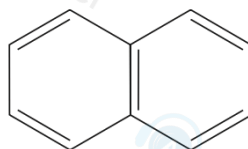


1 What is the molecular formula of naphthalene?



- A  $C_{10}H_8$
- B  $C_{10}H_{10}$
- C  $C_{12}H_{10}$
- D  $C_{12}H_{12}$

(Total for Question 1 = 1 mark)

17 The substances formed from the combustion of petrol in car engines include

- A water, carbon dioxide and hydrogen
- B water, carbon monoxide and hydrogen chloride
- C water, carbon dioxide and sulfur dioxide
- D water, carbon particulates and hydrogen

(Total for Question 17 = 1 mark)

10: Which reaction to produce copper(II) nitrate ( $M_r = 187.5$ ) has an atom economy of 46.5% by mass?

- A  $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
- B  $2Cu + Pt(NO_3)_4 \rightarrow 2Cu(NO_3)_2 + Pt$
- C  $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$
- D  $CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$

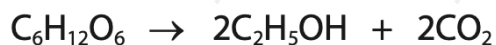
(Total for Question 10 = 1 mark)

13 Which molecule has the largest bond angle?

- A  $BF_3$
- B  $CF_4$
- C  $H_2O$
- D  $NH_3$

(Total for Question 13 = 1 mark)

8 Ethanol is formed from glucose during fermentation.



What is the atom economy by mass for the formation of ethanol in this reaction?

- A 26%
- B 49%
- C 51%
- D 96%

**(Total for Question 8 = 1 mark)**

8 Ethanoic acid can be produced by the oxidation of butane.

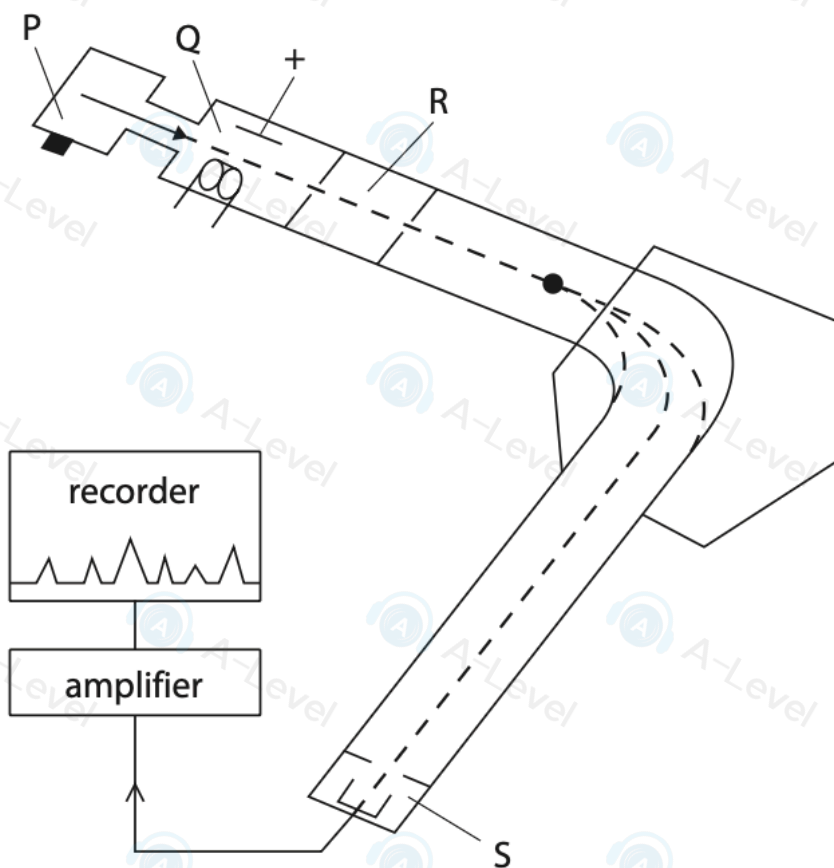


The atom economy, by mass, for the production of ethanoic acid is

- A 13%
- B 67%
- C 77%
- D 87%

**(Total for Question 8 = 1 mark)**

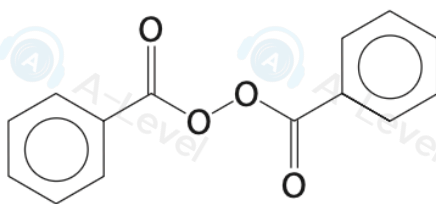
8 In which region of a mass spectrometer are particles ionised?



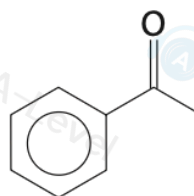
- A region P
- B region Q
- C region R
- D region S

(Total for Question 8 = 1 mark)

- 14** Polymerisation of alkenes occurs via a free radical mechanism. This reaction is started by the addition of small amounts of another compound. The structure of one of these compounds is shown.



This can be represented as R—O—O—R where R— is



Which step in the mechanism is an initiation step?

- A**  $\text{R—O—O—R} \rightarrow 2\text{R—O}^\bullet$
- B**  $\text{R—O—CH}_2\text{—CH}_2^\bullet + \text{CH}_2=\text{CH}_2 \rightarrow \text{R—O—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_2^\bullet$
- C**  $2\text{R—O—CH}_2\text{—CH}_2^\bullet \rightarrow \text{R—O—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—O—R}$
- D**  $\text{R—O}^\bullet + \text{CH}_2=\text{CH}_2 \rightarrow \text{R—O—CH}_2\text{—CH}_2^\bullet$

**(Total for Question 14 = 1 mark)**

- 11** Which row of the table shows properties consistent with the type of bonding shown?

	Bonding	Solubility in water	Melting temperature	Electrical conductivity of solid
<input checked="" type="checkbox"/> <b>A</b>	ionic	soluble	high	poor
<input checked="" type="checkbox"/> <b>B</b>	ionic	soluble	low	good
<input checked="" type="checkbox"/> <b>C</b>	metallic	soluble	low	good
<input checked="" type="checkbox"/> <b>D</b>	metallic	insoluble	high	poor

**(Total for Question 11 = 1 mark)**

13 Which solution contains chloride ions with a concentration of  $0.0500 \text{ mol dm}^{-3}$ ?

[ $A_r$  values: Ca = 40.1 Cl = 35.5 Na = 23.0]

	Solute	Mass of solute / g	Volume of solution / $\text{cm}^3$
<input checked="" type="checkbox"/> A	calcium chloride	1.39	250
<input checked="" type="checkbox"/> B	calcium chloride	1.39	500
<input checked="" type="checkbox"/> C	sodium chloride	1.46	250
<input checked="" type="checkbox"/> D	sodium chloride	1.46	1000

(Total for Question 13 = 1 mark)

1 What is the total number of **atoms** in 8.8 g of carbon dioxide?

[ $M_r$  value:  $\text{CO}_2 = 44$  Avogadro constant,  $L = 6.02 \times 10^{23} \text{ mol}^{-1}$ ]

A  $1.2 \times 10^{23}$

B  $3.6 \times 10^{23}$

C  $1.2 \times 10^{24}$

D  $3.6 \times 10^{24}$

(Total for Question 1 = 1 mark)

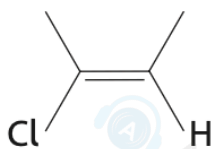
2 Which diagram represents the electronic structure of a nitrogen atom?

	1s	2s	2p		
<input checked="" type="checkbox"/> A	$\uparrow\downarrow$	$\uparrow$	$\uparrow\downarrow$	$\uparrow$	$\uparrow$
<input checked="" type="checkbox"/> B	$\uparrow\downarrow$	$\uparrow$	$\uparrow\downarrow$	$\uparrow\downarrow$	
<input checked="" type="checkbox"/> C	$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow$	$\uparrow$	$\uparrow$
<input checked="" type="checkbox"/> D	$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow$	

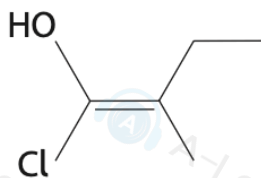
(Total for Question 2 = 1 mark)

20 Which structure is a Z-isomer?

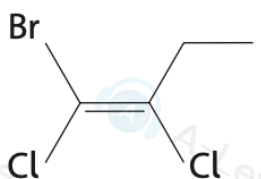
A



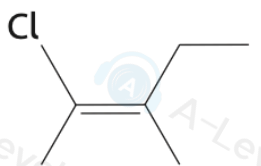
B



C



D



(Total for Question 20 = 1 mark)

8 A block of lead measuring 10 cm × 10 cm × 10 cm contains  $3.295 \times 10^{25}$  atoms.

Calculate the density of lead.

[ $A_r$  value: Pb = 207.2 Avogadro constant,  $L = 6.02 \times 10^{23} \text{ mol}^{-1}$ ]

A  $3.79 \text{ g cm}^{-3}$

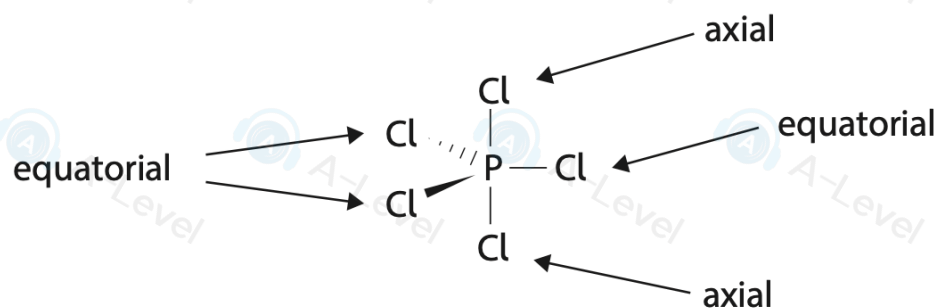
B  $4.49 \text{ g cm}^{-3}$

C  $11.34 \text{ g cm}^{-3}$

D  $54.73 \text{ g cm}^{-3}$

(Total for Question 8 = 1 mark)

13 In the gas phase,  $\text{PCl}_5$  exists as molecules. They are trigonal bipyramidal.



Each chlorine atom can be replaced one at a time by a fluorine atom. The two axial chlorine atoms are replaced before the three equatorial atoms.

Which of the resulting molecules does **not** have a permanent dipole?

- A  $\text{PCl}_4\text{F}$
- B  $\text{PCl}_3\text{F}_2$
- C  $\text{PCl}_2\text{F}_3$
- D  $\text{PClF}_4$

(Total for Question 13 = 1 mark)

2 What is the shape of a p orbital and the maximum number of electrons it can hold?

	shape	maximum number of electrons
<input checked="" type="checkbox"/> A		2
<input checked="" type="checkbox"/> B		6
<input checked="" type="checkbox"/> C		2
<input checked="" type="checkbox"/> D		6

(Total for Question 2 = 1 mark)

8: Which substance does **not** exist as a giant lattice?

- A silver (Ag)
- B sodium chloride (NaCl)
- C graphite (C)
- D buckminsterfullerene (C<sub>60</sub>)

**(Total for Question 8 = 1 mark)**

2 Which has the smallest ionic radius?

- A F<sup>-</sup>
- B Mg<sup>2+</sup>
- C Na<sup>+</sup>
- D O<sup>2-</sup>

**(Total for Question 2 = 1 mark)**

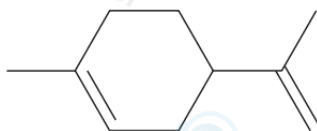
10 Sulfur has a higher melting temperature than white phosphorus, P<sub>4</sub>.

Which is a possible reason for this?

- A sulfur molecules have a greater permanent dipole than phosphorus molecules
- B sulfur has stronger covalent bonds than phosphorus
- C sulfur has a giant covalent structure and phosphorus has a simple molecular structure
- D sulfur molecules have more electrons than phosphorus molecules

**(Total for Question 10 = 1 mark)**

3 This question is about limonene.



(a) What is the molecular formula of limonene?

(1)

A  $C_{10}H_{10}$

B  $C_{10}H_{16}$

C  $C_{10}H_{18}$

D  $C_{10}H_{22}$

(b) Limonene is completely hydrogenated by hydrogen in the presence of a nickel catalyst. What is the **empirical formula** of the product formed?

(1)

A  $C_5H_{11}$

B  $C_5H_9$

C  $C_5H_8$

D  $CH_2$

(Total for Question 3 = 2 marks)

19 Many cars use fuels containing ethanol as well as hydrocarbons. The E numbers of these fuels show the percentage by volume of ethanol in the fuel. For example, an E5 fuel contains 5% ethanol and 95% hydrocarbons by volume.

(a) A brand of E10 fuel contains 92.2% hydrocarbons and 7.80% ethanol by mass.

The energy density is the amount of energy released per kg of a fuel burned.

The energy densities of the two components of this brand of fuel are shown.

$$\text{energy density of hydrocarbons} = 46.5 \text{ MJ kg}^{-1}$$

$$\text{energy density of ethanol} = 29.7 \text{ MJ kg}^{-1}$$

- (i) Calculate the **mean** energy density of this E10 fuel in  $\text{MJ kg}^{-1}$ .  
Give your answer to an appropriate number of significant figures.

(2)

- (ii) The density of the E10 fuel is  $0.729 \text{ g cm}^{-3}$ .

Calculate the mass of  $1500 \text{ cm}^3$  of the fuel.

(1)

- (iii) Calculate the energy released when  $1500 \text{ cm}^3$  of the E10 fuel is burned in excess oxygen, using your answers from (a)(i) and (a)(ii).

[If you did not calculate a value for the **mean** energy density of the E10 fuel in (a)(i), use a value of  $38.1 \text{ MJ kg}^{-1}$ . This is not the correct value.]

(1)

**24** A sample of a volatile liquid **X** was vaporised.  
At 473 K and 110 000 Pa, 3.50 g of **X** occupies 1.79 dm<sup>3</sup>.

(a) (i) Calculate the number of moles of **X** in the sample.

$$[R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}]$$

$$\text{Use } pV = nRT$$

**(4)**

(ii) Deduce the relative molecular mass of **X**.

**(1)**

(iii) Compound **X** contains 85.7 % carbon and 14.3 % hydrogen by mass.

Calculate the empirical formula of **X**.

**(2)**

(iv) Deduce the molecular formula of **X**.

**(1)**

- (b) A few drops of a purple solution of acidified potassium manganate(VII) were added to a sample of liquid **X** and shaken. The solution remained purple.

State what can be deduced about the structure of **X** from this experiment.

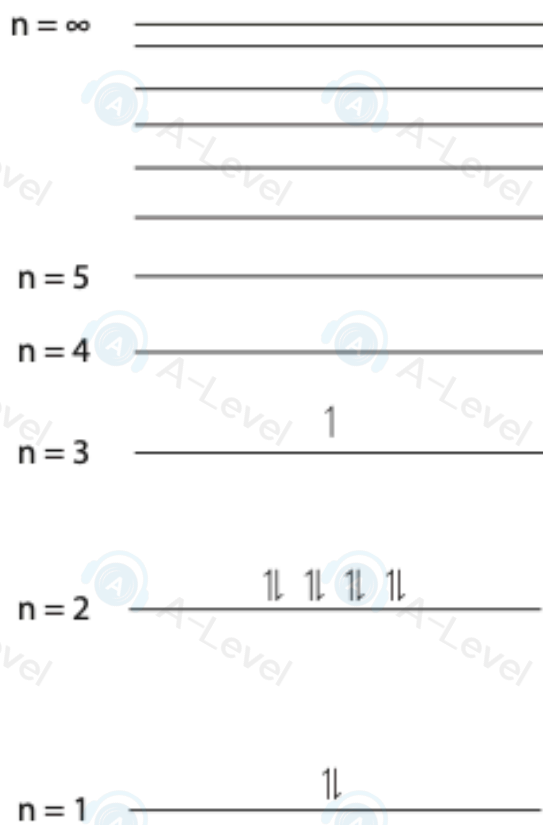
(1)

- (c) Identify, by name or formula, **two** possible structural isomers of **X** using your answers to (a)(iv) and (b).

(2)

**(Total for Question 24 = 11 marks)**

**22** The diagram shows the arrangement of electrons in the energy levels of a sodium atom.



(a) Give the reason why the two electrons in the  $n = 1$  energy level are represented by arrows pointing in opposite directions.

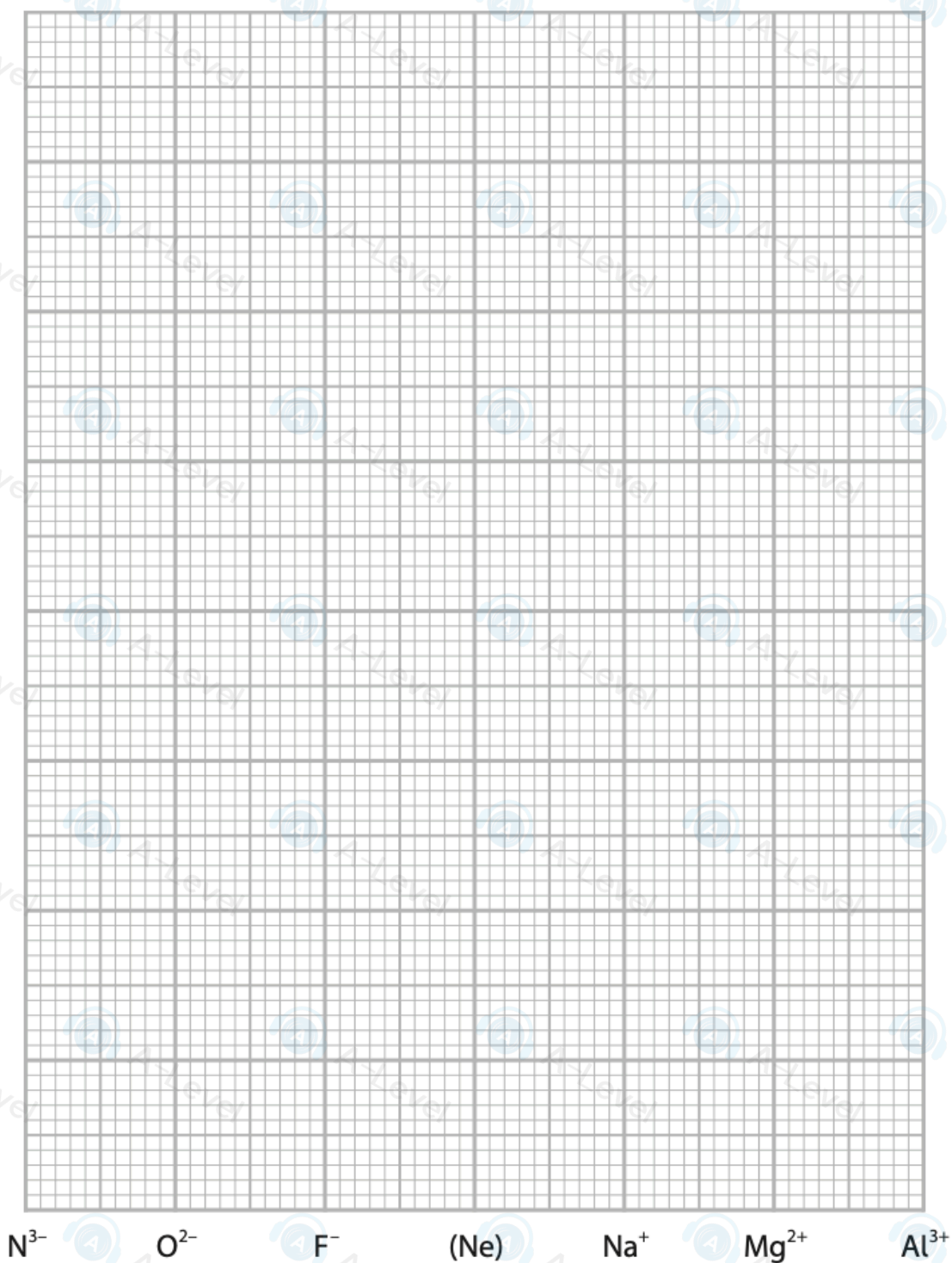
(1)

24 The radii of ions of some successive elements in the Periodic Table are shown.

Ion	$\text{N}^{3-}$	$\text{O}^{2-}$	$\text{F}^-$	$\text{Na}^+$	$\text{Mg}^{2+}$	$\text{Al}^{3+}$
Ionic radius / pm	171	140	133	102		54

(a) (i) Plot a graph of the data.

(2)



(ii) Predict the radius of the magnesium ion using a straight line of best fit on your graph.

(2)

(iii) Explain the trend in the ionic radii from the nitride ion to the aluminium ion.

(3)

(b) Sodium and fluorine react to form a compound.

(i) State the structure and bonding of sodium fluoride.

(1)

(ii) Explain how the electrical conductivity of sodium fluoride provides evidence for the existence of ions.

**(3)**

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(iii) Explain why the fluoride ion is difficult to polarise.

**(2)**

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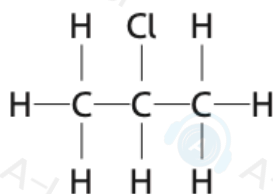
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**(Total for Question 24 = 13 marks)**

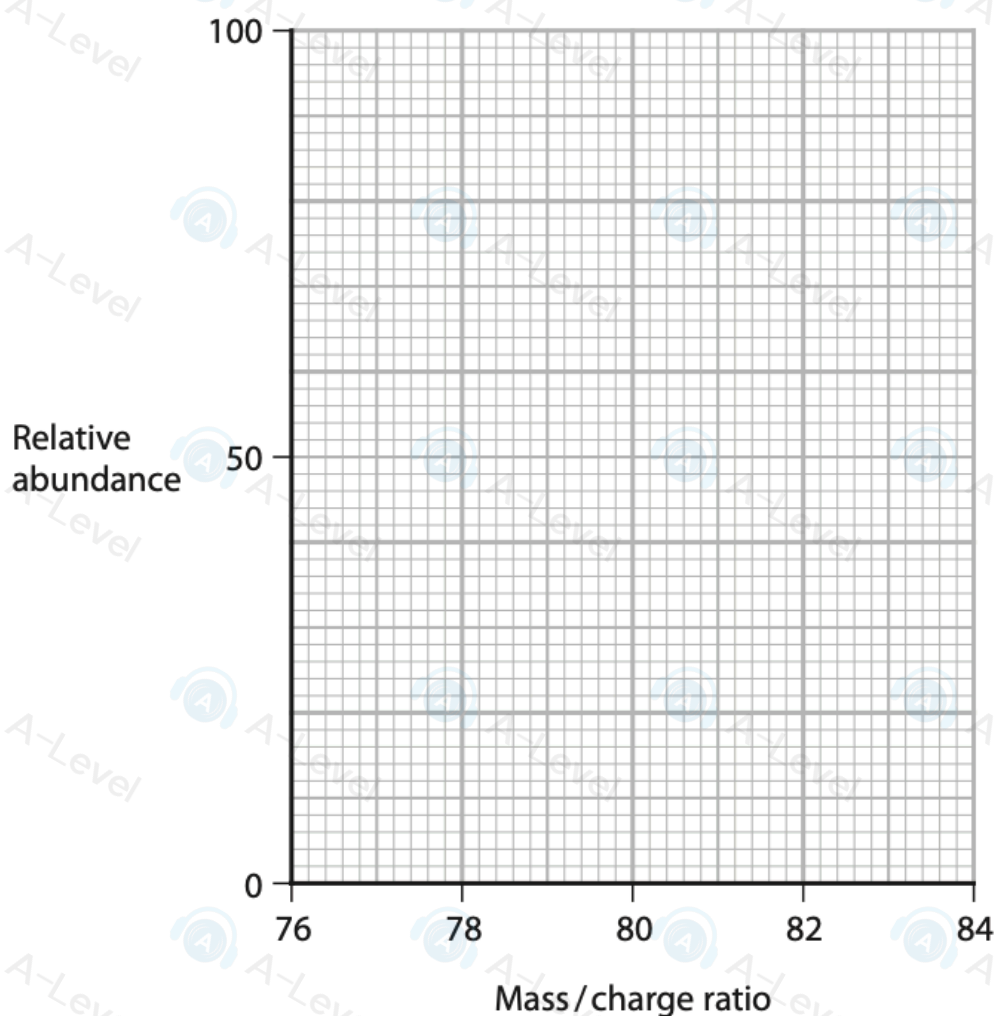
19 This question is about 2-Chloropropane.



- (a) 2-Chloropropane has a relative molecular mass of  $78.5 \text{ g mol}^{-1}$ .  
Chlorine has two common isotopes,  $^{35}\text{Cl}$  and  $^{37}\text{Cl}$ .  
There are three times more  $^{35}\text{Cl}$  atoms than  $^{37}\text{Cl}$  atoms.  
The main isotope of hydrogen is  $^1\text{H}$  and that of carbon is  $^{12}\text{C}$ .  
The diagram shows a mass spectrum grid.

Draw the peaks for the molecular ions of 2-Chloropropane resulting from these isotopes.

(2)



(b) 2-Chloropropane can be produced by reacting propane with chlorine in a homolytic free radical reaction.



(i) Show the initiation step of this reaction.  
Include appropriate arrows and the conditions necessary for this step.

(2)

(ii) Using your answer to (b)(i), state what is meant by the terms homolytic and free radical.

(2)

homolytic

free radical

(iii) Suggest why this method has limited use in the synthesis of organic compounds.

(1)