Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

S23-2410U10-1

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

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
Section A 1. to 6.	10	
Section B 7.	10	
8.	12	
9.	12	
10.	15	
11.	21	
Total	80	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.
Do not use gel pen or correction fluid.

You may use pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions.
Section B Answer **all** questions.

Write your answers in the spaces provided in this booklet. 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 **Q.7**(a).

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SECTION A

Answer **all** questions.

1. Complete the table below. [2]

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

2. Complete the table below to show the type or types of bonding present in the following solids. [2]

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

3. Give the oxidation number of rhenium in $ReOCl_4$. [1]

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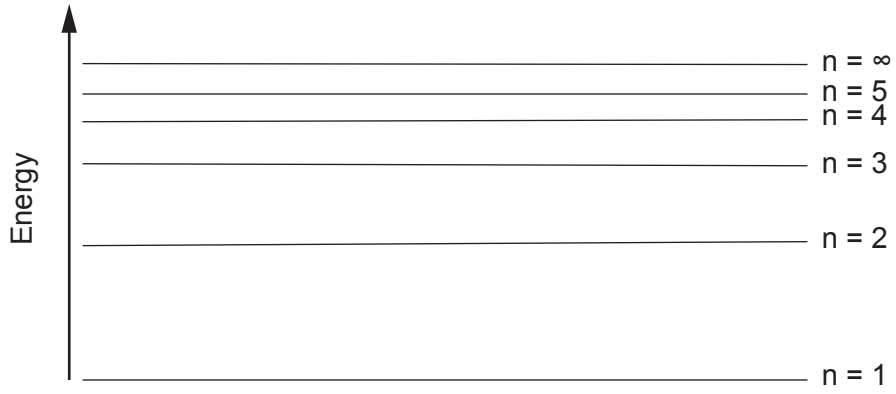
4. The diagram below shows the electron energy levels for a hydrogen atom.



(a) On the diagram, draw an arrow to represent the transition corresponding to the ionisation of the atom. Label this arrow **A**. [1]

(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]

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]

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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. [2]

Mass of reactants = ... g

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SECTION B

Answer **all** questions.

7. (a) The boiling temperatures of the hydrides of some Group 4 and Group 7 elements are shown in the table below.

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

Hydrogen has an electronegativity value of 2.1.

The electronegativity values of the Group 4 and Group 7 elements are given below.

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

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For the hydrides of the Group 4 and Group 7 elements shown in the table opposite

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

[6 QER]

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

..... CH_4 + ... Cu_2O ⟶ ..... Cu + ... CO_2 + ... H_2O

(i) Balance the equation. [1]

(ii) Explain why this reaction is described as a redox process. [1]

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(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.

Find the empirical formula of this compound. [2]

Empirical formula .....

10

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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. [2]

(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.

Show that the molecular formula of aluminium chloride in the vapour is Al_2Cl_6. [4]

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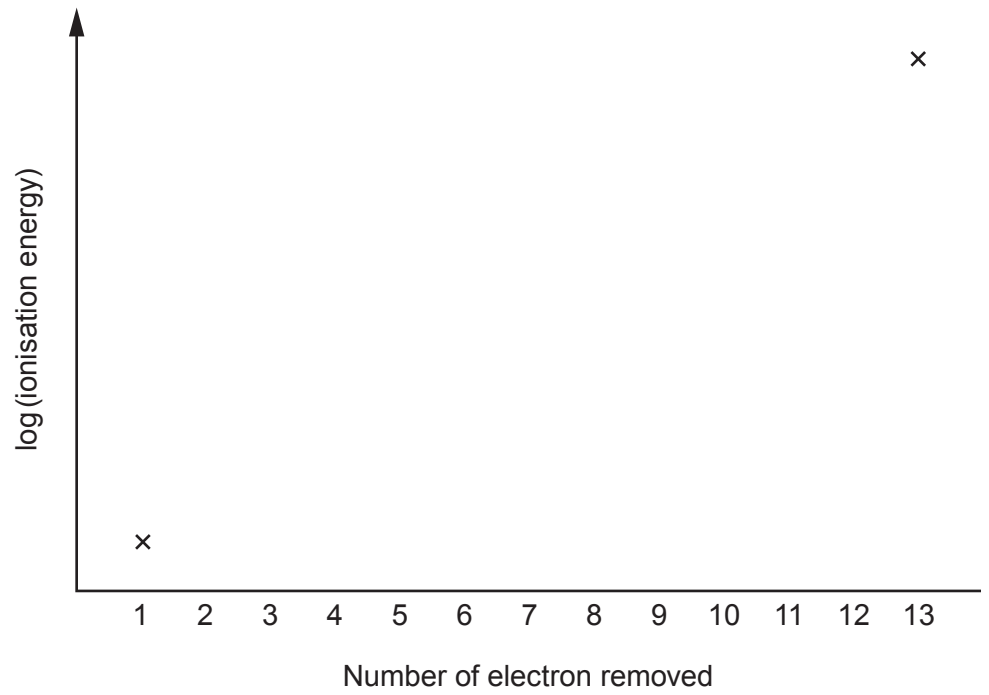
(c) (i) Sketch a graph of log (ionisation energy) for the successive ionisations of aluminium.

The first and last points have been plotted for you. [1]



(ii) I. Explain the general slope of the graph. [1]

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II. Explain the reason for any sharp changes in the graph. [1]

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Examiner only

(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.

(i) Give the mass number and symbol of the species produced when an atom of ^{26}Al decays. [1]

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(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. [2]

Mass = ... g

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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.

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

Explain why this is an acid-base reaction. [1]

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

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow 2NH_3 + Na_2SO_4 + 2H_2O$$

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

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

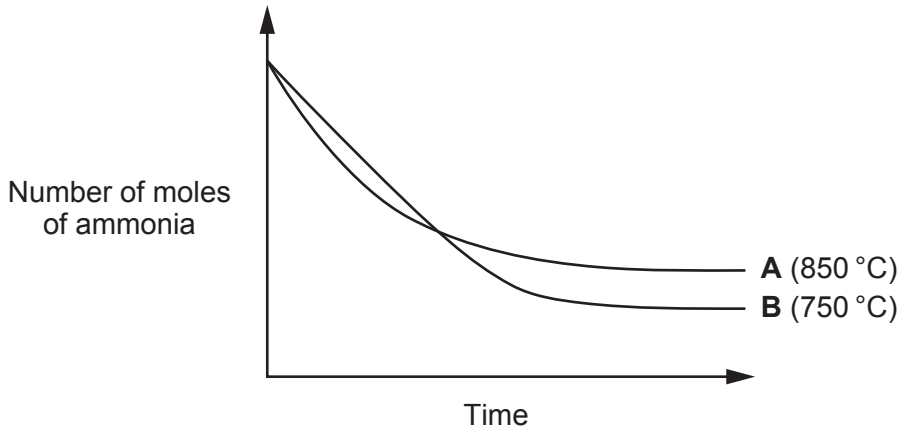
Concentration = ... mol dm^{-3}

Examiner only

(c) Another use of ammonia is in the production of nitric acid. In the first part of this process ammonia is oxidised in air.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

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



(i) State Le Chatelier's principle. [1]

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(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]

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(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]

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

Calculate its pH. [1]

pH = ...

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

Explain why she is correct. [2]

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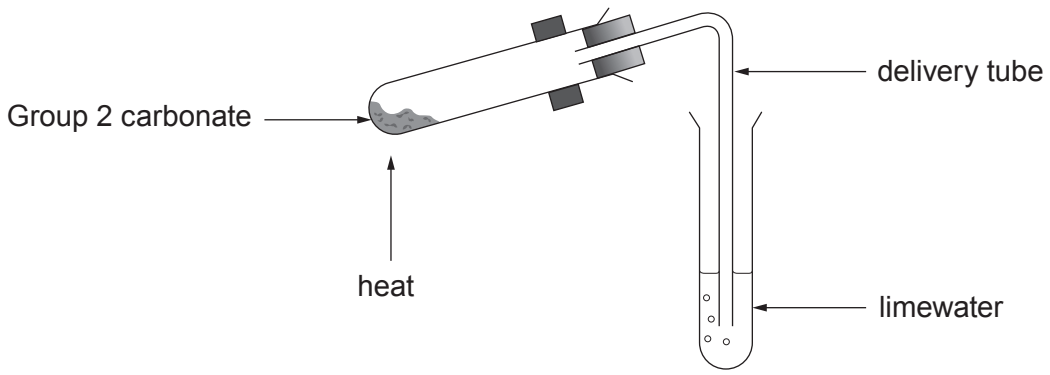
10. (a) A student investigated the thermal stability of Group 2 carbonates. She used the following apparatus and method.



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

Her results are shown below.

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

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(i) Suggest an improvement to the method to ensure that the experiment is a fair test. [1]

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(ii) Suggest why the delivery tube should be lifted out of the limewater before the flame is removed from under the boiling tube. [1]

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(iii) State what conclusion she can draw about the thermal stabilities of the Group 2 carbonates from these results. [1]

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(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. Give a reason for your answer. [1]

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Examiner only

(b) Barium nitrate also decomposes on heating.

$$2Ba(NO_3)_2(s) \longrightarrow 2BaO(s) + 4NO_2(g) + O_2(g)$$

(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. [3]

Volume = ... cm^3

(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).

Do you agree? Justify your answer. [1]

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Examiner only

(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]

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(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. [2]

0.135 nm **0.210 nm** **0.217 nm** **0.265 nm**

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(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. [2]

Abundance = ... %

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11. Seawater contains a number of dissolved salts. Although composition varies with location, 1 000 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.

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

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. 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

(i) Before starting the titration, the student rinses the burette with silver nitrate solution. Suggest why he does this. [1]

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(ii) Suggest why the student dilutes the seawater. [1]

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(iii) Describe how the student should dilute the seawater by a factor of five. [3]

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(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]

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(v) Write an ionic equation for the precipitation of silver chromate(VI). [1]

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(vi) Calculate the mass of chloride ions in 1 000 cm^3 of the original seawater, giving your answer to an **appropriate** number of significant figures. [4]

Mass of chloride ions = ... g

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(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.

(i) Describe how the student carried out the gravimetric analysis to find the mass of the barium sulfate precipitated. [5]

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(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. [3]

Volume = ... cm^3

(iii) Suggest why the volume of barium nitrate needed was different to the volume of seawater used. [1]

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END OF PAPER

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