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	

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.

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.

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).

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]

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]

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]

6. Consider the following species.

$^{16}_{8}O^{2-}$ $^{18}_{8}O$ $^{32}_{16}S^{2-}$

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

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

[1 mark]

(b) The sum of the number of electrons in $^{16}_{8}O^{2-}$ and $^{18}_{8}O$ is equal to the number of electrons in $^{32}_{16}S^{2-}$

[1 mark]

7. Hydrated copper(II) sulfate has the formula

$CuSO_4.5H_2O$

Calculate the number of moles of oxygen atoms present in $0 \cdot 5$ mol of hydrated copper(II) sulfate.

Oxygen atoms = _____ mol

[1 mark]

8. A 0•717 g sample of gas occupies 1000 cm^3 at 273 K and 1 atm. Calculate the relative formula mass of the gas.

Relative formula mass = _____

[2 marks]

(Total for SECTION A = 10 marks)

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.

Question 9 (a) (i) I continued

[2 marks]

continued on the next page . . .

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.

[4 marks]

continued on the next page . . .

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 . . .

Question 9 (a) (ii) continued

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

[1 mark]

(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 . . .

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]

(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.

[2 marks]

(Total for Question 9 = 15 marks)

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]

(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 . . .

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

[3 marks]

continued on the next page . . .

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 . . .

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 $25 \cdot 0\ cm^3$ of the acidic solution against standardised barium hydroxide solution and calculating the hydrogen ion concentration using the following equation.

$$Ba(OH)_2 + 2H^+ \longrightarrow Ba^{2+} + 2H_2O$$

The results are shown in the table below.

Volume of acidic solution	$25 \cdot 0\ cm^3$
Concentration of $Ba(OH)_2$	$5 \cdot 02 \times 10^{-3}\ mol\ dm^{-3}$
Titre	$23 \cdot 55\ cm^3$

continued on the next page . . .

Question 10 (c) (ii) continued

Use these results and the equation to calculate the number of moles of hydrogen ions, H^+, in $25 \cdot 0\ cm^3$ 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]

(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)

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.

(i) State how the graph shows that element X is in Group 2

_____

_____

_____

[1 mark]

continued on the next page . . .

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."

Is he correct? Justify your answer by referring to both parts of his statement.

[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 . . .

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.

Wavelength = _____ nm

[4 marks]

continued on the next page . . .

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."

(i) State the bond angles in the molecules given above.

$H-\widehat{C}-H$ _____ °

$Cl-\widehat{Al}-Cl$ _____ °

$Cl-\widehat{Be}-Cl$ _____ °

[3 marks]

continued on the next page . . .

Question 11 (c) continued

11. (c) (ii) Use your knowledge of VSEPR theory to explain why the second sentence is incorrect. Give an example to support your answer.

[2 marks]

(Total for Question 11 = 14 marks)

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.

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 . . .

Question 12 (a) continued

Explain your reasoning throughout.

[6 QER marks]

continued on the next page . . .

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.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

(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 . . .

Question 12 (b) continued

12. (b) (ii) The equilibrium constant, K_c, has a numerical value of $0 \cdot 350$ at a temperature of $350\,^{\circ}C$.

If the equilibrium concentration of carbon monoxide is $0 \cdot 725$ mol dm^{-3} and that of hydrogen is $0 \cdot 850$ mol dm^{-3}, calculate the equilibrium concentration of methanol at this temperature.

Concentration = _____ mol dm^{-3}

[2 marks]

continued on the next page . . .

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.

$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(l) + 3CO_2(g)$$

(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 . . .

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.

Volume = _____ m^3

[4 marks]

(Total for Question 12 = 17 marks)

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.

$$Na_2CO_3.xNaHCO_3.yH_2O$$

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 $1 \cdot 7$ g of sodium sesquicarbonate using a two – decimal place balance. Dissolve and make up to 250 cm^3 in a volumetric flask in the usual way.
- Measure $25 \cdot 0$ cm^3 of this solution into a conical flask and add a small amount of phenolphthalein indicator.
- Add $0 \cdot 100$ mol dm^{-3} hydrochloric acid from a burette whilst swirling the mixture until the phenolphthalein changes colour from PINK TO COLOURLESS.

continued on the next page . . .

Question 13 continued

- **Record the results.**
- **Add a few drops of methyl orange indicator and continue titrating until the methyl orange changes colour from YELLOW TO ORANGE.**
- **Record the results.**

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

continued on the next page . . .

Question 13 continued

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).

Mean titre A = _____ cm^3

Mean titre B = _____ cm^3

[3 marks]

continued on the next page . . .

Question 13 continued

13. (b) Name the piece of apparatus the student should have used to transfer $25 \cdot 0\ cm^3$ of the solution into the conical flask.

_____

[1 mark]

(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 . . .

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 . . .

Question 13 continued

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

$$CO_3^{2-} + H^+ \longrightarrow HCO_3^-$$

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

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

$n(Na_2CO_3)$ = _____ mol

[1 mark]

continued on the next page . . .

Question 13 (e) continued

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

$$HCO_3^- + H^+ \longrightarrow CO_2 + H_2O$$

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

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

moles HCl in mean titre B
= moles $NaHCO_3$ + moles Na_2CO_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.

Question 13 (e) (ii) continued

$n(NaHCO_3)$ = _____ mol

[2 marks]

continued on the next page . . .

Question 13 (e) continued

13. (e) (iii) Use your answers to parts (i) and (ii) to show that the value of *x* in $Na_2CO_3.xNaHCO_3.yH_2O$ is 1

[1 mark]

continued on the next page . . .

Question 13 (e) continued

13. (e) (iv) The relative formula mass of

$Na_2CO_3.xNaHCO_3.yH_2O$ 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

Question Number	Additional pages, if required. Write the question number(s) in the left – hand margin.

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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): _____

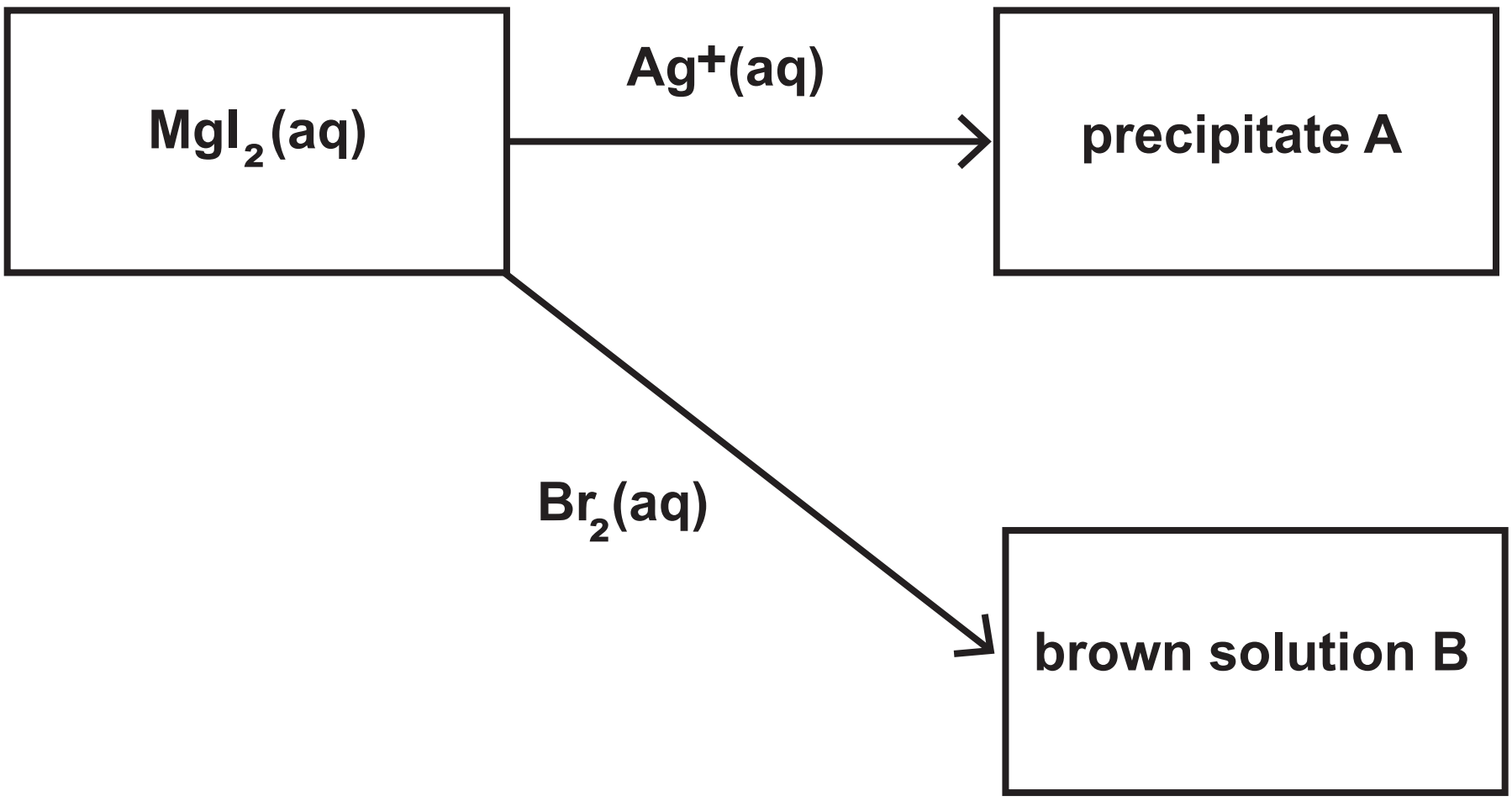
Centre Number: _____

Candidate Number: 2 _____

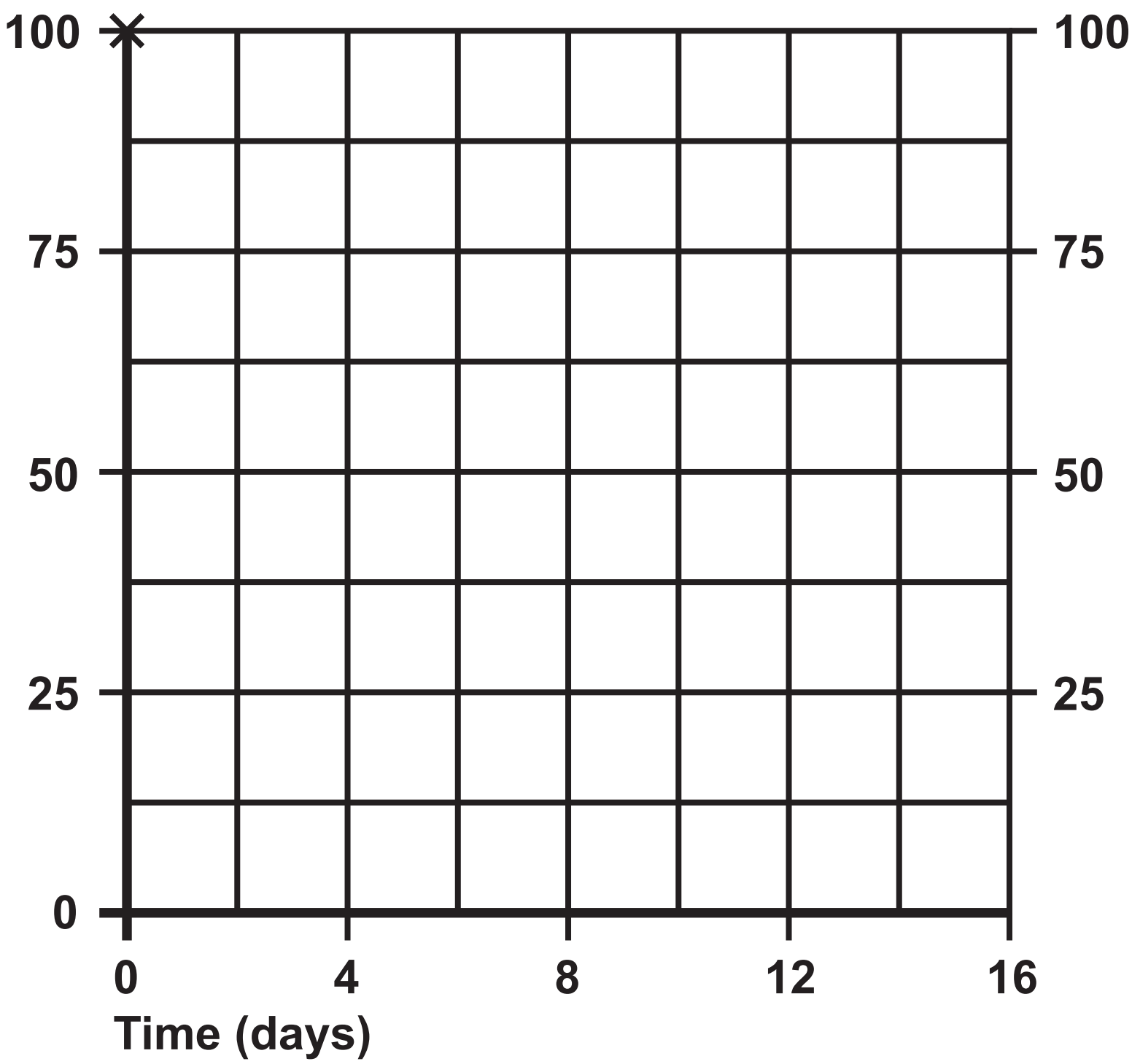
Question 4

Question 5

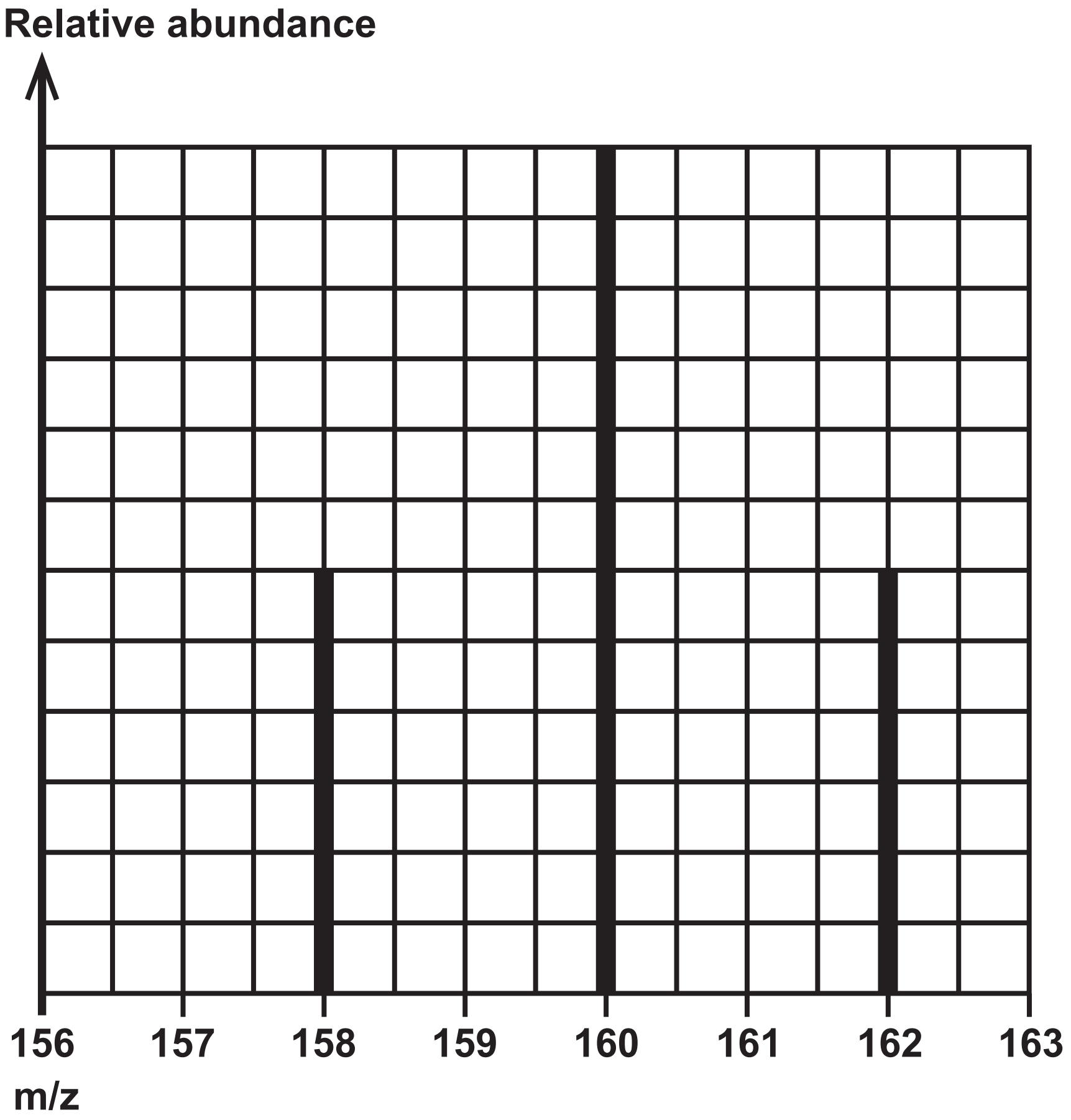
Question 9 (b)



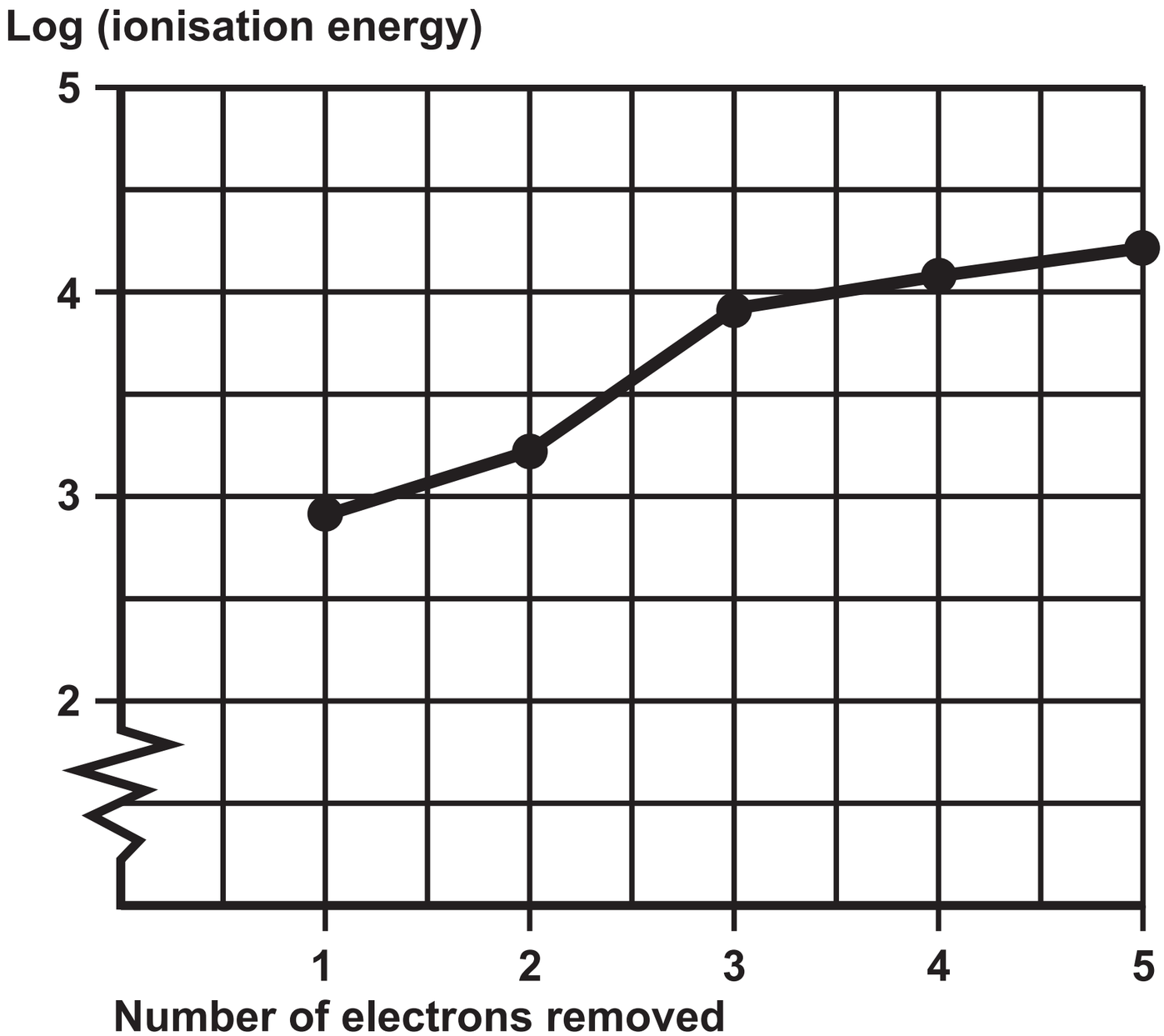
Question 10 (a) (ii)



Question 10 (b)

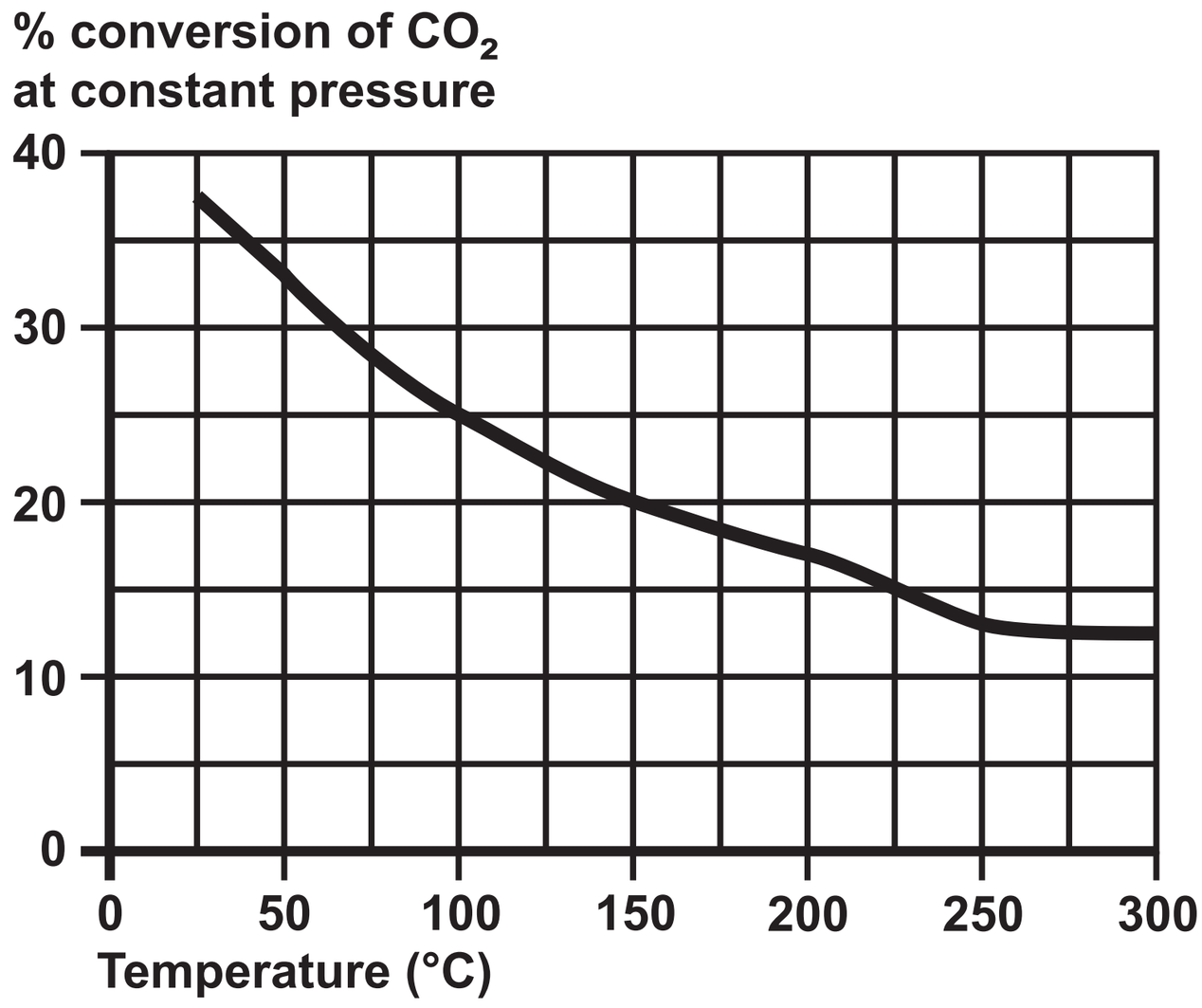


Question 11 (a)



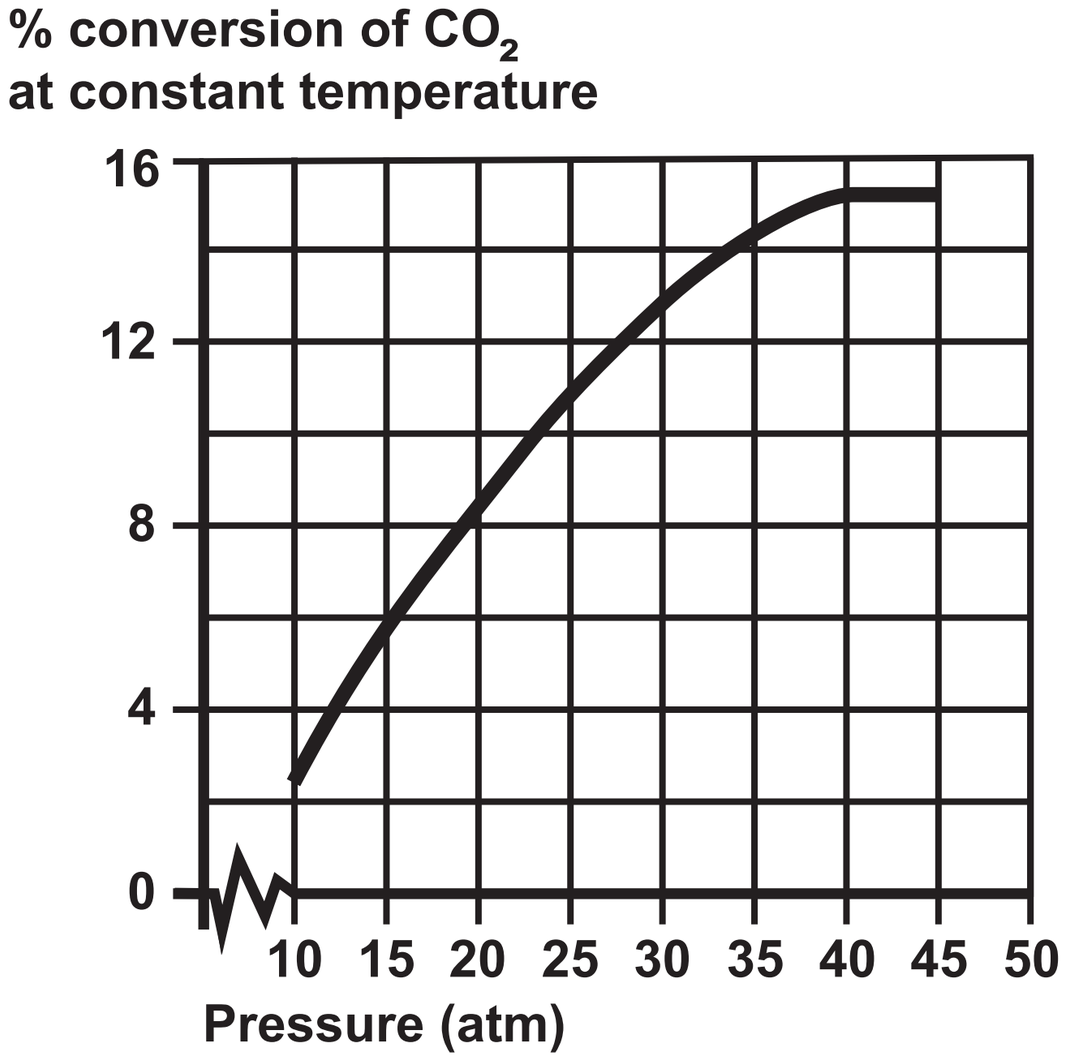
Question 12 (a)

GRAPH 1



Question 12 (a)

GRAPH 2



Question 13

TABLE

		1	2	3	4
With phenolphthalein (A)	Final volume / cm^3	7•80	30•70	7•75	30•25
	Initial volume / cm^3	0•00	23•30	0.30	22•75
	Titre **A** / cm^3	7•80	_____	_____	_____
With methyl orange (B)	Final volume / cm^3	23•30	45•60	22•75	45•10
	Initial volume / cm^3	7•80	30•70	7•75	30•25
	Titre **B** / cm^3	15•50	_____	_____	_____