National
Qualifications
2022

# X813/76/12

# Chemistry
# Paper 1 — Multiple choice

FRIDAY, 29 APRIL
9:00 AM – 9:40 AM

**Total marks — 25**

Attempt ALL questions.

**You may use a calculator.**

Instructions for the completion of Paper 1 are given on *page 02* of your answer booklet X813/76/02.

Record your answers on the answer grid on *page 03* of your answer booklet.

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher

Space for rough work is provided at the end of this booklet.

Before leaving the examination room you must give your answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

*X8137612*

**Total marks — 25**

**Attempt ALL questions**

**1.** An element contains covalent bonding and London dispersion forces.

The element could be:

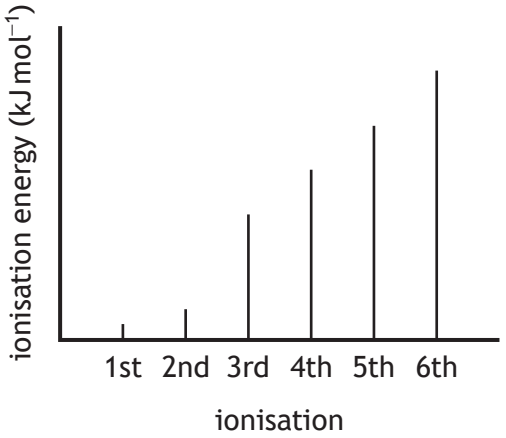
A boron

B neon

C sodium

D sulfur.

**2.** The graph below shows the relative quantities of energy equivalent to successive ionisation energies for an element.




The most stable ion formed from an atom of this element has a charge of:

A 2+

B 3+

C 2–

D 3–

**3.** HCl has a higher boiling point than $H_2$ because:

A the polar covalent bonds in HCl are stronger than the covalent bonds in $H_2$

B the polar covalent bonds in HCl are stronger than the van der Waals' forces in $H_2$

C the van der Waals' forces in HCl are stronger than the van der Waals' forces in $H_2$

D the van der Waals' forces in HCl are stronger than the covalent bonds in $H_2$.

**4.** Which line in the table would best describe elements that act as reducing agents?

| | Gains or loses electrons | Electronegativity |
|---|---|---|
| A | gains | low |
| B | loses | low |
| C | gains | high |
| D | loses | high |

**5.** The correct redox equation for the reaction of iron(II) ions with acidified dichromate ions is:

A $Cr_2O_7^{2-}(aq) + 14H^+(aq) + Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(\ell) + Fe(s)$

B $Cr_2O_7^{2-}(aq) + 14H^+(aq) + Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(\ell) + Fe^{3+}(aq)$

C $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(\ell) + 6Fe(s)$

D $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(\ell) + 6Fe^{3+}(aq)$

**6.** A mixture of magnesium bromide and magnesium sulfate is known to contain 3 moles of magnesium ions and 4 moles of bromide ions.

How many moles of sulfate ions are present?

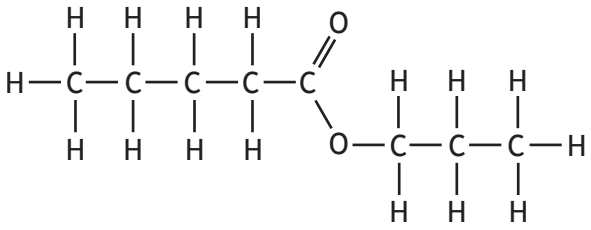
A 1

B 2

C 3

D 4

**7.**



The correct name for this ester is:

A butyl propanoate

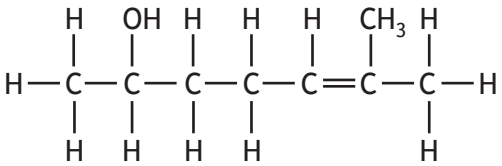
B propyl butanoate

C pentyl propanoate

D propyl pentanoate.

**[Turn over**

**8.** The structural formula for a compound is shown.



Which of the following is **not** an isomer of this compound?

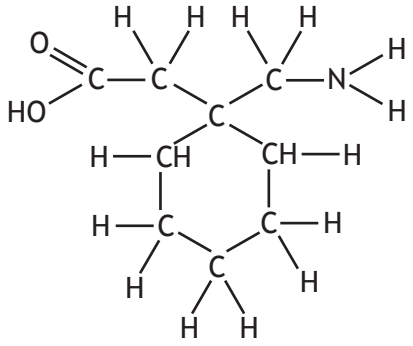
A octan-4-one

B 2-ethylhexanal

C 2-ethylhexan-1-ol

D 5-methylheptan-3-one

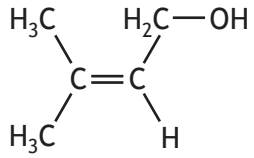
**9.** Gabapentin is a medicine that can be used to treat nerve pain.



Which line in the table shows the two functional groups present in this compound?

| | | |
|---|---|---|
| A | amine | carboxyl |
| B | amine | hydroxyl |
| C | hydroxyl | carboxyl |
| D | hydroxyl | carbonyl |

**10.** Prenol is a compound that occurs naturally in citrus fruits.



Which line in the table correctly describes the reaction of prenol with bromine solution and with hot copper(II) oxide?

| | **Reaction with bromine solution** | **Reaction with hot copper(II) oxide** |
|---|---|---|
| A | no reaction | no reaction |
| B | no reaction | brown solid formed |
| C | decolourises | brown solid formed |
| D | decolourises | no reaction |

**11.** The iodine number of an oil is the mass of iodine, in grams, that will react with 100 g of oil and is a measure of the degree of saturation.

Olive oil has an iodine number of 84 and palm oil has an iodine number of 48.

Which of the following statements is correct?

A Palm oil is more saturated and has a lower melting point than olive oil.

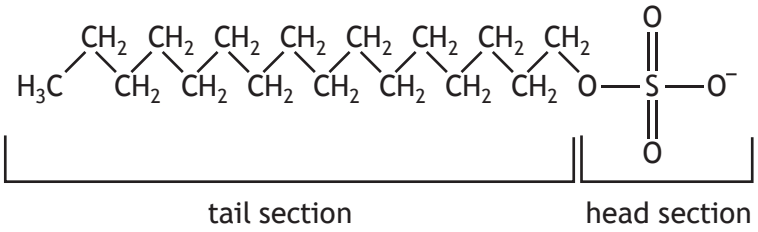
B Palm oil is more saturated and has a higher melting point than olive oil.

C Palm oil is less saturated and has a lower melting point than olive oil.

D Palm oil is less saturated and has a higher melting point than olive oil.

**[Turn over**

**12.** The structure of a soapless detergent molecule is given below.




Which line in the table describes a step in the cleansing action of a soapless detergent?

| | Head section | Tail section |
|---|---|---|
| A | The hydrophobic head dissolves in water. | The hydrophilic tail dissolves in oil. |
| B | The hydrophilic head dissolves in water. | The hydrophobic tail dissolves in oil. |
| C | The hydrophobic head dissolves in oil. | The hydrophilic tail dissolves in water. |
| D | The hydrophilic head dissolves in oil. | The hydrophobic tail dissolves in water. |

**13.** Which of the following is a secondary alcohol?

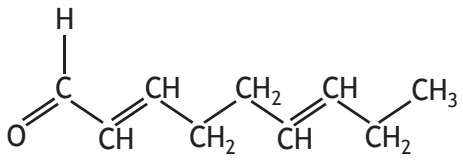
A 2-methylbutan-1-ol

B 2-methylbutan-2-ol

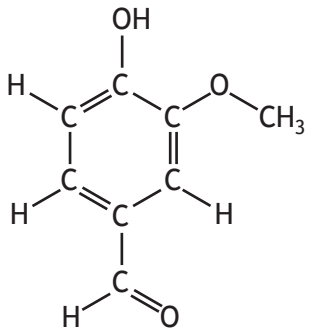
C butan-1-ol

D butan-2-ol

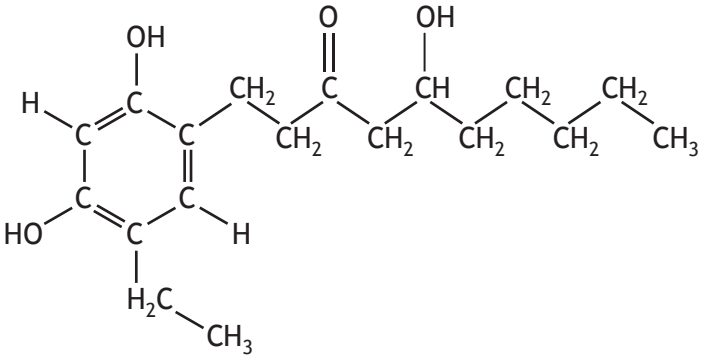
**14.** The compounds below are examples of flavour molecules found in some plants.



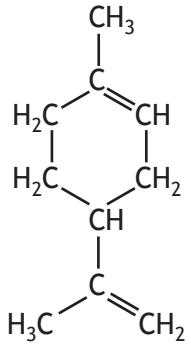
cucumber flavour



vanilla flavour



ginger flavour



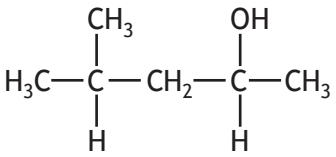
orange flavour

Which line in the table shows the solubilities of these compounds in water and in oil?

| | **Water soluble** | **Oil soluble** |
|---|---|---|
| A | cucumber and ginger | orange and vanilla |
| B | cucumber and orange | ginger and vanilla |
| C | ginger and vanilla | cucumber and orange |
| D | orange and vanilla | cucumber and ginger |

**[Turn over**

**15.** The structural formula for a compound is shown.



The product of oxidation of this compound is:

A 2-methylpentan-4-one

B 4-methylpentan-2-one

C 2-methylpentanal

D 4-methylpentanal.

**16.** Which of the following describes how to fill a burette with acid and take the initial reading in a titration?

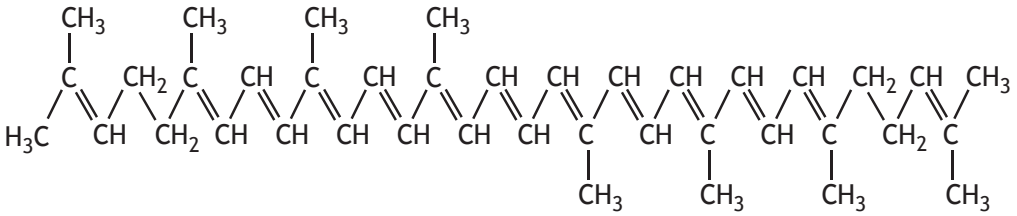
A Rinse the burette with the acid. Fill to above the scale with acid. Drain some of the acid and read from the top of the meniscus.

B Rinse the burette with deionised water. Fill to above the scale with acid. Drain some of the acid and read from the bottom of the meniscus.

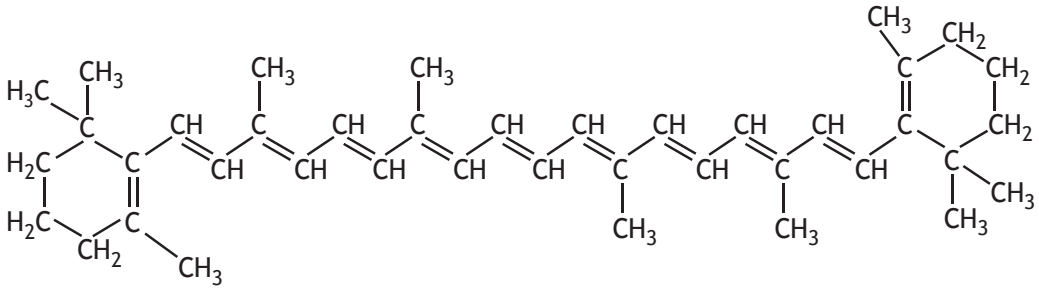
C Rinse the burette with the acid. Fill to above the scale with acid. Drain some of the acid and read from the bottom of the meniscus.

D Rinse the burette with deionised water. Fill to above the scale with acid. Drain some of the acid and read from the top of the meniscus.

**17.** Tomato juice contains a mixture of terpenes including lycopene and beta-carotene.
Terpenes can be separated using chromatography.



lycopene



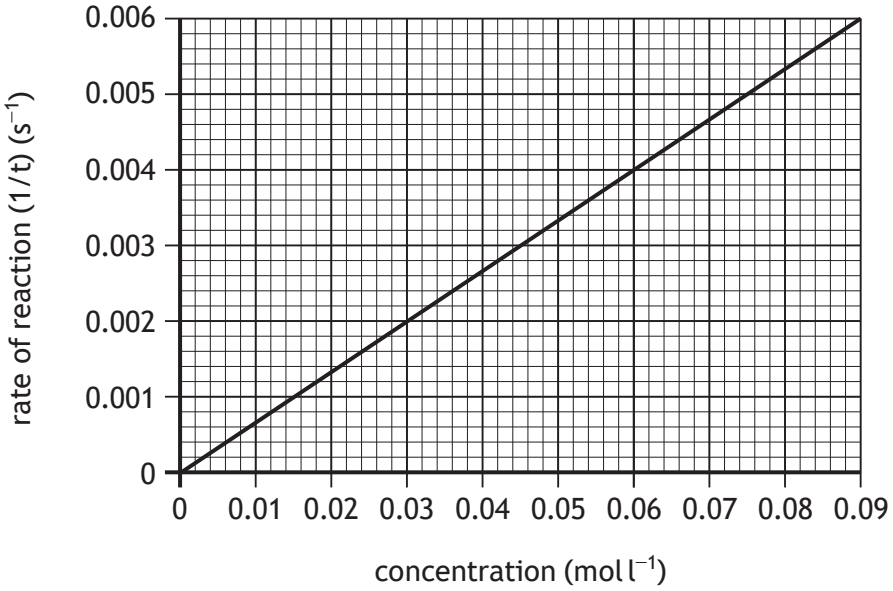
beta-carotene

Which of the following is the most suitable solvent to separate lycopene and beta-carotene?

A Ethanol
B Pentane
C Propanoic acid
D Water

**[Turn over**

**18.** The graph shows how the rate of a reaction varies with the concentration of a reactant.




When the concentration of the reactant is 0.06 mol $l^{-1}$, the reaction time is:

A 0.004 s

B 0.09 s

C 17 s

D 250 s.

**19.** Butene reacts with oxygen as shown.

$$C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(g)$$

100 $cm^3$ of butene was reacted with excess oxygen.

Compared with the total volume of gases before reaction, what would be the total volume of gases after complete reaction?

A 100 $cm^3$ more

B 100 $cm^3$ less

C 300 $cm^3$ more

D 300 $cm^3$ less

**20.** In aqueous solution ethanoic acid forms an equilibrium mixture with its ions.

$$CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$$

Which of the following solutions, when added to the equilibrium mixture, would favour the forward reaction?

A NaCl(aq)

B HCl(aq)

C NaOH(aq)

D $CH_3COONa(aq)$

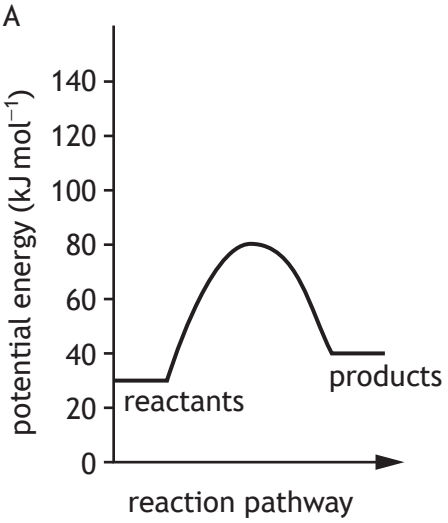
**[Turn over**

**21.** Some energy values associated with a chemical reaction are shown in the table.

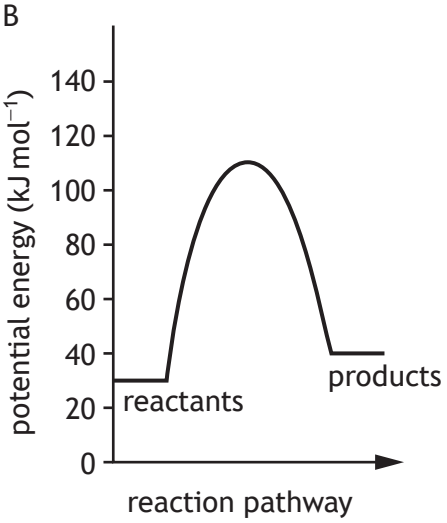
| Enthalpy of reactants ($kJ\ mol^{-1}$) | Activation energy of forward reaction ($kJ\ mol^{-1}$) | Activation energy of reverse reaction ($kJ\ mol^{-1}$) |
|---|---|---|
| 30 | 110 | 70 |

Which of the following correctly shows the potential energy diagram for the above conditions?

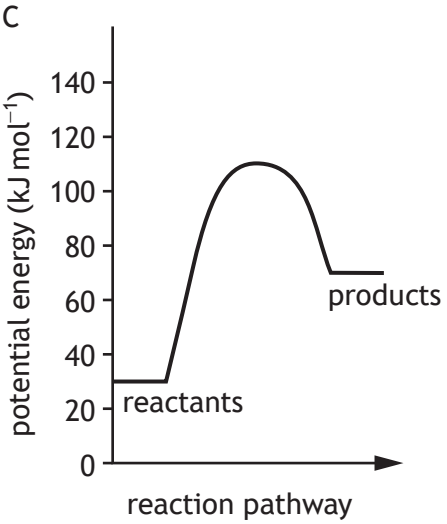
A



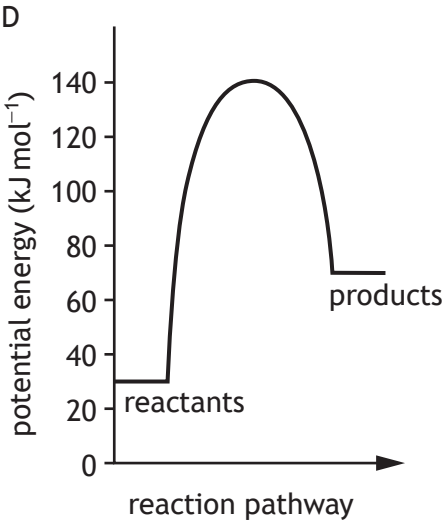

B



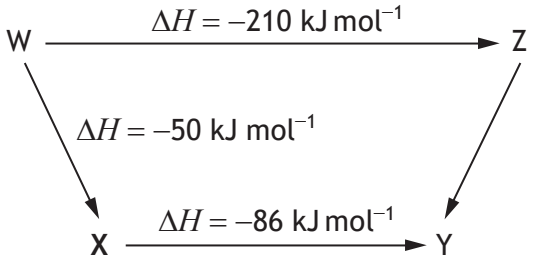

C




D



**22.** Consider the reaction pathway below.




According to Hess' law, the $\Delta H$ value, in kJ mol$^{-1}$, for reaction Z to Y is:

A −74

B +74

C −346

D +346

**23.** 50.0 cm$^3$ of 0.100 mol l$^{-1}$ ammonia solution was transferred to a 250 cm$^3$ volumetric flask. The flask was made up to the mark with deionised water.

The final concentration, in mol l$^{-1}$, of the ammonia solution is:

A $2.0 \times 10^{-2}$

B $2.5 \times 10^{-2}$

C $4.0 \times 10^{-2}$

D $5.0 \times 10^{-2}$

**24.** An experiment involves reacting 0.02 moles of silver ions with ions of a group 7 element to form 2.868 g of precipitate.

Which of the following is the precipitate?

A Silver(I) fluoride

B Silver(I) chloride

C Silver(I) bromide

D Silver(I) iodide

**[Turn over**

**25.** A titration experiment was carried out to determine the concentration of vitamin C in orange juice.

A sample of the orange juice solution was pipetted into a flask and 10 $cm^3$ water was added to dilute the sample. Starch indicator was added to the flask. The mixture was then titrated in the flask using iodine solution of known concentration.

Which line in the table shows the most appropriate apparatus to use when carrying out this procedure?

| | **To add water** | **Type of flask** |
|---|---|---|
| A | measuring cylinder | conical flask |
| B | beaker | conical flask |
| C | measuring cylinder | volumetric flask |
| D | beaker | volumetric flask |

**[END OF QUESTION PAPER]**

FOR OFFICIAL USE

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

National Qualifications 2022

Mark

# X813/76/01

# Chemistry Paper 2

FRIDAY, 29 APRIL

10:10 AM – 12:30 PM

*X8137601*

**Fill in these boxes and read what is printed below.**

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day | Month | Year

Scottish candidate number

**Total marks — 95**

Attempt ALL questions.

**You may use a calculator.**

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

*X813760101*

**Total marks — 95**

**Attempt ALL questions**

MARKS | DO NOT WRITE IN THIS MARGIN

**1.** Elements and compounds can exist as diatomic molecules.

(a) The seven elements that exist as diatomic molecules are shown in the periodic table below.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H | | | | | | | | | | | | | | | | | 2 He |
| 3 Li | 4 Be | | | | | | | | | | | 5 B | 6 C | 7 N | 8 O | 9 F | 10 Ne |
| 11 Na | 12 Mg | | | | | | | | | | | 13 Al | 14 Si | 15 P | 16 S | 17 Cl | 18 Ar |
| 19 K | 20 Ca | 21 Sc | 22 Ti | 23 V | 24 Cr | 25 Mn | 26 Fe | 27 Co | 28 Ni | 29 Cu | 30 Zn | 31 Ga | 32 Ge | 33 As | 34 Se | 35 Br | 36 Kr |
| 37 Rb | 38 Sr | 39 Y | 40 Zr | 41 Nb | 42 Mo | 43 Tc | 44 Ru | 45 Rh | 46 Pd | 47 Ag | 48 Cd | 49 In | 50 Sn | 51 Sb | 52 Te | 53 I | 54 Xe |
| 55 Cs | 56 Ba | | 72 Hf | 73 Ta | 74 W | 75 Re | 76 Os | 77 Ir | 78 Pt | 79 Au | 80 Hg | 81 Tl | 82 Pb | 83 Bi | 84 Po | 85 At | 86 Rn |
| 87 Fr | 88 Ra | | 104 Rf | 105 Db | 106 Sg | 107 Bh | 108 Hs | 109 Mt | 110 Ds | 111 Rg | 112 Cn | 113 Nh | 114 Fl | 115 Mc | 116 Lv | 117 Ts | 118 Og |

(i) Explain why diatomic elements form non-polar molecules. **1**

(ii) Nitrogen, oxygen and fluorine are found in the second period of the periodic table.

Explain the decrease in covalent radius going from nitrogen to fluorine. **1**

(b) First ionisation energies decrease going down a group.

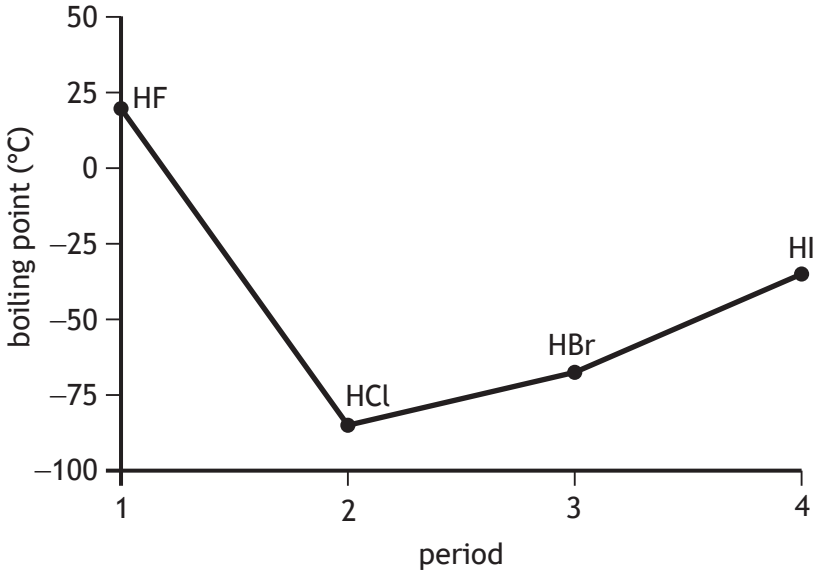
(i) State what is meant by the term *first ionisation energy*. **1**

**1. (b) (continued)**

(ii) Explain why the first ionisation energy of the group 7 elements decreases going down the group. **1**

(c) Hydrogen halides are diatomic molecules formed between hydrogen and the elements fluorine, chlorine, bromine and iodine.

The boiling points of the hydrogen halides are shown on the graph below.




(i) Hydrogen fluoride, HF, has the highest boiling point of the hydrogen halides.

State the name of the strongest type of intermolecular force found between hydrogen fluoride molecules and explain how this type of intermolecular force arises. **2**

**[Turn over**

**1. (c) (continued)**

(ii) The table shows the boiling points of hydrogen chloride, hydrogen bromide and hydrogen iodide.

| Hydrogen halide | Boiling point (°C) |
|---|---|
| Hydrogen chloride | −85 |
| Hydrogen bromide | −66 |
| Hydrogen iodide | −35 |

Explain **fully** why the boiling point increases from hydrogen chloride to hydrogen iodide. **2**

**2.** Fireworks contain a range of chemicals including a fuel, oxidising agents and metal salts.

(a) One oxidising agent used in fireworks is potassium perchlorate, $KClO_4$. This reacts with aluminium metal and produces a bright flash.

The equation for the reaction is

$$KClO_4 \quad + \quad Al \quad \rightarrow \quad KCl \quad + \quad Al_2O_3$$

Balance this equation. **1**

(b) Fireworks were traditionally made using compounds containing the chlorate ion, $ClO_3^-$, as an oxidising agent.

(i) Chlorate ions release oxygen when they decompose.

Potassium chlorate, $KClO_3$, ($GFM = 122.6$ g) reacts as shown.

$$2KClO_3(s) \rightarrow 3O_2(g) + 2KCl(s)$$

Calculate the volume of oxygen produced, in litres, when 4.6 g of potassium chlorate decomposes. **2**

*Take the volume of 1 mole of oxygen gas to be 24 litres.*

**[Turn over**

**2. (b) (continued)**

(ii) The decomposition of potassium chlorate can be speeded up by the addition of a catalyst.

State the effect of adding a catalyst on the enthalpy change for this reaction. **1**

(iii) A firework containing 5.5 g of potassium perchlorate ($GFM = 138.6$ g) releases 103 kJ of energy.

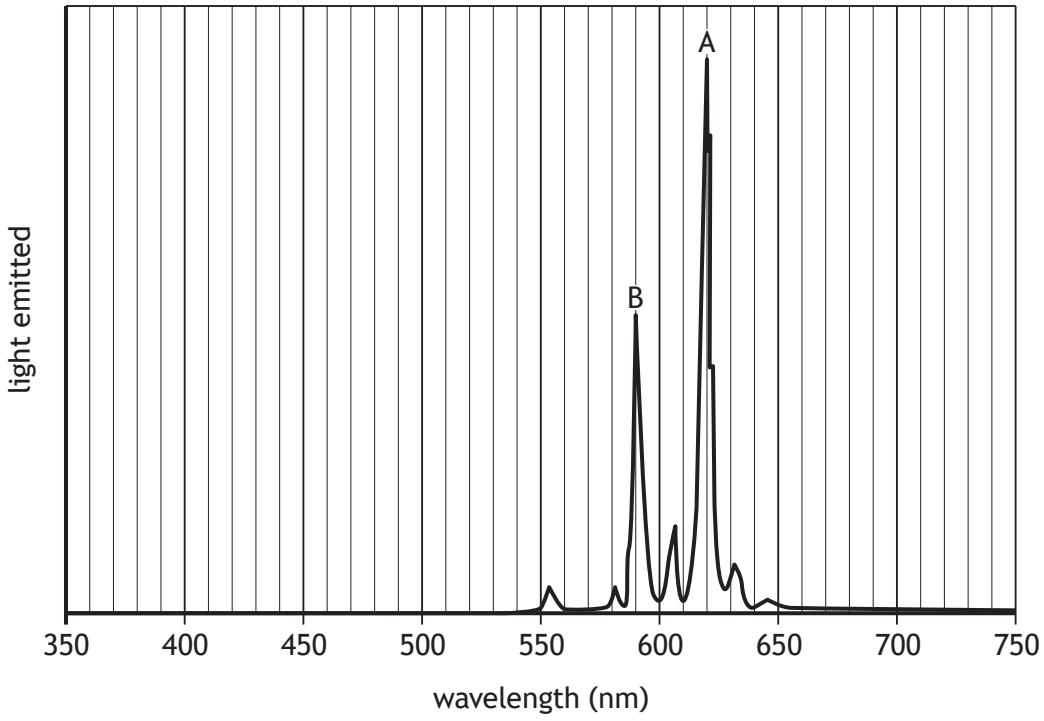
Calculate the energy, in kJ, released per mole of potassium perchlorate. **1**

**2. (b) (continued)**

(iv) Explain **fully** why increasing temperature increases the rate of a chemical reaction. **2**

(c) The different flame colours produced by metal salts are caused by different wavelengths of light being emitted. The flame colours associated with different wavelengths are given in the data booklet.

The following profile shows the colours emitted by one particular firework. Each peak represents a different colour of light.




Peak A has a wavelength of 620 nm, corresponding to red light.

Suggest the **metal** responsible for peak B on the spectrum. **1**

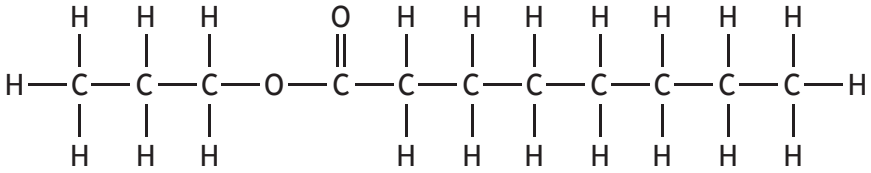
**[Turn over**

**3.** Atoms of different elements have different attractions for bonding electrons. Electronegativity is a measure of the attraction an atom involved in a bond has for the electrons in the bond.

**Using your knowledge of chemistry**, discuss the importance of electronegativity in bonding, structure and properties of compounds. **3**

**4.** Coconut oil contains a mixture of compounds.

(a) Propyl octanoate is a compound found in coconut oil.



(i) Name the functional group in propyl octanoate. **1**

(ii) Draw a structural formula for the carboxylic acid formed by hydrolysis of propyl octanoate. **1**

(iii) An isomer of propyl octanoate with the same functional group was hydrolysed. One of the products of this hydrolysis was butanoic acid.

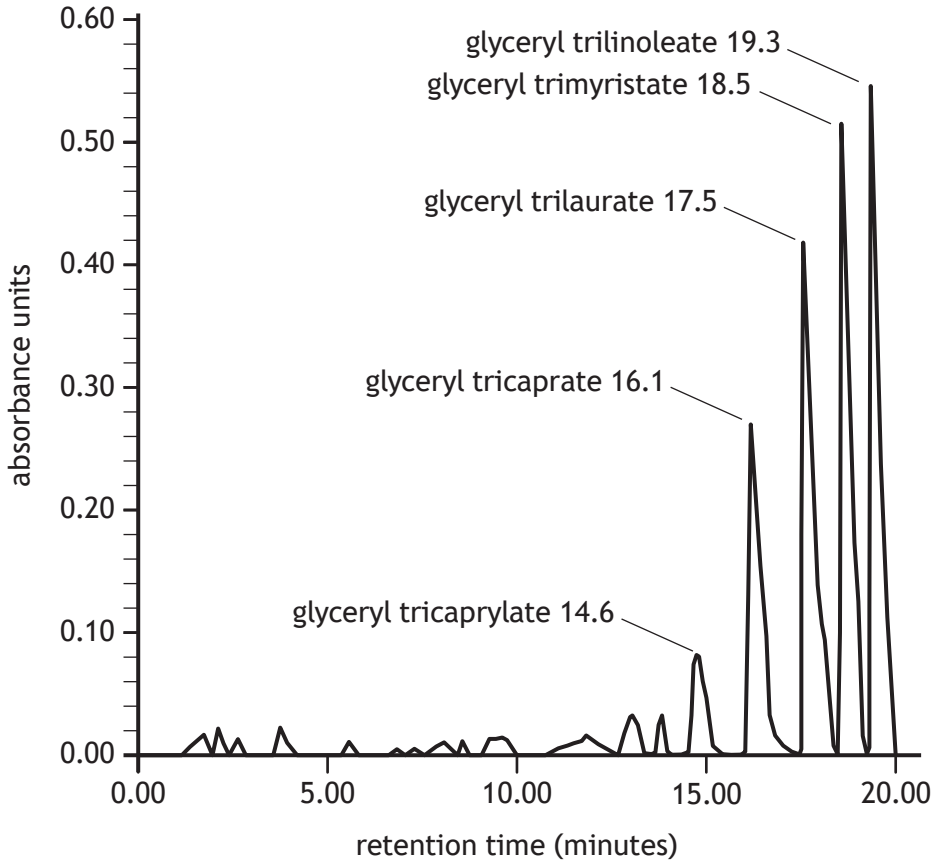
Suggest a name for the other product. **1**

**[Turn over**

**4. (continued)**

(b) Chromatography can be used to separate the fats and oils in coconut oil.

The result of a chromatography experiment is shown.




(i) Using the graph **and** the information in the table, predict the number of carbons in glyceryl trilaurate. **1**

| Name | Molecular formula | Melting point (°C) |
|---|---|---|
| Glyceryl tricaprylate | $C_{27}H_{50}O_6$ | 10 |
| Glyceryl tricaprate | $C_{33}H_{62}O_6$ | 31 |
| Glyceryl trilinoleate | $C_{57}H_{98}O_6$ | –5 |

**4. (b) (continued)**

(ii) Identify the compound listed in the table which is the most unsaturated. **1**

(c) Edible oils such as coconut oil can be used to make emulsifiers.

(i) State how emulsifiers are made from edible oils. **1**

(ii) Explain **fully** how emulsifiers prevent non-polar and polar liquids from separating into layers. **2**

**[Turn over**

**5.** Fusel oil is formed as a by-product during the production of bioethanol for fuel. It is a mixture of several alcohols.

(a) The shortened structural formula of one of the alcohols contained in fusel oil is shown.

$$CH_3CH(CH_3)CH_2CH_2OH$$

State the name of this alcohol. **1**

(b) Propan-1-ol is also found in fusel oil.

Propan-1-ol is reacted with an oxidising agent to produce propanal.

(i) Complete the ion-electron equation for the oxidation reaction. **1**

$$C_3H_7OH \rightarrow C_3H_6O$$

(ii) Acidified potassium dichromate can be used as the oxidising agent and reacts as shown below.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(\ell)$$

Suggest why the potassium dichromate must be acidified. **1**

**5. (b) (continued)**

(iii) State the colour change that would be observed when propan-1-ol reacts with acidified potassium dichromate. **1**

(iv) The equation for the reduction of another oxidising agent that could be used to oxidise propan-1-ol is shown below.

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

Name the reagent that provides this oxidising agent. **1**

(v) State why 2-methylbutan-2-ol cannot be oxidised using these oxidising agents. **1**

(vi) In the reaction of butan-1-ol to butanal, oxidation can be identified by an increase in the oxygen to hydrogen ratio.

Complete the table to show the oxygen to hydrogen ratios in butan-1-ol and butanal. **1**

| | **Oxygen to hydrogen ratio** |
|---|---|
| Butan-1-ol | |
| Butanal | |

**[Turn over**

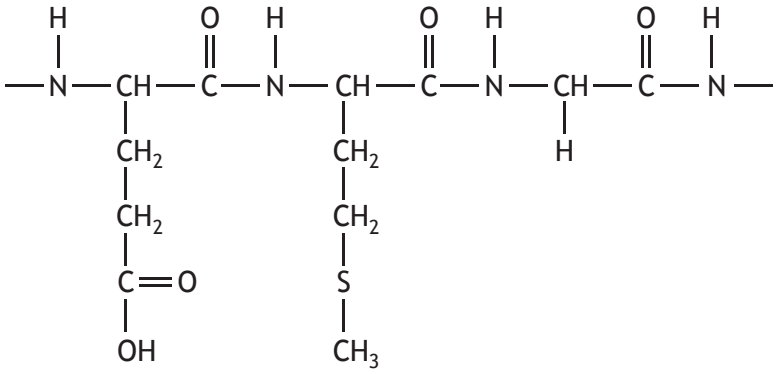
**6.** Sweet potatoes contain nutrients, including starch, vitamin C and proteins.

(a) Catalase is an enzyme contained in sweet potatoes that speeds up the breakdown of hydrogen peroxide.

(i) State what is meant by the term enzyme. **1**

(ii) Enzymes are a type of protein. Proteins are formed from smaller molecules called amino acids.

(A) A section of a protein is shown.



Circle a peptide link in the above structure. **1**

(An additional diagram can be found on *page 33*.)

(B) Draw a structural formula for one of the amino acids used to form this section of protein. **1**

**6. (a) (ii) (continued)**

(C) State what is meant by the term **essential** amino acid. **1**

(D) Name the type of reaction that takes place when amino acids join to form proteins. **1**

(iii) As sweet potatoes are cooked, the ability of catalase to break down hydrogen peroxide decreases.

Explain **fully** what happens to the enzyme structure to cause this reduction in activity. **2**

**[Turn over**

**6. (a) (continued)**

(iv) Hydrogen peroxide is broken down by catalase to produce water and oxygen.

An experiment was carried out to determine how much oxygen was produced from the breakdown of hydrogen peroxide by a sample of sweet potato.

Draw a diagram showing assembled apparatus that could be used to react hydrogen peroxide solution with sweet potato and measure the volume of oxygen produced.

Your diagram should include labels showing the names and positions of the reactants and the collected product. **3**

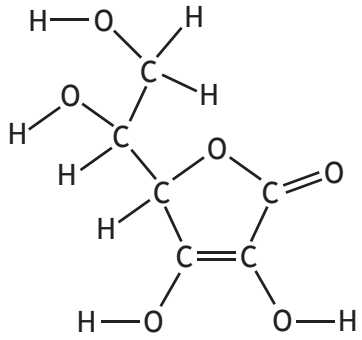
(b) Sweet potatoes are a good source of the antioxidant vitamin C.

(i) Antioxidants like vitamin C are added to food.

Explain why antioxidants are added to food. **1**

**6. (b) (continued)**

(ii) The structure of vitamin C is shown.



Explain **fully** why vitamin C is soluble in water. **2**

(c) Unlike sweet potatoes, white potatoes contain the chemical solanine, that can be toxic to humans in large doses. A dose of 3 mg per kg of body weight can cause toxic symptoms.

A typical white potato can contain 0.2 mg per g of solanine.

Calculate the mass of white potato that could produce a toxic dose to an adult weighing 65 kg. **3**

**[Turn over**

**7.** Natural gas is a source of methane.

(a) Methane, $CH_4$, can be used as a fuel.

In an experiment, methane was burned to raise the temperature of 100 $cm^3$ of water by 27 °C.

Using the enthalpy of combustion of methane (891 $kJ\,mol^{-1}$), calculate the mass of methane, in g, burned in this experiment. **3**

(b) The equation for the combustion of methane is shown.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Bond enthalpies can be used to calculate a theoretical enthalpy change for this reaction.

Using bond enthalpies from the data booklet, calculate the enthalpy change, in $kJ\,mol^{-1}$, for the combustion of methane. **2**

**7. (continued)**

(c) Methane reacts with steam to produce hydrogen.

$$\underset{GFM = 16\text{ g}}{CH_4(g)} + \underset{GFM = 18\text{ g}}{H_2O(g)} \rightarrow \underset{GFM = 28\text{ g}}{CO(g)} + \underset{GFM = 2\text{ g}}{3H_2(g)}$$

Calculate the atom economy for the formation of hydrogen. **2**

(d) Another naturally occurring gas is nitrogen dioxide, $NO_2$.

Nitrogen dioxide exists in equilibrium with dinitrogen tetroxide, $N_2O_4$.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -58\text{ kJ mol}^{-1}$$

Complete the table to show the conditions that would maximise the yield of **nitrogen dioxide**. **1**

| Condition | High/Low |
|---|---|
| Temperature | |
| Pressure | |

**[Turn over**

**7. (continued)**

(e) (i) In the United States Space Shuttle, dinitrogen tetroxide was reacted with methylhydrazine.

$$4CH_3NHNH_2(\ell) + 5N_2O_4(\ell) \rightarrow 4CO_2(g) + 12H_2O(g) + 9N_2(g)$$

Calculate the enthalpy of this reaction, in kJ, by using the data shown below. **2**

| | | | | |
|---|---|---|---|---|
| $C(s) + 3H_2(g) + N_2(g)$ | $\rightarrow$ | $CH_3NHNH_2(\ell)$ | $\Delta H = +54$ kJ mol$^{-1}$ |
| $N_2(g) + 2O_2(g)$ | $\rightarrow$ | $N_2O_4(\ell)$ | $\Delta H = -20$ kJ mol$^{-1}$ |
| $C(s) + O_2(g)$ | $\rightarrow$ | $CO_2(g)$ | $\Delta H = -394$ kJ mol$^{-1}$ |
| $H_2(g) + \frac{1}{2}O_2(g)$ | $\rightarrow$ | $H_2O(\ell)$ | $\Delta H = -286$ kJ mol$^{-1}$ |
| $H_2O(l)$ | $\rightarrow$ | $H_2O(g)$ | $\Delta H = +41$ kJ mol$^{-1}$ |

(ii) Draw the full structural formula for methylhydrazine, $CH_3NHNH_2$. **1**

**8.** Fizzy drinks are made by adding carbon dioxide gas, preservative, colouring and flavouring to water.

(a) Carbon dioxide for fizzy drinks can be produced using the water-gas shift reaction.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

(i) A catalyst for this reaction is copper(II) oxide.

Complete the table by circling one option on each line to show the effect of copper(II) oxide on the reaction. **2**

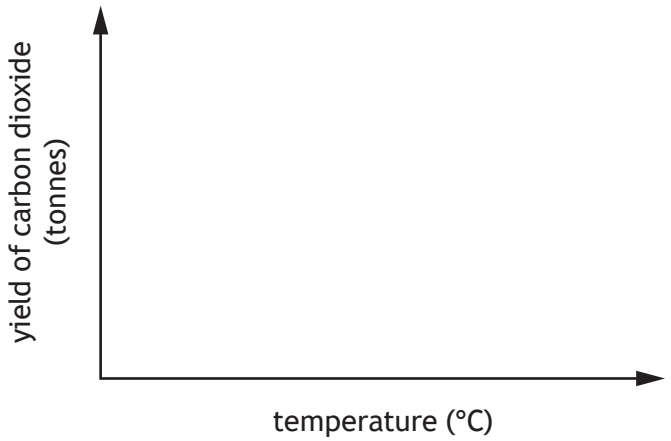
(An additional table can be found on *page 33*.)

| Feature of reaction | Effect of catalyst |
|---|---|
| Rate of forward reaction | increase/decrease/no effect |
| Rate of reverse reaction | increase/decrease/no effect |
| Position of equilibrium | moves to right/moves to left/no effect |

(ii) The water-gas shift reaction is exothermic.

Draw a line on the axes below to show how the yield of carbon dioxide would vary with increasing temperature. **1**

(An additional diagram can be found on *page 33*.)




**[Turn over**

**8. (continued)**

(b) A preservative added to some fizzy drinks is made by reacting sorbic acid and potassium hydroxide.

In an experiment, 7 g of sorbic acid, $C_6H_8O_2$, is reacted with 250 $cm^3$ of potassium hydroxide solution, concentration 0.5 mol $l^{-1}$.

$$C_6H_8O_2(s) + KOH(aq) \rightarrow H_2O(\ell) + C_6H_7O_2K(aq)$$

$GFM = 112$ g

Show, by calculation, that sorbic acid is the limiting reactant. **2**

**8. (continued)**

(c) Ammonium ferric citrate ($GFM$ = 261.8 g) gives some drinks a characteristic orange colour. A typical drink contains 0.002% of ammonium ferric citrate.

A 1% solution contains 1 g made up to 100 $cm^3$ of solution.

Calculate the number of moles of ammonium ferric citrate required to make 330 $cm^3$ of this fizzy drink. **2**

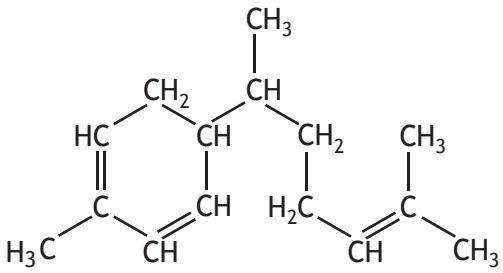
**[Turn over**

**8. (continued)**

(d) Ginger root is used as a flavouring for some fizzy drinks.

(i) Ginger oil is an essential oil obtained from ginger root.

Zingiberene is one of the main components in this essential oil.



zingiberene

(A) State one property of an essential oil. **1**

(B) Zingiberene is formed from isoprene units.

(I) Name the type of compound formed when isoprene units join together. **1**

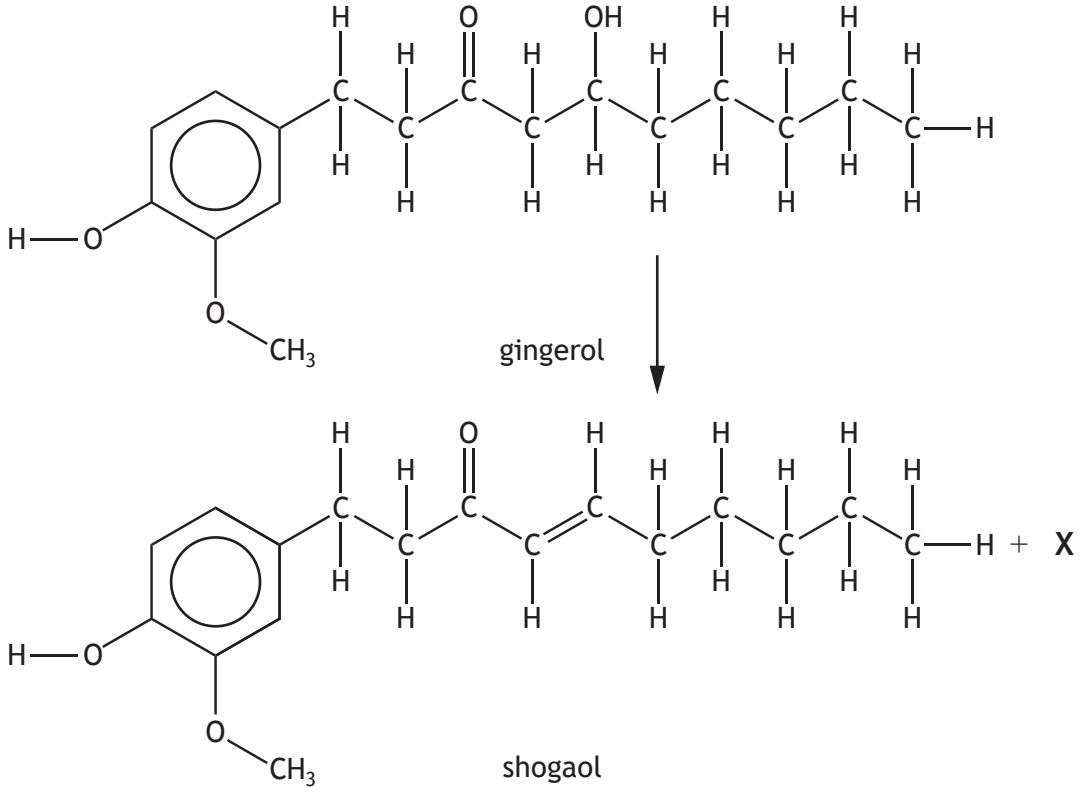
(II) Isoprene is also called 2-methyl-1,3-butadiene.

Draw a structural formula for isoprene. **1**

(III) State the number of isoprene units in a zingiberene molecule. **1**

**8. (d) (continued)**

(ii) Gingerol is another compound found in ginger root. Gingerol can form the compound shogaol as shown.




(A) Name product **X**. **1**

(B) Name two functional groups present in gingerol and shogaol that are **not** present in zingiberene. **1**

**[Turn over**

**9.** For a particular set of reaction conditions, the actual yield is the quantity of desired product made in a reaction.

Some examples of reactions with their desired products are shown.

| Equation | Desired product |
|---|---|
| $Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$ | $BaSO_4(s)$ |
| $CH_3OH(\ell) + C_2H_5COOH(\ell) \rightleftharpoons C_2H_5COOCH_3(\ell) + H_2O(\ell)$ | $C_2H_5COOCH_3(\ell)$ |
| $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ | $H_2(g)$ |

**Using your knowledge of chemistry**, describe how the actual yield in a reaction could be determined.

Your answer should include experimental procedures that could be used to determine the quantity of product made in reactions such as the examples shown in the table. **3**

**10.** A refrigerant is a chemical used in cooling processes. Some refrigerant compounds can damage the ozone layer.

(a) The ozone depletion potential (ODP) of a refrigerant compound is the relative amount of damage that it can cause to the ozone layer. The higher the number, the greater the damage.

| | Refrigerant compound | Ozone depletion potential |
|---|---|---|
| 1 | $C_2F_4Br_2$ | 6.00 |
| 2 | $CF_2ClBr$ | 3.00 |
| 3 | $C_2FCl_5$ | 1.00 |
| 4 | $C_2F_3Cl_3$ | 0.85 |
| 5 | $C_2F_4Cl_2$ | 0.58 |
| 6 | $C_2H_3Cl_3$ | 0.16 |

(i) Describe a relationship between the formulae of refrigerant compounds 3, 4 and their ODP. **1**

(ii) Identify which pair of compounds should be used to show the effect of replacing chlorine atoms with bromine atoms in refrigerant compounds. **1**

(iii) The refrigerants carbon dioxide, $CO_2$, and ammonia, $NH_3$, have ODP values of 0.00.

Suggest why this is the case. **1**

**10. (continued)**

(b) The compound difluoromethane, $CH_2F_2$, is also used as a refrigerant. It is made by reacting fluorine gas with fluoromethane, $CH_3F$, in a free radical chain reaction.

(i) State what is meant by a free radical. **1**

(ii) The first step in the reaction involves splitting a fluorine molecule to produce two fluorine radicals.

$$F_2 \rightarrow 2F\bullet$$

(A) State the name given to this step. **1**

(B) Write an equation for a possible propagation step in this reaction. **1**

(c) Household fridges use coolants made from refrigerant compounds. A common coolant is made from 50% difluoromethane, $CH_2F_2$, ($GFM = 52$ g) and 50% pentafluoroethane, $CF_3CHF_2$, ($GFM = 120$ g).

A typical fridge contains 0.05 kg of coolant.

Calculate the number of moles of pentafluoroethane required to make this mass of coolant. **1**

**[Turn over**

**11.** Spinach is a leafy green vegetable.

(a) Fertilisers containing copper(II) ethanoate are used to supply spinach with copper ions.

Copper(II) ethanoate can be made by reacting copper(II) carbonate with ethanoic acid.

(i) Name the other products of this reaction. **1**

(ii) Write the ionic formula of copper(II) ethanoate. **1**

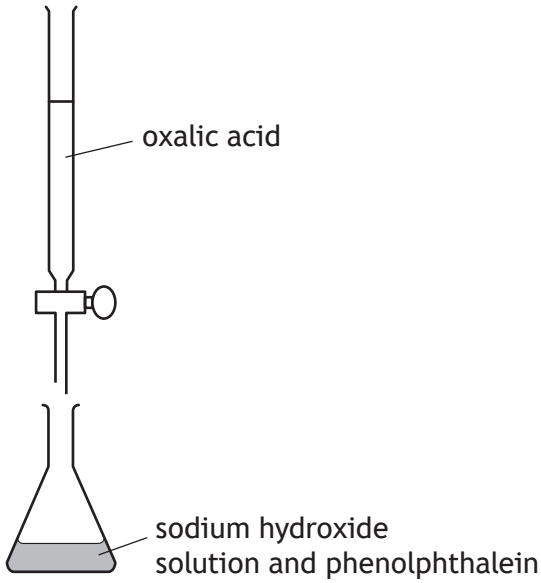
(b) Spinach is a source of oxalic acid.

A standard solution of oxalic acid can be used to determine the accurate concentration of a sodium hydroxide solution.

Given an accurately known mass of oxalic acid, describe **fully** how 250 $cm^3$ of a standard solution of oxalic acid could be prepared. **3**

**11. (continued)**

(c) The concentration of sodium hydroxide can be determined by titration with oxalic acid.




An accurate volume of sodium hydroxide solution is measured into a conical flask using a pipette.

(i) Draw a diagram of a pipette suitable for measuring an accurate volume. **1**

(ii) The indicator used in this titration is phenolphthalein. Phenolphthalein is colourless in acidic and neutral solutions but is pink in alkaline conditions.

State the colour change that would be observed at the end point in this titration. **1**

**[Turn over**

**11. (c) (continued)**

(iii) The titration was repeated until results were obtained that were within 0.2 $cm^3$ of each other.

State the term used to describe titre volumes within 0.2 $cm^3$ of each other. **1**

(d) The equation for the reaction of oxalic acid and sodium hydroxide is shown.

$$H_2C_2O_4(aq) + 2NaOH(aq) \rightarrow Na_2C_2O_4(aq) + 2H_2O(\ell)$$

The concentration of sodium hydroxide solution was determined by titrating 25.0 $cm^3$ samples with 0.126 mol $l^{-1}$ oxalic acid solution.

The average volume of oxalic acid solution required in the titration was 26.75 $cm^3$.

Calculate the concentration, in mol $l^{-1}$, of the sodium hydroxide. **3**

**[END OF QUESTION PAPER]**