



GCE AS/A LEVEL

2410U10 – 1

TUESDAY, 14 MAY 2024 – MORNING

CHEMISTRY – AS UNIT 1

**THE LANGUAGE OF CHEMISTRY,
STRUCTURE OF MATTER AND
SIMPLE REACTIONS**

**1 hour 30 minutes plus your additional
time allowance**

Surname: _____

First Name(s): _____

Centre Number: _____

Candidate Number: 2 _____

For Examiner's use only			
	Question	Maximum Mark	Mark Awarded
SECTION A	1. to 8.	10	
SECTION B	9.	15	
	10.	12	
	11.	14	
	12.	17	
	13.	12	
	Total	80	

(Turn over)

ADDITIONAL MATERIALS

- A calculator and a ruler
- DATA BOOKLET supplied by WJEC

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball – point pen, black felt tip or your usual method.

Write your name, centre number and candidate number in the spaces on the front cover.

continued on the next page . . .

(Turn over)

INSTRUCTIONS TO CANDIDATES

continued

SECTION A Answer ALL questions.

SECTION B Answer ALL questions.

Write your answers in the spaces provided.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

(Turn over)

INFORMATION FOR CANDIDATES

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

The maximum mark for this paper is 80

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in Q12 (a).

(Turn over)

SECTION A

Answer ALL questions.

- 1. State why chlorine is used in water treatment.**

[1 mark]

- 2. State the pattern in electronegativity across Period 3 in the Periodic Table.**

[1 mark]

continued on the next page . . .

(Turn over)

- 3. Name the element in Period 3 that has a half – filled set of p – orbitals.**
-
-

[1 mark]

- 4. Refer to the diagram for Question 4 in the separate Diagram Booklet.**

By inserting arrows to represent electrons, complete the electronic structure of a vanadium atom.

[1 mark]

(Turn over)

5. Magnesium nitrate decomposes when heated to form magnesium oxide, nitrogen dioxide and oxygen.

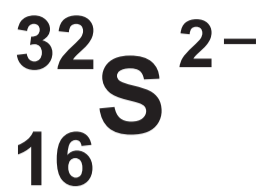
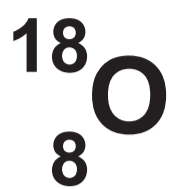
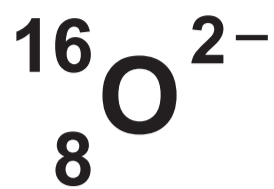
Refer to the equation for Question 5 in the separate Diagram Booklet.

Balance the equation for this reaction.

[1 mark]

(Turn over)

6. Consider the following species.



State whether you agree with the following statements, giving a reason for your conclusion.

(a) ${}^{32}_{16}\text{S}^{2-}$ has twice the number of neutrons that there are in ${}^{18}_{8}\text{O}$.

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 continued

6. (b) The sum of the number of electrons in $^{16}_8\text{O}^{2-}$ and $^{18}_8\text{O}$

is equal to the number of

electrons in $^{32}_{16}\text{S}^{2-}$

[1 mark]

(Turn over)

7. Hydrated copper(II) sulfate has the formula $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

Calculate the number of moles of oxygen atoms present in 0.5 mol of hydrated copper(II) sulfate.

Oxygen atoms = _____ mol

[1 mark]

(Turn over)

8. A 0.717 g sample of gas occupies 1000 cm³ at 273 K and 1 atm.

Calculate the relative formula mass of the gas.

Answer space continues on the next page.

Question 8 continued

Relative formula mass

=

[2 marks]

(Total for SECTION A = 10 marks)

(Turn over)

SECTION B

Answer ALL questions.

9. (a) The properties of elements and their compounds are determined by their structure and bonding.

(i) Diamond and graphite are allotropes of carbon.

I. Describe the structure and bonding in diamond and in graphite.

Diagrams may be used as part of your answer.

Answer space continues on the next page.

(Turn over)

15

Question 9 (a) (i) I continued

Answer space continues

(Turn over)

Question 9 (a) (i) I continued

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 (a) (i) continued

9. (a) (i) II. State ONE physical property which is common to both diamond and graphite and ONE which is not. Explain BOTH properties in terms of the structure and bonding you have described.

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 9 (a) continued

9. (a) (ii) I. Draw a dot and cross diagram to show the formation of the bonding in sodium chloride.

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 (a) (ii) continued

9. (a) (ii) II. State why the crystal structures of sodium chloride and caesium chloride are different.

[1 mark]

continued on the next page . . .

(Turn over)

Question 9 continued

9. (b) Refer to the diagram for Question 9 (b) in the separate Diagram Booklet.

Two reactions of aqueous magnesium iodide are given in the reaction scheme.

(i) State the colour of precipitate A and give the IONIC equation for its formation.

Colour

IONIC equation

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 (b) continued

9. (b) (ii) Name the product that gives solution B its brown colour and state the role of aqueous bromine in this reaction.

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 continued

9. (c) Describe a chemical test, apart from a flame test, which would distinguish between aqueous solutions of magnesium iodide and barium iodide.

Your answer should include the reagent(s) used and the observations made in each case.

(Turn over)

24

[2 marks]

(Total for Question 9 = 15 marks)

(Turn over)

10. (a) Iodine – 124 is an unstable radioactive isotope that decays by positron emission. It has a half – life of 4 days.

(i) Write an equation to show this decay.

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 (a) continued

10. (a) (ii) Refer to the diagram for Question 10 (a) (ii) in the separate Diagram Booklet. The diagram is an incomplete graph. Complete the graph to show how the radioactivity of a sample of iodine – 124 would vary with time.

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 continued

10. (b) Refer to the diagram for Question 10 (b) in the separate Diagram Booklet. The molecular ion region of the mass spectrum of bromine, Br_2 is shown in the diagram.

Explain the presence of the three peaks and why their height ratio is 1:2:1

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 10 continued

10. (c) A student was asked to find the pH of an acidic solution. She used a pH meter and found it to be 1.92

(i) Calculate the hydrogen ion concentration of this solution.

$[H^+] =$ _____ mol dm^{-3}

[1 mark]

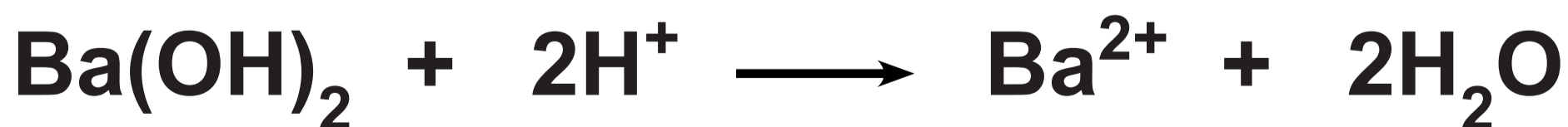
continued on the next page . . .

(Turn over)

Question 10 (c) continued

10. (c) (ii) Since the pH meter had not been used for a while, the teacher wanted to check the accuracy of the reading.

He asked the student to check this by titrating 25.0 cm³ of the acidic solution against standardised barium hydroxide solution and calculating the hydrogen ion concentration using the following equation.



continued on the next page . . .

(Turn over)

Question 10 (c) continued

The results are shown in the table below.

Volume of acidic solution	25.0 cm^3
Concentration of $\text{Ba}(\text{OH})_2$	$5.02 \times 10^{-3} \text{ mol dm}^{-3}$
Titre	23.55 cm^3

continued on the next page . . .

(Turn over)

Question 10 (c) continued

Use these results and the equation to calculate the number of moles of hydrogen ions, H^+ , in 25.0 cm^3 of the acidic solution and hence the hydrogen ion concentration.

Answer space continues on the next page.

Question 10 (c) (ii) continued

[H⁺] = _____ mol dm⁻³
[3 marks]

continued on the next page . . .

(Turn over)

Question 10 (c) continued

10. (c) (iii) The student said that the reading on the pH meter was incorrect.

Do you agree? Justify your answer by comparing your answers to parts (i) and (ii).

[1 mark]

(Total for Question 10 = 12 marks)

(Turn over)

11. Two students were discussing how electrons affect ionisation energies and the shape of molecules.

(a) Refer to the graph for Question 11 (a) in the separate Diagram Booklet. Elements X, Y and Z are in the same period of the Periodic Table. The graph shows the first five ionisation energies of element X.

continued on the next page . . .

(Turn over)

Question 11 (a) continued

**11. (a) (i) State how the graph shows
that element X is in Group 2**

[1 mark]

continued on the next page . . .

(Turn over)

Question 11 (a) continued

11. (a) (ii) Element Y has an atomic number one less than X, while element Z has an atomic number one more than X.

Since there is a general increase in first ionisation energies across a period, one student said:

“Element X’s first ionisation energy will be higher than that of element Y and lower than that of element Z.”

continued on the next page . . .

(Turn over)

[3 marks]

11. (b) (i) Write an equation to represent the second ionisation energy of sodium.
Include state symbols.

[1 mark]

continued on the next page . . .

(Turn over)

Question 11 (b) continued

11. (b) (ii) The second ionisation energy of sodium is 4560 kJ mol^{-1}

Calculate the value of the wavelength, in nm, of the radiation that corresponds to this energy change.

Answer space continues on the next page.

Question 11 (b) (ii) continued

Wavelength = _____ nm

[4 marks]

continued on the next page . . .

(Turn over)

Question 11 continued

11. (c) The second student said:

“When you consider CH_4 , AlCl_3 and BeCl_2 , the bond angle between the atoms in the molecule decreases as the number of bonds increases.

Therefore, the greater the number of bonds in any molecule the smaller the bond angle.”

continued on the next page . . .

(Turn over)

Question 11 (c) continued

- (i) State the bond angles in the molecules given on page 42



[3 marks]

continued on the next page . . .

(Turn over)

45

[2 marks]

(Total for Question 11 = 14 marks)

(Turn over)

12. (a) Refer to the graphs for Question 12 (a) in the separate Diagram Booklet. There are several stages in the industrial production of methanol from methane.

The final stage involves an equilibrium where carbon dioxide is converted into methanol.

GRAPH 1 and GRAPH 2

show the percentage conversion of carbon dioxide into methanol at EQUILIBRIUM under different conditions of temperature and pressure.

continued on the next page . . .

(Turn over)

Question 12 (a) continued

Equilibrium data is not the only information used when choosing the optimum temperature and pressure for the reaction.

Use the graphs and your knowledge to

- give as much information as possible about the reaction**
- suggest optimum conditions for the reaction and indicate what further information is needed to make this judgment**

continued on the next page . . .

(Turn over)

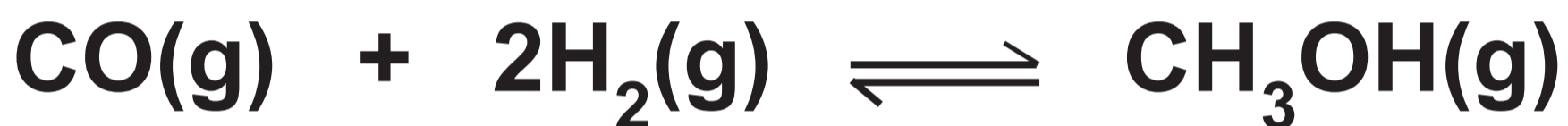
[6 QER marks]

continued on the next page . . .

(Turn over)

Question 12 continued

- 12. (b) The hydrogenation of carbon monoxide is a different method of producing methanol. The equation for this reaction is given below.**



continued on the next page . . .

(Turn over)

Question 12 (b) continued

- 12. (b) (i) Write an expression for the equilibrium constant, K_c , and give its unit, if any.**

$K_c =$

Unit _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 12 (b) continued

12. (b) (ii) The equilibrium constant, K_c , has a numerical value of 0.350 at a temperature of 350 °C.

If the equilibrium concentration of carbon monoxide is 0.725 mol dm⁻³ and that of hydrogen is 0.850 mol dm⁻³ calculate the equilibrium concentration of methanol at this temperature.

Answer space continues on the next page.

(Turn over)

Question 12 (b) (ii) continued

Concentration = _____ mol dm⁻³
[2 marks]

continued on the next page . . .

(Turn over)

Question 12 continued

12. (c) Carbon monoxide is used in the reduction of iron(III) oxide in the blast furnace.

The equation for this reaction is given below.



continued on the next page . . .

(Turn over)

Question 12 (c) continued

12. (c) (i) Calculate the atom economy for the formation of iron in this reaction. Give your answer to an APPROPRIATE number of significant figures.

Atom economy = _____ %

[3 marks]

continued on the next page . . .

(Turn over)

Question 12 (c) continued

- 12. (c) (ii) Calculate the volume, in m^3 , of carbon dioxide that would be produced if 20 tonnes of iron(III) oxide were reduced at a temperature of 1100°C and a pressure of 1 atm.**

Answer space continues on the next page.

(Turn over)

Question 12 (c) (ii) continued

Volume = _____ m³

[4 marks]

(Total for Question 12 = 17 marks)

(Turn over)

13. Sodium sesquicarbonate is a white crystalline solid which is used in bath salts, water treatment and as a cleaning and laundry product. Its formula can be represented as follows.



A student is asked to carry out an experiment to find the value of x using the following double titration method.

- Weigh out accurately about 1.7 g of sodium sesquicarbonate using a two – decimal place balance.**

Dissolve and make up to 250 cm³ in a volumetric flask in the usual way.

continued on the next page . . .

(Turn over)

Question 13 continued

- **Measure 25.0 cm^3 of this solution into a conical flask and add a small amount of phenolphthalein indicator.**
- **Add $0.100 \text{ mol dm}^{-3}$ hydrochloric acid from a burette whilst swirling the mixture until the phenolphthalein changes colour from PINK TO COLOURLESS.**
- **Record the results.**
- **Add a few drops of methyl orange indicator and continue titrating until the methyl orange changes colour from YELLOW TO ORANGE.**

continued on the next page . . .

(Turn over)

Question 13 continued

- **Record the results.**

The results of the titrations are shown in the table provided for Question 13 in the separate Diagram Booklet.

- 13. (a) Complete the table and calculate the mean titre at the phenolphthalein end – point (A) and the mean titre at the methyl orange end – point (B).**

Space for working continues on the next page.

(Turn over)

Question 13 (a) continued

Mean titre A = _____ cm³

Mean titre B = _____ cm³

[3 marks]

continued on the next page . . .

(Turn over)

Question 13 continued

13. (b) Name the piece of apparatus the student should have used to transfer 25.0 cm^3 of the solution into the conical flask.

[1 mark]

continued on the next page . . .

(Turn over)

Question 13 continued

13. (c) The percentage error due to the burette in the first titration with phenolphthalein is just over 1%. Suggest what the student could have changed in the method to halve this figure.

[1 mark]

continued on the next page . . .

(Turn over)

Question 13 continued

13. (d) Despite having a larger percentage error due to the burette, suggest a reason why mean titre A could be more accurate than mean titre B.

[1 mark]

continued on the next page . . .

(Turn over)

Question 13 continued

- 13. (e) (i) The equation for the reaction taking place in the phenolphthalein titration is as follows.**



Mean titre A is the volume needed to convert all the carbonate ions present to hydrogencarbonate ions.

continued on the next page. . .

(Turn over)

Question 13 (e) (i) continued

Use this information and the student's results to calculate the number of moles of carbonate present in the original solution.

$$n(\text{Na}_2\text{CO}_3) = \underline{\hspace{15em}} \text{ mol}$$

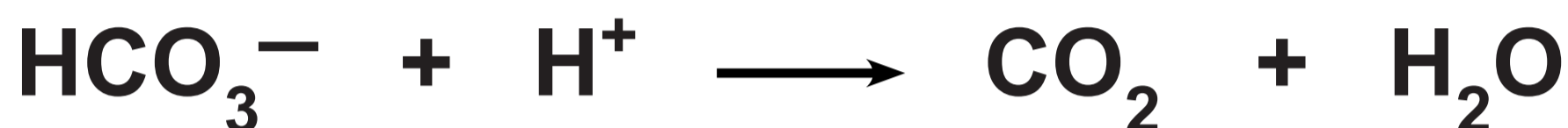
[1 mark]

continued on the next page . . .

(Turn over)

Question 13 (e) continued

13. (e) (ii) The equation for the reaction taking place in the methyl orange titration is as follows.



Mean titre B is the volume needed to convert all the hydrogencarbonate ions present to carbon dioxide and water.

continued on the next page . . .

Question 13 (e) (ii) continued

This hydrogencarbonate is from the original hydrogencarbonate AND the converted carbonate, therefore

moles HCl in mean titre B

$$\text{= moles NaHCO}_3 + \text{moles Na}_2\text{CO}_3$$

Use this information and the student's results to calculate the number of moles of hydrogencarbonate present in the original solution.

Answer space continues on the next page.

(Turn over)

Question 13 (e) (ii) continued

$n(\text{NaHCO}_3) =$ _____ mol

[2 marks]

continued on the next page . . .

(Turn over)

Question 13 (e) continued

13. (e) (iii) Use your answers to parts (i) and (ii) to show that the value of x in



[1 mark]

continued on the next page . . .

(Turn over)

Question 13 (e) continued

13. (e) (iv) The relative formula mass of $\text{Na}_2\text{CO}_3 \cdot x\text{NaHCO}_3 \cdot y\text{H}_2\text{O}$ is 226

Calculate the value of y .

$y =$ _____

[2 marks]

(Total for Question 13 = 12 marks)

Total for SECTION B = 70 marks

TOTAL FOR PAPER = 80 MARKS

END OF PAPER

(Turn over)



GCE AS/A LEVEL

2410U10-1

TUESDAY, 14 MAY 2024 – MORNING

**CHEMISTRY – AS UNIT 1
THE LANGUAGE OF CHEMISTRY,
STRUCTURE OF MATTER AND
SIMPLE REACTIONS**

**The Diagram Booklet MUST be handed in
to the invigilators and sent for marking.**

Diagram Booklet

Surname: _____

First Name(s): _____

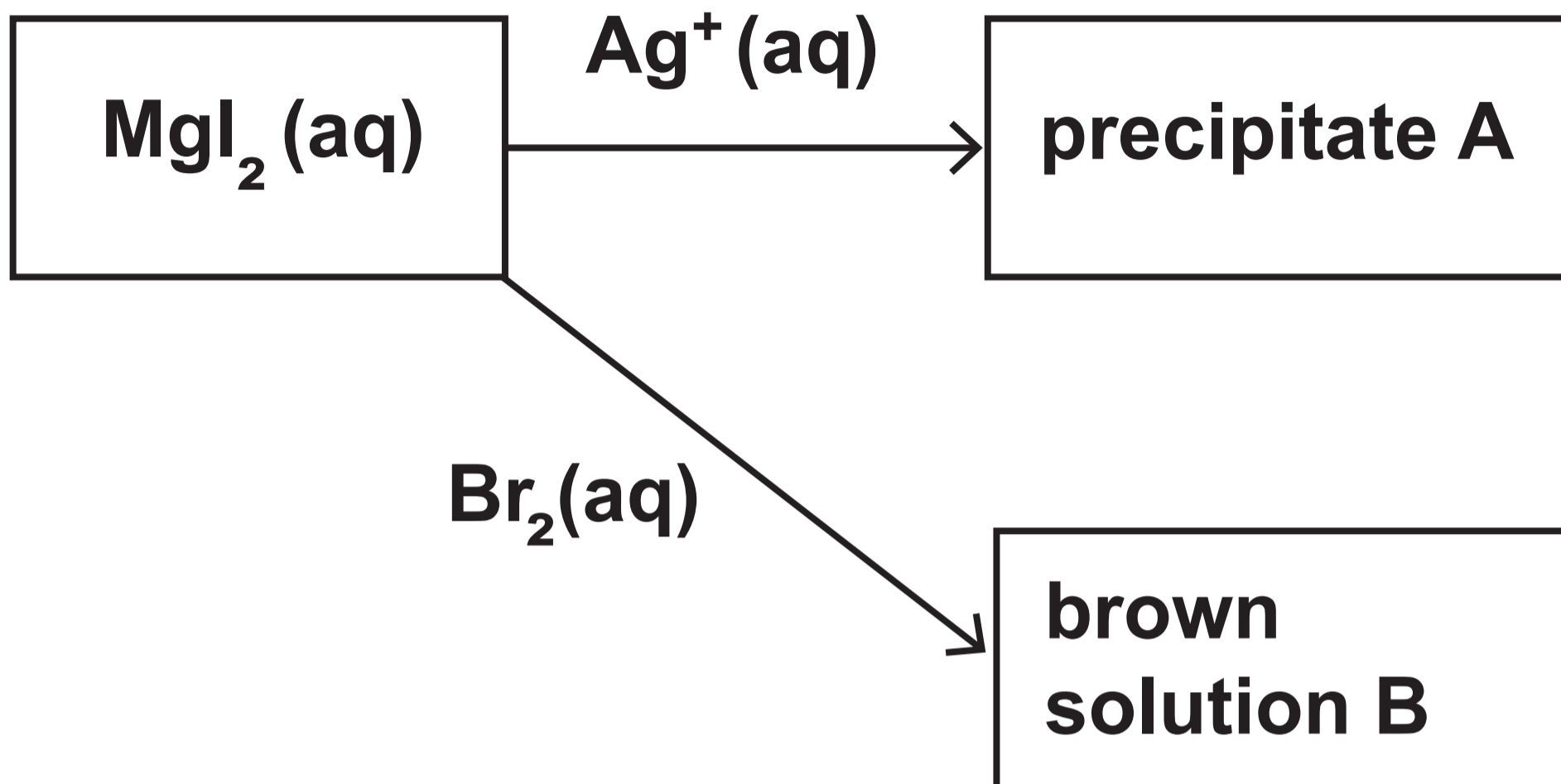
Centre Number: _____

Candidate Number: 2 _____

Question 5

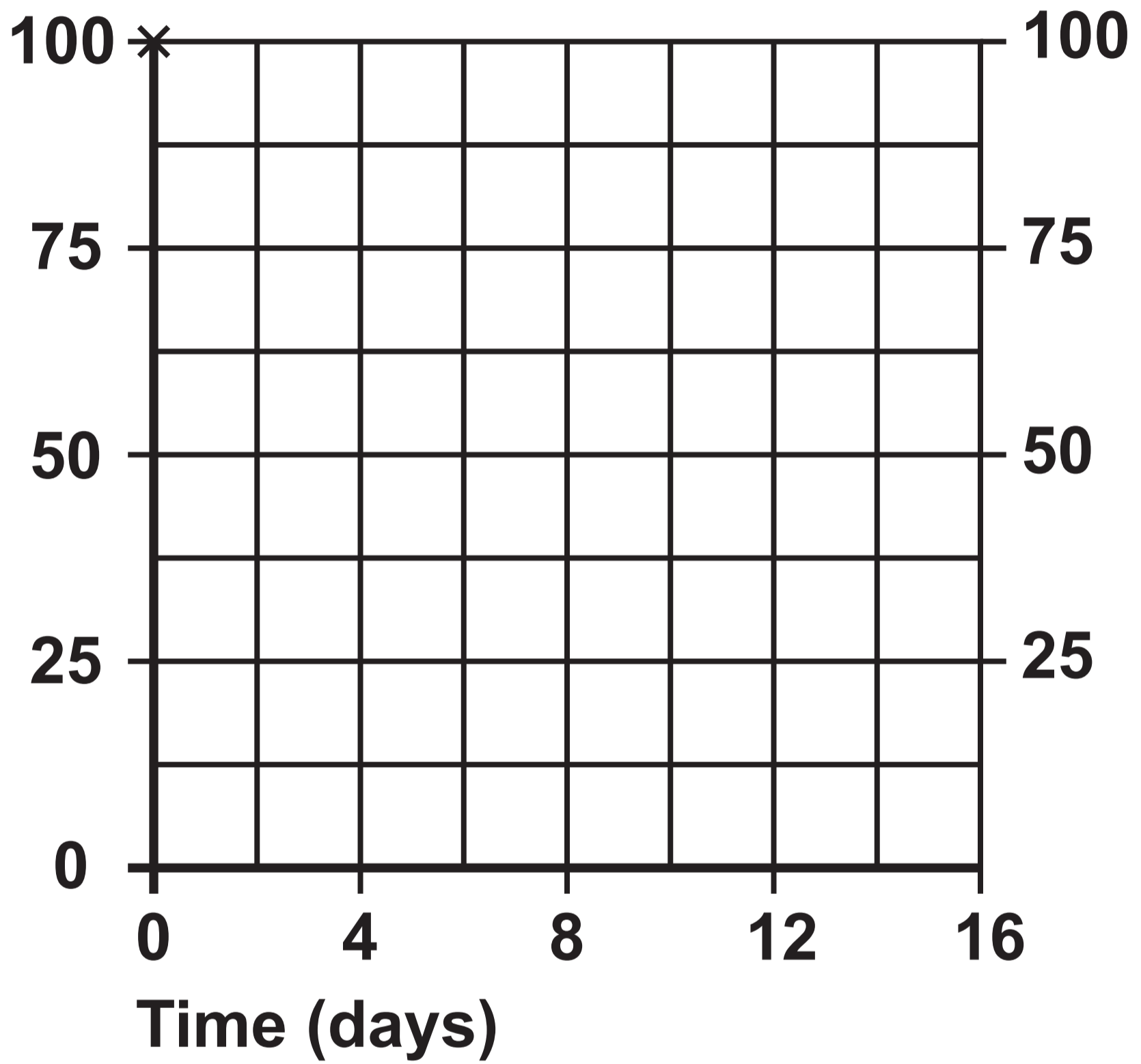


Question 9 (b)



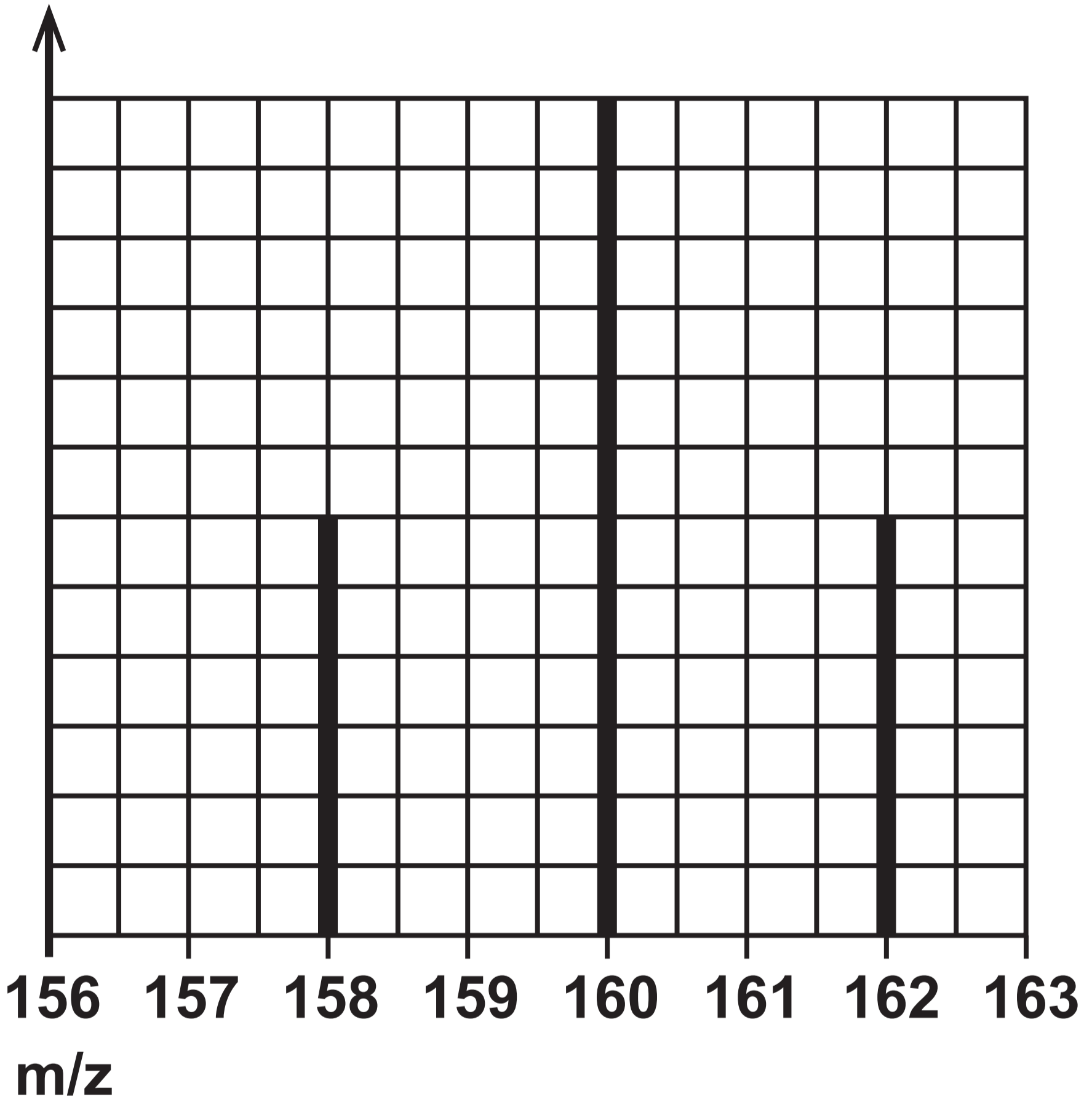
Question 10 (a) (ii)

Radioactivity (arbitrary units)



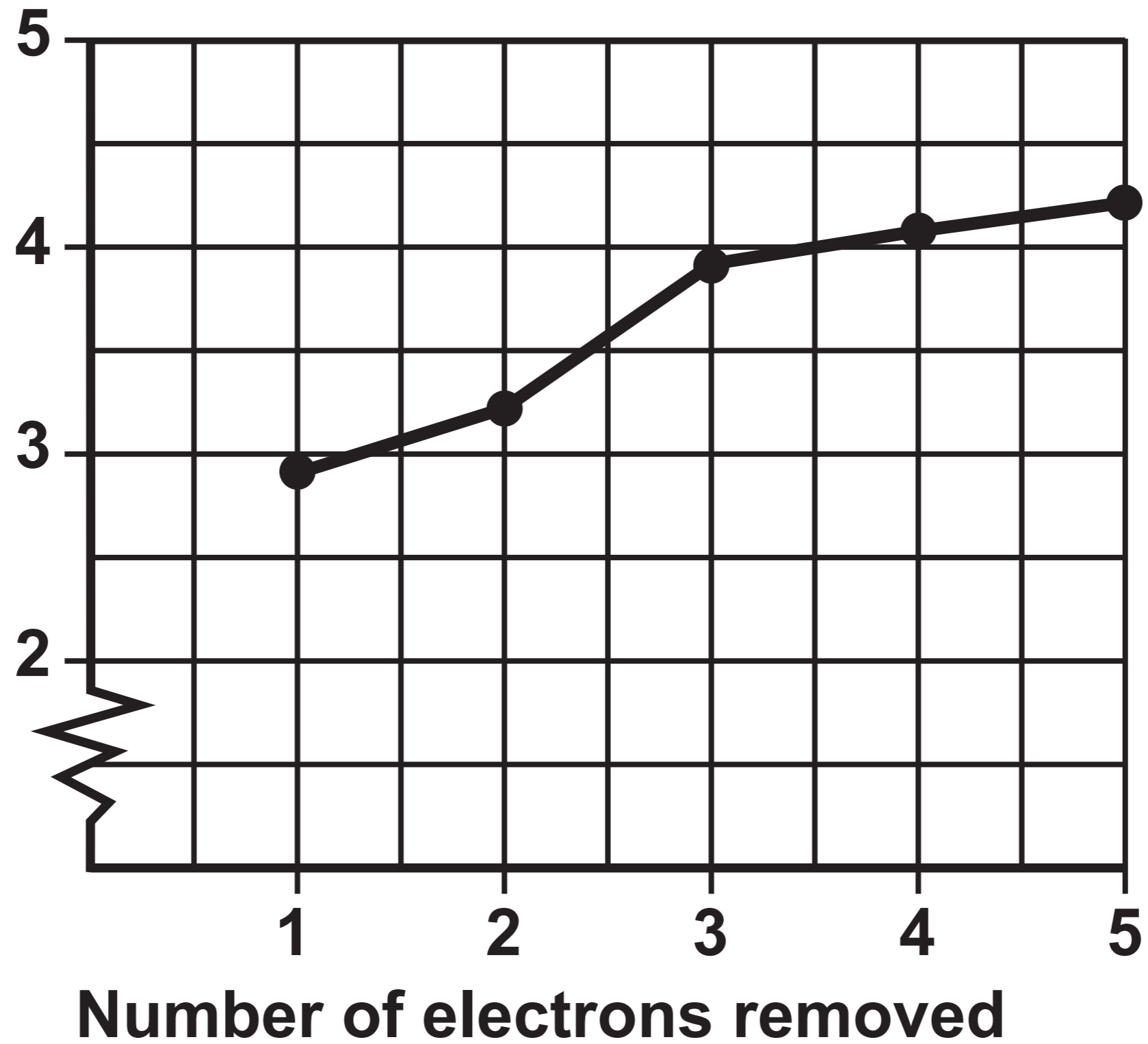
Question 10 (b)

Relative abundance



Question 11

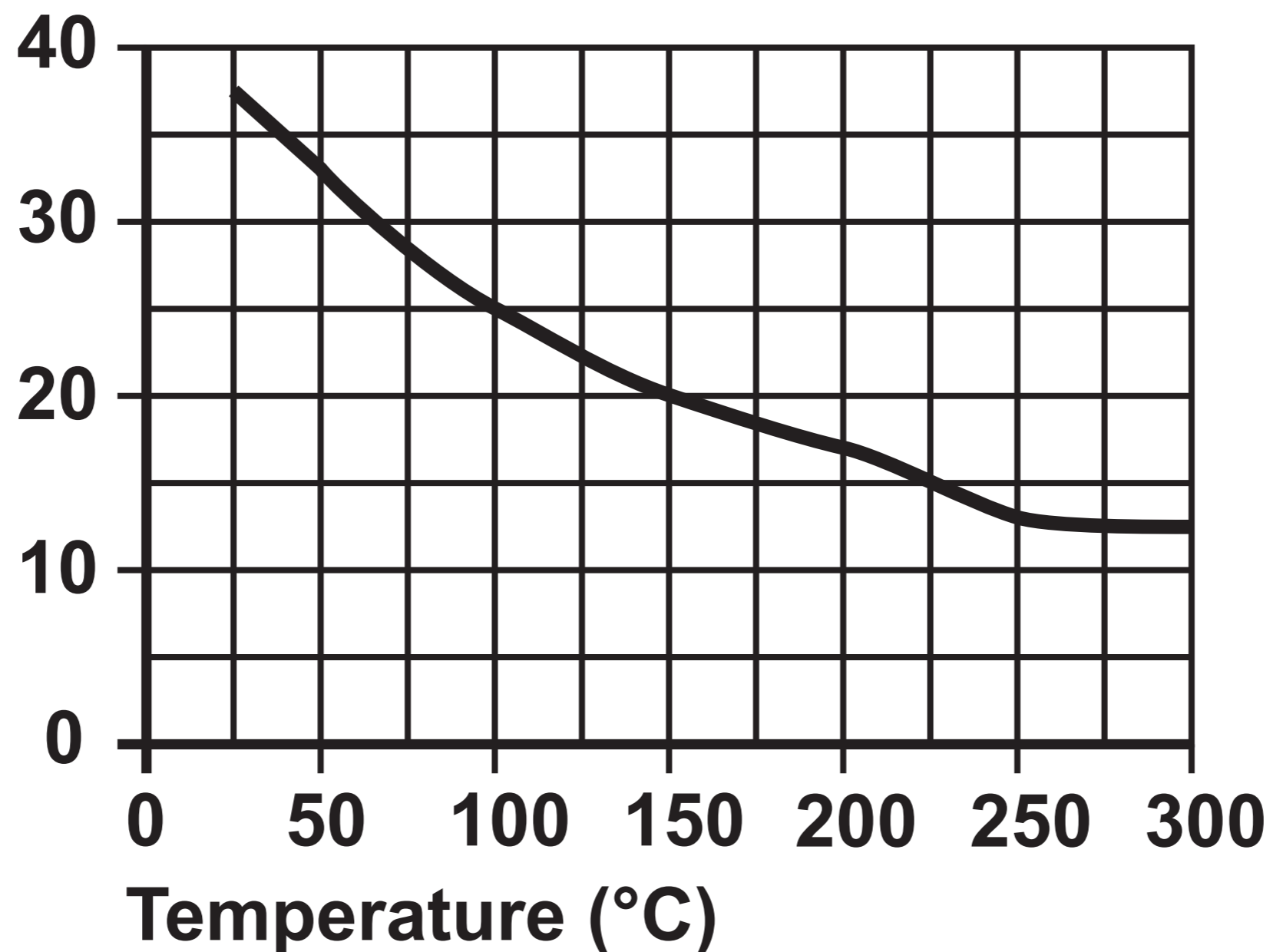
Log (ionisation energy)



Question 12 (a)

GRAPH 1

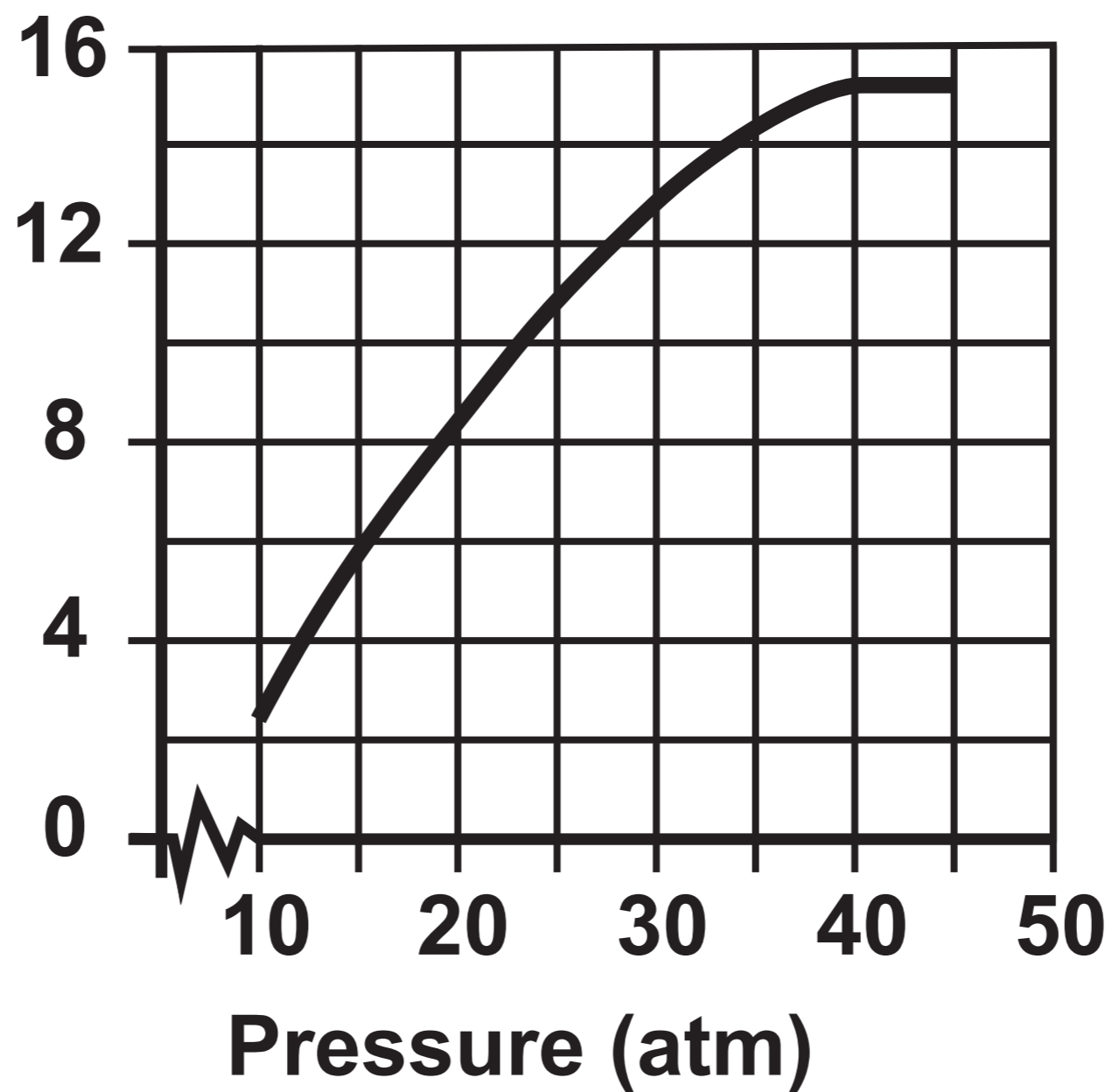
**% conversion of CO₂
at constant pressure**



Question 12 (a)

GRAPH 2

**% conversion of CO₂
at constant temperature**



Question 13 – TABLE

		1	2	3	4
With phenolphthalein (A)	Final volume / cm³	7•80	30•70	7•75	30•25
	Initial volume / cm³	0•00	23•30	0•30	22•75
	Titre A / cm³	7•80	_____	_____	_____
With methyl orange (B)	Final volume / cm³	23•30	45•60	22•75	45•10
	Initial volume / cm³	7•80	30•70	7•75	30•25
	Titre B / cm³	15•50	_____	_____	_____