AQA

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 13 May 2025 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.

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

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

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

Do not write outside the box

Section A

Answer **all** questions in this section.

0 1 This question is about the extraction of titanium.

The first stage in the extraction of titanium is the formation of titanium(IV) chloride, $TiCl_4$

$$TiO_2(s) + 2C(s) + 2Cl_2(g) \longrightarrow TiCl_4(l) + 2CO(g)$$

0 1 . 1 Calculate the percentage atom economy to form $TiCl_4$ in this first stage of the extraction.

[2 marks]

Percentage atom economy _____

0 1 . 2 Suggest **one** economic advantage of using a process with a high percentage atom economy.

[1 mark]

_____

_____

Do not write outside the box

The second stage of the extraction is the reaction between $TiCl_4$ and magnesium.

0 1 . 3 Give the equation for the reaction between $TiCl_4$ and magnesium.

State the role of magnesium in this reaction.

[2 marks]

Equation

Role of magnesium

0 1 . 4 Titanium is an expensive metal because its extraction process uses magnesium.

Suggest why magnesium is expensive.

[1 mark]

6

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 2 This question is about the halogens and their compounds.

0 2 . 1 **Table 1** shows the boiling points of some halogens.

Table 1

Halogen	Boiling point / °C
Fluorine	–188
Chlorine	–35
Bromine	59

Explain the trend in the boiling points of these halogens.

[2 marks]

0 2 . 2 Chlorine is toxic but is added to drinking water.

State why chlorine is added to drinking water.

Explain why this is safe to do even though chlorine is toxic.

[2 marks]

Why chlorine is added

Why this is safe

Question 2 continues on the next page

Do not write outside the box

0 2 . 3 Give an equation for the reaction of chlorine with water in sunlight.

[1 mark]

0 2 . 4 Give the equation for the reaction between NaOH and Cl_2 to form NaClO

[1 mark]

0 2 . 5 When gently warmed in aqueous solution, NaClO reacts to form NaCl and $NaClO_3$

Complete the equation to ensure that it is correctly balanced.

Deduce the oxidation state of Cl in $NaClO_3$

[2 marks]

$$____\ NaClO \rightarrow ____\ NaCl + ___\ NaClO_3$$

Oxidation state of Cl in $NaClO_3$ _____

0 2 . 6 Deduce the half-equation, in acidic conditions, for the conversion of ClO_3^- into Cl^-

[1 mark]

Do not write outside the box

0 2 . 7 A halide ion X^- reduces concentrated sulfuric acid to hydrogen sulfide.

Identify the halide ion.

Give an equation for the reaction.

[2 marks]

Halide ion _____

Equation

_____

0 2 . 8 Some solid sodium halides react with concentrated sulfuric acid without any redox reaction taking place.

Identify a sodium halide that behaves in this way.

Give an equation for the reaction.

State the role of the halide ion in this reaction.

[3 marks]

Sodium halide _____

Equation

_____

Role of halide ion _____

14

Turn over for the next question

Do not write outside the box

0 3 This question is about atomic structure and time of flight (TOF) mass spectrometry.

0 3 . 1 Give the full electron configuration of a fluoride ion (F^-).

[1 mark]

0 3 . 2 The $\mathbf{Q}^{2+}$ ion has electron configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$

Identify **Q**.

[1 mark]

0 3 . 3 Give the meaning of the term relative atomic mass.

[2 marks]

0 3 . 4 A TOF mass spectrometer is used to determine the relative atomic mass of a metal.

Explain why the sample of the metal must be ionised before passing into the flight tube.

Describe how the ion is detected.

Describe how the abundance of each isotope is determined.

[3 marks]

Why sample must be ionised

How ion is detected

How abundance is determined

Do not write outside the box

A sample of metal was analysed using a TOF mass spectrometer.

The mass spectrum showed four peaks.

Table 2 shows data about the four peaks in this spectrum.

Table 2

m*/*z	**Percentage abundance**
50	4.3
52	82.8
53	10.5
54	2.4

0 3 . 5 State the *m*/*z* value of the ion that would be the last to reach the detector.

[1 mark]

0 3 . 6 Calculate the relative atomic mass of this sample of metal.

Give your answer to 1 decimal place.

[2 marks]

Relative atomic mass _____

Question 3 continues on the next page

Do not write outside the box

0 3 . 7 These are the data for one of the isotopes in this analysis.

Length of flight tube = 0.850 m

Time of flight = 6.41×10^{-4} s

$KE = 7.59 \times 10^{-20}$ J

The kinetic energy of an ion is given by the equation $KE = \frac{1}{2} mv^2$
KE = kinetic energy / J
m = mass / kg
v = speed / m s^{-1}

Calculate the mass, in g, of one ion of this isotope.

[3 marks]

Mass _____ g

13

Do not write outside the box

0 4 This question is about the Group 2 metals Mg to Ba

0 4 . 1 Strontium and calcium have the same metallic structure.

Explain why strontium has a lower melting point than calcium.

[2 marks]

0 4 . 2 The atomic radius increases down Group 2 from Mg to Ba

Give a reason for this trend.

[1 mark]

0 4 . 3 Give an equation, including state symbols, for the reaction between barium and water.

[1 mark]

0 4 . 4 Give an equation, including state symbols, for the process that occurs when the second ionisation energy of calcium is measured.

[1 mark]

0 4 . 5 Identify the Group 2 metal with the lowest second ionisation energy.

[1 mark]

6

Do not write outside the box

0 5 An experiment is done to determine the relative molecular mass of a solid acid, H_2A

H_2A reacts with sodium hydroxide as shown.

$$H_2A + 2\,NaOH \rightarrow Na_2A + 2\,H_2O$$

Method

- 2.09 g of H_2A are dissolved in water and the solution is made up to 250.0 cm^3 in a volumetric flask.
- 25.0 cm^3 of this solution are transferred to a conical flask using a pipette.
- A few drops of phenolphthalein are added.
- 0.380 mol dm^{-3} sodium hydroxide solution is added from a burette until the indicator changes colour.

Table 3 shows the results of the experiment.

Table 3

	Rough	**1**	**2**	**3**
Final burette reading / cm^3	11.05	23.40	34.25	44.80
Initial burette reading / cm^3	0.00	12.75	23.40	34.25
Titre / cm^3	11.05	10.65	10.85	10.55

0 5 . 1 Calculate the relative molecular mass of H_2A

[5 marks]

Do not write outside the box

Relative molecular mass of H_2A _____

0 5 . 2 The uncertainty in the use of the burette in each titration is ±0.15 cm^3

Calculate the percentage uncertainty in the use of the burette in titration **1**.

[1 mark]

Percentage uncertainty _____

0 5 . 3 Suggest **one** way to reduce the percentage uncertainty in each titration without changing the apparatus.

Justify your answer.

[2 marks]

Suggestion _____

_____

_____

Justification _____

_____

_____

8

Turn over ►

Do not write outside the box

0 6 . 1 A student completes a series of test-tube reactions on two solutions, **A** and **B**.

Each solution contains an unknown inorganic compound.

Table 4 shows the observations in these reactions.

Table 4

	Solution A	**Solution B**
Test 1 Add $H_2SO_4(aq)$	White precipitate formed	Effervescence
Test 2 Add $HNO_3(aq)$ followed by $AgNO_3(aq)$	White precipitate formed	Effervescence
Test 3 Add NaOH(aq) and warm gently. Hold a piece of damp red litmus paper over the end of the test tube.	No visible change	Red litmus turns blue

Show how the observations can be used to identify the inorganic compound in **Solution A** and the inorganic compound in **Solution B**.

Give **ionic** equations for the reactions that occur.

[6 marks]

Do not write outside the box

0 6 . 2 Describe a test to confirm that a solution contains hydroxide ions.

[1 mark]

7

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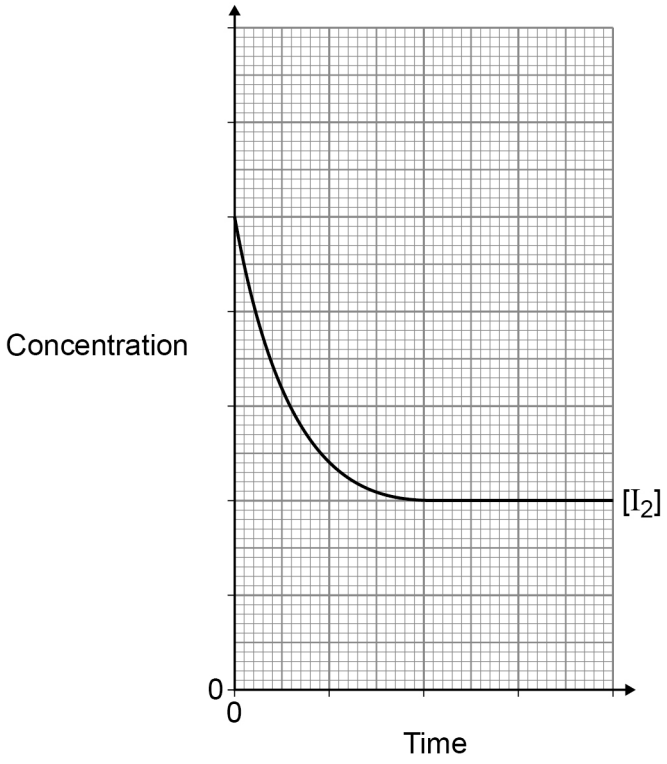
0 7 This question is about chemical equilibria.

A mixture of hydrogen and iodine is allowed to reach equilibrium in a sealed container.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +52 \text{ kJ mol}^{-1}$$

Figure 1 shows how the concentration of iodine changes with time.

Figure 1



0 7 . 1 Draw a line on **Figure 1** to show how the concentration of hydrogen iodide changes with time.

[2 marks]

0 7 . 2 State and explain the effect of increasing the temperature on the equilibrium yield of hydrogen iodide.

[3 marks]

Effect on yield _____

Explanation _____

_____

_____

_____

Do not write outside the box

Carbon dioxide can react with hydrogen to form methanol.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

2.50 mol of CO_2 are mixed with 6.00 mol of H_2 in a sealed container with a volume of 4.60 dm^3

The mixture is left to reach equilibrium at a fixed temperature.

At equilibrium, 1.30 mol of CO_2 remain.

0 7 . 3 Give an expression for the equilibrium constant, K_c, for this reaction.

Calculate a value for the equilibrium constant at this fixed temperature.
Give the units of the equilibrium constant.

[6 marks]

Expression for K_c

Calculation

K_c _____ Units _____

11

Turn over ►

Do not write outside the box

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.

0 8 What is the formula of gallium sulfate(VI)?

[1 mark]

A $Ga_2(SO_4)_3$ ⬭

B $Ga_3(SO_4)_2$ ⬭

C $Ga_2(SO_3)_3$ ⬭

D $GaSO_4$ ⬭

0 9 What is the mass, in kg, of 2000 m^3 of carbon monoxide gas at 100 kPa and 25 °C?

R = 8.31 J K^{-1} mol^{-1}

[1 mark]

A 2.261 ⬭

B 2.696 ⬭

C 2261 ⬭

D 2696 ⬭

Do not write outside the box

1 0 What is the percentage by mass of sodium in sodium sulfate(VI)?

[1 mark]

A 19.3 ⬭

B 22.3 ⬭

C 32.4 ⬭

D 36.5 ⬭

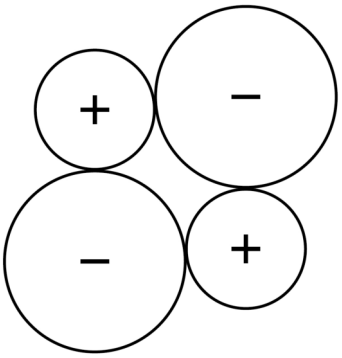
Turn over for the next question

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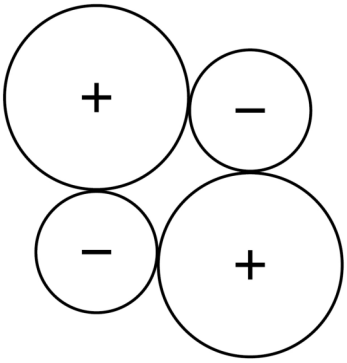
1 1 Which diagram best shows the arrangement and the relative sizes of the ions in solid sodium chloride?

[1 mark]

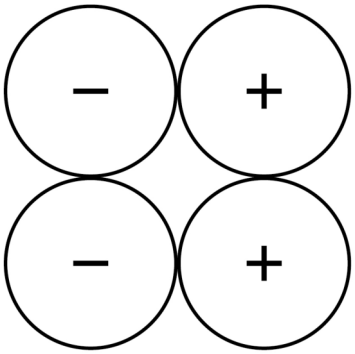
A



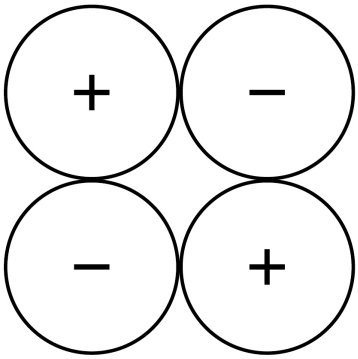
B



C



D



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1 2 Which row shows the order of discovery?

[1 mark]

	Earliest →		Latest	
A	electron	neutron	nucleus	⬭
B	electron	nucleus	neutron	⬭
C	nucleus	electron	neutron	⬭
D	nucleus	neutron	electron	⬭

1 3 What is the maximum mass of sodium chloride that can be made from 10.0 g of sodium and 10.0 g of chlorine?

[1 mark]

A 8.24 g ⬭

B 16.5 g ⬭

C 20.0 g ⬭

D 25.4 g ⬭

1 4 Which Period 3 element has these successive ionisation energies?

[1 mark]

	1st	2nd	3rd	4th	5th	6th
Ionisation energy / kJ mol^{-1}	786	1580	3230	4360	16 000	20 000

A Al ⬭

B Si ⬭

C P ⬭

D S ⬭

Do not write outside the box

1 5 Which equilibrium has a lower yield of product when the pressure in the system is increased at constant temperature?

[1 mark]

A $2\,NOCl(g) \rightleftharpoons 2\,NO(g) + Cl_2(g)$ ⬭

B $2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$ ⬭

C $I_2(g) + H_2(g) \rightleftharpoons 2\,HI(g)$ ⬭

D $N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$ ⬭

1 6 Which element has atoms that contain only two unpaired electrons?

[1 mark]

A cobalt ⬭

B magnesium ⬭

C nickel ⬭

D phosphorus ⬭

1 7 Which silver halide(s) react(s) with concentrated ammonia solution to form a colourless solution?

[1 mark]

A silver chloride only ⬭

B silver chloride and silver bromide ⬭

C silver bromide and silver iodide ⬭

D silver iodide only ⬭

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1 8 The reaction between hydrochloric acid and sodium hydroxide is exothermic.

Which row shows the solutions that will give the greatest temperature increase when mixed?

[1 mark]

	HCl(aq)		NaOH(aq)		
	Volume / cm^3	**Concentration / mol dm^{-3}**	**Volume / cm^3**	**Concentration / mol dm^{-3}**	
A	200	1.0	200	1.0	⬭
B	50	1.0	50	1.0	⬭
C	50	1.5	100	1.0	⬭
D	50	1.5	50	1.5	⬭

1 9 Which of these molecules is polar?

[1 mark]

A BF_3 ⬭

B CO_2 ⬭

C CCl_4 ⬭

D SCl_2 ⬭

2 0 Which statement about SO_2 acting as a reducing agent is correct?

[1 mark]

A SO_2 gains electrons and the oxidation state of sulfur decreases. ⬭

B SO_2 gains electrons and the oxidation state of sulfur increases. ⬭

C SO_2 loses electrons and the oxidation state of sulfur decreases. ⬭

D SO_2 loses electrons and the oxidation state of sulfur increases. ⬭

Turn over for the next question

Do not write outside the box

2 1 A student is asked to prepare a solution of hydrochloric acid with a concentration of 0.0400 mol dm^{-3}

What volume of distilled water should the student add to 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid to prepare this solution?

[1 mark]

A 25 cm^3 ⬭

B 50 cm^3 ⬭

C 1225 cm^3 ⬭

D 1250 cm^3 ⬭

2 2 At temperature ***T*** and pressure ***P***, 0.287 g of nitrogen has a volume of 25.0 cm^3

Which quantity of substance at temperature ***T*** and pressure ***P*** contains the same number of **atoms** as 0.287 g of nitrogen in 25.0 cm^3?

[1 mark]

A 25.0 cm^3 of argon ⬭

B 1.312 g of sulfur dioxide ⬭

C 0.287 g of carbon dioxide ⬭

D 25.0 cm^3 of oxygen ⬭

15

END OF QUESTIONS

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