GCE AS/A LEVEL

2410U10-1

TUESDAY, 16 MAY 2023 – 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**
1. to 6.	10	
7.	10	
8.	12	
9.	12	
10.	15	
11.	21	
Total	80	

(Turn over)

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a

- **calculator;**
- **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.

Answer ALL questions in SECTION A.

Answer ALL questions in SECTION B.

Write your answers in the spaces provided.

If you run out of space, use the additional pages 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 question 7 (a).

SECTION A

ANSWER ALL QUESTIONS.

1. Look at the table for Question 1 in the separate Diagram Booklet.

   Complete the table.

   [2 marks]

2. Look at the table for Question 2 in the separate Diagram Booklet.

   Complete the table to show the type or types of bonding present in the solids shown.

   [2 marks]

3. Give the oxidation number of rhenium in $ReOCl_4$

_____

[1 mark]

4. Look at the diagram for Question 4 in the separate Diagram Booklet.

The diagram shows the electron energy levels for a hydrogen atom.

(a) On the diagram, draw an arrow to represent the transition corresponding to the ionisation of the atom.

Label this arrow **A**.

[1 mark]

continued on the next page . . .

Question 4 continued

4. (b) On the diagram, draw an arrow to represent the transition corresponding to the first line in the visible region in the atomic spectrum.

Label this arrow B.

[1 mark]

5. A student said that

$^{32}_{16}S^{2-}$ and $^{40}_{20}Ca^{2+}$ have the same electronic configuration.

Do you agree?

Give a reason for your answer.

[1 mark]

6. Copper can be extracted from copper(II) oxide using hydrogen.

If the atom economy for this reaction is 78% and 4.2 g of copper is formed, calculate the total mass of the reactants.

Space for working:

Question 6 continued

Mass of reactants = _____ g

[2 marks]

(Total for SECTION A = 10 marks)

SECTION B

ANSWER ALL QUESTIONS.

7. (a) Look at Table 1 and Table 2 for Question 7 (a) in the separate Diagram Booklet.

The boiling temperatures of the hydrides of some Group 4 and Group 7 elements are shown in Table 1.

Hydrogen has an electronegativity value of 2.1

continued on the next page . . .

Question 7 (a) continued

The electronegativity values of the Group 4 and Group 7 elements are given in Table 2.

For the hydrides of the Group 4 and Group 7 elements shown in Table 1 and Table 2

- **describe any trends and anomalies in boiling temperature**
- **explain any differences in boiling temperature in terms of the intermolecular forces present.**

continued on the next page . . .

Question 7 (a) continued

(Turn over)

[6 marks QER]

continued on the next page . . .

Question 7 continued

7. (b) Look at the equation for Question 7 (b) in the separate Diagram Booklet.

Methane reacts with copper(I) oxide according to the equation shown.

(i) Balance the equation.

[1 mark]

continued on the next page . . .

Question 7 (b) continued

7. (b) (ii) Explain why this reaction is described as a redox process.

[1 mark]

continued on the next page . . .

Question 7 continued

7. (c) Compounds containing a Group 1 metal, a Group 3 metal and hydrogen only are known as complex metal hydrides. There has been much interest in their use as hydrogen storage systems for future fuel cell – powered vehicles.

One such hydride contains 38.7% Li and 50.1% Al.

continued on the next page . . .

Question 7 (c) continued

Find the empirical formula of this compound.

Space for working:

Question 7 (c) continued

Empirical formula _____

[2 marks]

(Total for Question 7 = 10 marks)

8. (a) Aluminium reacts with oxygen to form aluminium oxide.

Using outer electrons only, draw a dot and cross diagram to show the bonding in aluminium oxide.

Space for drawing:

continued on the next page . . .

Question 8 (a) continued

[2 marks]

continued on the next page . . .

Question 8 continued

8. (b) Aluminium also reacts with chlorine to form aluminium chloride.

A 0.400 g sample of aluminium chloride was heated to 220°C. The vapour produced occupied a volume of 60.8 cm^3 at a pressure of 101 kPa.

continued on the next page . . .

Question 8 (b) continued

Show that the molecular formula of aluminium chloride in the vapour is Al_2Cl_6

Space for working:

continued on the next page . . .

Question 8 (b) continued

[4 marks]

continued on the next page . . .

Question 8 continued

8. (c) (i) Look at the diagram for Question 8 (c) (i) in the separate Diagram Booklet.

Sketch a graph of log (ionisation energy) for the successive ionisations of aluminium.

The first and last points have been plotted for you.

[1 mark]

continued on the next page . . .

Question 8 (c) continued

8. (c) (ii) I. Explain the general slope of the graph.

[1 mark]

continued on the next page . . .

Question 8 (c) (ii) continued

8. (c) (ii) II. Explain the reason for any sharp changes in the graph.

[1 mark]

continued on the next page . . .

Question 8 continued

8. (d) Although aluminium has 25 known isotopes only two of them occur naturally. These are ^{27}Al which is stable and ^{26}Al which is radioactive.

^{26}Al decays by electron capture and its half – life is 7.2×10^5 years.

continued on the next page . . .

Question 8 (d) continued

8. (d) (i) Give the mass number and symbol of the species produced when an atom of ^{26}Al decays.

_____

[1 mark]

continued on the next page . . .

Question 8 (d) continued

8. (d) (ii) If 8.0 mg of ^{26}Al decays by electron capture, calculate the mass in GRAMS of ^{26}Al left after 2.88×10^6 years.

Space for working:

continued on the next page . . .

Question 8 (d) continued

Mass = _____ g

[2 marks]

(Total for Question 8 = 12 marks)

9. (a) Over 180 million tonnes of ammonia are manufactured each year.

The main use of ammonia is in the production of salts such as ammonium sulfate, which is used as a fertiliser.

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

continued on the next page . . .

Question 9 (a) continued

Explain why this is an acid – base reaction.

[1 mark]

continued on the next page . . .

Question 9 continued

9. (b) Look at the equation for Question 9 (b) in the separate Diagram Booklet.

Sodium hydroxide reacts with ammonium sulfate to form ammonia, sodium sulfate and water as shown in the equation.

A 1.86 g sample of ammonium sulfate was neutralised by exactly 26.70 cm^3 of a sodium hydroxide solution.

continued on the next page . . .

Question 9 (b) continued

Calculate the concentration, in mol dm^{-3} of the sodium hydroxide solution used.

Space for working:

continued on the next page . . .

Question 9 (b) continued

Concentration = _____ mol dm^{-3}

[3 marks]

continued on the next page . . .

Question 9 continued

9. (c) Another use of ammonia is in the production of nitric acid.

In the first part of this process ammonia is oxidised in air.

Look at the equation for Question 9 (c) in the separate Diagram Booklet.

Look at the graph for Question 9 (c) in the separate Diagram Booklet.

continued on the next page . . .

Question 9 (c) continued

The graph shows how the number of moles of ammonia present changes as the reaction proceeds until equilibrium is reached.

9. (c) (i) State Le Chatelier's principle.

_____

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 9 (c) continued

9. (c) (ii) A student looked at curves A and B and said that the forward reaction is exothermic.

Is he correct? Justify your answer by using Le Chatelier's principle.

[2 marks]

continued on the next page . . .

Question 9 (c) continued

9. (c) (iii) On the graph, draw a curve that represents the reaction at 850°C but with a catalyst added to the reaction mixture.

Label this curve C. Explain the shape of the curve.

[2 marks]

Question 9 continued

9. (d) A solution of nitric acid has a concentration of $0.0550 \text{ mol dm}^{-3}$

Calculate its pH.

Space for working:

continued on the next page . . .

Question 9 (d) continued

pH = _____

[1 mark]

continued on the next page . . .

Question 9 continued

9. (e) A student said that the bonds in an ammonia molecule are not purely covalent.

Explain why she is correct.

_____

_____

[2 marks]

(Total for Question 9 = 12 marks)

10. (a) Look at the diagram for Question 10 (a) in the separate Diagram Booklet.

A student investigated the thermal stability of Group 2 carbonates.

She used the apparatus shown in the diagram and the method given on the next page.

continued on the next page . . .

Question 10 (a) continued

METHOD

1. **Start a stopwatch at the moment you begin to heat the carbonate and continue to heat for 4 minutes or until the limewater turns cloudy.**
2. **After the limewater turns cloudy lift the delivery tube out of the limewater then remove the flame from under the boiling tube.**
3. **Repeat the heating procedure for each carbonate in turn.**

continued on the next page . . .

Question 10 (a) continued

4. **Use a spatula – measure of the appropriate carbonate, fresh limewater and heat with the hottest Bunsen burner flame each time.**

   Look at the table for Question 10 (a) in the separate Diagram Booklet.

   Her results are shown in the table.

continued on the next page . . .

Question 10 (a) continued

10. (a) (i) Suggest an improvement to the method to ensure that the experiment is a fair test.

[1 mark]

continued on the next page . . .

Question 10 (a) continued

10. (a) (ii) Suggest why the delivery tube should be lifted out of the limewater before the flame is removed from under the boiling tube.

[1 mark]

continued on the next page . . .

Question 10 (a) continued

10. (a) (iii) State what conclusion she can draw about the thermal stabilities of the Group 2 carbonates from these results.

[1 mark]

continued on the next page . . .

Question 10 (a) continued

10. (a) (iv) The student was told that the temperature at which barium carbonate decomposes is **1360°C**. The maximum temperature of a typical Bunsen burner flame is around **800°C**.

State whether the limewater would have turned cloudy if she had used two Bunsen burners to heat the barium carbonate.

continued on the next page . . .

Question 10 (a) (iv) continued

Give a reason for your answer.

[1 mark]

continued on the next page . . .

Question 10 continued

10. (b) Barium nitrate also decomposes on heating.

Look at the equation for Question 10 (b) in the separate Diagram Booklet.

continued on the next page . . .

Question 10 (b) continued

10. (b) (i) In an experiment 0.960 g of barium nitrate was heated strongly for 2 minutes.

Calculate the maximum volume, in cm^3, of gas that could be produced at a temperature of 25°C and a pressure of 1 atm.

Space for working:

continued on the next page . . .

Question 10 (b) (i) continued

Volume = _____ cm^3

[3 marks]

continued on the next page . . .

Question 10 (b) continued

10. (b) (ii) The volume of a gas is directly proportional to its temperature at constant pressure.

A student said that if the gas formed in this experiment were collected at a temperature of 50°C and at 1 atm pressure, the volume formed would be double that calculated in part (i).

continued on the next page . . .

Question 10 (b) (ii) continued

Do you agree?

Justify your answer.

[1 mark]

continued on the next page . . .

Question 10 continued

10. (c) State the conditions necessary for EACH of barium oxide and barium metal to conduct electricity. Explain this property in terms of structure and bonding in each case.

[3 marks]

continued on the next page . . .

Question 10 continued

10. (d) The atomic radius of a barium atom is 0.217 nm.

From the list below, choose the value for the IONIC radius of a barium ion. Give a reason for your choice.

0.135 nm **0.210 nm**

0.217 nm **0.265 nm**

[2 marks]

continued on the next page . . .

Question 10 continued

10. (e) A sample of barium contains two isotopes. The first isotope has a relative isotopic mass of 134.9 and the second a relative isotopic mass of 137.9

The relative atomic mass of the sample of barium is 137.3

Calculate the percentage abundance of the first isotope.

continued on the next page . . .

Question 10 (e) continued

Space for working:

continued on the next page . . .

Question 10 (e) continued

Abundance = _____ %

[2 marks]

(Total for Question 10 = 15 marks)

11. Seawater contains a number of dissolved salts.

Although composition varies with location, 1000 cm^3 of seawater contains about 20 g of chloride ions, Cl^-, and about 3 g of sulfate ions, SO_4^{2-}

A student is given a sample of seawater from Rhossili Bay and asked to determine the chloride ion content by volumetric analysis and the sulfate ion content by gravimetric analysis.

continued on the next page . . .

Question 11 continued

11. (a) Determination of chloride ion content by volumetric analysis.

Look at the information provided for Question 11 (a) in the separate Diagram Booklet.

continued on the next page . . .

Question 11 (a) continued

11. (a) (i) Before starting the titration, the student rinses the burette with silver nitrate solution. Suggest why he does this.

[1 mark]

continued on the next page . . .

Question 11 (a) continued

11. (a) (ii) Suggest why the student dilutes the seawater.

_____

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 11 (a) continued

11. (a) (iii) Describe how the student should dilute the seawater by a factor of five.

[3 marks]

continued on the next page . . .

Question 11 (a) continued

11. (a) (iv) Describe and explain ONE action the student might take just before the endpoint of the titration, to ensure that the volume of silver nitrate added at the endpoint is accurate.

[2 marks]

continued on the next page . . .

Question 11 (a) continued

11. (a) (v) Write an ionic equation for the precipitation of silver chromate(VI).

[1 mark]

continued on the next page . . .

Question 11 (a) continued

11. (a) (vi) Calculate the mass of chloride ions in 1000 cm^3 of the original seawater, giving your answer to an APPROPRIATE number of significant figures.

Space for working:

continued on the next page . . .

Question 11 (a) (vi) continued

Mass of chloride ions = _____ g

[4 marks]

continued on the next page . . .

Question 11 continued

11. (b) Determination of sulfate ion content by gravimetric analysis.

- **100 cm^3 of undiluted seawater and 0.100 mol dm^{-3} barium nitrate solution were used.**
- **The mass of the barium sulfate precipitate was 0.65 g.**
- **You may assume that ALL of the sulfate ions in the seawater were precipitated.**

continued on the next page . . .

Question 11 (b) continued

11. (b) (i) Describe how the student carried out the gravimetric analysis to find the mass of the barium sulfate precipitated.

(Turn over)

[5 marks]

continued on the next page . . .

Question 11 (b) continued

11. (b) (ii) Calculate the minimum volume, in cm^3, of barium nitrate solution needed to precipitate all of the sulfate ions in 100 cm^3 of the seawater.

Space for working:

continued on the next page . . .

Question 11 (b) (ii) continued

Volume = _____ cm^3

[3 marks]

continued on the next page . . .

Question 11 (b) continued

11. (b) (iii) Suggest why the volume of barium nitrate needed was different to the volume of seawater used.

[1 mark]

(Total for Question 11 = 21 marks)

END OF PAPER

TOTAL 80 MARKS

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

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TUESDAY, 16 MAY 2023 – 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 1

Table

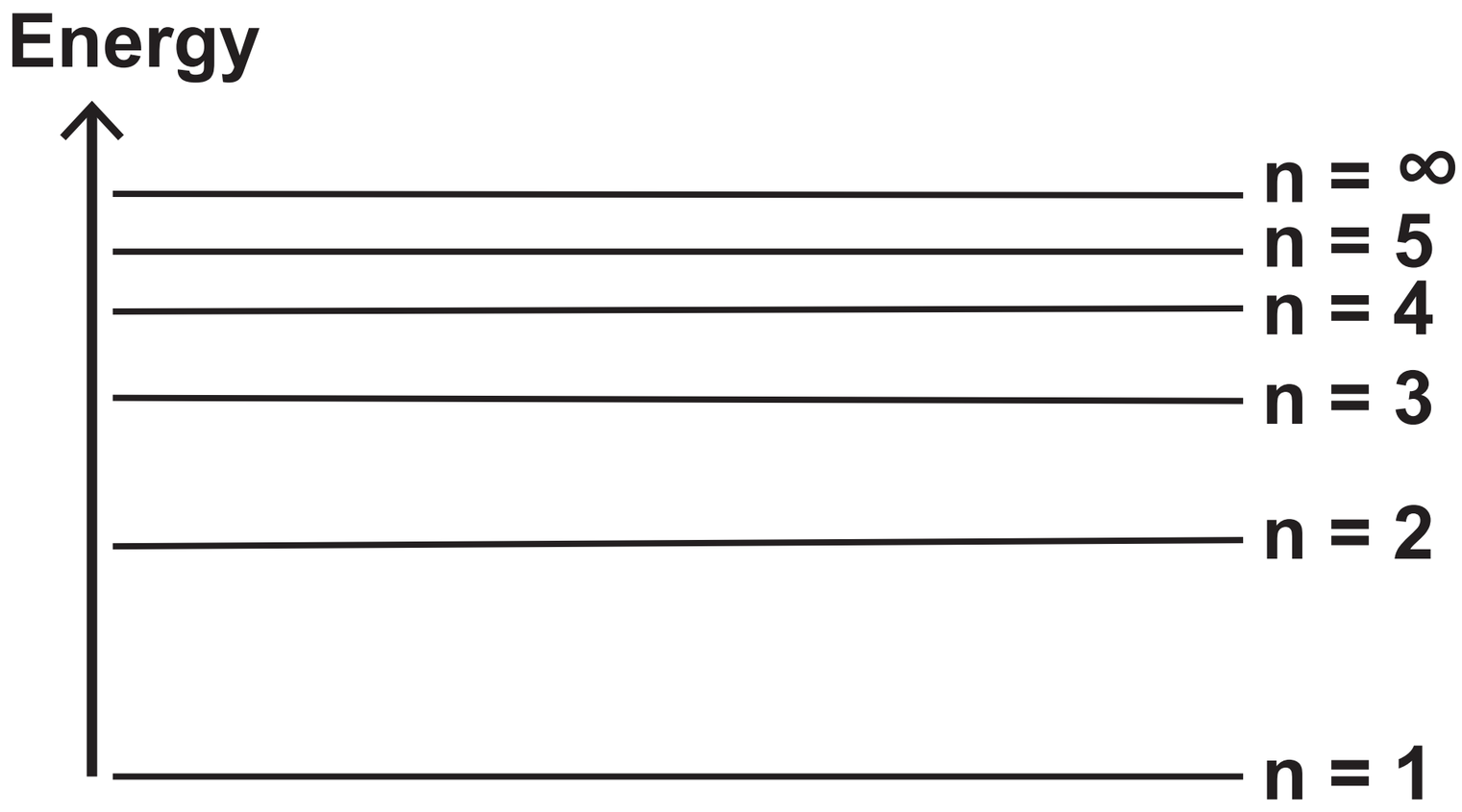
Molecule	Number of bonding pairs of electrons in outer shell	Number of lone pairs of electrons in outer shell	Shape
$BeCl_2$	2	0	
PCl_3			pyramidal

Question 2

Table

Solid	Type or types of bonding
calcium	_____ _____
iodine	_____ _____

Question 4



Question 7 (a)

Table 1

Group 4 hydride	Boiling temperature / °C	Group 7 hydride	Boiling temperature / °C
CH_4	–161	HF	20
SiH_4	–112	HCl	–85
GeH_4	–88	HBr	–66

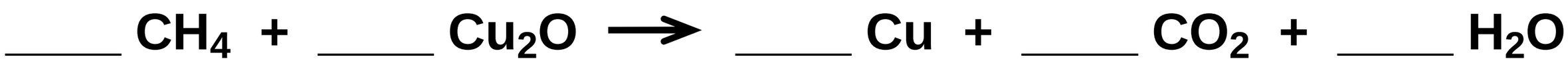
Question 7 (a)

Table 2

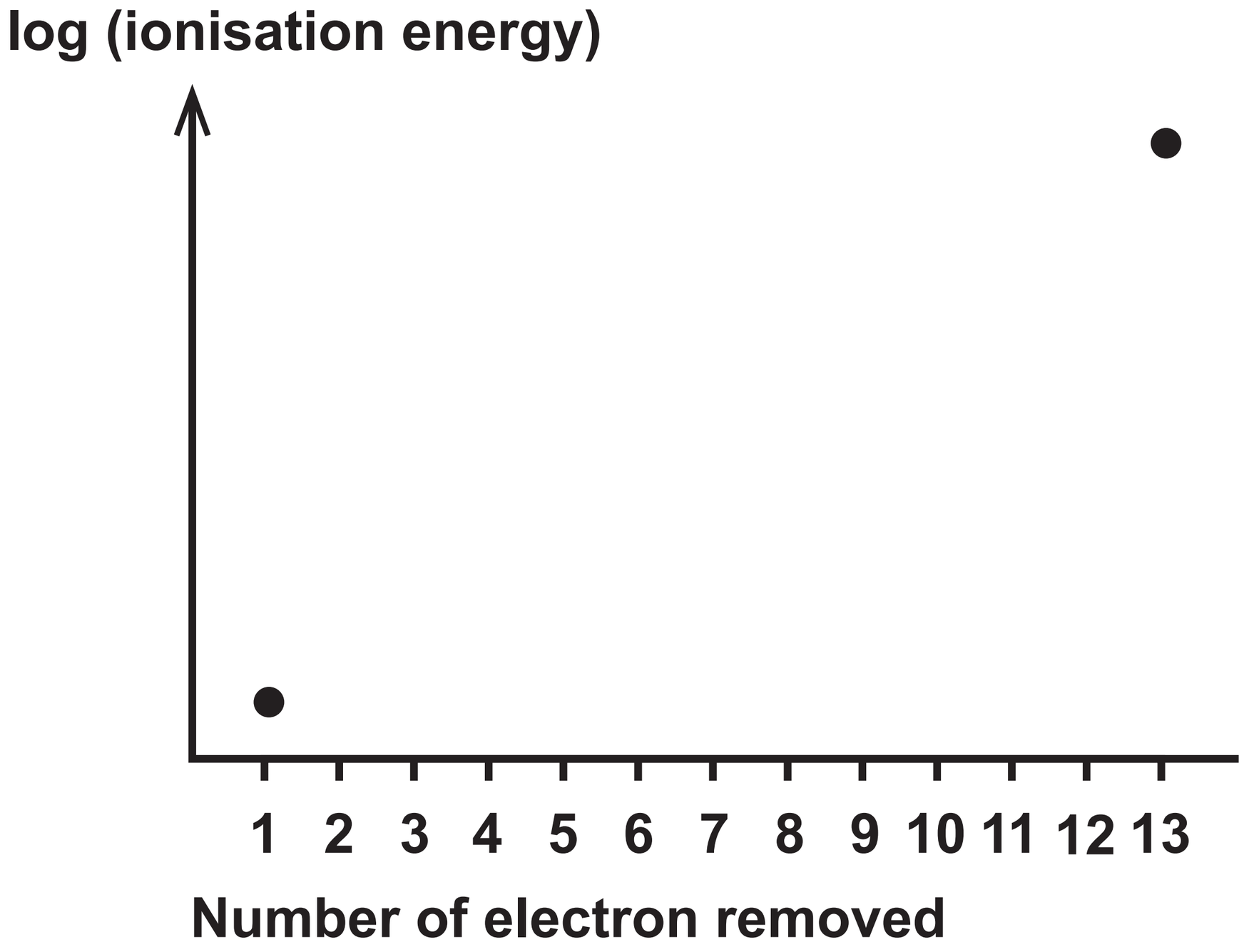
Element	Electronegativity	Element	Electronegativity
C	2.5	F	4.0
Si	1.8	Cl	3.0
Ge	1.8	Br	2.8

Question 7 (b)

Equation



Question 8 (c) (i)

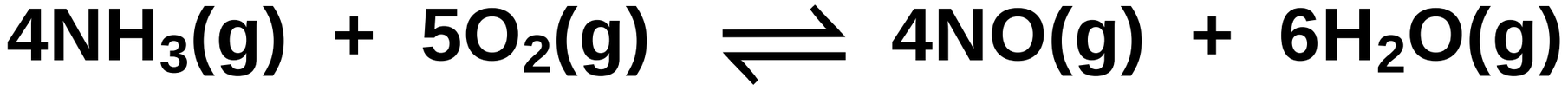


Question 9 (b)

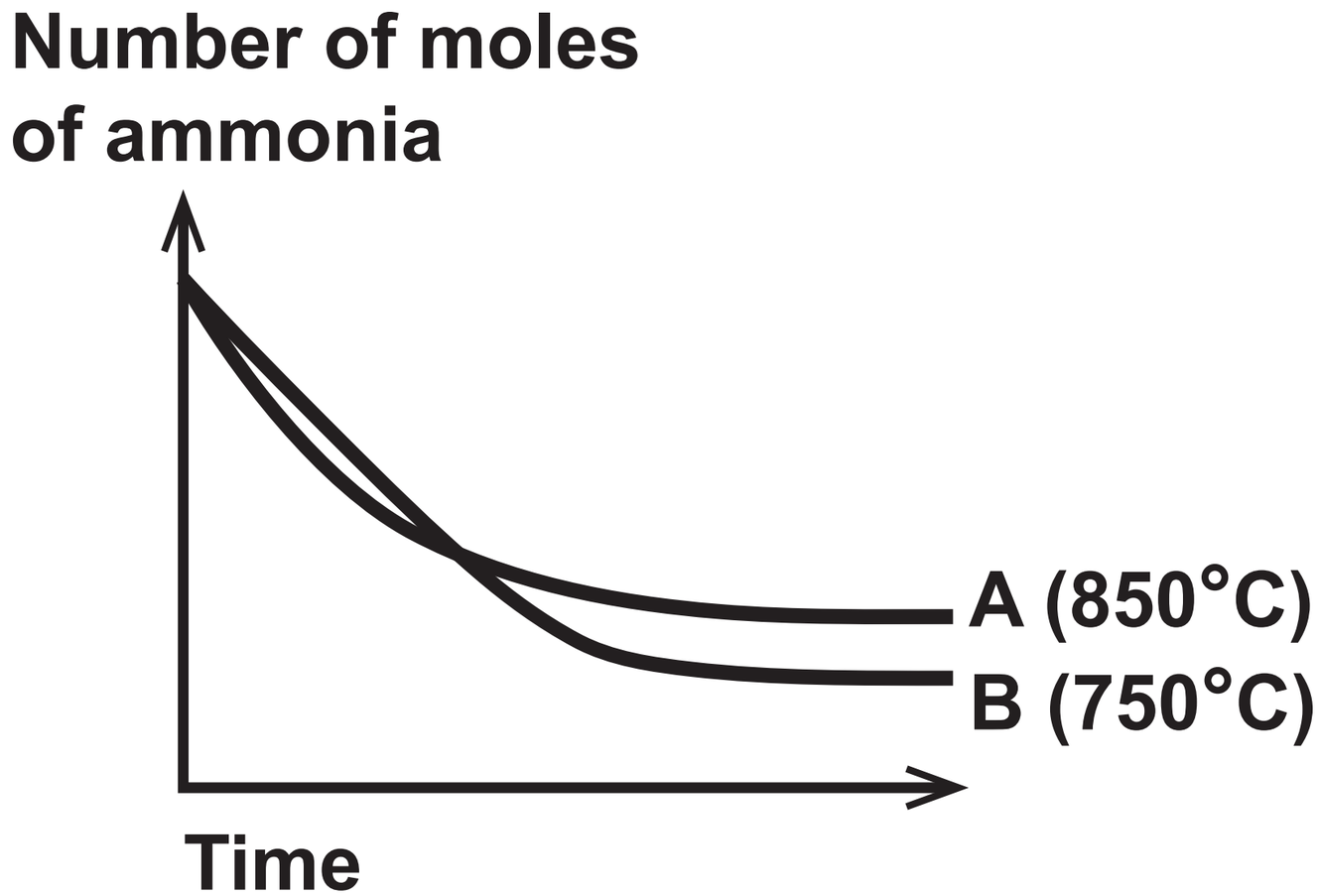
Equation

Question 9 (c)

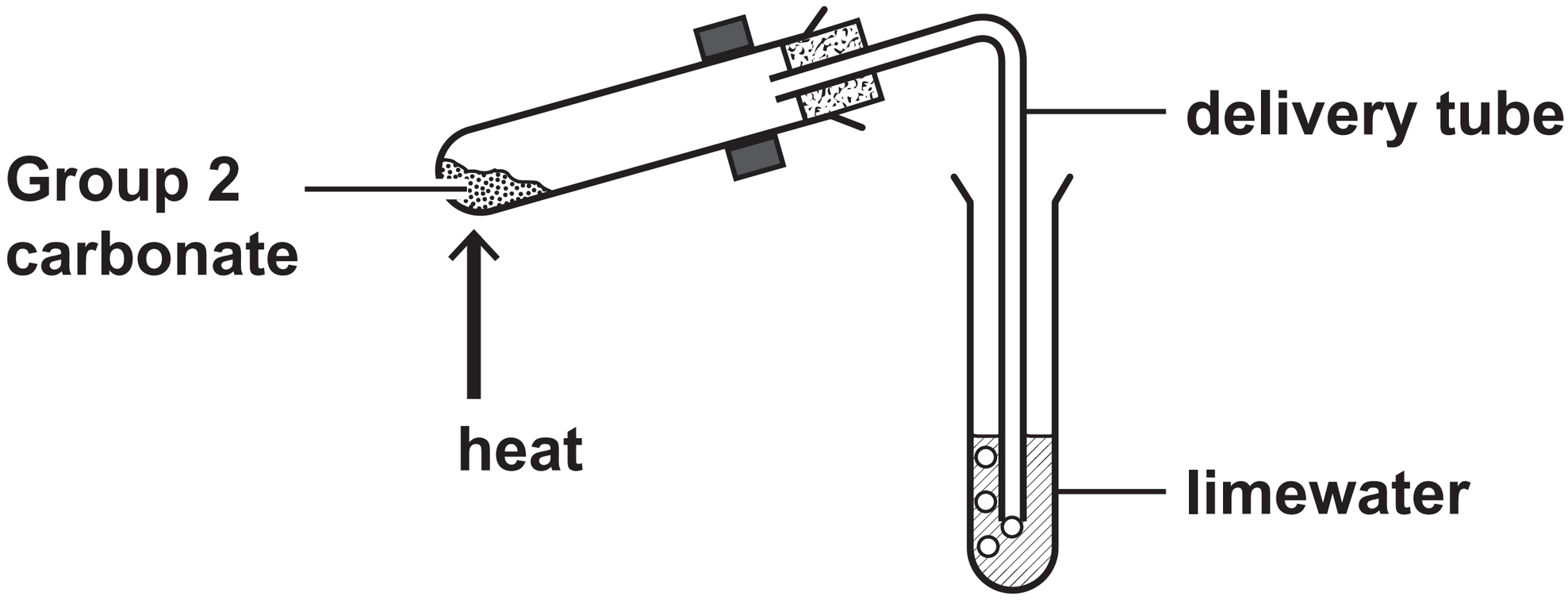
Equation



Question 9 (c)



Question 10 (a)



Question 10 (a)

Table

Carbonate	Time taken for limewater to turn cloudy / s
$MgCO_3$	20
$CaCO_3$	40
$SrCO_3$	230
$BaCO_3$	does not turn cloudy

Question 10 (b)

Equation

Question 11 (a)

Information

The method is similar to an acid – base titration.

A silver nitrate solution of known concentration is used to precipitate chloride ions as silver chloride.

$$Ag^{+}(aq) + Cl^{-}(aq) \longrightarrow AgCl(s)$$

The seawater is diluted by a factor of five before it is used in the titration.

The endpoint of this titration is difficult to determine directly, so potassium chromate(VI), K_2CrO_4, is used as an indicator.

continued on the next page . . .

Question 11 (a) continued

When all of the chloride ions have been used up, the chromate(VI) ions react with silver ions and produce silver chromate(VI), which forms a red precipitate. The instant a permanent red tinge appears in the solution, the endpoint has been reached.

Volume of diluted seawater in the conical flask = 25.0 cm^3

Concentration of silver nitrate solution in the burette = 0.100 mol dm^{-3}

Mean titre = 26.40 cm^3