Cambridge Assessment

# A Level

## Chemistry

**Session:** 2000 June
**Type:** Question paper
**Code:** 9254

OCR
RECOGNISING ACHIEVEMENT

**General Certificate of Education Advanced Level**

former Cambridge linear syllabus

# CHEMISTRY 9254/1

PAPER 1

Monday **5 JUNE 2000** Afternoon 2 hours

Additional materials:
Answer paper
Data Booklet
Electronic calculator and/or Mathematical tables
Graph paper

**TIME** 2 hours

## INSTRUCTIONS TO CANDIDATES

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

Answer **six** questions.

Answer **two** questions from Section A, **one** question from Section B, **two** questions from Section C and **one** other question chosen from any 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.

A Data Booklet is provided.

Mathematical tables are available. You may use a calculator.

You are reminded of the need for good English and clear presentation in your answers.



**This question paper consists of 8 printed pages.**

SB (SM/JB) QF04885


[Turn over

## Section A

Answer at least **two** questions from this section.

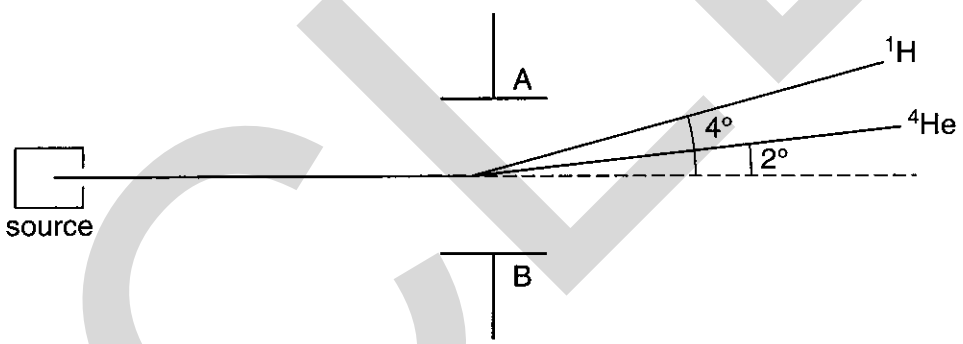
**1** **(a)** Define the terms **(i)** *isotope*,
**(ii)** *isotopic mass*. [2]

**(b)** **(i)** Give the symbols (showing the nucleon numbers and charges) of the following three particles.

| particle | protons | neutrons | electrons |
|---|---|---|---|
| **P** | 6 | 8 | 6 |
| **Q** | 7 | 7 | 10 |
| **R** | 8 | 7 | 7 |

**(ii)** Use the *Data Booklet* to identify which are **not** the usual isotopes of the elements concerned. [6]

**(c)** A plasma is a gaseous mixture in which the atoms have been completely stripped of their electrons, leaving bare nuclei. Because of possible use in controlled nuclear fusion reactions, plasma behaviour has been intensively studied. When passed between two plates carrying a certain electric charge, $^{1}H$ and $^{4}He$ nuclei are deflected as follows.




Giving reasons for your answers, suggest

**(i)** the polarity (+ or –) of plate A,

**(ii)** why $^{1}H$ is deflected twice as much as $^{4}He$,

**(iii)** the angles of deflection of I: $^{2}H$ nuclei,
II: $^{3}He$ nuclei. [4]

2 Carbon dioxide is used as a coolant gas in some nuclear reactors. Unlike hydrogen or helium, carbon dioxide shows marked deviations from the ideal behaviour that is predicted by the kinetic theory of gases.

**(a)** State **two** assumptions of the kinetic theory, and use these to explain why you might expect the behaviour of carbon dioxide to be less ideal than that of hydrogen. [3]

**(b)** Under what conditions of temperature and pressure would you expect the behaviour of carbon dioxide to be most like that of an ideal gas? [2]

**(c)** The volume of 1 mol of carbon dioxide was measured at various pressures but at a constant temperature of 285 K. The following results were obtained.

| pressure, $p$ /Pa | volume, $V$ /$m^3$ | pressure x volume, $pV$ /$m^3$ Pa |
|---|---|---|
| $4.0 \times 10^5$ | $5.80 \times 10^{-3}$ | 2320 |
| $8.0 \times 10^5$ | $2.85 \times 10^{-3}$ | |
| $15.0 \times 10^5$ | $1.46 \times 10^{-3}$ | |
| $20.0 \times 10^5$ | $1.07 \times 10^{-3}$ | |

**(i)** Complete the calculations for the third column and use these data to plot a graph of the product $pV$ against pressure $p$.

**(ii)** State how the value of the product $pV$ **should** change with pressure for an ideal gas.

**(iii)** Use the graph to calculate the volume of 1 mol of carbon dioxide at a pressure of $10 \times 10^5$ Pa. Calculate the volume at 285 K that the ideal gas equation predicts for this pressure and comment on the difference between two values. [7]

3 **(a)** Magnesium fluoride, $MgF_2$, is a solid of high melting point (1261 °C) whereas sulphur difluoride, $SF_2$, is a gas.

**(i)** Suggest how these two fluorides differ in their bonding and suggest a reason for this difference.

**(ii)** Draw dot-and-cross diagrams (outer shells only) to show the different electron arrangements in the two compounds. [5]

**(b)** Using the following data, and relevant data from the *Data Booklet*, construct a thermochemical cycle to calculate the enthalpy change of formation of $MgF_2$.

Include state symbols in your cycle.

| | value /kJ $mol^{-1}$ |
|---|---|
| lattice energy of $MgF_2(s)$ | -2957 |
| electron affinity of fluorine ($F(g) \longrightarrow F^-(g)$) | -328 |
| enthalpy change of atomisation of magnesium | +148 |

[5]

**(c)** The compound $SF_2$ readily reacts with fluorine to give $SF_4$. Suggest reasons why $MgF_2$ does not react with more fluorine to give $MgF_4$. [2]

## Section B

Answer at least **one** question from this section.

**4** **(a)** State the electronic configuration of the chromium atom, and predict **two** of the likely oxidation states of chromium. [2]

**(b)** Use the *Data Booklet* to predict the outcome of mixing acidified aqueous potassium dichromate(VI) with

**(i)** aqueous iron(II) sulphate,

**(ii)** aqueous potassium iodide.

In each case, calculate the $E^{\ominus}_{cell}$ for the reaction and write a balanced equation. [4]

**(c)** When an iron sheet is made the anode during the electrolysis of very concentrated aqueous potassium hydroxide, an anion containing iron in a high oxidation state is formed in solution. The addition of an excess of barium nitrate to this solution precipitates a red solid having the following composition by mass:
Ba, 53.3 %; Fe, 21.7 %; O, 24.9 %.

**(i)** Calculate the empirical formula of the red solid and the oxidation number of the iron in it.

**(ii)** After a current has been passed through the solution for some time, the addition of barium nitrate produces 1.00 g of the red solid. Calculate how many moles of red solid are formed, and hence calculate how many coulombs of electricity were needed. [6]

**5** Sulphur forms two oxides, $SO_2$ and $SO_3$.

**(a)** By considering both bonding and non-bonding electrons, suggest shapes for these two simple molecules. [2]

**(b)** Sulphur trioxide is a key intermediate in the production of sulphuric acid from sulphur in the Contact process.

Describe the reactions by which it is formed and explain how it is converted into sulphuric acid in the later stages of the process. Write equations where appropriate and explain why the particular conditions are used. [6]

**(c)** Gardeners sometimes fumigate their greenhouses to rid them of pests and moulds by burning a sulphur 'candle'. A gaseous concentration of sulphur dioxide of 50 ppm (parts per million) by volume is effective.

Calculate how many grams of sulphur a gardener needs to burn in order to produce a concentration of 50 ppm of $SO_2$ in a greenhouse that measures 2 m x 3 m x 4 m.
[Volume of 1 mol of gas = 24 $dm^3$ (0.024 $m^3$) at r.t.p.] [4]



[Turn over

## Section C

Answer at least **two** questions from this section.

**6** Hex-3-ene occurs in two isomeric forms but cyclohexene occurs in only one form.

**(a)** Draw the displayed formulae of the two isomers of hex-3-ene and explain why such isomerism is not possible with cyclohexene. [3]

**(b)** Describe the mechanism of the reaction between hex-3-ene and bromine.

Your account should
- name the type of reaction undergone,
- state the conditions of the reaction,
- show the movement of electrons during the reaction,
- include the formulae of the product and any intermediates. [4]

**(c)** Explain why the reaction of either isomer of hex-3-ene with hydrogen bromide gives the same equimolar (1:1) mixture of two isomers of the product. [2]

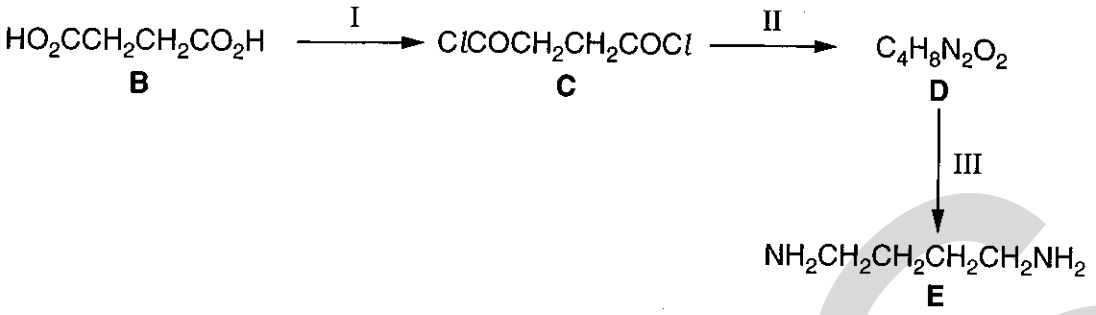
**(d)** The compound hex-3-en-1-ol, **A**, has a strong 'leafy' smell of newly cut grass and is used in perfumery.

$$CH_3CH_2CH{=}CHCH_2CH_2OH$$

**A**

Suggest the structural formulae of the compounds produced when **A** is treated with an excess of hot concentrated $KMnO_4$ in acid solution. [3]

7 The compound butane-1,4-diamine, **E**, can be synthesised by the following route.




**(a)** Suggest reagents for steps I and II. [2]

**(b)** Name the functional group present in **D** and suggest its structural formula. [2]

**(c)** What type of reaction occurs in step III? [1]

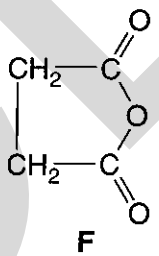
**(d)** **E** can react with **C** to form a polymer.

**(i)** What type of polymerisation is this?

**(ii)** Draw the displayed formula of one repeat unit of the polymer formed. [3]

**(e)** Compound **C** reacts with water much more vigorously than 1,4-dichlorobutane does. Suggest an explanation of this and identify the organic product from **C**. [2]

**(f)** When heated strongly, **B** produces compound **F**.




**F**

**(i)** What type of reaction has occurred in the formation of **F**?

**(ii)** **F** slowly reacts with water, giving **B** again. Suggest the structural formula of the compound that might be produced if **F** were to react with ethanol rather than water. [2]

8 The limescale that collects in kettles in hard water areas is mostly calcium carbonate. It can be removed fairly harmlessly by a warm solution of vinegar, which contains ethanoic acid. The limescale dissolves with fizzing and a solution of calcium ethanoate remains.

**(a)** Write a balanced equation for the reaction between ethanoic acid and calcium carbonate. [1]

When the solution produced in **(a)** is evaporated, and the resulting solid calcium ethanoate heated strongly in a test-tube, an organic compound **G** is formed which condenses to a colourless liquid. The residue in the tube consists of calcium carbonate.

**(b)** When 0.10 g of **G** was injected into a gas syringe at a temperature of 383 K and a pressure of $1.0 \times 10^5$ Pa (1 atm), 55 $cm^3$ of vapour were produced.

Calculate the relative molecular mass of **G**. [2]

**(c)** Compound **G** is neutral and water-soluble. **G** does not react with sodium metal nor with Fehling's solution but it does react with alkaline aqueous iodine. Suggest a structural formula for **G**. Justify your answer by reference to these properties of **G**. [5]

**(d)** Construct a balanced equation for the formation of **G** by the action of heat on calcium ethanoate. [1]

**(e)** Suggest a simple one-step test you could carry out to confirm the identity of the functional group present in **G**. You should give the reagent and the observation you would make. [2]

**(f)** Suggest the structural formula of the organic product you might expect when calcium propanoate, $(CH_3CH_2CO_2)_2Ca$, is heated strongly. [1]

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| Candidate Name | Centre Number | Candidate Number |
|---|---|---|
| | | |

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# CHEMISTRY

# 9254/2

PAPER 2

Tuesday **13 JUNE 2000** Morning 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials:
Data Booklet
Mathematical tables and/or calculator

**TIME** 1 hour 15 minutes

## 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.

Question 6 is to be answered in continuous prose, whose style and content should be directed at the appropriate level of the course. In this question, 4 marks are allocated to the assessment of Quality of Language.

Mathematical tables are available. You may use a calculator.

A Data Booklet is provided.

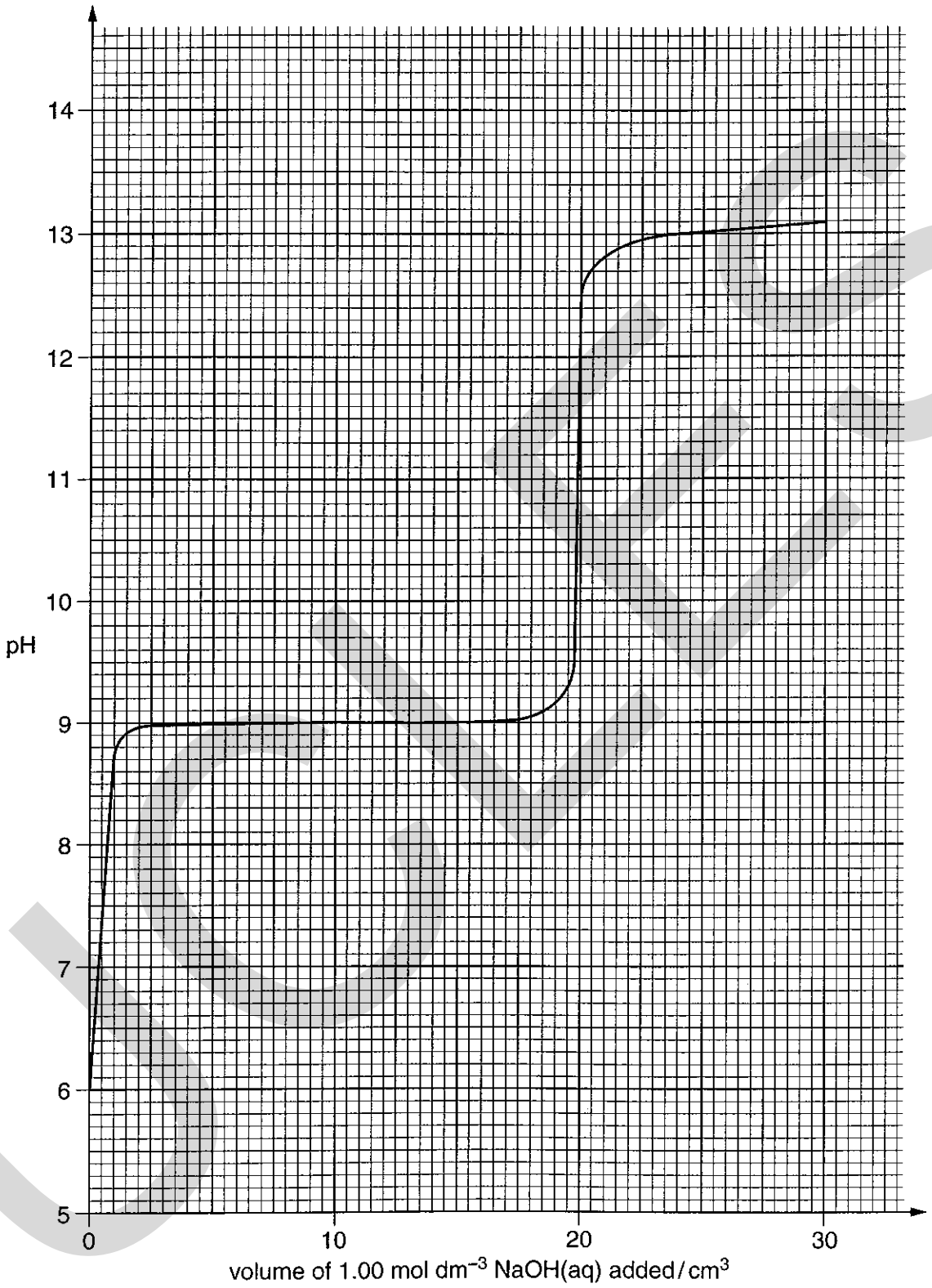
| FOR EXAMINER'S USE | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| TOTAL | |

**This question paper consists of 8 printed pages.**




[Turn over

**1** In an experiment, 50.0 $cm^3$ of aqueous magnesium chloride were titrated with 1.00 mol $dm^{-3}$ sodium hydroxide. The pH of the solution changed as in the diagram.




**(a)** Write an equation (ionic or molecular) for the reaction between aqueous $MgCl_2$ and aqueous NaOH. Include state symbols so that any precipitation is clearly indicated.

.....[1]

**(b)** Calculate the concentration, in mol $dm^{-3}$, of the aqueous $MgCl_2$.

[1]

**(c)** When 10 $cm^3$ of aqueous NaOH were added,

**(i)** calculate the hydroxide ion concentration from the pH of the mixture,

.....

**(ii)** estimate the hydrated magnesium ion concentration, assuming that it is half the original concentration.

.....

[2]

**(d)** **(i)** Write an expression for the solubility product, $K_{sp}$, of magnesium hydroxide.

**(ii)** Use your values from **(c)** to calculate this $K_{sp}$, including the units.

[2]

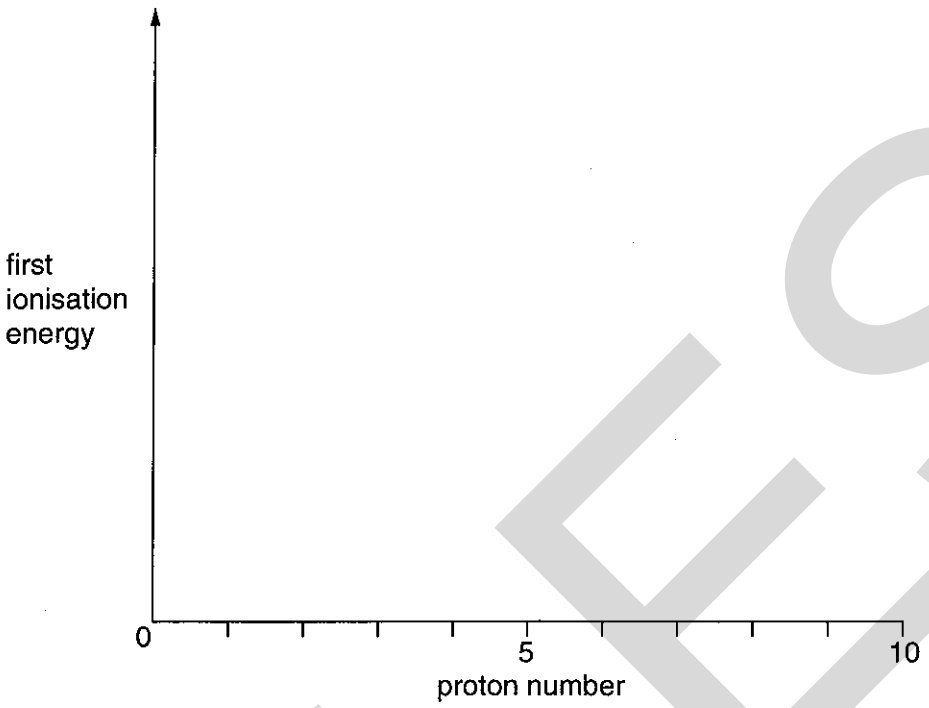
**(e)** Show by calculation why the pH after the addition of 30 $cm^3$ of aqueous NaOH should be 13.1.

[1]

[Total : 7]

**2** **(a)** *The use of the Data Booklet is relevant to this question.*

**(i)** Sketch how the first ionisation energies of the elements change from lithium to neon.




**(ii)** Give the equation that represents the first ionisation energy of nitrogen.

.....

**(iii)** Explain why the first ionisation energy of oxygen is less than that of nitrogen.

.....

.....

.....

.....[4]

**(b)** **(i)** State the electronic configuration of nitrogen.

.....

**(ii)** Draw and label the shapes of the two types of electron orbital found in nitrogen atoms.

[3]

[Total : 7]

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

Nitrogen exhibits a range of oxidation numbers in its compounds.

**(a)** Complete the table below which refers to possible reduction products of nitric acid.

| formula of product | oxidation number of nitrogen |
|---|---|
| $NO_2$ | |
| $N_2O$ | |
| $NH_2OH$ | |
| $NH_4^+$ | |

[2]

**(b)** **(i)** Copper can reduce nitric acid to $NO_2$. Write a balanced equation for this reaction.

.....

**(ii)** Aluminium can reduce nitric acid to $NH_4^+$. Write a balanced equation for this reaction.

.....

**(iii)** Suggest a reason why the reduction products of nitric acid are different for each of these two metals.

.....

.....

.....[3]

**(c)** The compound $NH_2OH$ is oxidised by $Fe^{3+}(aq)$, which is itself reduced to $Fe^{2+}(aq)$.

In an experiment, 25.0 $cm^3$ of 0.100 mol $dm^{-3}$ $NH_2OH$ required 25.0 $cm^3$ of 0.200 mol $dm^{-3}$ $Fe^{3+}$ for complete reaction.

**(i)** How many moles of $Fe^{3+}$ react with one mole of $NH_2OH$?

.....

**(ii)** What change in oxidation number does the nitrogen in $NH_2OH$ undergo?

.....

**(iii)** Which formula from the table in **(a)** corresponds to the nitrogen-containing product of this reaction?

.....

**(iv)** Construct an equation for the reaction of $NH_2OH$ with $Fe^{3+}$.

.....

[4]

[Total : 9]

4 The volatile liquid *Fluothane*, $CF_3CHBrCl$, is commonly used as an anaesthetic in hospitals. It has the advantage that it does not readily react with sodalime (which contains NaOH), used in closed anaesthetic systems to remove the $CO_2$ breathed out by patients.

**(a)** Write an equation for the absorption of $CO_2$ by NaOH.

.....[1]

When *Fluothane* was being developed, it was tested to ensure it did **not** react with NaOH. If it had reacted, bromide ions would have been produced.

**(b)** **(i)** Write an equation for a bromoalkane, e.g. RBr, reacting with aqueous NaOH.

.....

**(ii)** What type of reaction is this?

.....

[2]

**(c)** In an attempt to hydrolyse *Fluothane*, a mixture of *Fluothane* and sodalime was stirred for an hour. It was then acidified and tested with the following reagents.

Describe what you would expect to observe if bromide ions had been produced, and write an equation in each case.

**(i)** aqueous silver nitrate

observation .....

equation .....

**(ii)** aqueous chlorine

observation .....

equation .....

[4]

**(d)** The attempted hydrolysis failed to break the C-Br bond in *Fluothane*. It may be confidently assumed, therefore, that the other two types of C-Hal bond in *Fluothane* also remain intact when hydrolysis is attempted.

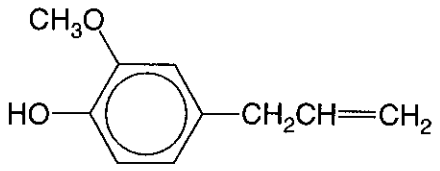
Give a reason for the confidence of this assumption.

.....

.....[1]

[Total : 8]

**5** Eugenol is an important compound in many spices, e.g. cinnamon and cloves.




[The $CH_3O$ group is inert and can be disregarded in this question.]

**(a)** Explain why eugenol is more soluble in aqueous sodium hydroxide than in water.

.....

.....

.....[2]

**(b)** Draw the structures of the organic products when eugenol reacts with each of the following reagents.

| | |
|---|---|
| **(i)** cold, dilute manganate(VII) ions | **(ii)** hot, concentrated manganate(VII) ions |
| **(iii)** ethanoyl chloride | **(iv)** aqueous bromine |

[5]

**(c)** Eugenol can polymerise.

**(i)** What kind of polymerisation can occur with eugenol?

.....

**(ii)** Draw **one** repeat unit for the polymer of eugenol.

[2]

[Total : 9]

**6** Crude oil is largely a mixture of alkanes.

**(a)** Describe how crude oil is used as a source of aliphatic and aromatic hydrocarbons.

.....

.....

.....

.....

.....

.....

.....

.....

.....[2]

**(b)** Discuss how 'cracking' can be used to obtain more useful alkanes and alkenes of lower $M_r$ from larger hydrocarbon molecules.

Illustrate your answers in **(a)** and **(b)** with suitable examples.

.....

.....

.....

.....

.....

.....

.....

.....

.....[2]

Quality of Language [4]

[Total : 8]

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# CHEMISTRY 9254/3

PAPER 3 Multiple Choice

Tuesday **13 JUNE 2000** Morning 1 hour

Additional materials:
- Data Booklet
- Electronic Calculator and/or Mathematical tables
- Multiple Choice answer sheet
- Soft clean eraser
- Soft pencil (Type B or HB is recommended)

**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 in 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. You may use a calculator.

Any rough working should be done in this booklet.



**This question paper consists of 16 printed pages.**



[Turn over

## Section A

For each question, there are four possible answers, **A**, **B**, **C**, and **D**. Choose the one you consider to be correct.

**1** Since 1850, most books have been printed on acidic paper, which eventually becomes brittle and disintegrates. These books can be preserved by treatment with diethylzinc vapour, $Zn(C_2H_5)_2$, which reacts both with acid residues and also with small amounts of water retained in the paper.

Diethylzinc reacts with an acid to give ethane.

$$Zn(C_2H_5)_2 + 2HX \longrightarrow ZnX_2 + 2C_2H_6$$

Which products are likely to result from the reaction of diethylzinc with water?

**A** $ZnH_2 + C_2H_6$

**B** $ZnH_2 + C_2H_5OH$

**C** $Zn(OH)_2 + C_2H_6$

**D** $Zn(OH)_2 + C_2H_5OH$

**2** Which statement about one mole of a metal is always correct?

**A** It contains the same number of atoms as 1 mol of hydrogen atoms.

**B** It contains the same number of atoms as $\frac{1}{12}$ mol of $^{12}C$.

**C** It has the same mass as 1 mol of hydrogen atoms.

**D** It is liberated by 1 mol of electrons.

**3** The second ionisation energy of calcium is $1150\,kJ\,mol^{-1}$.

Which of the following correctly represents this statement?

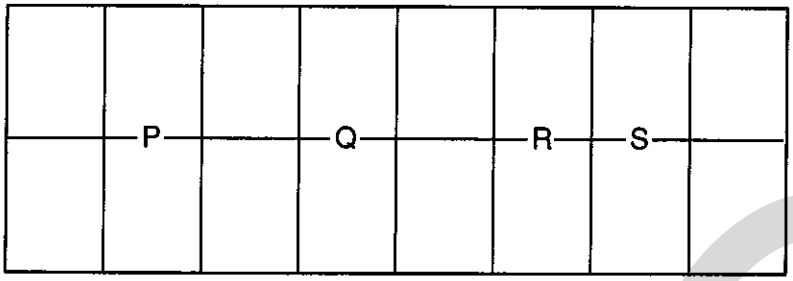
**A** $Ca(g) \longrightarrow Ca^{2+}(g) + 2e^-$; $\Delta H^{\ominus} = +1150\,kJ\,mol^{-1}$

**B** $Ca^+(g) \longrightarrow Ca^{2+}(g) + e^-$; $\Delta H^{\ominus} = +1150\,kJ\,mol^{-1}$

**C** $Ca^+(g) \longrightarrow Ca^{2+}(g) + e^-$; $\Delta H^{\ominus} = -1150\,kJ\,mol^{-1}$

**D** $Ca(s) \longrightarrow Ca^{2+}(aq) + 2e^-$; $\Delta H^{\ominus} = +1150\,kJ\,mol^{-1}$

4 The grid represents two periods of the Periodic Table, for the elements 3 to 18.

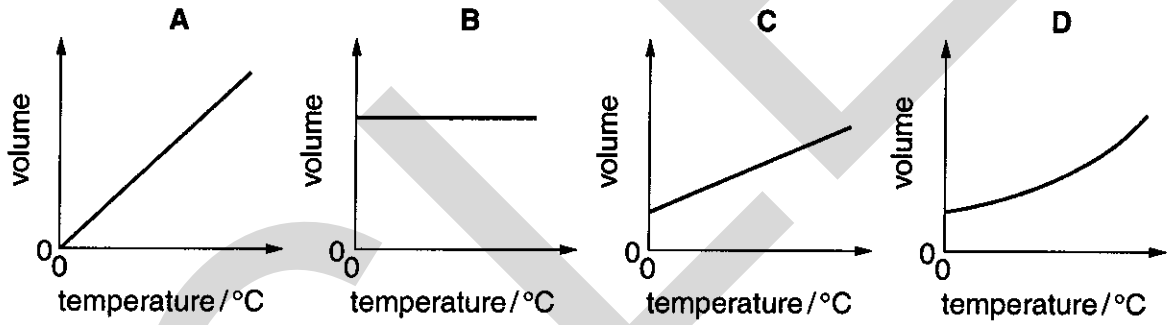



An element from one group, P, Q, R or S, reacts with an element from another of these groups to produce a compound with a giant covalent structure.

Which are the two groups?

**A** P and R **B** Q and R **C** Q and S **D** R and S

5 Which graph is correct for a given mass of an ideal gas at constant pressure?




6 Phosphine reacts with hydrogen iodide to form phosphonium iodide in the reaction shown.

$$PH_3(g) + HI(g) \longrightarrow PH_4^+I^-(s), \qquad \Delta H^{\ominus} = -101.8\,kJ\,mol^{-1}$$

Given that $\Delta H_f^{\ominus}$ for $PH_3(g)$ = +5.4 kJ mol$^{-1}$, and $\Delta H_f^{\ominus}$ for HI(g) = +26.5 kJ mol$^{-1}$, what is the standard enthalpy change of formation of phosphonium iodide?

**A** −133.7 kJ mol$^{-1}$ **B** −69.9 kJ mol$^{-1}$ **C** +69.9 kJ mol$^{-1}$ **D** +133.7 kJ mol$^{-1}$

7 In an experiment to measure the enthalpy change of neutralisation of hydrochloric acid, 20 $cm^3$ of solution containing 0.04 mol of HCl is placed in a plastic cup of negligible heat capacity.
A 20 $cm^3$ sample of aqueous sodium hydroxide containing 0.04 mol of NaOH, at the same initial temperature, is added and the temperature rises by 15 K.

If the heat capacity per unit volume of the final solution is 4.2 $J\,K^{-1}\,cm^{-3}$, what is the enthalpy change of neutralisation of hydrochloric acid?

**A** $\frac{20 \times 4.2 \times 15}{0.04}\ J\,mol^{-1}$

**B** $40 \times 4.2 \times 15 \times 0.08\ J\,mol^{-1}$

**C** $\frac{40 \times 4.2 \times 15}{0.04}\ J\,mol^{-1}$

**D** $\frac{20 \times 4.2 \times 15}{0.08}\ J\,mol^{-1}$

8 Photochromic glass, used for sunglasses, darkens when exposed to bright light and becomes more transparent again when the light is less bright. The depth of colour of the glass is related to the concentration of silver atoms.

The following reactions are involved.

reaction 1 $Ag^+ + Cl^- \rightleftharpoons Ag + Cl$

reaction 2 $Cu^+ + Cl \longrightarrow Cu^{2+} + Cl^-$

reaction 3 $Cu^{2+} + Ag \longrightarrow Cu^+ + Ag^+$

Which statement about these reactions is correct?

**A** $Cu^+$ and $Cu^{2+}$ ions act as catalysts.

**B** $Cu^+$ ions act as an oxidising agent in reaction 2.

**C** Reaction 2 is the one in which light is absorbed.

**D** $Ag^+$ ions are oxidised in reaction 1.

9 Known amounts of hydrogen and iodine are allowed to come to equilibrium at 500 °C in a vessel of known volume.

$$H_2 + I_2 \rightleftharpoons 2HI$$

From which experimental method can $K_c$ be found?

**A** measuring the total pressure in the vessel

**B** slow cooling to 20 °C, breaking open the vessel under aqueous potassium iodide, and titrating the iodine present with aqueous sodium thiosulphate

**C** rapid cooling to 20 °C, breaking open the vessel under aqueous potassium iodide, and titrating the iodine present with aqueous sodium thiosulphate

**D** withdrawal of a measured sample of the equilibrium mixture, followed by complete decomposition of the hydrogen iodide present, and then titrating the total amount of iodine with aqueous sodium thiosulphate

10 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.

11 The table gives data for the reaction between X and Y at constant temperature.

| experiment | [X] / mol dm$^{-3}$ | [Y] / mol dm$^{-3}$ | initial rate / mol dm$^{-3}$ s$^{-1}$ |
|---|---|---|---|
| 1 | 0.3 | 0.2 | $4.0 \times 10^{-4}$ |
| 2 | 0.6 | 0.4 | $1.6 \times 10^{-3}$ |
| 3 | 0.6 | 0.8 | $6.4 \times 10^{-3}$ |

What is the rate equation for the reaction?

**A** rate = $k[X][Y]^2$

**B** rate = $k[X]^2[Y]$

**C** rate = $k[X]^2$

**D** rate = $k[Y]^2$

**12** Which property of the first six elements of Period 3 (sodium to sulphur) continuously increases numerically?

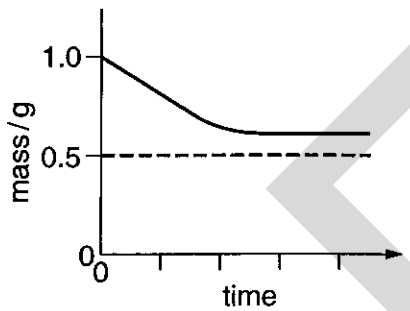
**A** atomic radius

**B** first ionisation energy

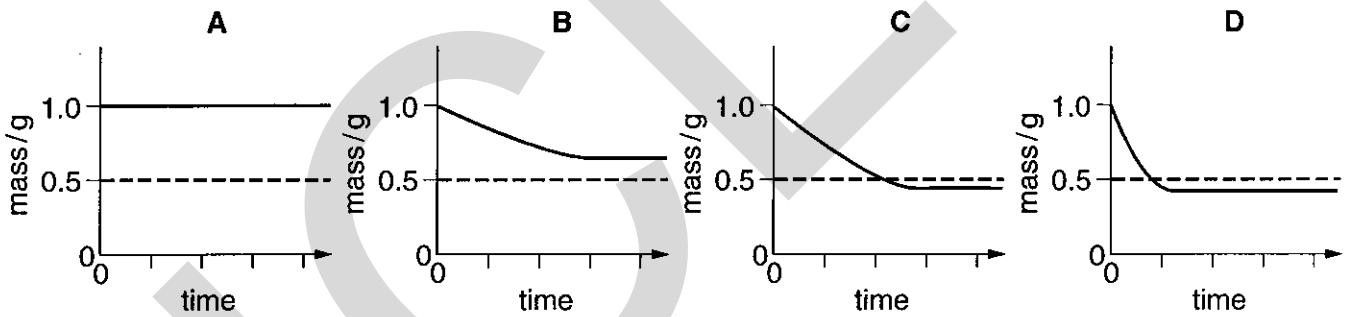
**C** maximum oxidation number in oxide

**D** melting point

**13** The graph represents the change in mass that occurs when 1.0 g of powdered calcium carbonate, $CaCO_3$, is heated at a temperature, *T*.




Which graph would be obtained by heating 1.0 g of powdered magnesium carbonate, $MgCO_3$, at the same temperature, *T*?




**14** Carbon disulphide, $CS_2$, is a volatile flammable liquid used in the manufacture of cellophane.

On combustion, $CS_2$ is oxidised as follows.

$$CS_2(g) + 3O_2(g) \longrightarrow CO_2(g) + 2SO_2(g)$$

A 20 $cm^3$ sample of carbon disulphide vapour is ignited with 100 $cm^3$ of oxygen. The final volume of gas after burning is treated with an excess of aqueous alkali.

Which percentage of this final volume dissolves in the alkali?

[All volumes measured at the same temperature and pressure, conditions under which $CS_2$ is a gas.]

**A** 20 % **B** 40 % **C** 60 % **D** 80 %

**15** Which anions containing chlorine are formed when chlorine is passed into cold aqueous potassium hydroxide?

**A** $Cl^-$ and $ClO^-$

**B** $Cl^-$ and $ClO_3^-$

**C** $Cl^-$ and $ClO_4^-$

**D** $ClO^-$ and $ClO_3^-$

**16** A precipitate of copper(II) hydroxide dissolves in concentrated aqueous ammonia due to the formation of a complex ion.

Which complex ion is formed?

**A** $[Cu(NH_3)_2]^{2+}$

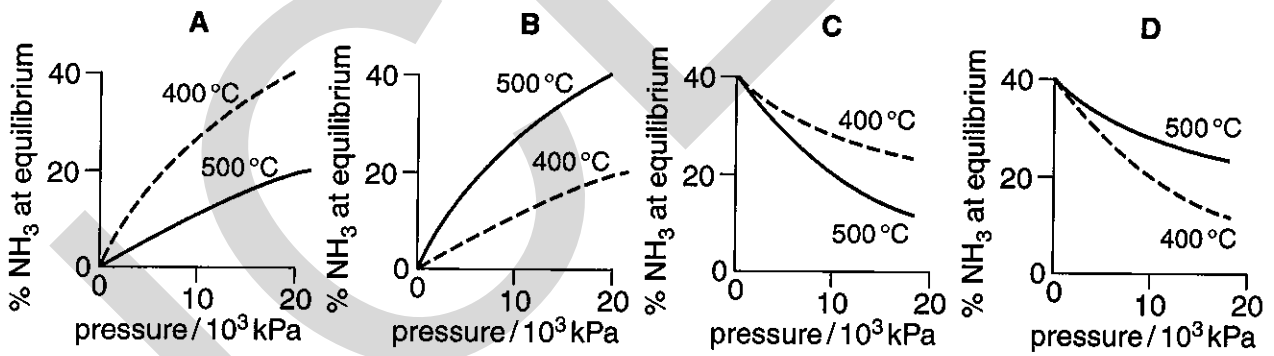
**B** $[Cu(NH_3)_4]^{2+}$

**C** $Cu(NH_3)_4(OH)_2$

**D** $[Cu(NH_4)_4]^{2+}$

**17** The percentage of ammonia obtainable, if equilibrium were established during the Haber process, is plotted against the operating pressure for two temperatures, 400 °C and 500 °C.

Which of the following correctly represents the two graphs?




**18** Which descriptions of nitrogen dioxide and sulphur dioxide are correct?

| | property | $NO_2$ | $SO_2$ |
|---|---|---|---|
| **A** | colour | colourless | brown |
| **B** | how formed in atmosphere | from burning fossil fuels | from car exhausts |
| **C** | how prepared | burning element in air | heating appropriate Group II salt |
| **D** | use in food technology | not used | as a preservative |

**19** Benzene reacts with chlorine as shown.

$$C_6H_6 + Cl_2 \longrightarrow C_6H_5Cl + HCl$$

Which term describes this type of reaction?

**A** electrophilic substitution

**B** free-radical substitution

**C** nucleophilic addition

**D** nucleophilic substitution

**20** The substances shown can be present in the exhaust fumes of a car engine.

Which substance could contribute to 'acid rain'?

**A** CO **B** $C_2H_4$ **C** NO **D** PbO

**21** Samples of the gases $CH_3Cl$ and $Cl_2$ are mixed together and irradiated with light.

Which compound is produced in trace amounts by a termination stage in the chain reaction?

**A** $HCl$ **B** $CH_2{=}CH_2$ **C** $CH_2ClCH_2Cl$ **D** $CH_3CH_3$

**22** Some chlorobutanes were separately treated with hot ethanolic sodium hydroxide. Two of these gave the same hydrocarbon, $C_4H_6$.

From which pair of chlorobutanes was this hydrocarbon obtained?

**A** $CH_3CH_2CH_2CH_2Cl$ and $CH_3CH_2CH_2CHCl_2$

**B** $CH_3CHClCHClCH_3$ and $ClCH_2CH_2CH_2CH_2Cl$

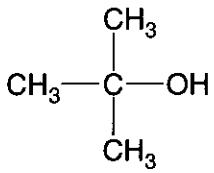
**C** $CH_3CH_2CH_2CH_2Cl$ and $ClCH_2CH_2CH_2CH_2Cl$

**D** $CH_3CH_2CH_2CH_2Cl$ and $CH_3CH_2CHClCH_3$

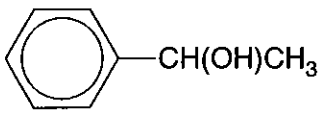
**23** Which compound gives an acidic solution with water?

**A** $CH_3CH_2CH_2CHO$

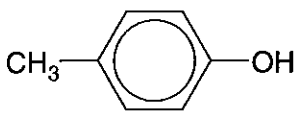
**B**



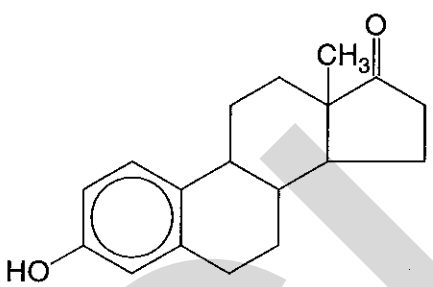
**C**



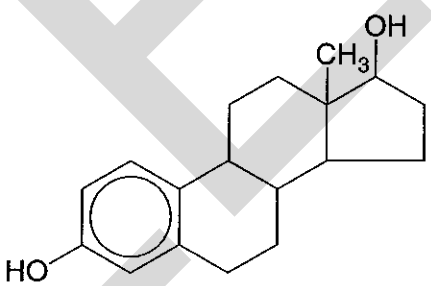
**D**



**24** Two female sex hormones are oestrone and oestradiol.



oestrone



oestradiol

Which reagent can be used to distinguish between the two hormones?

**A** $Br_2(aq)$ at room temperature

**B** 2,4-dinitrophenylhydrazine reagent

**C** Fehling's reagent

**D** $I_2$ in NaOH(aq)

**25** Which procedure gives the best yield of ethyl ethanoate, $CH_3CO_2C_2H_5$, starting from ethanoic acid, $CH_3CO_2H$, and ethanol, $C_2H_5OH$?

**A** reacting $CH_3CO_2H$ with $SOCl_2$, then adding $C_2H_5OH$

**B** reacting $C_2H_5OH$ with $SOCl_2$, then adding $CH_3CO_2H$

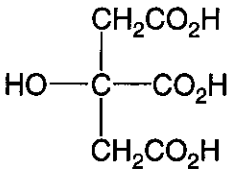
**C** refluxing a mixture of $CH_3CO_2H$ and $C_2H_5OH$ with NaOH(aq)

**D** refluxing $C_2H_5OH$ with concentrated $H_2SO_4$, then adding $CH_3CO_2H$



[Turn over

**26** Citric acid, which causes the sharp taste of lemon juice, has the following formula.



What reacts completely with 1 mol of citric acid?

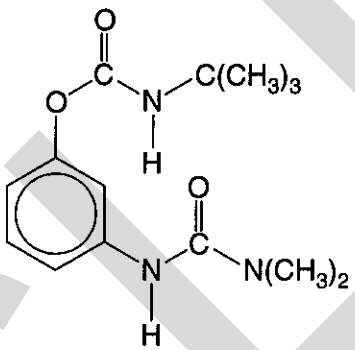
**A** 3 mol of $PCl_5(s)$

**B** 4 mol of $HCl(g)$

**C** 4 mol of Na(s)

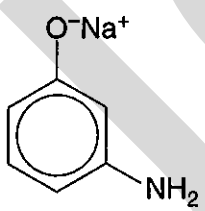
**D** 4 mol of NaOH(aq)

**27** The structure of the herbicide *Karbutilate* may be represented as shown.

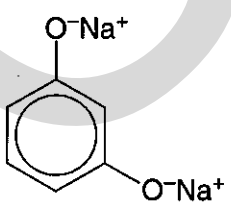


What would be formed by prolonged boiling of *Karbutilate* with aqueous sodium hydroxide?

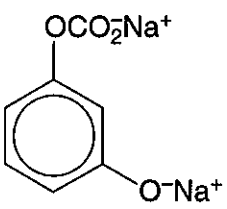
**A**



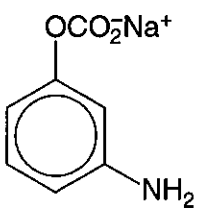
**B**



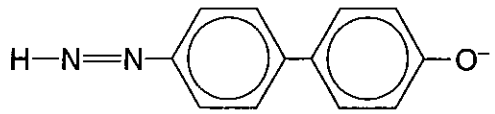
**C**

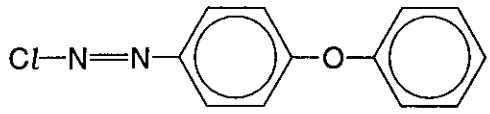


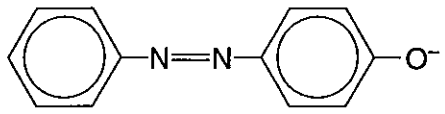
**D**

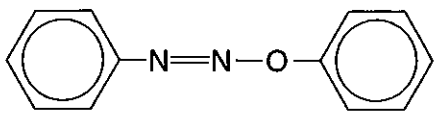


**28** What is the formula of the organic product obtained from the coupling reaction of benzenediazonium chloride, $C_6H_5N_2Cl$, and the phenate ion, $C_6H_5O^-$?

**A** 

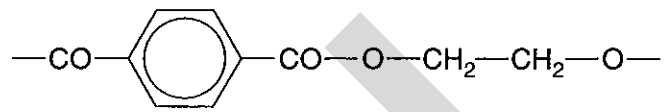
**B** 

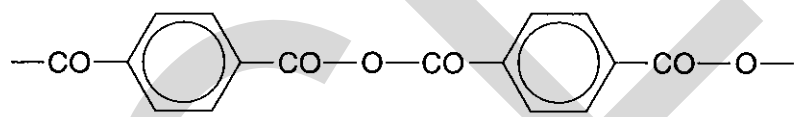
**C** 

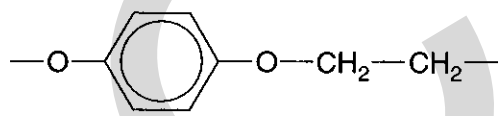
**D** 

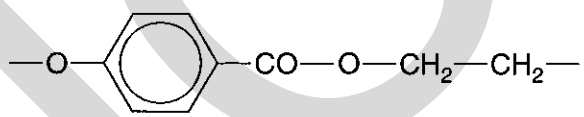
**29** *Terylene* is a condensation polymer.

What is the repeat unit of *Terylene*?

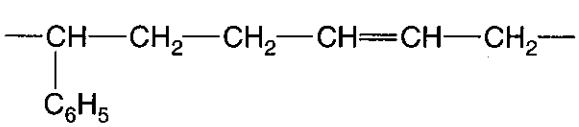
**A** 

**B** 

**C** 

**D** 

**30** The diagram shows the repeat unit for a synthetic rubber.



What are the monomers for this polymer?

**A** $C_6H_5CH_3$ and $CH_3CH{=}CHCH_3$

**B** $C_6H_5CH_3$ and $CH_2{=}CHCH{=}CH_2$

**C** $C_6H_5CH{=}CH_2$ and $CH_2{=}CHCH{=}CH_2$

**D** $C_6H_5CH{=}CH_2$ and $CH_3CH{=}CHCH_3$



[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.

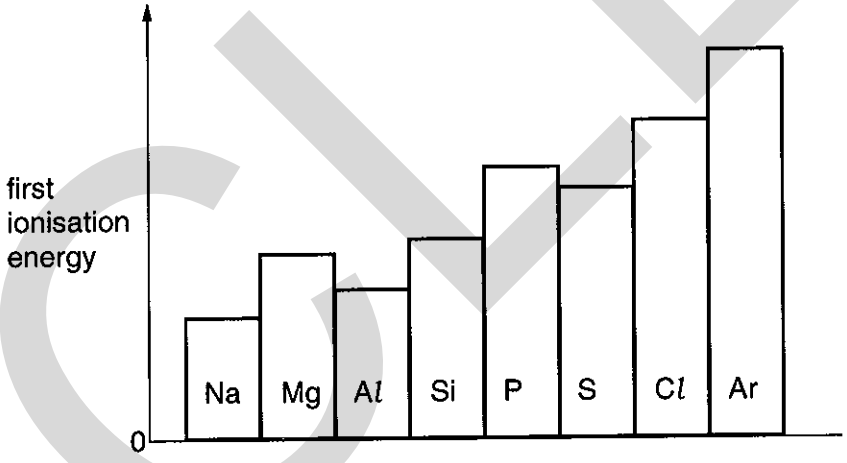
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements which you consider to be correct).

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** The first ionisation energies of elements in the third Period are shown.




Which factors explain why the value of the first ionisation energy of sulphur is lower than that of phosphorus?

**1** repulsion between the pair of 3p electrons

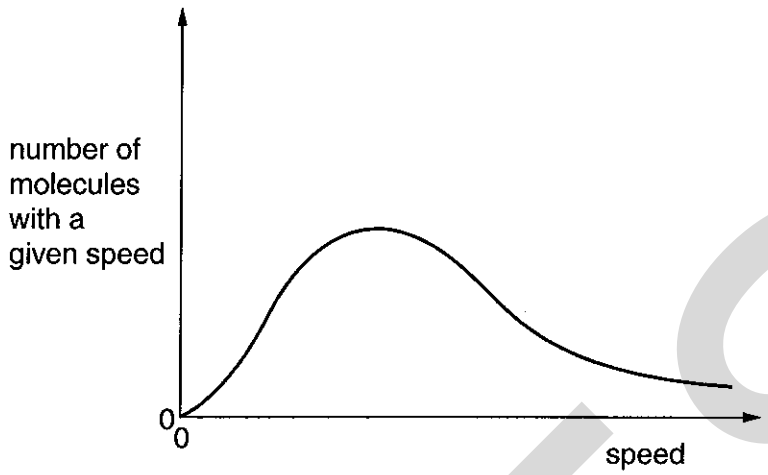
**2** greater shielding by inner electrons

**3** increase of principal quantum number

**32** Which molecules are linear in shape?

**1** $BeCl_2$ **2** $CO_2$ **3** $Cl_2O$

**33** The graph shows the Boltzmann distribution of molecular speeds.




Which statements are correct?

**1** Raising the temperature always decreases the number of molecules with a given speed.

**2** The area under the curve is proportional to the number of molecules present.

**3** Raising the temperature moves the maximum of the curve to the right.

**34** The use of chlorine as a disinfectant in swimming pools is now widely banned and the weak acid trichloroisocyanuric acid is used instead.

$$\text{trichloroisocyanuric acid} + OH^- \rightleftharpoons ClO^- + \text{cyanuric acid}$$

The $ClO^-$ ion is the effective disinfectant.

Why is it necessary to keep the pH of the water at 7.5?

**1** The concentration of $H^+$ is too low for the following reaction to occur:

$$2H^+(aq) + ClO^-(aq) + Cl^-(aq) \longrightarrow H_2O(l) + Cl_2(g)$$

**2** The concentration of the $ClO^-$ ion depends on the pH.

**3** At a pH of 7.5, the concentration of the $ClO^-$ ion is at a maximum.

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 |

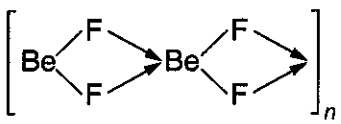
No other combination of statements is used as a correct response.

**35** Beryllium is the first member of Group II and forms covalent compounds which are said to be electron deficient. In many ways, beryllium resembles aluminium.

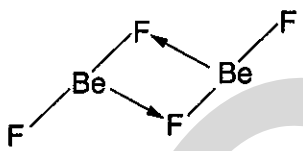
Which of the following are possible?

**1** $BeF_4^{2-}$

**2**

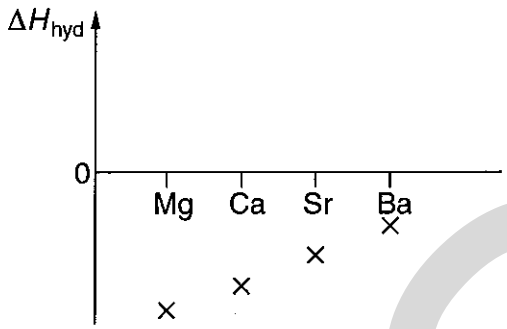



**3**

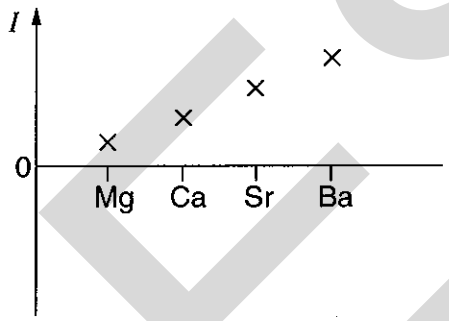


**36** Which diagrams correctly show the trend in a property of the Group II elements Mg, Ca, Sr, Ba?

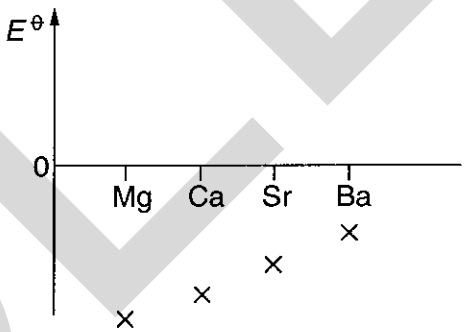
**1** $\Delta H_{hyd}$, the enthalpy change of hydration of $M^{2+}(g)$




**2** $I$, the first ionisation energy




**3** $E^{\ominus}$, the standard electrode potential of the $M^{2+}(aq)|M(s)$ electrode




**37** Which statements about carbon, silicon and their compounds are correct?

**1** Silicon tetrachloride reacts more violently with water than does carbon tetrachloride.

**2** Silicon(IV) oxide has a higher melting point than carbon dioxide.

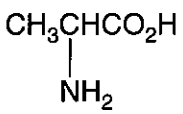
**3** Silicon exhibits more oxidation states than does carbon.

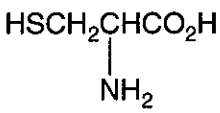
The responses **A** to **D** should be selected on the basis of

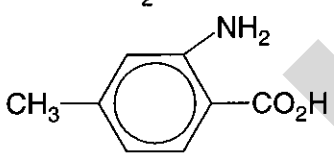
| A | B | C | D |
|---|---|---|---|
| **1**, **2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

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

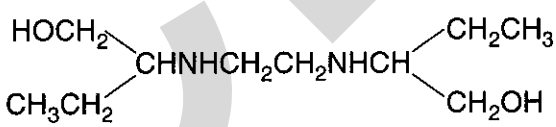
**38** Which amino acids have optical isomers?

**1** 

**2** 

**3** 

**39** Ethambutol has been used since 1960 as a drug for treating tuberculosis.



Which reagents, under suitable conditions, could convert it into an organic compound containing a halogen?

**1** hydrogen bromide

**2** alkaline aqueous iodine

**3** ethanoyl chloride

**40** All of the following reagents react with ethanal, $CH_3CHO$.

Which reagents give a product that retains the C—C═ structure?

**1** 2,4-dinitrophenylhydrazine reagent

**2** ethanolic hydrogen cyanide

**3** lithium tetrahydridoaluminate(III), $LiAlH_4$

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RECOGNISING ACHIEVEMENT

**General Certificate of Education Advanced Level**
former Cambridge linear syllabus

# CHEMISTRY 9254/4

PAPER 4 Option Topics

Wednesday **21 JUNE 2000** Morning 1 hour 15 minutes

Additional materials:
Answer paper
Data Booklet
Graph paper
Electronic calculator and/or Mathematical tables

**TIME** 1 hour 15 minutes

## 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 prepared.

You may use a calculator.

A Data Booklet is provided.

You are reminded of the need for good English and clear presentation in your answers.



**This question paper consists of 13 printed pages and 3 blank pages.**

SB (SM/DJ) QF04887


[Turn over

## BIOCHEMISTRY

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

**1** **(a)** **(i)** Draw a diagram showing **three** strands of a β-pleated sheet structure of the protein the formula of which is given below.

Copy the formula below writing it as a **displayed formula**. Leave space above and below your drawing so that you can draw one strand above and the other below.

-CHRNHCOCHRNHCOCHRNHCO-

Indicate the hydrogen bonds between the strands by dotted lines.

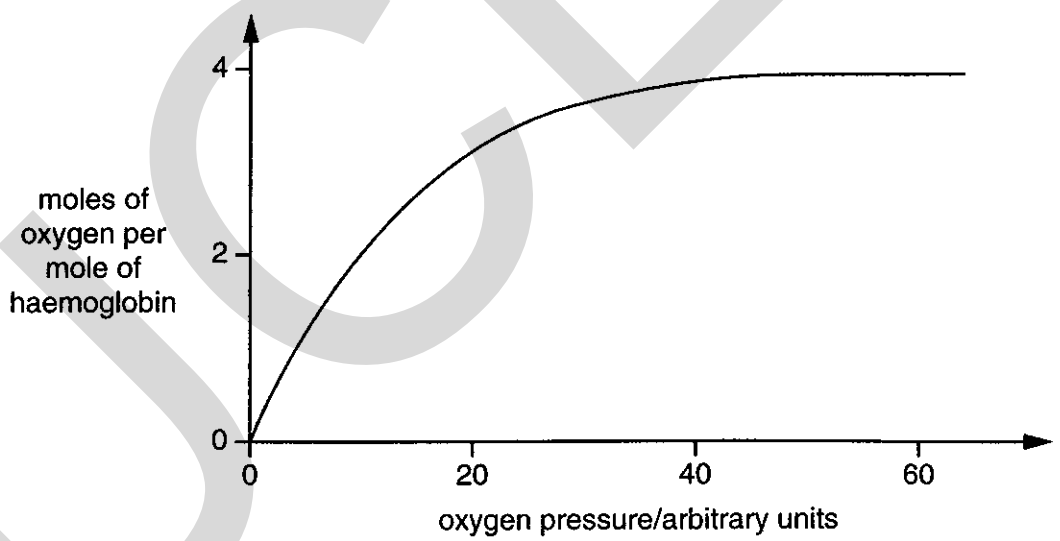
**(ii)** What type of protein forms β-pleated sheets?

**(iii)** Suggest how the R groups are directed in a β-pleated sheet. [6]

**(b)** The folding of polypeptide chains is due to the interactions of the R groups. Suggest simple examples of **four** different types of R group interactions, illustrating each one with a suitable formula of the R group concerned. [4]

**2** **(a)** Describe the structure and function of haemoglobin. [4]

**(b)** The absorption of oxygen by haemoglobin is given in the following graph.




**(i)** Suggest an explanation for the shape of the curve.

**(ii)** The graph has a similar shape to that obtained from the kinetics of enzyme catalysed reactions. What would be an approximate value of the corresponding Michaelis constant, $K_m$, for the oxygen/haemoglobin reaction?

**(iii)** How does the variable on the vertical axis of this graph differ from that in an enzyme catalysed reaction?

[6]

3 **(a)** Describe the structure of a section of DNA. [6]

**(b)** Explain why the backbone of DNA is hydrophilic. [2]

**(c)** **(i)** What functional group forms the bond between the two units of the backbone of DNA?

**(ii)** Explain why this group is susceptible to hydrolysis. [2]

## ENVIRONMENTAL CHEMISTRY

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

**4** **(a)** The ozone layer in the stratosphere offers a vital protection to life on the Earth's surface. It is maintained by the equilibrium that exists between ozone and oxygen.

**(i)** Explain, in detail, how the equilibrium between ozone and oxygen is maintained.

**(ii)** What effect does the ozone layer have on the sunlight passing through it?

**(iii)** What type of chemical reaction at the Earth's surface would be inhibited by the presence of the ozone layer?

[6]

**(b)** The ozone layer is being damaged by the presence of nitrogen monoxide in the stratosphere.

**(i)** Give **one** example of the production of nitrogen monoxide through human activity.

**(ii)** Explain, giving appropriate equations, how nitrogen monoxide molecules are involved in the destruction of ozone.

[4]

**5** **(a)** Aluminium is widely distributed in the Earth's crust. It is commonly involved as a component of the structure of silicate clays forming aluminium oxide (gibbsite) layers. Aluminium ions may also be found within the silicate layers.

**(i)** Describe how the gibbsite layer is involved in the structure of a 2:1 clay such as montmorillonite.

**(ii)** Explain how the presence of aluminium ions within the silicate layer gives the clay a cation exchange capacity.

**(iii)** Why is a cation exchange capacity important for effective plant growth?

[5]

**(b)** The presence of aluminium ions in the soil solution enhances acidity and causes lead ions to become more mobile.

**(i)** Using equations, explain how aluminium ions enhance acidity.

**(ii)** Briefly explain why increased acidity causes lead ions to become more mobile.

[5]

6 **(a)** Typically the air contains 0.035% by volume of carbon dioxide. For the following equilibrium,

$$CO_2\,(g) \rightleftharpoons CO_2(aq)$$

the equilibrium constant (Henry's Law constant), $K_H = 3.3 \times 10^{-4}$ mol $dm^{-3}$ $kPa^{-1}$.

Use these figures to calculate the solubility of carbon dioxide in water at a pressure of 101.3 kPa. [3]

**(b)** Dissolved carbon dioxide reacts with water to produce both hydrogencarbonate and carbonate ions.

**(i)** Write an expression for the equilibrium constant for the following reaction.

$$HCO_3^-(aq) \rightleftharpoons CO_3^{2-}(aq) + H^+(aq)$$

**(ii)** At room temperature this equilibrium constant has a value of $4.7 \times 10^{-11}$ mol $dm^{-3}$. A sample of water is found to contain a concentration of hydrogencarbonate ions which is ten times greater than the concentration of carbonate ions.

Calculate the pH of this water.

**(iii)** Another sample of water containing hydrogencarbonate and carbonate ions has a pH of 8.3. Use this pH and your answer to **(ii)** above to estimate the ratio of hydrogencarbonate to carbonate ions present.

**(iv)** In practice, most waters also contain decaying organic matter. Explain how this will affect the pH.

[7]

## FOOD CHEMISTRY

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

7 **(a)** The fatty component of milk is present in the form of an emulsion of droplets dispersed in water.

Write the structural formula of a fat molecule that might be present in milk. State the reason why you chose the fatty acid involved. [2]

**(b)** What structural features of a molecule allow it to act as an emulsifying agent? Explain how an emulsifying agent works. Suggest a natural emulsifier that could be present in milk. [4]

**(c)** Dairy products are sources of vitamin A and of minerals.

**(i)** With which component of milk is vitamin A associated?

**(ii)** Name or describe a deficiency disorder caused by a lack of vitamin A in the diet.

[2]

**(d)** Discuss the role of vitamin D in human diet. [2]

8 **(a)** **(i)** Explain the chemical classification of sucrose (cane sugar), which is also an ingredient of most jams.

**(ii)** In jam making, sucrose is boiled with fruit. The acids present in the fruit produce a mixture called 'invert sugar'. Use a word equation to help explain this reaction and suggest the meaning of the word *invert* in this context.

[4]

**(b)** **(i)** Jams are colloidal systems. Explain the nature of the colloidal systems in jams.

**(ii)** Explain why boiling in an open pan is necessary in jam making and why over-boiling may not help the jam to set.

[6]

9 **(a)** **(i)** Describe the degradation of food by micro-organisms.

**(ii)** State the effect of each form of spoilage on the food.

[6]

**(b)** **(i)** Explain how vinegar is produced and write an equation for the general reaction involved.

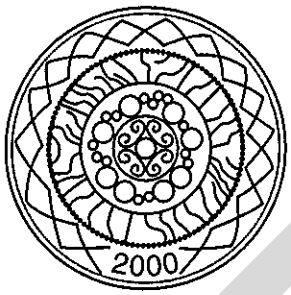
**(ii)** Wines are often distilled to produce spirits. Suggest reasons why vinegar is not distilled to make a more concentrated product.

[4]

## PHASE EQUILIBRIA

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

**10** Many countries are celebrating the millennium by issuing a commemorative coin for everyday use made of two different coloured alloys, like the one shown in the diagram.




The gold-coloured outer circle of the coin could be made from the traditional cupronickel alloy and the inner circle from a copper/nickel/zinc alloy, which is silver coloured.

There is a raised join between the two parts of the coin.

The m.p. of Ni is 1450 °C and that of Cu is 1080 °C.

**(a)** The melting point curve of cupronickel is the straight line joining the melting points of the two components. Make a sketch (graph paper is not necessary) of the m.p./composition diagram, labelling the axes and the areas of the sketch. [2]

**(b)** It is claimed that such a coin has advantages over traditional coins both for

**(i)** security,

**(ii)** the disabled.

Suggest what these advantages might be. [2]

**(c)** Aluminium and copper have a different type of m.p./composition diagram as a eutectic of m.p. 535 °C is formed at 67% copper by mass.

Make a sketch of the m.p./composition diagram, labelling the axes and the areas of the sketch. The m.p. of Al is 660 °C. [3]

**(d)** **(i)** Use the atomic radii from the *Data Booklet* to suggest why Cu and Ni do not form a eutectic, but Cu and Al do.

**(ii)** Suggest also how the solid alloys Cu/Ni and Cu/Al might differ in their appearance under a microscope. [3]

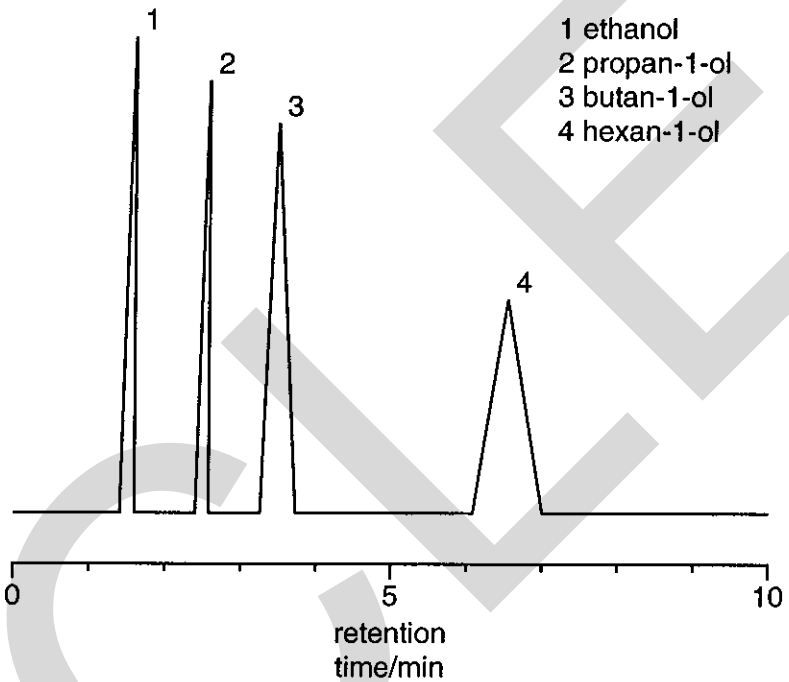
**11** **(a)** What is meant by the *melting point* and by the *boiling point* of a substance? [2]

**(b)** Sketch the phase diagram of water, including its melting point and its boiling point. Label the areas and explain any atypical behaviour shown by water. [4]

**(c)** Rivers often freeze in very cold weather but the seas into which the rivers flow stay unfrozen. Suggest reasons for this observation and illustrate this on your phase diagram. [4]

**12** **(a)** Describe simply and explain the method of gas/liquid chromatography (GLC). [3]

**(b)** A 1:1:1:1 mixture of ethanol, propan-1-ol, butan-1-ol and hexan-1-ol was injected into a GLC. The chromatogram below was obtained. The conditions of the run are stated below the diagram.




The temperature of the oven is 100 °C.
The carrier gas is nitrogen flowing at a rate of 30 $cm^3$ $min^{-1}$.
The stationary phase is carbowax.
The column is 2.0 m long and has an effective cross-section of 6 $mm^2$.

**(i)** Calculate how long the nitrogen takes to pass through the column.

**(ii)** Estimate the volume of nitrogen that passes through the column to carry the ethanol fraction.

**(iii)** Explain why the temperature of the oven (100 °C) does not have to be higher than the boiling points of all the alcohols.

**(iv)** Explain why the carbowax is likely to be hydrophobic (non-polar).

**(v)** Explain the relative heights and shapes of the peaks in the chromatogram.

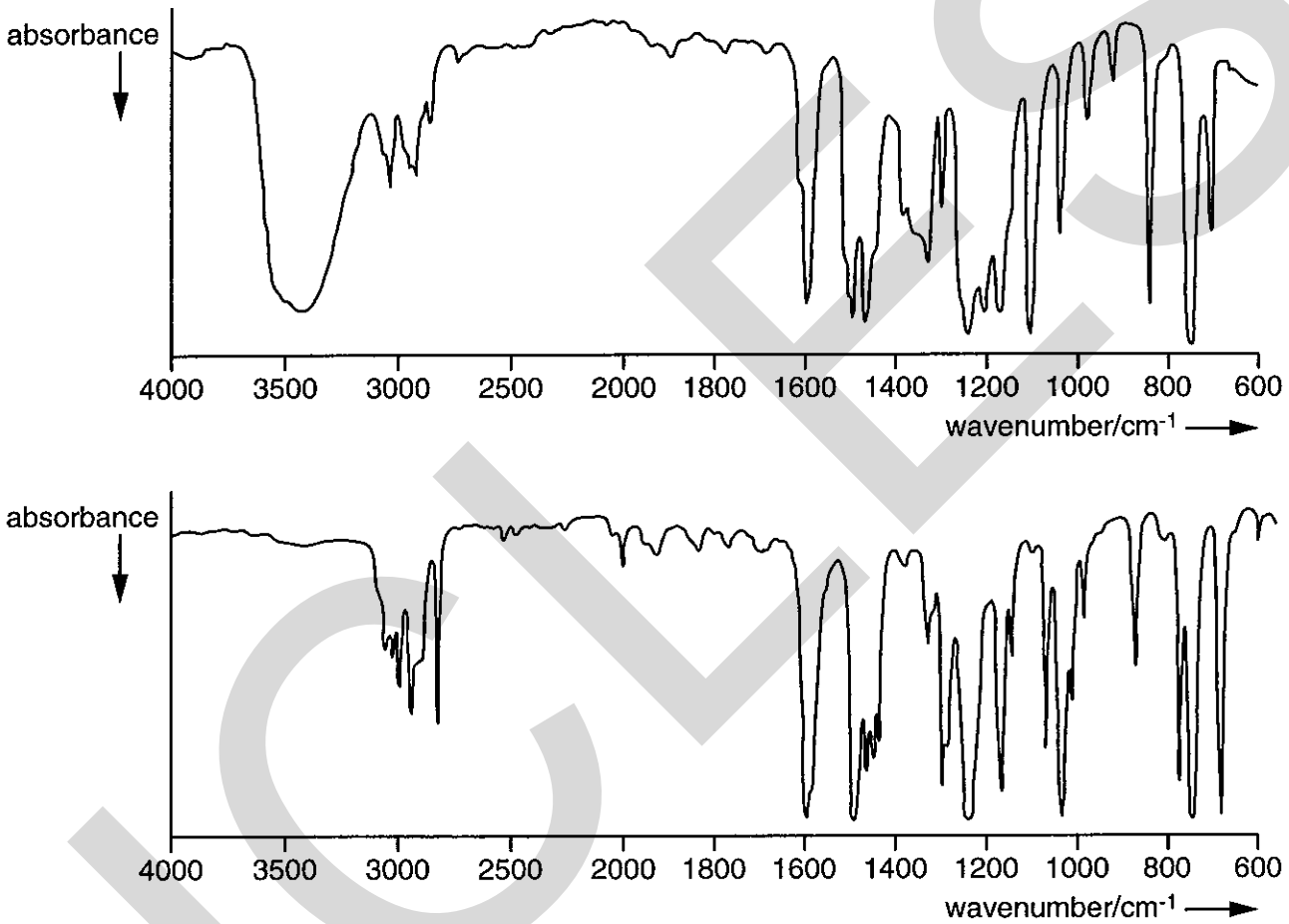
[7]

## SPECTROSCOPY

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

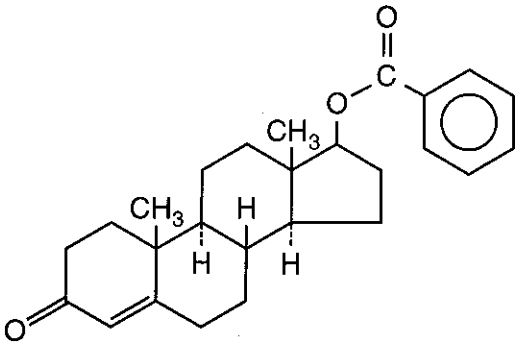
**13** **(a)** Outline **two** methods of preparing a sample of a solid compound in order to obtain an infra-red spectrum. [6]

**(b)** The two spectra shown were obtained from isomeric compounds **J** and **K** with the formula $C_7H_8O$.

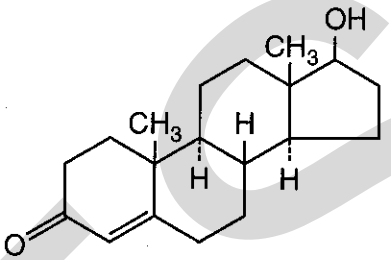



Deduce possible structures for compounds **J** and **K**, explaining in detail how you arrived at your answers. [4]

**14** The use of banned substances to enhance performance continues to be a problem in athletic competition. One of the groups of banned substances is 'anabolic steroids' which are closely related to natural hormones found in the body. The structures of one of these anabolic steroids, *Nandrolone*, and the related hormone, testosterone, are shown.




*Nandrolone*




testosterone

**(a)** Indicate which structural features of *Nandrolone* compared to testosterone could be used to distinguish the two compounds with the following spectroscopic techniques.

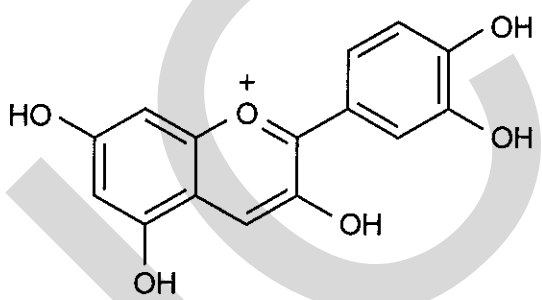
**(i)** infra-red spectroscopy

**(ii)** ultraviolet spectroscopy

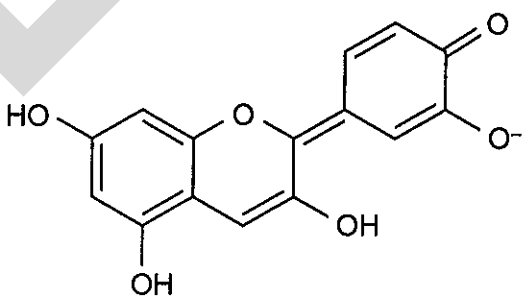
**(iii)** n.m.r. spectroscopy

[5]

**(b)** The red colour of poppies, and the blue colour of cornflowers are both caused by the same molecule, cyanidin. In poppies the sap is acidic, whilst in cornflowers the sap is alkaline.




red form in acid




blue form in alkali

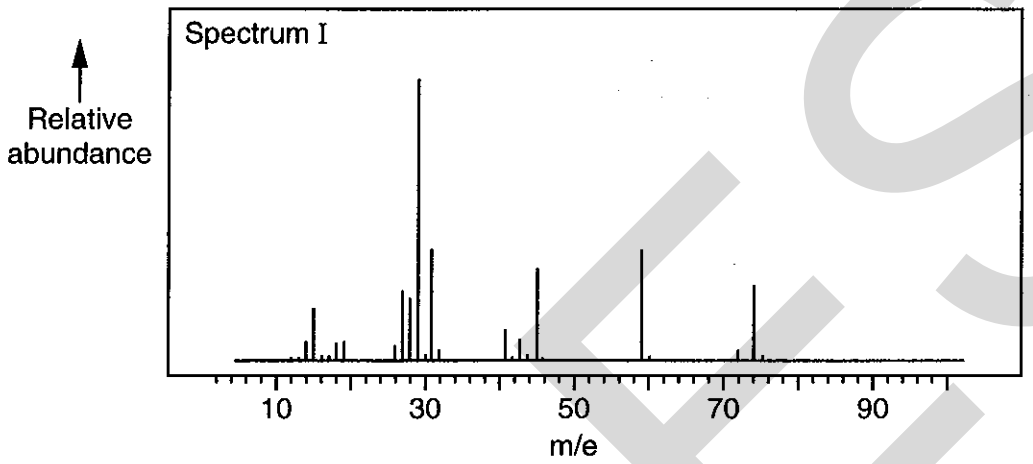
**(i)** Explain what structural features of this substance cause it to absorb energy in the visible region of the spectrum.

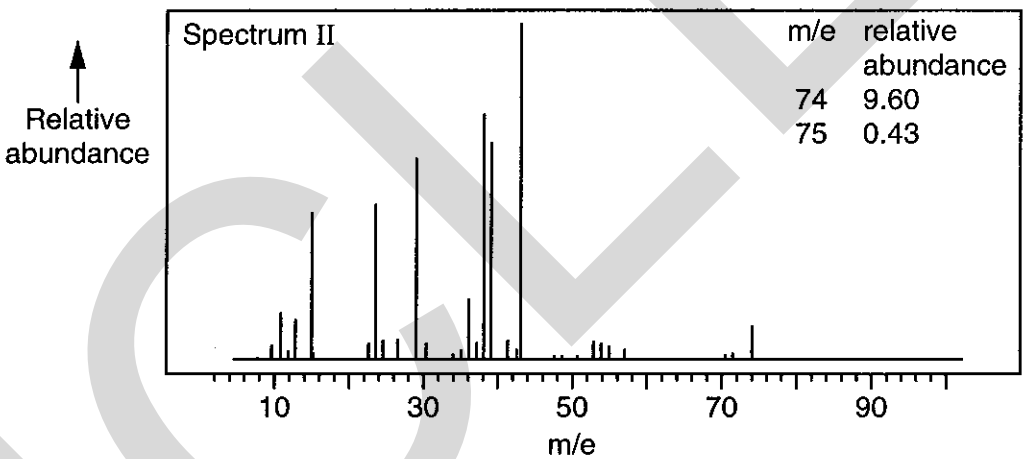
**(ii)** How does the addition of acid cause the structure to absorb in a different region of the spectrum?

[5]

**15 (a)** The mass spectra below were obtained from the two isomers of $C_4H_{10}O$ shown.


**P** **Q**

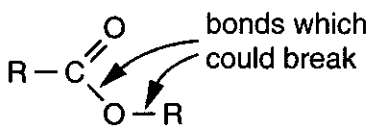



Identify which compound produced which mass spectrum, giving **three** pieces of evidence you have used to decide. [4]

**(b)** Use the **M** and **M+1** peaks to confirm that there are four carbon atoms in the compound shown in spectrum II. [2]

**(c)** In the hydrolysis of an ester, the reaction could occur with the breaking of one of two bonds in the molecule.




Explain how mass spectrometry could identify which bond breaks. [4]



[Turn over

## TRANSITION ELEMENTS

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

**16** **(a)** Paramagnetism is the property of being attracted to a magnetic field. Explain why some transition metal complexes are paramagnetic, whilst others are not. [2]

**(b)** Explain the chemical and magnetic behaviour illustrated in the following reactions.

A blue solution of a vanadium salt is paramagnetic. When a portion of the solution containing 0.01 mol of vanadium is reacted exactly with an acidified solution containing 0.002 mol of $KMnO_4$, the paramagnetism decreases to zero.

When another 0.01 mol of the vanadium salt is reduced by 0.005 mol of $Sn^{2+}(aq)$, the paramagnetism of the resulting solution increases.

**(i)** What is the oxidation state of the vanadium in the blue solution?

**(ii)** Use the *Data Booklet* to deduce the final oxidation states of the vanadium in the two solutions, and write balanced equations for the two reactions.

**(iii)** Suggest the colours of the final solutions, and explain why the paramagnetism changes in each case.

[8]

**17** **(a)** The element iron or its compounds can act as a *heterogeneous catalyst* or a *homogeneous catalyst*.

**(i)** Explain the terms in italics.

**(ii)** Give an example of iron acting in each of these catalytic roles, writing equations for the reactions and explaining for each one how iron acts as a catalyst.

[7]

**(b)** Make use of the *Data Booklet* to explain the following observations.

Although acidic solutions of iron(II) salts are only slowly oxidised by air, the precipitate that is obtained on adding NaOH(aq) to a solution of an iron(II) salt rapidly turns brown on the surface. [3]

**18** **(a)** Copper(I) sulphate, $Cu_2SO_4$, can be made from copper(I) oxide under non-aqueous conditions. On adding this salt to water, it immediately undergoes a disproportionation reaction.

**(i)** Suggest, with a reason, the colour of copper(I) sulphate.

**(ii)** Using suitable data from the *Data Booklet* explain why the disproportionation reaction occurs, and write an equation for it.

[5]

**(b)** One method of determining the percentage of copper in a copper-containing ore is to dissolve the copper salts in an excess of dilute sulphuric acid, add an excess of potassium iodide, and titrate the iodine formed with sodium thiosulphate solution.

Iodine and sodium thiosulphate react in the ratio $I_2$:$Na_2S_2O_3$ = 1:2

**(i)** Describe what you would observe when the potassium iodide is added to the sulphuric acid solution of copper salts. Write an ionic equation for the reaction.

**(ii)** When a 2.0 g sample of an ore was subjected to the above treatment, it was found that 15.8 $cm^3$ of 0.100 mol $dm^{-3}$ thiosulphate was needed to react with the iodine produced. Use the ratio above and your equation in **(i)** to calculate the number of moles, and hence the percentage by mass, of copper in the sample.

[5]

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OCR
RECOGNISING ACHIEVEMENT

| Candidate Name | Centre Number | Candidate Number |
|---|---|---|
| | | |

**General Certificate of Education Advanced Level**
former Cambridge linear syllabus

# CHEMISTRY 9254/5

PAPER 5 Practical Test

Thursday **25 MAY 2000** Morning 2 hours 30 minutes

Candidates answer on the question paper.
Additional materials:
As listed in Instructions to Supervisors
Electronic calculator and/or 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** 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.
You may use a calculator.
You are advised to show all working in calculations.
Use of a Data Booklet is unnecessary.
Qualitative analysis notes are printed on pages 14 and 15.

| FOR EXAMINER'S USE | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| TOTAL | |

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



[Turn over

1 The purpose of this experiment is to investigate the reaction between chromate(VI) ions and iodide ions.

**FA 1** is a 0.0500 mol $dm^{-3}$ potassium chromate(VI), $K_2CrO_4$.

**FA 2** is a solution containing 37.23 g $dm^{-3}$ of sodium thiosulphate-5-water, $Na_2S_2O_3.5H_2O$.

Other solutions to be used in the question:

Potassium iodide, KI. 10% solution
1 mol $dm^{-3}$ sulphuric acid
Starch indicator

Pipette 25.0 $cm^3$ of **FA 1** into a conical flask.
Using the measuring cylinder provided add to the flask 10 $cm^3$ of 10% aqueous potassium iodide and 10 $cm^3$ of bench 1 mol $dm^{-3}$ sulphuric acid.

Titrate the iodine liberated with **FA 2**, aqueous sodium thiosulphate, until the red-brown colour of the iodine has disappeared and a faint yellow colour remains.

Add a few drops of starch indicator and continue the titrations until the blue-black colour of the starch-iodine complex just disappears to leave a blue/green solution.

**Repeat the titration as many times as you think necessary to obtain accurate results. Make certain that the recorded results show the accuracy of your practical work.**

**Titration of FA 1 with FA 2**

| | | | | |
|---|---|---|---|---|
| Final burette reading / $cm^3$<br>Initial burette reading / $cm^3$ | | | | |
| Volume of **FA 2** used / $cm^3$ | | | | |

[15]

**Summary**

The iodine liberated by 25.0 $cm^3$ of **FA 1** required ..... $cm^3$ of **FA 2**.

Show which results you used to obtain this value of the volume of **FA 2** by placing a tick (✓) under the readings used.

Thiosulphate ions and aqueous iodine react according to the following half-equations:

$2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2e^-$

$I_2(aq) + 2e^- \rightarrow 2I^-(aq)$

**You are advised to show full working in all parts of the calculations.**

**(a)** Calculate the concentration, in mol $dm^{-3}$, of **FA 2**.
[$A_r$: Na, 23.0; S, 32.1; O, 16.0; H, 1.0.]

[2]

**(b)** Calculate how many moles of sodium thiosulphate were run from the burette into the conical flask.

[1]

**(c)** Calculate how many moles of iodine reacted with the sodium thiosulphate run from the burette.

[1]

**(d)** Calculate how many moles of chromate(VI) ion, $CrO_4^{2-}$, were present in a 25.0 $cm^3$ pipette volume of **FA 1**.

[1]

**(e)** Calculate how many moles of potassium iodide are oxidised by one mole of potassium chromate(VI).

[3]

**(f)** The solution at the end-point is blue/green. What ion of chromium is present to give this colour?

.....[1]

**(g)** Use the information in **(e)** and **(f)** to write a balanced ionic equation for the reaction between chromate(VI) ions, $CrO_4^{2-}$, and iodide ions, $I^-$, in the presence of an acid, $H^+$.

.....[1]

[Total : 25]

2 **FA 3** is magnesium powder, Mg.
**FA 4** is 2.0 mol $dm^{-3}$ hydrochloric acid, HCl.

You are required to determine the temperature and enthalpy changes for the following reaction.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

**(a)** Accurately weigh, to two decimal places, an empty weighing bottle. Place between 0.55 g and 0.65 g of **FA 3**, magnesium powder, into the weighing bottle. Record your weighings in Table 2.1 below. If your balance has a Tare facility, do **not** use it.

**Table 2.1 – Weighing of FA 3**

| | | |
|---|---|---|
| Mass of empty weighing bottle | /g | |
| Mass of weighing bottle + **FA 3** | /g | |
| Mass of weighing weighing bottle + residual **FA 3** | /g | |
| Mass of **FA 3** placed in plastic cup | /g | |

[3]

**(b) (i)** Pipette 50.0 $cm^3$ of **FA 4**, 2.0 mol $dm^{-3}$ hydrochloric acid, into a plastic cup. Stir gently with the thermometer and take the temperature of the solution every half minute for $2\frac{1}{2}$ minutes. Record your readings in Table 2.2. on page 6.

At exactly 3 minutes, add the **FA 3** from the weighing bottle to the plastic cup.

**Do not try to read the temperature at 3 minutes.**

Stir the mixture thoroughly, and continue to record the temperature every half minute from $3\frac{1}{2}$ minutes to 10 minutes. [6]

**(b) (ii)** Reweigh the weighing bottle and any residual magnesium powder and record the mass in Table 2.1 above.





[Turn over

**Table 2.2 – Temperature readings**

| *Time / min* | *Temperature / °C* | *Time / min* | *Temperature / °C* |
|---|---|---|---|
| 0 | | $5\frac{1}{2}$ | |
| $\frac{1}{2}$ | | 6 | |
| 1 | | $6\frac{1}{2}$ | |
| $1\frac{1}{2}$ | | 7 | |
| 2 | | $7\frac{1}{2}$ | |
| $2\frac{1}{2}$ | | 8 | |
| 3 | | $8\frac{1}{2}$ | |
| $3\frac{1}{2}$ | | 9 | |
| 4 | | $9\frac{1}{2}$ | |
| $4\frac{1}{2}$ | | 10 | |
| 5 | | | |

**(c)** Plot a graph of temperature against time on the grid opposite. [5]

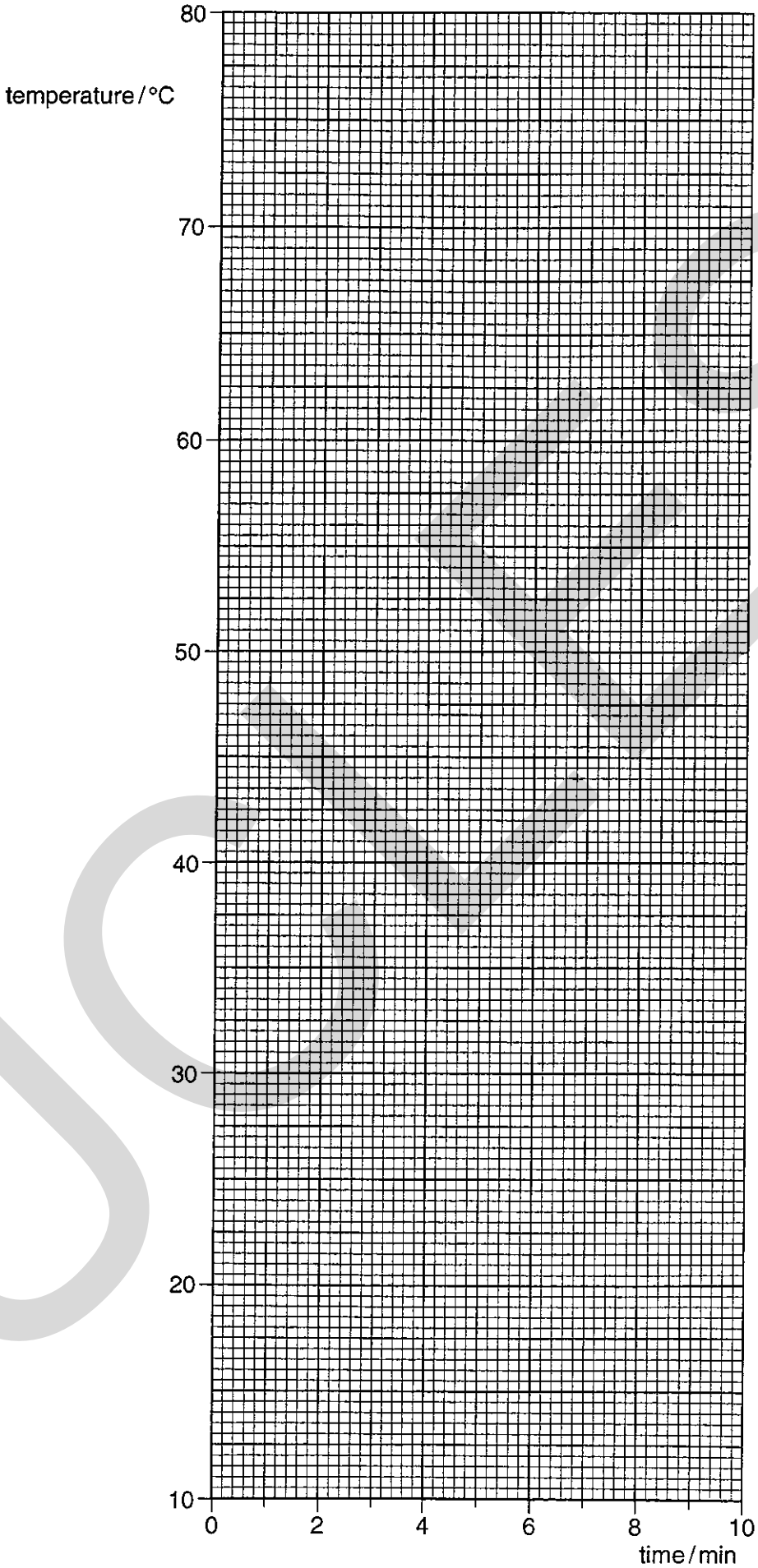
**(d)** By careful extrapolation of your graph, estimate the temperature of the mixture at 3 minutes.

Extrapolated temperature = .....°C

Use this value to obtain the highest temperature change produced by the reaction.

Temperature change = .....°C

[1]


temperature / °C
80
70
60
50
40
30
20
10
0
2
4
6
8
10
time / min

**(e)** Calculate how many moles of magnesium were added to the plastic cup.
[$A_r$; Mg, 24.3.]

[1]

**(f)** Calculate the heat energy produced when the magnesium is added to the excess acid in the plastic cup.

[You may assume that 4.30 J are required to raise the temperature of 1.00 $cm^3$ of any dilute aqueous solution by 1.00 °C.]

[1]

**(g)** Calculate the molar enthalpy change, $\Delta H$, for the reaction.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Include three significant figures, the correct sign and appropriate units in your answer.

$\Delta H$ = ..... [2]

For Examiner's Use

## Evaluation of the Experiment

**(h)** Suggest the major sources of error in determining the enthalpy change for this reaction.

.....

.....

.....

.....

.....

.....

.....

**(i)** Suggest changes that could be made to the experimental technique to improve accuracy.

.....

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.....

.....

[6]

[Total : 25]

| | |
|---|---|
| a | |
| b | |
| c | |
| d | |
| e | |
| f | |
| g | |

3 You are provided with **FA 5** in a stoppered tube and **FA 6** which is a concentrated solution of **FA 5** in water.

**FA5** is a mixture of two solids and contains **one cation** and **one anion from the following list:** ($NH_4^+$, $Mg^{2+}$, $Al^{3+}$, $Ca^{2+}$, $Cr^{3+}$, $Mn^{2+}$, $Fe^{2+}$, $Fe^{3+}$, $Cu^{2+}$, $Pb^{2+}$, $Zn^{2+}$, $Ba^{2+}$; $CO_3^{2-}$, $NO_2^-$, $NO_3^-$, $SO_3^{2-}$, $SO_4^{2-}$, $Cl^-$, $Br^-$, $I^-$, $CrO_4^{2-}$). and a **second anion**. You will be asked to make observations and general comments about this second anion but not to give its identity.

In all tests, the reagent should be added gradually until no further change is observed, with shaking after each addition.

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 on which they are based.

Marks will not be given for chemical equations.
**No additional or confirmatory tests for ions present should be attempted.**

**Candidates are reminded that definite deductions may be made from tests with negative results.**

| *Test* | *Observations* [8] | *Deductions* [5] |
|---|---|---|
| **Tests on FA 6**<br><br>**(a)** To 2 cm depth of **FA 6** in a test-tube add an equal depth of dilute hydrochloric acid,<br><br>then add aqueous barium chloride. | | |
| **(b)** To 2 cm depth of **FA 6** in a test-tube add a small quantity of aqueous silver nitrate,<br><br>then add dilute, aqueous ammonia until in excess. | | |

| Test | Observations | Deductions |
|---|---|---|
| **(c)** To 2 cm depth of **FA 6** in a test-tube add aqueous sodium hydroxide. | | |
| **(d)** To 2 cm depth of **FA 6** in a test-tube add dilute, aqueous ammonia. | | |
| **(e)** To 2 cm depth of **FA 6** in a test-tube add aqueous iron(III) chloride. | | |
| **Tests on FA 5**<br><br>**(f)** Add dilute sulphuric acid to solid **FA 5** in a boiling tube and warm gently.<br><br>Test the vapour evolved with litmus paper. | | |
| **(g)** Add solid **FA 5** to 2 cm depth of ethanol in a boiling tube. Add 2 or 3 drops of concentrated sulphuric acid.<br><br>**Carefully** warm the mixture until it boils and continue to boil **gently** for about 1 minute. Then pour the contents into the 100 $cm^3$ beaker labelled aqueous sodium carbonate. | | |

**Summary**

Identify the cation and the anion present in **FA 5** and **FA 6** ..... and .....[1]
Comment on the nature of the second anion present in the mixture.

.....[1]



[Turn over

## Assessment of Planning Skills

**(i)** **Five** aqueous solutions are provided, **FA 7, FA 8, FA 9, FA 10,** and **FA 11.**

Each solution contains **one** of the following:

aluminium sulphate, barium chloride, magnesium sulphate, sodium hydroxide, zinc nitrate.

The **solution names** and **FA codes** are **not** in the same order.

**You are provided with a solution of potassium chromate(VI), to be used for experiment 1 below.**

Using the information on Pages 14 and 15, plan a series of test-tube experiments using only the five solutions **FA 7** to **FA 11** and aqueous potassium chromate(VI), in order to deduce which compound is present in each of the **FA** solutions.
You should commence your plan by adding potassium chromate(VI) to each of the solutions **FA 7** to **FA 11**. Record your expected results in the first empty box.
Your completed plan should be set out in the table below and refer only to named compounds (not to **FA** codes).

**Use of any form of indicator or additional reagent will be penalised.**

| | *Experiment* | *Expected Observation with each solution tested and Deductions from these Observations.* |
|---|---|---|
| 1 | Add potassium chromate(VI) to separate samples of the five solutions. | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |

| | |
|---|---|
| a | |
| b | |
| c | |
| d | |
| e | |

[5]

**(ii)** Carry out your plan and record your observations below.

The observations recorded in the table **must match** the numbered experiments in your Completed plan on page 12.

Record the identity of each solution as soon as it is established.

| *Expt* | *Observations* | *Identity of solution or solutions* |
|---|---|---|
| 1 | | **FA** is |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |

[5]

[Total : 25]

## QUALITATIVE ANALYSIS NOTES

*[Key: ppt. = precipitate.]*

### 1 Reactions of aqueous cations

| | *reaction with* | |
|---|---|---|
| | NaOH(aq) | $NH_3$(aq) |
| aluminium, $Al^{3+}$(aq) | white ppt. soluble in excess | white ppt. insoluble in excess |
| ammonium, $NH_4^+$(aq) | ammonia produced on heating | |
| barium, $Ba^{2+}$(aq) | no ppt. (if reagents are pure) | no ppt. |
| calcium, $Ca^{2+}$(aq) | white ppt. with high [$Ca^{2+}$ (aq)] | no ppt. |
| chromium(III), $Cr^{3+}$(aq) | grey-green ppt. soluble in excess giving dark green solution | grey-green ppt. insoluble in excess |
| copper(II), $Cu^{2+}$(aq) | pale blue ppt. insoluble in excess | blue ppt. soluble in excess giving dark blue solution |
| iron(II), $Fe^{2+}$(aq) | green ppt. insoluble in excess | green ppt. insoluble in excess |
| iron(III), $Fe^{3+}$(aq) | red-brown ppt. insoluble in excess | red-brown ppt. insoluble in excess |
| lead(II), $Pb^{2+}$(aq) | white ppt. soluble in excess | white ppt. insoluble in excess |
| magnesium, $Mg^{2+}$(aq) | white ppt. insoluble in excess | white ppt. insoluble in excess |
| manganese(II), $Mn^{2+}$(aq) | off-white ppt. insoluble in excess | off-white ppt. insoluble in excess |
| zinc, $Zn^{2+}$(aq) | white ppt. soluble in excess | white ppt. soluble in excess |

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

## 2 Reactions of anions

| *ion* | *reaction* |
|---|---|
| carbonate, $CO_3^{2-}$ | $CO_2$ liberated by dilute acids |
| chromate(VI), $CrO_4^{2-}$(aq) | yellow solution turns orange with $H^+$(aq);<br>gives yellow ppt. with $Ba^{2+}$(aq);<br>gives bright yellow ppt. with $Pb^{2+}$(aq) |
| chloride, $Cl^-$(aq) | gives white ppt. with $Ag^+$(aq) (soluble in $NH_3$(aq));<br>gives white ppt. with $Pb^{2+}$(aq) |
| bromide, $Br^-$(aq) | gives cream ppt. with $Ag^+$(aq) (partially soluble in $NH_3$(aq));<br>gives white ppt. with $Pb^{2+}$(aq) |
| Iodide, $I^-$(aq) | gives yellow ppt. with $Ag^+$(aq) (insoluble in $NH_3$(aq));<br>gives yellow ppt. with $Pb^{2+}$(aq) |
| nitrate, $NO_3^-$(aq) | $NH_3$ liberated on heating with $OH^-$(aq) and *Al* foil |
| nitrite, $NO_2^-$(aq) | $NH_3$ liberated on heating with $OH^-$(aq) and *Al* foil,<br>NO liberated by dilute acids<br>(colourless NO → (pale) brown $NO_2$ in air) |
| sulphate, $SO_4^{2-}$(aq) | gives white ppt. with $Ba^{2+}$(aq) or with $Pb^{2+}$(aq) (insoluble in excess dilute strong acid) |
| sulphite, $SO_3^{2-}$(aq) | $SO_2$ liberated with dilute acids;<br>gives white ppt. with $Ba^{2+}$(aq) (soluble in excess dilute strong acid) |

## 3 Tests for gases

| *gas* | *test and test result* |
|---|---|
| ammonia, $NH_3$ | turns damp red litmus paper blue |
| carbon dioxide, $CO_2$ | gives a white ppt. with limewater<br>(ppt. dissolves with excess $CO_2$) |
| chlorine, $Cl_2$ | bleaches damp litmus paper |
| hydrogen, $H_2$ | 'pops' with a lighted splint |
| oxygen, $O_2$ | relights a glowing splint |
| sulphur dioxide, $SO_2$ | turns potassium dichromate(VI) (aq) from orange to green |

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