FOR OFFICIAL USE

Total
Section B

X012/301

NATIONAL
QUALIFICATIONS
2011

THURSDAY, 26 MAY
9.00 AM – 11.30 AM

CHEMISTRY
HIGHER

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth
Day Month Year

Scottish candidate number

Number of seat

Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet.

SECTION A—Questions 1–40 (40 marks)

Instructions for completion of **Section A** are given on page two.

For this section of the examination you must use an **HB pencil**.

SECTION B (60 marks)

1 All questions should be attempted.

2 The questions may be answered in any order but all answers are to be written in the spaces provided in this answer book, **and must be written clearly and legibly in ink**.

3 Rough work, if any should be necessary, should be written in this book and then scored through when the fair copy has been written. If further space is required, a supplementary sheet for rough work may be obtained from the Invigilator.

4 Additional space for answers will be found at the end of the book. If further space is required, supplementary sheets may be obtained from the Invigilator and should be inserted inside the **front** cover of this book.

5 The size of the space provided for an answer should not be taken as an indication of how much to write. It is not necessary to use all the space.

6 Before leaving the examination room you must give this book to the Invigilator. If you do not, you may lose all the marks for this paper.

SECTION A

Read carefully

1 Check that the answer sheet provided is for **Chemistry Higher (Section A)**.

2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.

3 Check that the answer sheet you have been given has **your name**, **date of birth**, **SCN** (Scottish Candidate Number) and **Centre Name** printed on it.

Do not change any of these details.

4 If any of this information is wrong, tell the Invigilator immediately.

5 If this information is correct, **print** your name and seat number in the boxes provided.

6 The answer to each question is **either** A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).

7 There is **only one correct** answer to each question.

8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.

9 At the end of the examination, put the **answer sheet for Section A inside the front cover of your answer book**.

Sample Question

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

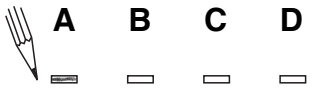
A chromatography

B fractional distillation

C fractional crystallisation

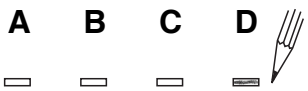
D filtration.

The correct answer is **A—**chromatography. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).



Changing an answer

If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



1. Which of the following gases could be described as monatomic?

A Bromine

B Methane

C Hydrogen

D Helium

2. Different isotopes of the same element have identical

A electron arrangements

B nuclei

C numbers of neutrons

D mass numbers.

3. Which of the following pairs of solutions will **not** react to produce a precipitate?

A Copper(II) chloride and lithium sulphate

B Potassium carbonate and zinc sulphate

C Silver nitrate and sodium chloride

D Ammonium phosphate and magnesium chloride

4. Which of the following sugars does **not** react with Benedict's solution?

A Glucose

B Fructose

C Maltose

D Sucrose

5. Which of the following gases would contain the **greatest** number of molecules in a 100 g sample, at room temperature?

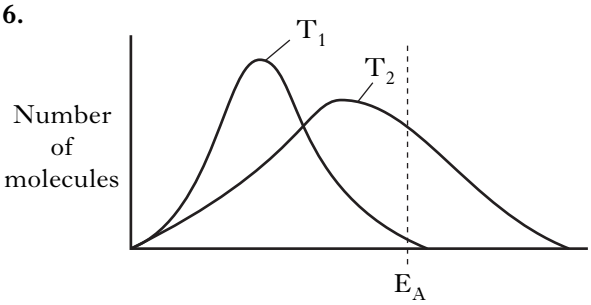
A Fluorine

B Hydrogen

C Nitrogen

D Oxygen

6.



Which line in the table is correct for a reaction as the temperature **decreases** from T_2 to T_1?

	Activation energy (E_A)	**Number of successful collisions**
A	remains the same	increases
B	decreases	decreases
C	decreases	increases
D	remains the same	decreases

7. A pupil added 0·1 mol of zinc to a solution containing 0·05 mol of silver(I) nitrate.

$Zn(s) + 2AgNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + 2Ag(s)$

Which of the following statements about the experiment is correct?

A 0·05 mol of zinc reacts.

B 0·05 mol of silver is displaced.

C Silver nitrate is in excess.

D All of the zinc reacts.

8. A reaction takes place in two stages.

Stage 1

$S_2O_8^{2-}(aq) + 2I^-(aq) + 2Fe^{2+}(aq) \rightarrow 2SO_4^{2-}(aq) + 2I^-(aq) + 2Fe^{3+}(aq)$

Stage 2

$2SO_4^{2-}(aq) + 2I^-(aq) + 2Fe^{3+}(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq) + 2Fe^{2+}(aq)$

The ion that is the catalyst in the reaction is

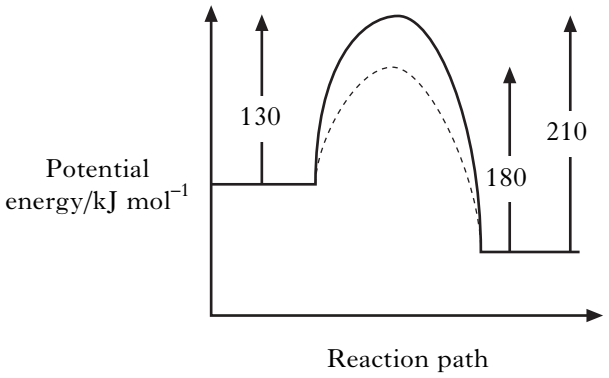
A $S_2O_8^{2-}(aq)$

B $I^-(aq)$

C $Fe^{2+}(aq)$

D $SO_4^{2-}(aq)$.

9. The following potential diagram is for a reaction carried out with and without a catalyst.



The activation energy for the catalysed reaction is

A 30 kJ mol^{-1}

B 80 kJ mol^{-1}

C 100 kJ mol^{-1}

D 130 kJ mol^{-1}.

10. Which of the following equations represents an enthalpy of combustion?

A $C_2H_6(g) + 3\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$

B $C_2H_5OH(\ell) + O_2(g) \rightarrow CH_3COOH(\ell) + H_2O(\ell)$

C $CH_3CHO(\ell) + \frac{1}{2}O_2(g) \rightarrow CH_3COOH(\ell)$

D $CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(\ell)$

11. A potassium atom is larger than a sodium atom because potassium has

A a larger nuclear charge

B a larger nucleus

C more occupied energy levels

D a smaller ionisation energy.

12. Hydrogen will form a non-polar covalent bond with an element which has an electronegativity value of

A 0·9

B 1·5

C 2·2

D 2·5.

13. Which property of a chloride would prove that it contained ionic bonding?

A It conducts electricity when molten.

B It is soluble in a polar solvent.

C It is a solid at room temperature.

D It has a high boiling point.

14. A mixture of potassium chloride and potassium carbonate is known to contain 0·1 mol of chloride ions and 0·1 mol of carbonate ions.

How many moles of potassium ions are present?

A 0·15

B 0·20

C 0·25

D 0·30

15. Which of the following has the largest volume under the same conditions of temperature and pressure?

A 1 g hydrogen

B 14 g nitrogen

C 20·2 g neon

D 35·5 g chlorine

16. 20 cm^3 of butane is burned in 150 cm^3 of oxygen.

$C_4H_{10}(g) + 6\frac{1}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$

What is the total volume of gas present after complete combustion of the butane?

A 80 cm^3

B 100 cm^3

C 180 cm^3

D 200 cm^3

17. Which of the following types of hydrocarbons when added to petrol would **not** reduce "knocking"?

A Cycloalkanes

B Aromatic hydrocarbons

C Branched-chain alkanes

D Straight-chain alkanes

18. Which of the following fuels when burned would make no contribution to global warming?

A Hydrogen

B Natural gas

C Petrol

D Coal

19. Which of the following hydrocarbons always gives the same product when one of its hydrogen atoms is replaced by a chlorine atom?

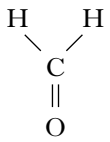
A Hexane

B Hex-1-ene

C Cyclohexane

D Cyclohexene

20.



The name of this compound is

A methanol

B methanal

C methanoic acid

D methanone.

21. Which of the following is an isomer of ethyl propanoate?

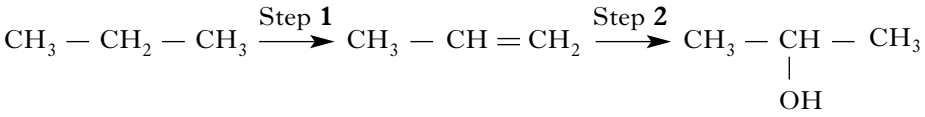
A Pentan-2-one

B Pentanoic acid

C Methyl propanoate

D Pentane-1,2-diol

22. Propan-2-ol can be prepared from propane as follows.

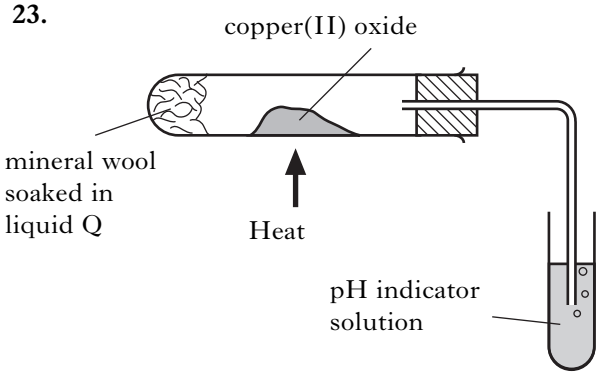


Which line in the table correctly describes the types of reaction taking place at Steps **1** and **2**?

	Step 1	**Step 2**
A	cracking	hydration
B	cracking	hydrolysis
C	dehydration	hydration
D	dehydration	hydrolysis

[Turn over

23.



After heating for several minutes, as shown in the diagram, the pH indicator solution turned red.

Liquid **Q** could be

A propanone

B paraffin

C propan-1-ol

D propan-2-ol.

24. Which of the following compounds is hydrolysed when warmed with sodium hydroxide solution?

A $CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_3$

B $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-O-CH_3$

C $CH_3-\overset{\overset{OH}{|}}{CH}-CH_2-CH_3$

D $CH_3-CH_2-\underset{\underset{CH_3}{|}}{CH}-\overset{\overset{O}{\|}}{C}-H$

25. Which of the following is most likely to be used as a flavouring?

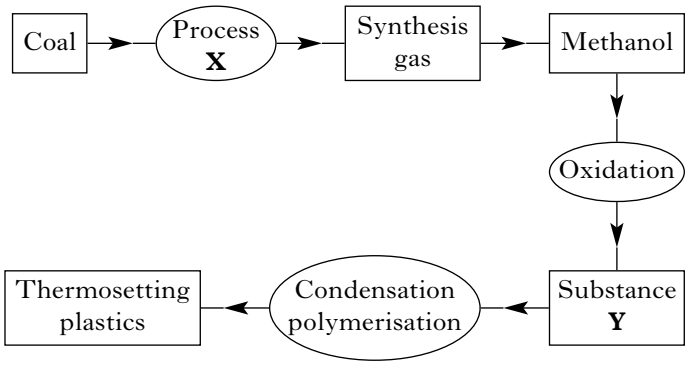
A CH_3CH_2CHO

B $CH_3CH_2CH_2COOH$

C $CH_3CH(OH)CH_2CH_3$

D $CH_3CH_2CH_2COOCH_2CH_3$

26. Thermosetting plastics can be made by the following sequence of reactions.



Which line in the table shows the correct names for Process **X** and Substance **Y**?

	Process X	**Substance Y**
A	combustion	methanal
B	combustion	methanoic acid
C	steam reforming	methanoic acid
D	steam reforming	methanal

27. Which of the following is an amine?

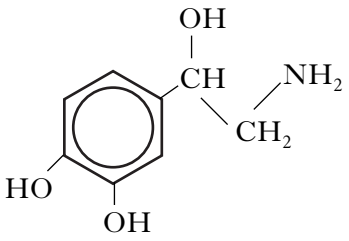
A $H-\underset{\underset{H}{|}}{\overset{H}{\overset{|}{C}}}-N-\overset{\overset{O}{\|}}{C}-H$

B $H-\underset{\underset{H}{|}}{\overset{H}{\overset{|}{C}}}-N-H$

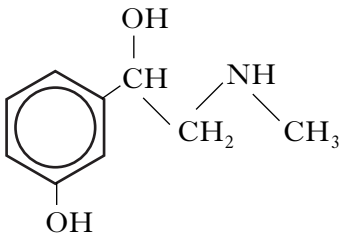
C $H-\underset{\underset{H}{|}}{\overset{H}{\overset{|}{C}}}-N=C=O$

D $H-\overset{H}{\overset{|}{C}}=\overset{H}{\overset{|}{C}}-C\equiv N$

28. Noradrenaline and phenylephrine cause increases in the blood pressure because the part of each of these molecules that they have in common has the correct shape to allow them to bind to a certain human protein.

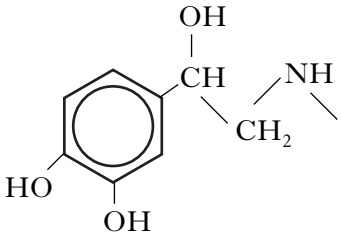


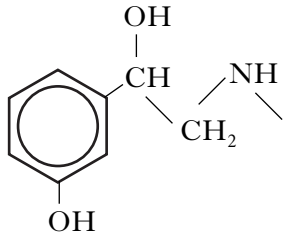
noradrenaline

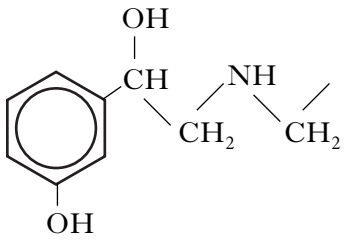


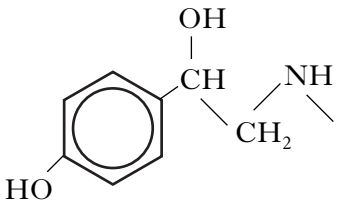
phenylephrine

The part of these molecules which is the correct shape to bind to the protein is

A 

B 

C 

D 

29. Which of the following polymers is photoconductive?

A Kevlar

B Biopol

C Poly(ethenol)

D Poly(vinyl carbazole)

30. Which of the following compounds can be classified as proteins?

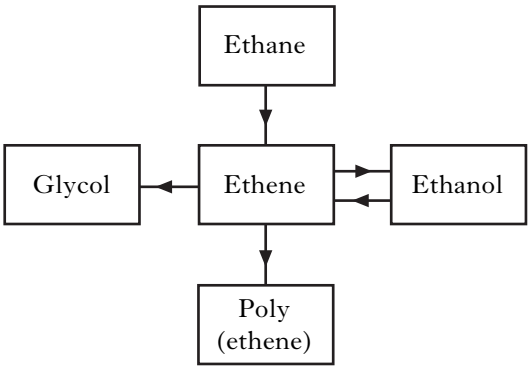
A Fats

B Oils

C Enzymes

D Amino acids

31. The flow chart summarises some industrial processes involving ethene.



The feedstocks for ethene in these processes are

A ethane and glycol

B ethane and ethanol

C glycol and poly(ethene)

D glycol, poly(ethene) and ethanol.

32. The enthalpy change for $K(s) \rightarrow K(g)$ is $88\,kJ\ mol^{-1}$.

Using the above information and information from the data booklet (page 10), the enthalpy change for $K(s) \rightarrow K^{2+}(g) + 2e^-$ is

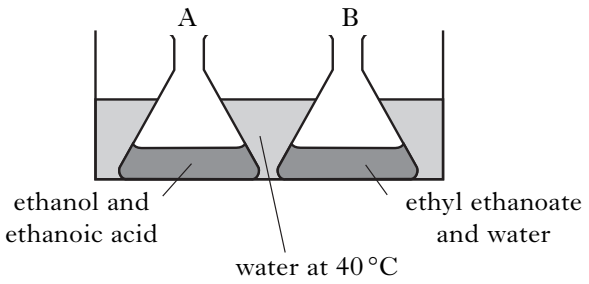
A $513\,kJ\ mol^{-1}$

B $3060\,kJ\ mol^{-1}$

C $3485\,kJ\ mol^{-1}$

D $3573\,kJ\ mol^{-1}$.

33. Two flasks, A and B, were placed in a water bath at 40 °C.



After several days the contents of both flasks were analysed.

Which result would be expected?

A Flask A contains ethyl ethanoate, water, ethanol and ethanoic acid; flask B is unchanged.

B Flask A contains only ethyl ethanoate and water; flask B is unchanged.

C Flask A contains only ethyl ethanoate and water; flask B contains ethyl ethanoate, water, ethanol and ethanoic acid.

D Flask A and flask B contain ethyl ethanoate, water, ethanol and ethanoic acid.

34. $NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

$\Delta H = -36\,kJ\ mol^{-1}$

The solubility of ammonia in water will be increased by

A increasing pressure and cooling

B decreasing pressure and cooling

C decreasing pressure and warming

D increasing pressure and warming.

35. The pH of a $0{\cdot}1\ mol\,l^{-1}$ solution of an acid was measured and found to be pH 4.

The pH of a $0{\cdot}001\ mol\,l^{-1}$ solution of an alkali was measured and found to be pH 11.

Which line in the table is correct?

	Acid	**Alkali**
A	weak	weak
B	weak	strong
C	strong	weak
D	strong	strong

36. Which of the following solutions contains equal concentrations of $H^+(aq)$ and $OH^-(aq)$ ions?

A $NH_4Cl(aq)$

B $Na_2CO_3(aq)$

C $KNO_3(aq)$

D $CH_3COOK(aq)$

37. During a redox process in acid solution, iodate ions are converted into iodine.

$2IO_3^-(aq) + 12H^+(aq) + \mathbf{x}e^- \rightarrow I_2(aq) + 6H_2O(\ell)$

To balance the equation, what is the value of **x**?

A 2

B 6

C 10

D 12

38. The following reactions take place when nitric acid is added to zinc.

$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(\ell)$

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

How many moles of $NO_3^-(aq)$ are reduced by one mole of zinc?

A $\frac{2}{3}$

B 1

C $\frac{3}{2}$

D 2

39. If 96 500 C of electricity are passed through separate solutions of copper(II) chloride and nickel(II) chloride, then

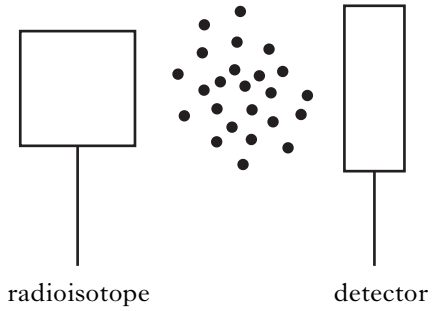
A equal masses of copper and nickel will be deposited

B the same number of atoms of each metal will be deposited

C the metals will be plated on the positive electrode

D different numbers of moles of each metal will be deposited.

40. Some smoke detectors make use of radiation which is very easily stopped by tiny smoke particles moving between the radioactive source and the detector.



The most suitable type of radioisotope for a smoke detector would be

A an alpha-emitter with a long half-life

B a gamma-emitter with a short half-life

C an alpha-emitter with a short half-life

D a gamma-emitter with a long half-life.

Candidates are reminded that the answer sheet MUST be returned INSIDE the front cover of this answer book.

[Turn over

SECTION B

Marks

All answers must be written clearly and legibly in ink.

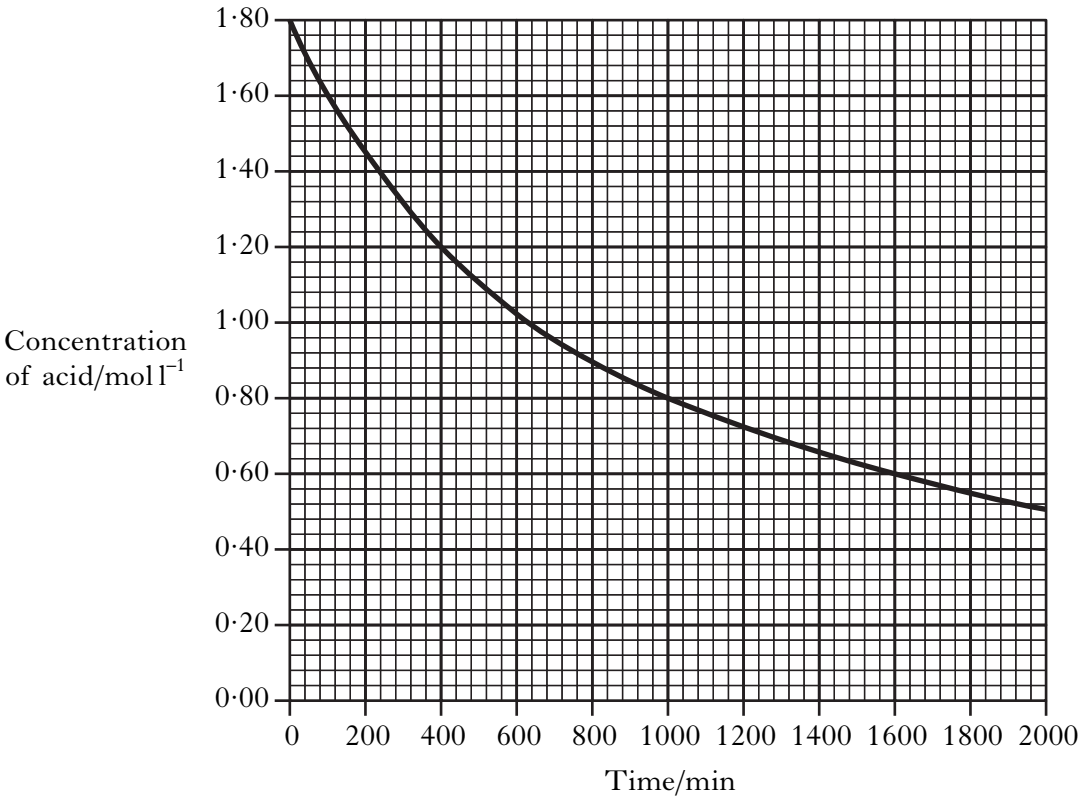
1. Chloromethane, CH_3Cl, can be produced by reacting methanol solution with dilute hydrochloric acid using a solution of zinc chloride as a catalyst.

$$CH_3OH(aq) + HCl(aq) \xrightarrow{ZnCl_2(aq)} CH_3Cl(aq) + H_2O(\ell)$$

(*a*) What type of catalysis is taking place?

1

(*b*) The graph shows how the concentration of the hydrochloric acid changed over a period of time when the reaction was carried out at 20 °C.



(i) Calculate the average rate, in mol l^{-1} min^{-1}, in the first 400 minutes.

1

(ii) On the graph above, sketch a curve to show how the concentration of hydrochloric acid would change over time if the reaction is repeated at 30 °C.
(Additional graph paper, if required, can be found on *Page thirty-five*).

1

(3)

DO NOT WRITE IN THIS MARGIN

Marks

2. The elements from sodium to argon make up the third period of the Periodic Table.

(*a*) On crossing the third period from left to right there is a general increase in the first ionisation energy of the elements.

(i) Why does the first ionisation energy increase across the period?

1

(ii) Write an equation corresponding to the first ionisation energy of chlorine.

1

(*b*) The electronegativities of elements in the third period are listed on page 10 of the databook.

Why is no value provided for the noble gas, argon?

1

(3)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

3. A student writes the following two statements. **Both are incorrect**. In each case explain the mistake in the student's reasoning.

(*a*) All ionic compounds are solids at room temperature. Many covalent compounds are gases at room temperature. This proves that ionic bonds are stronger than covalent bonds.

1

(*b*) The formula for magnesium chloride is $MgCl_2$ because, in solid magnesium chloride, each magnesium ion is bonded to two chloride ions.

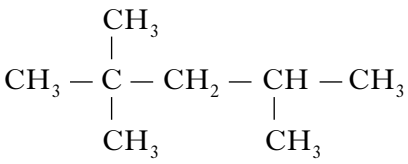
1

(2)

Marks

4. Petrol is a complex blend of many chemicals.

(*a*) A typical hydrocarbon found in petrol is shown below.



What is the systematic name for this compound?

1

(*b*) In what way is a petrol that has been blended for use in winter different from a summer blend?

1

(*c*) The ester methyl stearate is also a useful vehicle fuel.

A student prepared this ester from methanol and stearic acid during the Prescribed Practical Activity, "Making Esters".

Describe how this ester was prepared.

2

(4)

DO NOT WRITE IN THIS MARGIN

Marks

5. Chlorine gas can be produced by heating calcium hypochlorite, $Ca(OCl)_2$, in dilute hydrochloric acid.

$$Ca(OCl)_2(s) + 2HCl(aq) \rightarrow Ca(OH)_2(aq) + 2Cl_2(g)$$

(*a*) Calculate the mass of calcium hypochlorite that would be needed to produce 0·096 litres of chlorine gas.

(Take the molar volume of chlorine gas to be 24 litres mol^{-1}.)

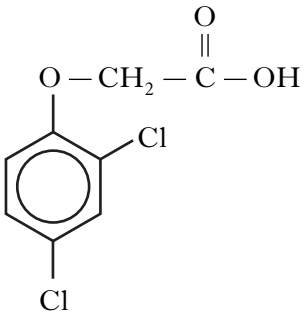
Show your working clearly.

2

Marks

5. (continued)

(*b*) Chlorine is used in the manufacture of herbicides such as 2,4-dichlorophenoxyethanoic acid.



Another commonly used herbicide is 4-chloro-2-methylphenoxyethanoic acid.

Draw a structural formula for 4-chloro-2-methylphenoxyethanoic acid.

1

(3)

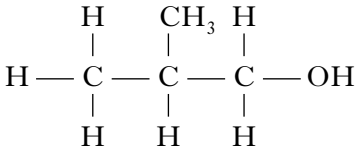
[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

6. Hairspray is a mixture of chemicals.

(*a*) A primary alcohol, 2-methylpropan-1-ol, is added to hairspray to help it dry quickly on the hair.

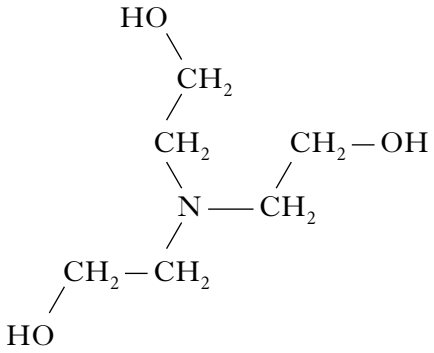


Draw a structural formula for a secondary alcohol that is an isomer of 2-methylpropan-1-ol.

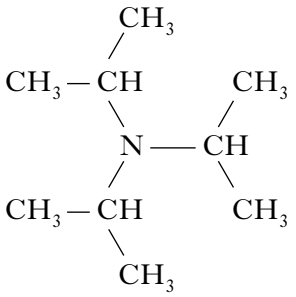
1

Marks

(*b*) Triethanol amine and triisopropyl amine are bases used to neutralise acidic compounds in the hairspray to prevent damage to the hair.



triethanol amine



triisopropyl amine

molecular mass	149	molecular mass	143
boiling point	335 °C	boiling point	47 °C

In terms of the intermolecular bonding present, **explain clearly** why triethanol amine has a much higher boiling point than triisopropyl amine.

2

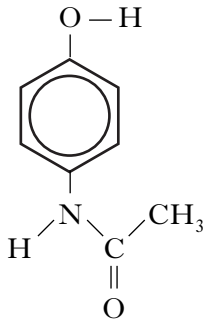
(3)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

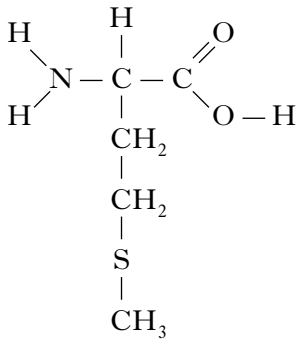
7. Paracetamol is a widely used painkiller.



(*a*) Write the molecular formula for paracetamol.

1

(*b*) One antidote for paracetamol overdose is methionine.



To what family of organic compounds does methionine belong?

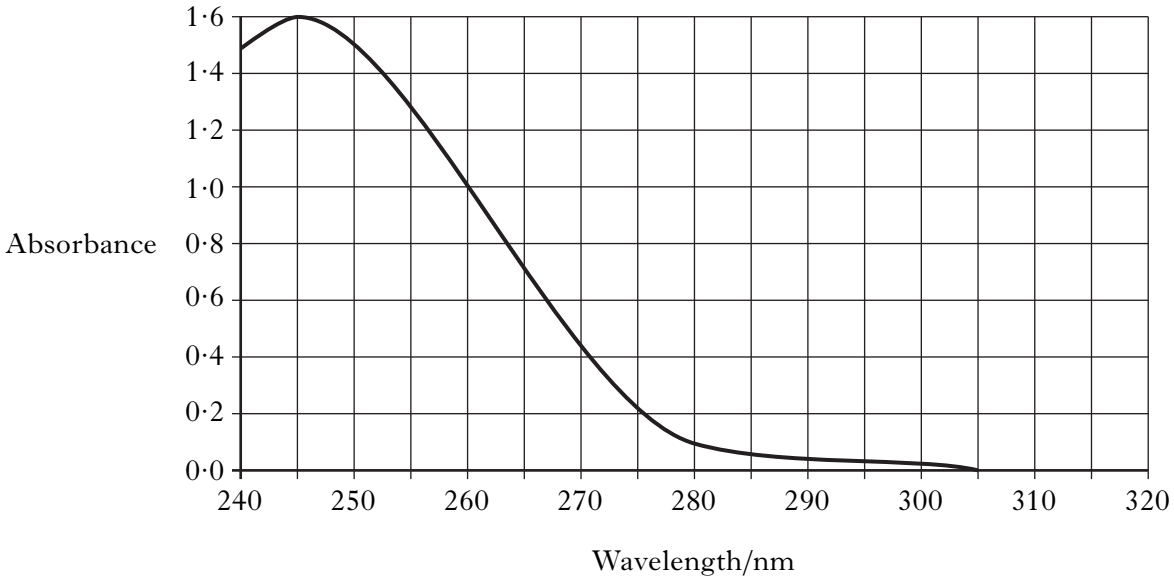
1

Marks

7. (continued)

(*c*) The concentration of paracetamol in a solution can be determined by measuring how much UV radiation it absorbs.

The graph shows how the absorbance of a sample containing $0{\cdot}040\,g\,l^{-1}$ paracetamol varies with wavelength.



The quantity of UV radiation of wavelength 245 nm absorbed is directly proportional to the concentration of paracetamol.

The absorbance of a second sample of paracetamol solution measured at 245 nm was 0·90.

What is the concentration, in $g\,l^{-1}$, of this second paracetamol solution?

1

(3)

[Turn over

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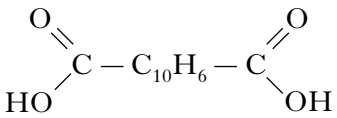
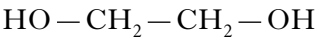
Marks

8. Diols are widely used in the manufacture of polyester polymers.

Polyethylene naphthalate is used to manufacture food containers. The monomers used to produce this polymer are shown.



naphthalenedicarboxylic acid

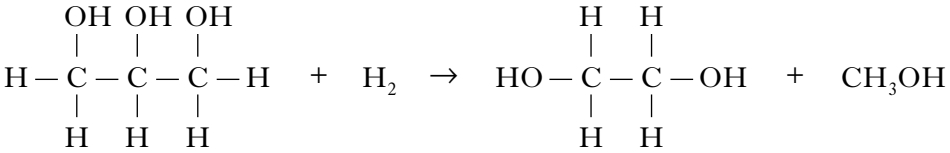


ethane-1,2-diol

(*a*) Draw the repeating unit for polyethylene naphthalate.

1

(*b*) Ethane-1,2-diol is produced in industry by reacting glycerol with hydrogen.



glycerol ethane-1,2-diol

Excess hydrogen reacts with 27·6 kg of glycerol to produce 13·4 kg of ethane-1,2-diol.

Calculate the percentage yield of ethane-1,2-diol.

Show your working clearly.

2

(3)

DO NOT WRITE IN THIS MARGIN

Marks

9. When vegetable oils are hydrolysed, mixtures of fatty acids are obtained. The fatty acids can be classified by their degree of unsaturation.

The table below shows the composition of each of the mixtures of fatty acids obtained when palm oil and olive oil were hydrolysed.

	Palm oil	**Olive oil**
Saturated fatty acids	51%	16%
Monounsaturated fatty acids	39%	75%
Polyunsaturated fatty acids	10%	9%

(*a*) Why does palm oil have a higher melting point than olive oil?

1

(*b*) One of the fatty acids produced by the hydrolysis of palm oil is linoleic acid, $C_{17}H_{31}COOH$.

To which class (saturated, monounsaturated or polyunsaturated) does this fatty acid belong?

1

(*c*) When a mixture of palm oil and olive oil is hydrolysed using a solution of sodium hydroxide, a mixture of the sodium salts of the fatty acids is obtained.

State a use for these fatty acid salts.

1

(3)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

10. Christian Schoenbein discovered ozone, O_3, in 1839.

(*a*) Ozone in air can be detected using paper strips that have been soaked in a mixture of starch and potassium iodide solution. The paper changes colour when ozone is present.

Ozone reacts with potassium iodide and water to form iodine, oxygen and potassium hydroxide.

(i) Write the balanced chemical equation for this reaction.

1

(ii) What colour would be seen on the paper when ozone is present?

1

(*b*) Ozone and oxygen gases are produced at the same electrode during the electrolysis of dilute sulphuric acid.

The ion-electron equation for the production of ozone is:

$$3H_2O(\ell) \rightarrow O_3(g) + 6H^+(aq) + 6e^-$$

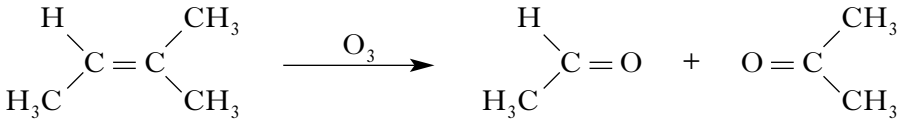
Draw a labelled diagram of the assembled apparatus that could be used to carry out the electrolysis of dilute sulphuric acid, showing how the ozone/oxygen gas mixture can be collected.

2

Marks

10. (continued)

(*c*) When ozone is bubbled through a solution containing an alkene, an ozonolysis reaction takes place.



compound **X** compound **Y**

(i) $2\,cm^3$ of an oxidising agent was added to $5\,cm^3$ of compound **X** in a test tube. After a few minutes a colour change from orange to green was observed.

Name the oxidising agent used.

1

(ii) Draw a structural formula for the alkene which, on ozonolysis, would produce propanal and butan-2-one.

1

(6)

DO NOT WRITE IN THIS MARGIN

Marks

11. Sulphurous acid, H_2SO_3, is a weak acid produced when sulphur-containing compounds in fuels are burned.

(*a*) What is meant by a **weak** acid?

1

(*b*) The table below shows the results of two experiments that were carried out to compare sulphurous acid with the strong acid, hydrochloric acid.

	Sulphurous acid 0·1 mol l^{-1}	**Hydrochloric acid 0·1 mol l^{-1}**
Rate of reaction with strip of magnesium	slow	fast
Volume of acid required to neutralise 20 cm^3 of 0·1 mol l^{-1} sodium hydroxide solution	10 cm^3	20 cm^3

(i) Why did the magnesium react more quickly with the hydrochloric acid?

1

(ii) Why is a smaller volume of sulphurous acid solution needed to neutralise the sodium hydroxide solution?

1

DO NOT WRITE IN THIS MARGIN

Marks

11. (*b*) (continued)

(iii) The concentration of the sodium hydroxide solution used was 0·1 mol l^{-1}. Calculate the pH of this solution.

1

(4)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

12. The element iodine has only one isotope that is stable. Several of the radioactive isotopes of iodine have medical uses. Iodine-131, for example, is used in the study of the thyroid gland and it decays by beta emission.

(*a*) Why are some atoms unstable?

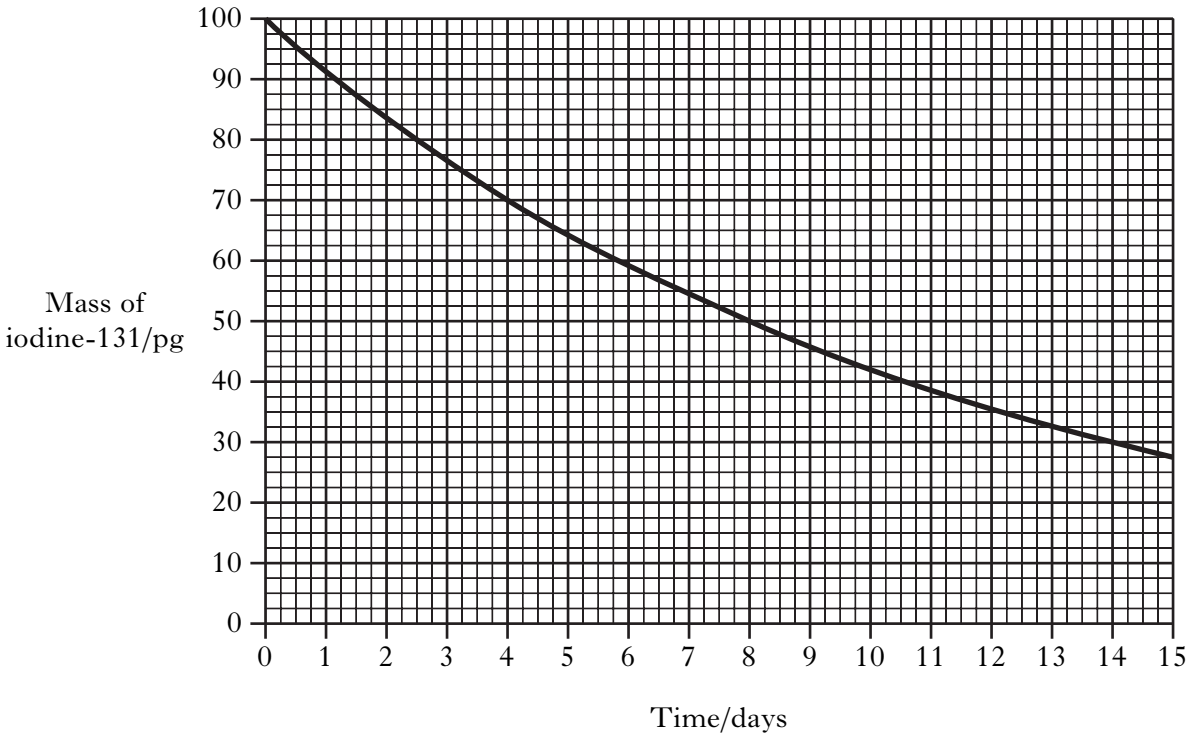
1

(*b*) Complete the balanced nuclear equation for the beta decay of iodine-131.

$$^{131}_{53}\mathrm{I} \quad \rightarrow$$

1

(*c*) The graph shows how the mass of iodine-131 in a sample changes over a period of time.



(i) What is the half-life of this isotope?

1

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Marks

12. (*c*) (continued)

(ii) A sample of sodium iodide solution contained 100 pg of iodine-131 when it was prepared.

Four days later it was injected into a patient.

How many $^{131}I^-$ ions would the 4 day old sample contain?

($1\ pg = 1 \times 10^{-12}\ g$)

2

(5)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

13. Rivers and drains are carefully monitored to ensure that they remain uncontaminated by potentially harmful substances from nearby industries. Chromate ions, CrO_4^{2-}, are particularly hazardous.

(*a*) When chromate ions dissolve in water the following equilibrium is established.

$$\underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq) \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(\ell)$$

Explain fully the colour change that would be observed when solid sodium hydroxide is added to the solution.

2

(*b*) The concentration of chromate ions in water can be measured by titrating with a solution of iron(II) sulphate solution.

(i) To prepare the iron(II) sulphate solution used in this titration, iron(II) sulphate crystals were weighed accurately into a dry beaker.

Describe how these crystals should be dissolved and then transferred to a standard flask in order to produce a solution of accurately known concentration.

2

DO NOT WRITE IN THIS MARGIN

Marks

13. (*b*) (continued)

(ii) A 50·0 cm^3 sample of contaminated water containing chromate ions was titrated and found to require 27·4 cm^3 of 0·0200 $mol\,l^{-1}$ iron(II) sulphate solution to reach the end-point.

The redox equation for the reaction is:

$$3Fe^{2+}(aq) + CrO_4^{2-}(aq) + 8H^+(aq) \rightarrow 3Fe^{3+}(aq) + Cr^{3+}(aq) + 4H_2O(\ell)$$

Calculate the chromate ion concentration, in $mol\,l^{-1}$, present in the sample of water.

Show your working clearly.

2

(6)

[Turn over

Marks

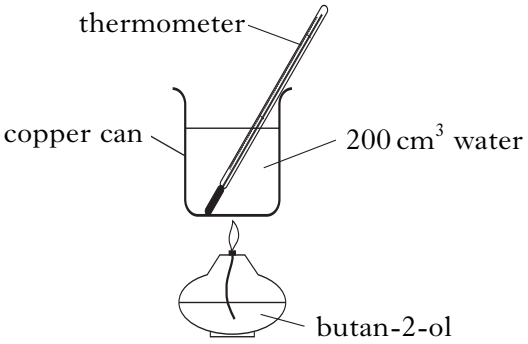
14. The enthalpies of combustion of some alcohols are shown in the table.

Name of alcohol	Enthalpy of combustion/kJ mol^{-1}
methanol	–727
ethanol	–1367
propan-1-ol	–2020

(*a*) Using this data, predict the enthalpy of combustion of butan-1-ol, in kJ mol^{-1}.

1

(*b*) A value for the enthalpy of combustion of butan-2-ol, C_4H_9OH, can be determined experimentally using the apparatus shown.



Mass of butan-2-ol burned = 1·0 g
Temperature rise of water = 40 °C

Use these results to calculate the enthalpy of combustion of butan-2-ol, in kJ mol^{-1}.

2

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Marks

14. (continued)

(*c*) Enthalpy changes can also be calculated using Hess's Law.

The enthalpy of formation for pentan-1-ol is shown below.

$$5C(s) + 6H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_5H_{11}OH(\ell) \qquad \Delta H = -354\,kJ\ mol^{-1}$$

Using this value, and the enthalpies of combustion of carbon and hydrogen from the data booklet, calculate the enthalpy of combustion of pentan-1-ol, in kJ mol^{-1}.

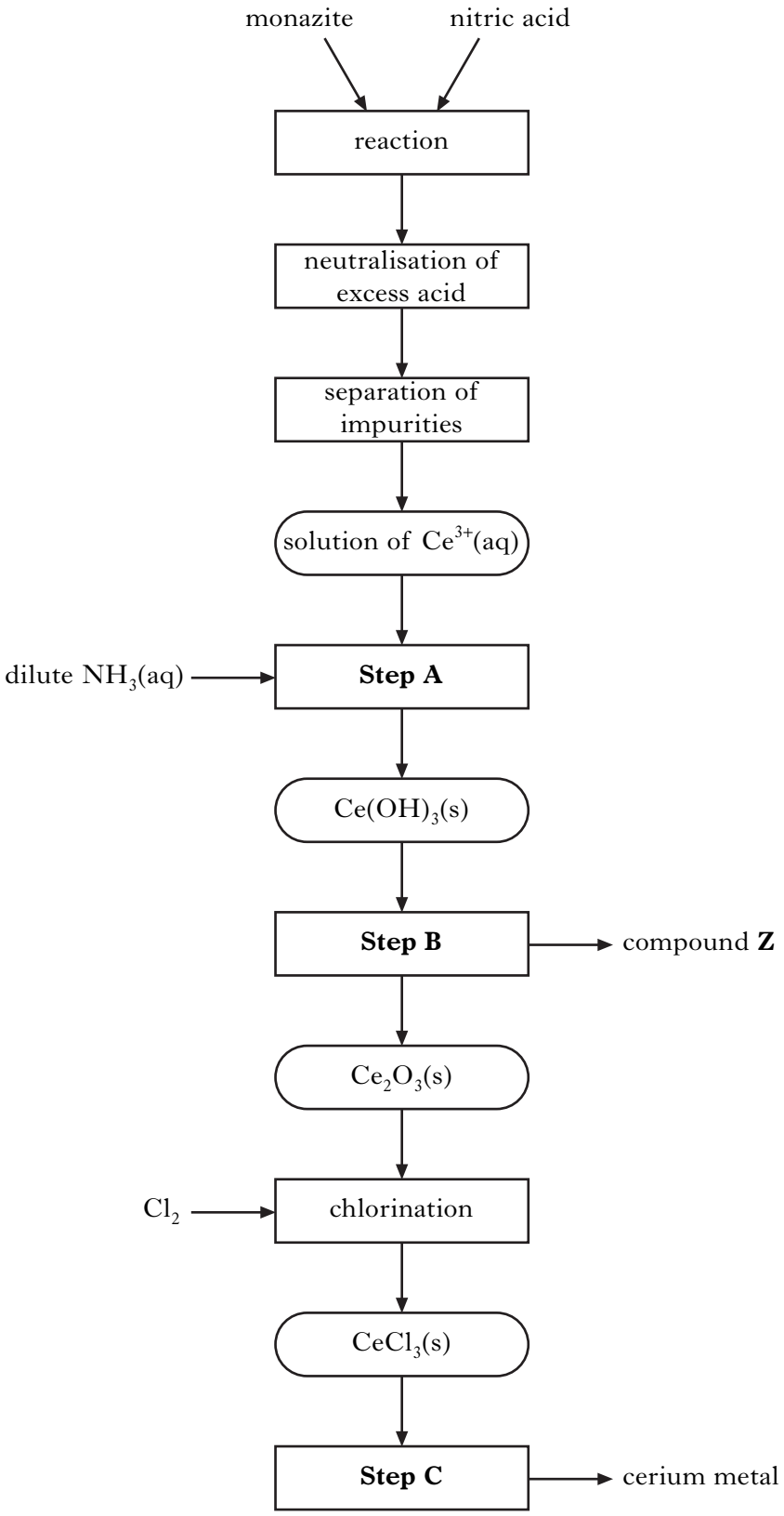
2

(5)

[Turn over

15. Cerium metal is extracted from the mineral monazite.

The flow diagram for the extraction of cerium from the mineral is shown below.



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15. (continued)

(*a*) Name the type of chemical reaction taking place in **Step A**.

1

(*b*) In **Step B**, cerium hydroxide is heated to form cerium oxide, Ce_2O_3, and compound **Z**.

Name compound **Z**.

1

(*c*) In **Step C**, cerium metal is obtained by electrolysis.

(i) What feature of the electrolysis can be used to reduce the cost of cerium production?

1

(ii) The equation for the reaction at the negative electrode is

$$Ce^{3+} + 3e^- \rightarrow Ce$$

Calculate the mass of cerium, in kg, produced in 10 minutes when a current of 4000 A is used.

Show your working clearly.

2

(5)

[Turn over for Question 16 on *Page thirty-four*

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Marks

16. The boiling point of water can be raised by the addition of a solute.

The increase in boiling point depends only on the **number** of solute particles but not the type of particle.

The increase in boiling point (ΔT_b), in °C, can be estimated using the formula shown.

$$\Delta T_b = 0{\cdot}51 \times c \times i$$

where

c is the concentration of the solution in mol l^{-1}.
i is the number of particles released into solution when one formula unit of the solute dissolves.

The value of i for a number of compounds is shown in the table below.

Solute	**i**
NaCl	2
$MgCl_2$	3
$(NH_4)_3PO_4$	4

(*a*) What is the value of i for sodium sulphate?

1

(*b*) Calculate the increase in boiling point, ΔT_b, for a 0·10 mol l^{-1} solution of ammonium phosphate.

1

(2)

[*END OF QUESTION PAPER*]

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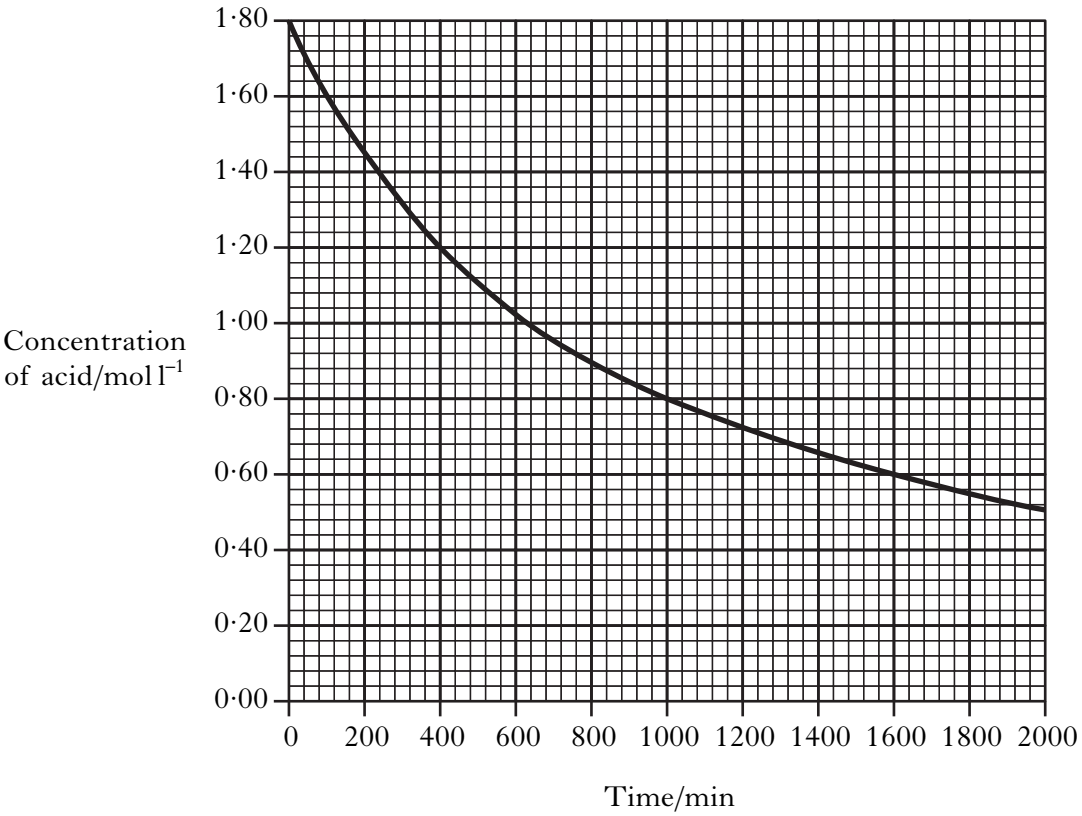
ADDITIONAL GRAPH PAPER FOR USE IN QUESTION 1(*b*) (ii)



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ADDITIONAL SPACE FOR ANSWERS