Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

AS CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

Tuesday 14 May 2024 Morning Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice

You are advised to spend about 65 minutes on **Section A** and 25 minutes on **Section B**.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
Section B	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 A student does a series of reactions with aqueous solutions of some potassium halides (**P**, **Q** and **R**) of equal concentration. Each solution contains a different halide ion (chloride, bromide or iodide).

The student adds 3 drops of bromine water to 3 drops of each aqueous solution of potassium halide. The student also adds 3 drops of the bromine water to 3 drops of water.

Table 1 shows the student's observations.

Table 1

	Observation when 3 drops of bromine water are added
Solution P	Orange solution
Solution Q	Brown solution
Solution R	Orange solution
Water	Orange solution

0 1 . 1 Identify the halide ion present in **Q**.

Give the ionic equation for the reaction that occurs when bromine water is added to **Q**.
[2 marks]

Halide ion in **Q** _____

Ionic equation

_____

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0 1 . 2 Explain, in terms of oxidising ability, why the observations from these reactions do **not** allow the student to identify the halide ion present in **P** and the halide ion present in **R**.

[2 marks]

0 1 . 3 The student does a second experiment to determine the halide ion in each of **P** and **R**.

The student adds a few drops of aqueous silver nitrate solution to 2 cm^3 of each potassium halide solution.

Table 2 shows the student's observations.

Table 2

	Student's Observation
P	Precipitate formed
R	Precipitate formed

Describe a further chemical test that the student can complete on the precipitates formed to identify the halide ion present in **P** and the halide ion present in **R**.

Describe how the observations from this test can be used to identify the halide ion present in **P** and the halide ion present in **R**.

[3 marks]

7

Turn over for the next question

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0 2 This question is about the elements in Group 2.

0 2 . 1 Explain why the third ionisation energy of beryllium is **much** higher than the second ionisation energy of beryllium.

[3 marks]

0 2 . 2 Magnesium reacts slowly with cold water but rapidly with steam.

Compare these reactions, in terms of the products formed.
You should identify one similarity in, and one difference between, these reactions.

[2 marks]

Similarity

Difference

0 2 . 3 The reaction of calcium with water is a redox reaction.

Explain, in terms of oxidation states, why this reaction involves both oxidation and reduction.

[2 marks]

7

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0 3 This question is about structure and bonding.

0 3 . 1 Define electronegativity.

[1 mark]

0 3 . 2 Explain why the C–Cl bond is polar.

[2 marks]

0 3 . 3 Although the C–Cl bond is polar, CCl_4 is a non-polar molecule.

Explain why.

[2 marks]

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0 3 . 4 There are van der Waals forces between non-polar molecules.

Explain what causes these forces.

[3 marks]

Barium reacts with oxygen to form barium oxide.

Barium oxide has a high melting point and an ionic lattice structure similar to that of sodium chloride.

0 3 . 5 Draw a 3D diagram to show how the particles are arranged in a barium oxide lattice. You should draw eight particles.

[2 marks]

10

Turn over ►

0 4 A student is provided with separate unlabelled samples of four different solutions for analysis.

The four solutions are known to be ammonium nitrate, potassium sulfate, sodium carbonate and magnesium nitrate, but the student does not know which sample is which.

Outline a series of test-tube reactions that the student can use to identify each of these solutions.

Include:

- the expected observations
- ionic equations for any reactions.

[6 marks]

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6

Turn over ►

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0 5 SF_6 and SF_3^+ have different shapes and different bond angles.

Deduce the shape of SF_6 and the shape of SF_3^+

State the bond angle in SF_6 and the bond angle in SF_3^+

Justify the bond angles by referring to electron pairs.

[6 marks]

6

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0 6 This question is about atomic structure and mass spectrometry.

0 6 . 1 Give the **full** electron configuration for Br

[1 mark]

A sample of bromine (Br_2) is analysed in a mass spectrometer.

The sample is ionised using electron impact ionisation.

0 6 . 2 Give an equation, including state symbols, for the process that occurs during the ionisation of bromine.

[1 mark]

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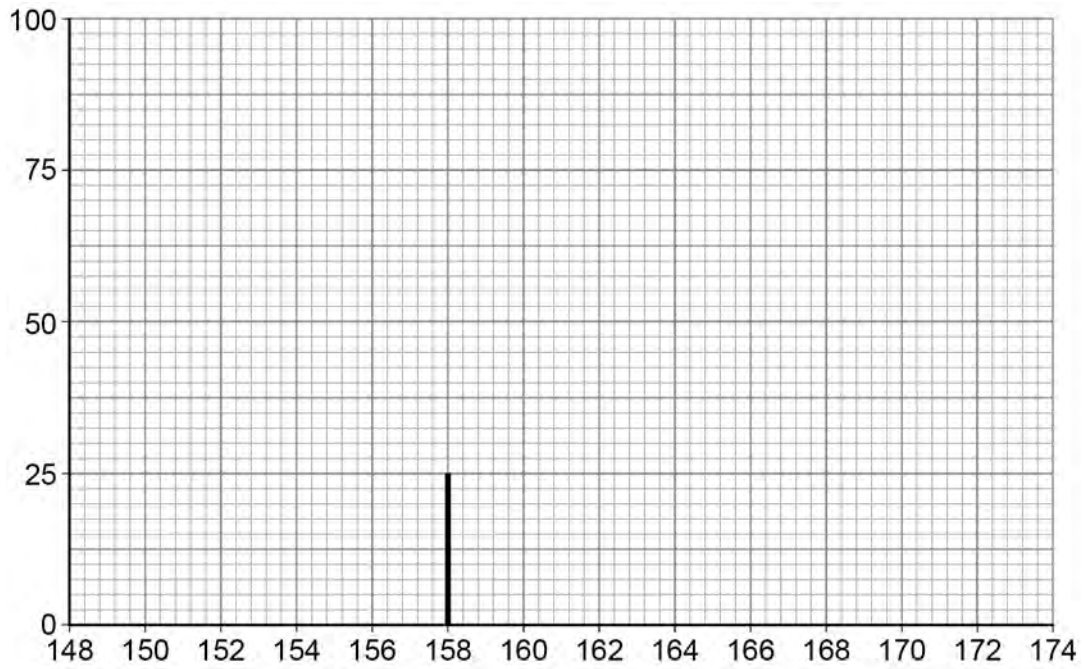
0 6 . 3 Bromine exists as two isotopes, ^{79}Br and ^{81}Br, which exist in equal abundance.

Figure 1 shows an incomplete mass spectrum for this sample of bromine.

Figure 1



Complete the spectrum by adding a label to each axis, and adding any further peaks you would expect to see.

[3 marks]

0 6 . 4 State how the detector enables the relative abundance of each ion to be determined.

[1 mark]

6

Turn over for the next question

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0 7 Some runners take tablets to help muscle recovery after long races.
These tablets contain magnesium oxide.

A student wants to find the percentage by mass of magnesium oxide in the tablets.
Magnesium oxide reacts with hydrochloric acid to form magnesium chloride.

$$MgO + 2HCl \longrightarrow MgCl_2 + H_2O$$

In an experiment, the student adds excess hydrochloric acid to some tablets.
The student then does a titration using sodium hydroxide to find how much of the excess acid is left.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

The student follows this method:

Step **1** Place a beaker on a balance and record the mass.

Step **2** Add 6 tablets to the beaker and record the mass.

Step **3** Add 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid to the beaker and stir until all the magnesium oxide has reacted.

Step **4** Make the mixture up to 250 cm^3 with distilled water in a volumetric flask.

Step **5** Transfer 25.0 cm^3 of this diluted mixture to a conical flask.

Step **6** Add 3 drops of a suitable indicator.

Step **7** Add 0.0900 mol dm^{-3} sodium hydroxide solution from a burette until the indicator changes colour.

Repeat Steps **5** to **7** until concordant results are obtained.

Results:

Mass of 6 tablets = 2.14 g Mean titre = 20.38 cm^3

0 7 . 1 Each reading from the balance has an uncertainty of ±0.005 g

Calculate the percentage uncertainty in using the balance in this experiment.

[1 mark]

Percentage uncertainty _____

Do not write outside the box

0 7 . 2 Calculate the amount, in moles, of hydrochloric acid that was added to the tablets in Step **3**.
Give your answer to an appropriate precision.

[1 mark]

Amount of hydrochloric acid _____ mol

0 7 . 3 Use your answer to Question **07.2** and the information given to calculate the percentage by mass of magnesium oxide in the tablets.

[6 marks]

Percentage by mass of MgO _____

8

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0 8 This question is about silver nitrate.

0 8 . 1 Define standard enthalpy of formation.

[2 marks]

0 8 . 2 Silver nitrate(V) is formed when silver nitrate(III) undergoes thermal decomposition.

$$2\,AgNO_2(s) \longrightarrow Ag(s) + AgNO_3(s) + NO(g) \qquad \Delta H = +56.2 \text{ kJ mol}^{-1}$$

The standard enthalpy of formation of $AgNO_3(s)$ is -123.0 kJ mol^{-1}

The standard enthalpy of formation of NO(g) is +90.4 kJ mol^{-1}

Determine the standard enthalpy of formation of $AgNO_2(s)$

[2 marks]

Standard enthalpy of formation _____ kJ mol^{-1}

0 8 . 3 Suggest why the enthalpy change for the thermal decomposition of solid silver nitrate(III) is difficult to determine experimentally.

[1 mark]

Do not write outside the box

Silver nitrate(V) solution reacts with solid sodium chloride.

$$AgNO_3(aq) + NaCl(s) \longrightarrow AgCl(s) + NaNO_3(aq)$$

A student does an experiment to determine the enthalpy change for this reaction.

The student follows this method:

1. Measure out 50 cm^3 of 0.10 mol dm^{-3} aqueous silver nitrate(V) using a clean, dry measuring cylinder.
2. Pour the silver nitrate(V) solution into a glass beaker.
3. Weigh out 2.00 g of solid sodium chloride (an excess) using a weighing boat and tip the solid into the silver nitrate(V) solution. Reweigh the weighing boat to determine the mass of sodium chloride added.
4. Add a lid to the beaker that has two small holes for a stirring rod and for a thermometer.
5. Stir the mixture with a plastic stirring rod whilst recording the temperature with a thermometer.
6. Record the maximum temperature reached.

0 8 . 4 Identify **three** aspects of this method which could cause inaccurate results.

Describe how the student could improve these three aspects of the method to obtain more accurate results.

[6 marks]

Inaccuracy 1 _____

Improvement 1 _____

_____

Inaccuracy 2 _____

Improvement 2 _____

_____

Inaccuracy 3 _____

Improvement 3 _____

_____

11

Turn over ►

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0 9 This question is about redox reactions.

0 9 . 1 State, in terms of electrons, the meaning of the term oxidising agent.

[1 mark]

0 9 . 2 Give a half-equation to show the oxidation of copper to copper(II) ions.

[1 mark]

0 9 . 3 Give a half-equation to show the reduction of NO_3^- ions in acidic solution to NO_2

[1 mark]

0 9 . 4 Use your answers to Question **09.2** and Question **09.3** to deduce an overall equation for the reduction of NO_3^- ions by copper.

[1 mark]

4

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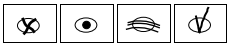
Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.
For each question completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional sheets for this working.

1 0 What is the percentage atom economy for the formation of sodium nitrate in the reaction between sodium carbonate and nitric acid?

$$Na_2CO_3 + 2\,HNO_3 \rightarrow 2\,NaNO_3 + H_2O + CO_2$$

[1 mark]

A 36.6% ⬭

B 50.3% ⬭

C 57.8% ⬭

D 73.3% ⬭

1 1 Which involves the formation of a dative covalent bond?

[1 mark]

A $PCl_3 + Cl_2 \rightarrow PCl_5$ ⬭

B $Na^+ + H^- \rightarrow NaH$ ⬭

C $Mg + Cl_2 \rightarrow MgCl_2$ ⬭

D $BH_3 + H^- \rightarrow BH_4^-$ ⬭

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1 2 The table shows some results from a titration.

Titration	Rough	Titre 1	Titre 2	Titre 3
Initial reading / cm^3	0.00	11.30	0.00	8.55
Final reading / cm^3	26.85	37.20	26.20	34.55
Titre volume / cm^3	26.85	25.90	26.20	26.00

What is the correct mean titre?

[1 mark]

A 25.95 cm^3 ⬭

B 26.03 cm^3 ⬭

C 26.10 cm^3 ⬭

D 26.24 cm^3 ⬭

1 3 Which species is **never** formed during the reactions of chlorine with water?

[1 mark]

A Chloride ions ⬭

B Chlorate(I) ions ⬭

C Hydrogen ⬭

D Oxygen ⬭

1 4 Which statement is correct?

[1 mark]

A Calcium oxide is used to remove sulfur dioxide from flue gases. ⬭

B Calcium has a larger atomic radius than barium. ⬭

C Magnesium has a lower electronegativity than barium. ⬭

D Magnesium is used to oxidise titanium(IV) chloride in the extraction of titanium. ⬭

Do not write outside the box

1 5 Which element has the lowest melting point?

[1 mark]

A Na ⬭

B Mg ⬭

C K ⬭

D Ca ⬭

1 6 Which row correctly shows general trends in properties across Period 3?

[1 mark]

	Atomic radius	**First ionisation energy**	
A	decreases	increases	⬭
B	decreases	decreases	⬭
C	increases	increases	⬭
D	increases	decreases	⬭

1 7 Ammonia is oxidised as shown.

$$w\,NH_3 + x\,O_2 \rightarrow y\,H_2O + z\,NO$$

Which whole number values for *w*, *x*, *y* and *z* balance the equation?

[1 mark]

	w	*x*	*y*	*z*	
A	2	3	3	2	⬭
B	4	7	4	4	⬭
C	4	5	6	4	⬭
D	6	7	9	6	⬭

Do not write outside the box

1 8 What is the empirical formula of an oxide of chlorine that contains 42.5% by mass of chlorine?

[1 mark]

A ClO_2 ⬭

B ClO_3 ⬭

C Cl_2O_3 ⬭

D Cl_2O_5 ⬭

1 9 Which of these solid sodium halides does **not** reduce concentrated sulfuric acid?

[1 mark]

A NaAt ⬭

B NaBr ⬭

C NaCl ⬭

D NaI ⬭

2 0 Samples of four different substances are analysed using time of flight mass spectrometry.

In each case, the samples are ionised to form ions with a single positive charge. The ions are accelerated to the same kinetic energy.

Which sample gives ions with the shortest time of flight?

[1 mark]

A A sample of ^{45}Sc that is ionised using electron impact ionisation. ⬭

B A sample of C_3H_8 that is ionised using electrospray ionisation. ⬭

C A sample of CH_3CH_2OH that is ionised using electrospray ionisation. ⬭

D A sample of CO_2 that is ionised using electron impact ionisation. ⬭

Do not write outside the box

2 1 Which isotope has 2 more protons and 3 more neutrons than an atom of ^{112}Cd?

[1 mark]

A $^{115}_{48}Cd$ ⬭

B $^{115}_{50}Sn$ ⬭

C $^{117}_{50}Sn$ ⬭

D $^{117}_{51}Sb$ ⬭

2 2 Which equation shows the process that occurs during the second ionisation of magnesium?

[1 mark]

A $Mg(g) \longrightarrow Mg^{+}(g) + e^{-}$ ⬭

B $Mg(g) \longrightarrow Mg^{2+}(g) + 2e^{-}$ ⬭

C $Mg^{+}(g) \longrightarrow Mg^{2+}(g) + e^{-}$ ⬭

D $Mg^{2+}(g) \longrightarrow Mg^{3+}(g) + e^{-}$ ⬭

2 3 Which of these practical steps will improve the accuracy of a titration?

[1 mark]

A Using a 10.0 cm^3 pipette instead of a 25.0 cm^3 pipette. ⬭

B Rinsing the sides of the conical flask with water. ⬭

C Rinsing the burette with water before filling. ⬭

D Using 6 drops of indicator instead of 3 drops of indicator. ⬭

Turn over for the next question

Do not write outside the box

2 4 Which atom has the greatest number of unpaired electrons?

[1 mark]

A P ⬭

B V ⬭

C Fe ⬭

D Cu ⬭

15

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

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