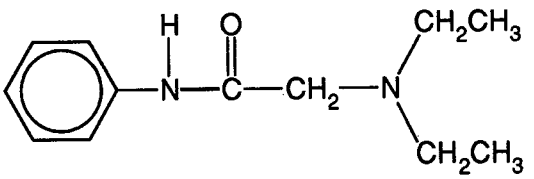
	with aqueous ammonium thiocyanate	*with alkaline aqueous ammonium thiocyanate*
A	Fe-NH_3 complex	$Fe(OH)_3$
B	Fe-CNS^- complex	Fe-NH_3 complex
C	Fe-CNS^- complex	$Fe(OH)_3$
D	Fe-CNS^- complex	Fe-OH^- complex

[Turn over

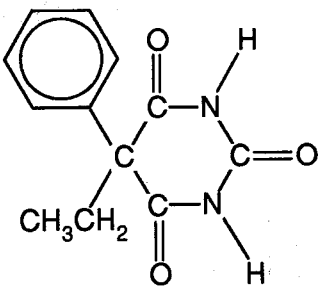
20 Many drugs show optical isomerism. The diagrams show the structure of three drugs.



amphetamine



lidocaine



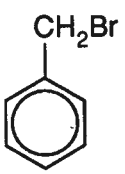
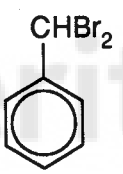
phenobarbital

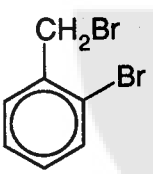
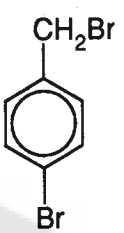
What is the total number of chiral carbon centres in these three structures?

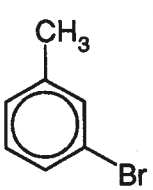
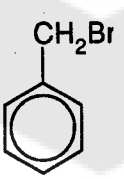
A 1 **B** 2 **C** 3 **D** 4

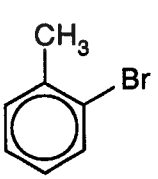
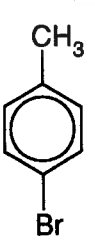
21 Iron filings were added to a solution containing equimolar quantities of methylbenzene and bromine. The mixture was immediately placed in the dark until no further change took place.

Which of the following are likely to have been the main products?

A  and 

B  and 

C  and 

D  and 

22 What is the product of a nucleophilic substitution reaction between 2-iodobutane and sodium ethoxide?

A $CH_3CH{=}CHCH_3$

B $CH_3CH_2CH(OCH_3)CH_2CH_3$

C $CH_3CH_2CH(CH_3)OCH_2CH_3$

D $(CH_3)_2CHCH_2OCH_2CH_3$

23 A compound **Q**, $C_4H_{10}O$, gives the compound **R**, C_4H_8O, on oxidation. **R** gives a yellow precipitate on warming with alkaline aqueous iodine.

Which of the following could be **Q**?

A $CH_3CH_2CH_2CH_2OH$

B $(CH_3)_2CHCH_2OH$

C $CH_3CH_2CH(OH)CH_3$

D $(CH_3)_3COH$

24 When propanal reacts with Tollens' reagent, what are the principal inorganic and organic products?

A Ag and $CH_3CH_2CH_2OH$

B Ag and $CH_3CH_2CO_2H$

C $AgNO_3$ and $CH_3CH_2CO_2H$

D Ag_2O and $CH_3CH_2CO_2H$

25 An account in a student's notebook read:

'An excess of aqueous bromine was added to aqueous phenol in a test-tube. 2,4,6-Tribromophenol was produced as a creamy-white precipitate suspended in a yellow alkaline solution.'

Which statement in this account must have been **incorrect**?

A The precipitate is not 2,4,6-tribromophenol, but a mixture of 2- and 4-bromophenol.

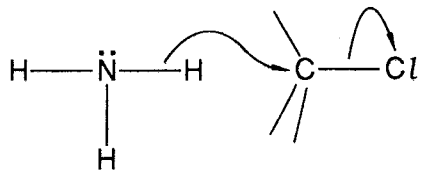
B The precipitate obtained is not creamy-white, but yellow.

C The resultant solution is not alkaline, but acidic.

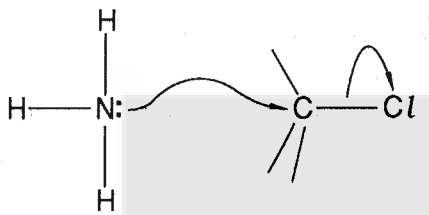
D The resultant solution is not yellow, but purple.

26 Which diagram correctly represents the transfer of electrons when ammonia reacts with a chloroalkane (alkyl chloride)?

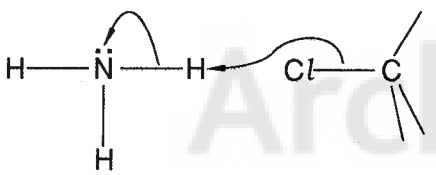
A



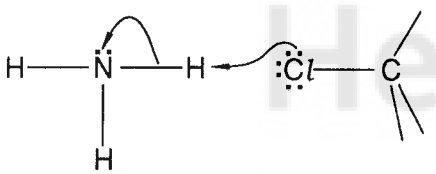
B



C



D



27 Which compound is a product of the hydrolysis of $CH_3CO_2C_3H_7$ by boiling aqueous sodium hydroxide?

A CH_3OH **B** C_3H_8 **C** C_3H_7OH **D** $C_3H_7CO_2^- Na^+$

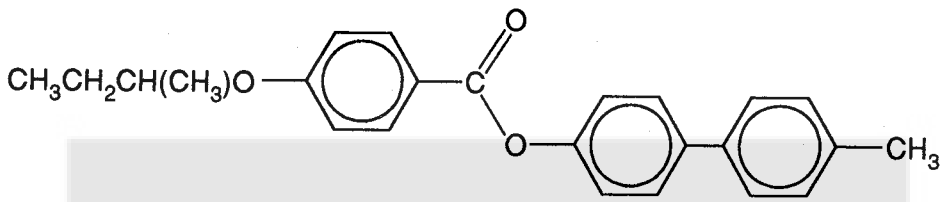
28 The display of a digital watch needs a liquid crystal which is

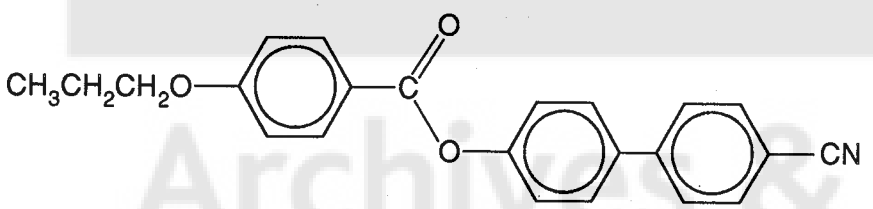
(i) stable to acidic hydrolysis;

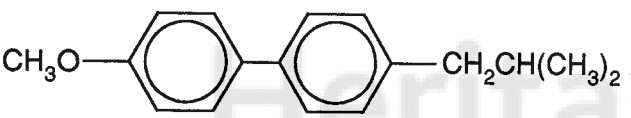
(ii) stable to alkaline hydrolysis;

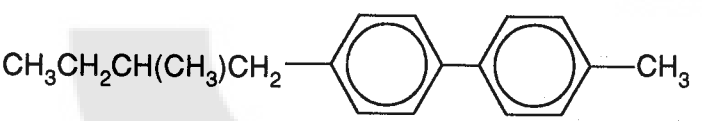
(iii) chiral.

Which of the following compounds, all of which form liquid crystals, meets these requirements?

A 

B 

C 

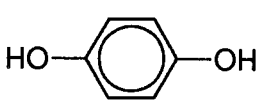
D 

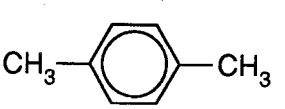
29 Which of the following reagents reacts only with the acid group of the amino acid $H_2NCH_2CO_2H$?

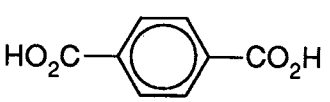
A $HCl(aq)$ **B** $HNO_2(aq)$ **C** C_2H_5OH **D** C_6H_5COCl

30 Which of the following pairs of compounds are the monomers of a condensation polymer?

A $CH_3O_2CCH_2CH_2CO_2CH_3$ and $CH_2{=}CHCH{=}CH_2$

B  and $H_2N(CH_2)_6NH_2$

C $O{=}CHCH_2CH_2CH{=}O$ and 

D  and $H_2NCH_2CH_2NH_2$

[Turn over

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements which you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 For which of the following reactions does the value of $\Delta H^{\ominus}$ represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?

1 $C(s) + O_2(g) \longrightarrow CO_2(g)$

2 $2C(s) + O_2(g) \longrightarrow 2CO(g)$

3 $CO(g) + \frac{1}{2}O_2(g) \longrightarrow CO_2(g)$

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

Which halide ions should be oxidised to the corresponding halogen by acidified potassium dichromate(VI) under standard conditions?

1 $Cl^-(aq)$ **2** $Br^-(aq)$ **3** $I^-(aq)$

33 What can be deduced from the following information?

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g); \Delta H = -98\ kJ\ mol^{-1}$$

1 Increasing the pressure increases the equilibrium yield of $SO_3(g)$.

2 The maximum mass of sulphur trioxide that can be made from 64 g of sulphur dioxide is 80 g.

3 Increasing the temperature decreases the rate of the forward reaction.

34 In which of the following conversions does the oxidation number of the nitrogen change by two?

1 $NH_2OH \longrightarrow NH_3$

2 $N_2 \longrightarrow NO$

3 $NO_2 \longrightarrow HNO_3$

35 The Group IV element germanium is widely used in the manufacture of semiconductors and other electronic components. The existence of this element in Group IV between silicon and tin was predicted by Mendeleev some years before it was discovered.

From its position in the group, what properties of germanium may be predicted?

1 Its most stable oxide has the formula GeO_2.

2 The oxide GeO_2 forms ions GeO_3^{2-}.

3 The bonding in $GeCl_4$ is covalent.

36 When hydrogen peroxide is added to acidified potassium dichromate(VI), the reaction that occurs is:

$$Cr_2O_7^{2-} + 3H_2O_2 + 8H^+ \longrightarrow 2Cr^{3+} + 3O_2 + 7H_2O.$$

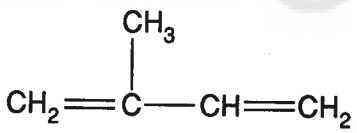
Which of the following statements are correct for this reaction?

1 The hydrogen peroxide acts as a reducing agent.

2 The colour changes from orange to green.

3 The oxidation number of chromium does not change.

37 2-Methylbuta-1,3-diene can be polymerised to make synthetic rubbers. The structure of this monomer is shown below.



Which of the following statements about 2-methylbuta-1,3-diene are correct?

1 It decolourises aqueous bromine.

2 It is chiral (optically active).

3 It undergoes nucleophilic addition reactions.

38 Which of the following reagents react in a similar manner both with ethanal and with benzaldehyde?

1 alkaline aqueous iodine

2 a solution of 2,4-dinitrophenylhydrazine

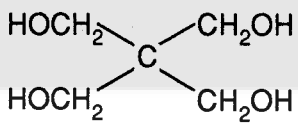
3 aqueous diamminesilver ions (Tollens' reagent)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

39 Pentaerythritol is an intermediate in the manufacture of paint.



pentaerythritol

Which of the following statements about pentaerythritol are correct?

1 It decolourises acidified potassium manganate(VII) on warming.

2 It reacts with metallic sodium.

3 Its empirical formula is CH_3O.

40 Which of the following statements suggests the presence of free radicals in the chlorination of methane?

1 Hydrogen chloride is present in the product.

2 The reaction proceeds most quickly in sunlight or ultraviolet light.

3 Ethane is present in small quantities in the product.

Centre Number	Candidate Number

Candidate Name _____

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

General Certificate of Education Advanced Level

CHEMISTRY 9250/5

PAPER 5 Practical Test

Friday **27 MAY 1994** Morning 2 hours 30 minutes

Candidates answer on the question paper.
Additional materials:
Mathematical tables

TIME 2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces at the top of this page.

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

Writing your answers in pencil is subject to penalty.

Mathematical tables are available.

A Data booklet is unnecessary.

Where relevant, the symbols for aluminium, chlorine and iodine are printed as: Al; Cl; I; respectively.

FOR EXAMINER'S USE	
1	
2	
3	
TOTAL	

This question paper consists of 12 printed pages.

[Turn over

1 **FA 1** is a hydrated salt $X.5H_2O$. You are required to determine the relative molecular mass, M_r, of X and calculate the percentage by mass of water of crystallisation in the salt.

Note. Tare facilities which your balance may have should **not** be used in this experiment.

Accurately weigh the hard-glass test-tube provided. Add between 2.00 g and 2.50 g of **FA 1** and reweigh the tube and contents. Record your reweighings in the following table.

Mass of tube and **FA 1** /g	
Mass of empty tube /g	
Mass of **FA 1** /g	

[3]

Heat the tube and contents strongly to drive off all the water of crystallisation from **FA 1.**

Place the tube on a heatproof mat to cool. (You may wish to proceed with one of the other questions at this point.) Then reweigh the tube and contents, entering your results in the following table.

Mass of tube and **FA 1** after heating /g	
Mass of empty tube /g	
Mass of **FA 1** after heating /g	

Ensure that all water has been driven off before beginning your calculations. [11]

(a) Calculate the mass of water driven off from your sample of **FA 1**.

[1]

(b) What is the mass of anhydrous *X* remaining in the tube?

[1]

(c) Calculate how many moles of water were driven off from your sample of **FA 1**. [$M_r(H_2O)$, 18]

[1]

For Examiner's Use

(d) Calculate the M_r of X.

[1]

(e) Calculate the percentage by mass of water of crystallisation in **FA 1.**

[1]

2 Potassium manganate(VII) oxidises *Y* and also *Z*. You are to find how many moles of
(i) *Y*,

(ii) *Z*,

separately react with one mole of potassium manganate(VII).

FA 2 is 0.0200 mol dm^{-3} $KMnO_4$;

FA 3 contains 0.120 mol dm^{-3} of *Y*;

FA 4 contains 0.0500 mol dm^{-3} of *Z*.

Place **FA 3** and **FA 4** in separate burettes, labelled clearly with the identities of their contents.

Experiment 1

By using a pipette, transfer 25.0 cm^3 of **FA 2** to a conical flask, add about 10 cm^3 of dilute sulphuric acid to the flask and run in **FA 3** from the burette until the red-brown colour formed in the mixture is discharged and the solution clears.

Repeat the titration as many times as you think necessary to obtain accurate results.

Titration of **FA 2** *with* **FA 3**

	Rough	Accurate		
Final burette reading /cm^3				
Initial burette reading /cm^3				
Volume of **FA 3** used /cm^3				

Cross out the word 'rough' if you regard that titration to be accurate.

Summary

..... cm^3 of **FA 2** required ..... cm^3 of **FA 3**.

Show which results you used to obtain this value of the volume of **FA 3**. [13]

For Examiner's Use

(a) Calculate how many moles of $KMnO_4$ there are in 25.0 cm^3 of **FA 2**.

[1]

(b) Calculate how many moles of *Y* there were in the volume of **FA 3** found necessary to react with 25.0 cm^3 of **FA 2**.

[1]

(c) Calculate how many moles of *Y* react with one mole of $KMnO_4$.

[2]

Experiment 2

By using a pipette, transfer 25.0 cm^3 of **FA 2** to a conical flask, add about 10 cm^3 of dilute sulphuric acid to the flask followed by 8.00 cm^3 of **FA 3** from the burette and then titrate the potassium manganate(VII) remaining in the mixture with **FA 4** from the other burette to the same end-point as in the previous titration.

Two accurate titrations will suffice.

Titration of **FA 2** *plus* **FA 3** *with* **FA 4.**

Final burette reading /cm^3		
Initial burette reading /cm^3		
Volume of **FA 4** used /cm^3		

Summary

The mixture of **FA2 and FA 3** required ..... cm^3 of **FA 4.**

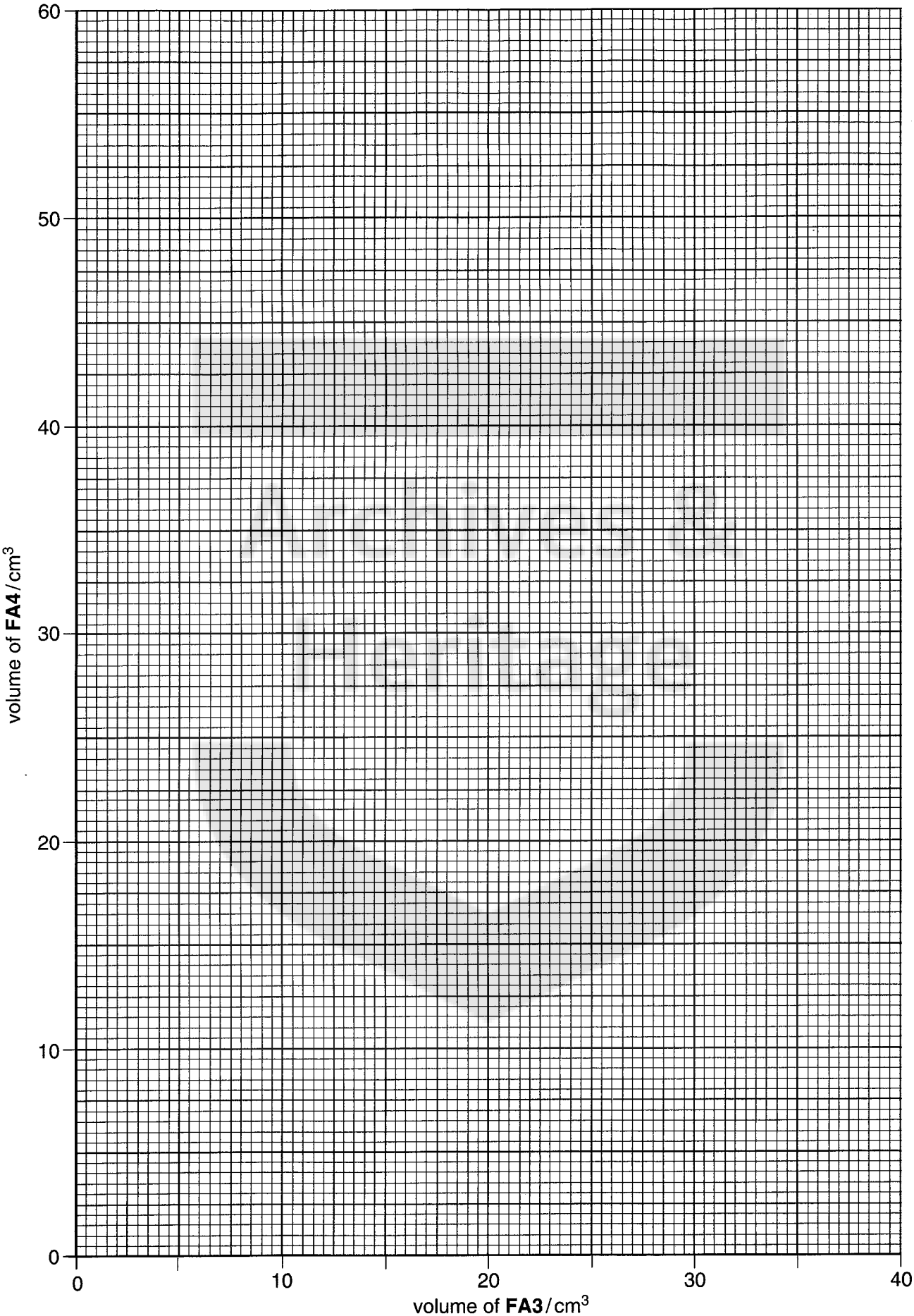
[8]

(d) (i) Complete the table below.

Experiment	Volume of **FA 3** /cm^3	Volume of **FA 4** /cm^3
1		0
2		

(ii) Plot the volume of **FA 3** against the volume of **FA 4** for **Experiments 1** and **2** on page 8.

[2]


60
50
40
30
20
10
0
volume of **FA4**/cm^3
0
10
20
30
40
volume of **FA3**/cm^3

For Examiner's Use

(e) Use your graph to find the volume of **FA 4** alone that would be necessary to reduce 25.0 cm^3 of **FA 2**. [1]

(f) Use your answer to **(e)** to calculate how many moles of *Z* react with 25.0 cm^3 of **FA 2**.

[1]

(g) Calculate how many moles of *Z* react with one mole of $KMnO_4$.

[2]

[Turn over

For Examiner's Use

3 Carry out the following experiments with **FA 5** which contains one cation and up to three anions from the following list: NH_4^+, Mg^{2+}, Al^{3+}, Ca^{2+}, Cr^{3+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Cu^{2+}, Zn^{2+}, Ba^{2+}, Pb^{2+}; CO_3^{2-}, NO_2^-, NO_3^-, SO_3^{2-}, SO_4^{2-}, Cl^-, Br^-, I^-, CrO_4^{2-}.

In all tests, the reagent should be added gradually until no further change is observed unless you are instructed otherwise.

Record your observations and the deductions you make from them in the spaces provided.

Your answers should include

(i) details of colour changes and precipitates formed;

(ii) the names of gases evolved and details of the test used to identify each one.

You should indicate clearly at what stage in a test a change occurs, writing any deductions you make alongside the observations upon which they are based.

Marks will be given only for the prescribed tests and will **not** be given for chemical equations. Additional tests must **not** be carried out.

Tests	Observations [15]	Deductions [10]
(a) Add dilute sulphuric acid followed by aqueous iron(II) sulphate to **FA 5**.		
(b) Add aqueous sodium hydroxide and a little aluminium powder to **FA 5**. Warm **cautiously**.		
(c) Add aqueous potassium iodide to **FA5**. Add aqueous sodium thiosulphate.		

(d) Add aqueous ammonia to **FA 5**.		
(e) Add aqueous sodium hydroxide to **FA 5**. Filter the mixture obtained. Perform tests **(i)** to **(iii)** on separate portions of the **filtrate**. Retain the residue for test **(iv)**.		
(i) Add dilute nitric acid.		
(ii) Add aqueous silver nitrate followed by dilute nitric acid, added gradually.		

(iii) Add aqueous barium chloride.		
Add dilute hydrochloric acid.		
(iv) Rinse the **residue** by pouring cold water over it. Discard the washings and then pour dilute sulphuric acid through the residue. Collect the filtrate produced.		
Add aqueous ammonia to this filtrate.		

Cation present in **FA 5** .....

Anions present in **FA 5** .....

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

General Certificate of Education Advanced Level

INSTRUCTIONS FOR 9250/5 (U.K. CENTRES)

PRACTICAL CHEMISTRY

MAY 1994

Great care should be taken that any confidential information given does not reach the candidates either directly or indirectly.

1 In order to assist in making preparations for the examination, the Chemistry teacher responsible may study the question paper on receipt at the Centre. This copy of the question paper must be kept under strict security at all times before the examination: it is to be re-sealed and locked up with the other copies of the question paper as soon as possible.

The teacher is strongly advised to try out all the experiments before the examination.

The 'General Apparatus' requirements and the 'Particular Requirements' are printed separately. It is *especially important* that the details on page 5 are kept secure.

2 The attention of Supervisors is drawn to the fact that the examination time is two and a half hours.

3 Candidates are allowed the use of reference material on both quantitative and qualitative analysis. All data for calculations will be provided on the question paper.

4 Supervisors are advised to remind candidates that **all** substances in the examination should be treated with caution. Only those tests described in the question paper should be attempted. Candidates must not attempt additional confirmatory tests (a statement advising candidates that such additional tests gain no credit being given in the question paper). Please also see under 'General Apparatus' on the use of pipette fillers and safety goggles.

In accordance with the COSHH (Control of Substances Hazardous to Health) Regulations, operative in the UK, a hazard appraisal of the examination has been carried out.

Attention is drawn, in particular, to certain materials used in the examination. The following codes are used where relevant.

C = corrosive substance

F = highly flammable substance

H = harmful or irritating substance

O = oxidising substance

T = toxic substance

In this context, the attention of Supervisors is drawn to the following publications relating to safety and first-aid:

(a) 'Hazcards', as published by CLEAPSS Development Group, Brunel University, Uxbridge, UB8 3PH (0895-51496);

(b) 'Hazcards in the Chemical Laboratory', as published by the Royal Society of Chemistry (4th edition, 1986, edited by L. Bretherick, ISBN 0-85186-489-9).

(c) 'Hazard Data Sheets', published by BDH Laboratory Supplies.

These Instructions consist of 6 printed pages and 2 blank pages.

SB (SC) QF42042

[Turn over

General Apparatus

1 In addition to the fittings and reagents ordinarily contained in a chemical laboratory, the apparatus and materials specified below will be necessary.

2 **It is assumed that bench solutions of the common acids and alkalis are available.**

3 Pipette fillers and safety goggles should be used where necessary.

For each candidate

a hard-glass test-tube;

a heatproof mat;

test-tube holder;

a 25.0 cm^3 pipette;

2 burettes;

at least 2 conical flasks for titrations;

2 sticky labels;

access to a balance reading to 0.01 g or better;

a test-tube rack and set of test-tubes;

a filter funnel and papers.

Particular requirements

1 As a possible aid to maintaining security, the descriptions of the particular chemicals required are given under two headings:

(a) overall specifications are given on page 3,

(b) the actual identities are given on page 5.

2 Materials with an **FA** code number should be so labelled for the candidates' benefit, **without** the identities being included on the label – where appropriate, the identity of an **FA** coded chemical is given in the question paper itself.

3 Conditions peculiar to this examination, if any, are given below.

Nil

Chemicals required

1 The chemicals required per question are described in general terms below.

2 Where quantities are specified for each candidate (shown after a colon against each listed item), they are meant as guides only and are quantities greater than candidates will normally need to use. It is suggested that about 80% of the specified quantities should be distributed to candidates with the remainder kept as a central reserve. More material may be supplied if requested by candidates, without penalty.

Where relevant, spare material should be available to cover accidental loss.

3 The specific qualitative analysis reagents needed for Question 3 are identified on page 5.

4 **For Question 1**

FA1: 3.5 g

For Question 2

[O] **FA2**: 200 cm^3
FA3: 200 cm^3
FA4: 100 cm^3
a plentiful supply of dilute sulphuric acid

For Question 3

[H] **FA5**: 40 cm^3
qualitative analysis reagents as specified on page 5.

[Turn over

Detailed Identities of Chemicals Required

1 It is *especially important* that great care is taken that the confidential information given below does not reach the candidates either directly or indirectly.

2 The identities of the chemicals with an **FA** code number are as follows.

Solids

Question 1

FA1: hydrated magnesium sulphate, $MgSO_4.7H_2O$.

Liquids

Question 2

[O] **FA 2**: 0.020 mol dm^{-3} potassium manganate(VII), $KMnO_4$ (aq)

FA3: ammonium iron(II) sulphate hexahydrate, $(NH_4)_2SO_4.FeSO_4.6H_2O$, 47 g dissolved in dilute sulphuric acid and made up to 1 dm^3 with water.

FA4: ammonium iron(II) sulphate solution of half the concentration of **FA3**, prepared similarly.

Question 3

[H] **FA5**: an aqueous solution containing about
50 g dm^{-3} potassium chromate(VI), K_2CrO_4, and
50 g dm^{-3} hydrated copper(II) nitrate, $Cu(NO_3)_2.3H_2O$,
with just sufficient dilute nitric acid added to dissolve the precipitate formed.

3 The qualitative analysis reagents specifically required are set out below. If necessary, they may be made available from a communal supply: however, the attention of Invigilators should be drawn to the fact that such an arrangement may enhance the opportunity for malpractice between candidates.

(i) aqueous iron(II) sulphate, $FeSO_4.7H_2O$, about 200 g dm^{-3}

(ii) aluminium powder
[note: the grade of powder provided should be such that the reaction in **Q.3(b)** is not unduly vigorous]

(iii) aqueous potassium iodide, KI, approximately 5% w/v

(iv) aqueous sodium thiosulphate, $Na_2S_2O_3.5H_2O$, about 200 g dm^{-3}

(v) [C] aqueous silver nitrate, $AgNO_3$, about 8 g dm^{-3}

(vi) [H] aqueous barium chloride, $BaCl_2.2H_2O$, about 100 g dm^{-3}

[Turn over

Accuracy of Solutions

1 **All the solutions are to be labelled as shown and they should each be bulked before use to ensure uniformity.**

Every effort should be made to keep the concentrations accurate within one part in two hundred of those specified.

If the concentrations differ slightly from those specified, the Examiners will make the necessary allowance. They should be informed of the exact concentrations.

2 It should also be noted that descriptions of solutions given in the question paper may not correspond exactly with the specification in these Instructions. **The candidates must assume the descriptions given in the question paper.**

3 In view of the difficulty of the preparation of large quantities of solution of uniform concentration, it is recommended that the maximum number of candidates per group be 30 and that separate supplies of solutions be prepared for each group. See also **1** below about making separate returns for each group of candidates.

Information Required by the Examiner

1 The Supervisor, or other competent chemist, is asked to carry out the experiments in Question 1 and Question 2, to enter the results on a spare copy of the question paper (clearly marked 'Supervisor's results'), and to complete and submit the attached Report Form. If the examination is held in more than one session or laboratory or for different sets of candidates, a separate return must be made for each group, **giving the index numbers of the candidates in each group**.

If candidates from more than one Centre are taking this examination in the same group, it is *essential* that a copy of the Supervisor's Report should be completed and sent with the scripts **for each centre**.

2 The Supervisor is asked to add a note of any particular difficulties experienced by a candidate, especially if the Examiner would be unable to discover them from the written answers.

3 The Report Form attached to this notice **must be completed and enclosed in the envelope with the scripts. Failure to do this may result in candidates being penalised**.