A

Surname ______________________

Forename(s) ______________________

Centre Number ______________________

Candidate Number ______________________

Candidate Signature ______________________

I declare this is my own work.

AS

CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

7404/1

Tuesday 16 May 2023 Morning

Time allowed: 1 hour 30 minutes

At the top of the page, write your surname and forename(s), your centre number, your candidate number and add your signature.

[Turn over]

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.
- Answer ALL questions.
- You must answer the questions in the spaces provided. Do NOT write 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.

DO NOT TURN OVER UNTIL TOLD TO DO SO

SECTION A

Answer ALL questions in this section.

0 1

This question is about the elements in Period 3.

0 1 . 1

Give the full electron configuration of the element in Period 3 with the highest first ionisation energy.
[1 mark]

0 1 . 2

Give an equation, including state symbols, to represent the process that occurs when the second ionisation energy of sodium is measured. [1 mark]

[Turn over]

0 1 . 3

TABLE 1 shows some successive ionisation energies for an element in Period 3.

TABLE 1

Ionisation number	Ionisation energy / kJ mol^{-1}
1	1000
2	2260
3	3390
4	4540
5	6990
6	8490
7	27 100
8	31 700

Identify the Period 3 element.

Explain your answer. [3 marks]

Element ____

____

Explanation ____

____

____

____

[Turn over]

5

0 2

This question is about the elements in Group 2.

0 2 . 1

Describe the structure and bonding in magnesium.
[2 marks]

0 2 . 2

State the trend in the atomic radius of the elements down Group 2 from Mg to Ba

Give a reason for this trend. [2 marks]

Trend ______________________________

____

Reason ______________________________

____

____

____

[Turn over]

0 2 . 3

Give an equation, including state symbols, for the reaction of magnesium with steam.

State TWO observations for this reaction. [3 marks]

Equation

____

Observation 1 ______________________________________

____

Observation 2 ______________________________________

____

0 2 . 4

The sulfates of the elements in Group 2 from Mg to Ba have different solubilities.

State the formula of the least soluble of these sulfates.

Give a use for this sulfate. [2 marks]

Formula ______________________________

____

Use ______________________________

____

[Turn over]

0 2 . 5

A sample of strontium is made up of only three isotopes: ^{86}Sr, ^{87}Sr and ^{88}Sr
This sample contains 83.00% by mass of ^{88}Sr
This sample of strontium has A_r = 87.73

Calculate the percentage abundance of each of the other two isotopes in this sample. [4 marks]

% abundance ^{87}Sr = ______________________________

% abundance ^{86}Sr = ______________________________

[Turn over]

0 2 . 6

$Mg(OH)_2$ is used as an antacid to treat indigestion.
A student does an experiment to determine the percentage by mass of $Mg(OH)_2$ in an indigestion tablet.

40.0 cm^3 of 0.200 mol dm^{-3} HCl (an excess) is added to 0.200 g of a powdered tablet.
The mixture is swirled thoroughly.
All of the $Mg(OH)_2$ reacts with HCl as shown.

$$Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$$

The amount of HCl remaining after this reaction is determined by titration with 0.100 mol dm^{-3} NaOH

29.25 cm^3 of 0.100 mol dm^{-3} NaOH are needed.

Calculate the percentage by mass of $Mg(OH)_2$ in the indigestion tablet. [6 marks]

Percentage by mass ______________________________

[Turn over]

19

0 3

A student uses this method to prepare a standard solution of sodium carbonate.

1. **Weigh a clean, dry, empty container on a balance that reads to 2 decimal places.**
2. **Add about 2.5 g of solid sodium carbonate to the container.**
3. **Tip the solid into a beaker.**
4. **Add approximately 100 cm^3 of distilled water to the beaker and stir until all the solid has dissolved.**
5. **Pour the solution into a 250 cm^3 volumetric flask.**
6. **Add distilled water until the top of the meniscus is level with the graduation mark.**

0 3 . 1

Suggest THREE improvements to this method.
[3 marks]

1 ____

____

____

2 ____

3

03.2

A different student uses the correct method to prepare 250 cm^3 of sodium carbonate solution in a volumetric flask.
The uncertainty for the volumetric flask is ±0.20 cm^3

Calculate the percentage uncertainty in the volume of this sodium carbonate solution. [1 mark]

Percentage uncertainty ____________________

[Turn over]

4

0 4

M is a Group 2 metal that forms the nitrate $M(NO_3)_2$
0.320 g of $M(NO_3)_2$ is heated strongly and decomposes completely.

$$2M(NO_3)_2(s) \longrightarrow 2MO(s) + 4NO_2(g) + O_2(g)$$

The mixture of gases formed has a volume of 225 cm^3 at 450 °C and 101 000 Pa

Determine the M_r of $M(NO_3)_2$

Identify M.

The gas constant, R = 8.31 J K^{-1} mol^{-1} [5 marks]

M_r of $M(NO_3)_2$ ______________________

Identity of M ______________________

[Turn over]

5

0 5

This question is about the shapes of molecules.

Discuss the difference between the shapes of CF_4 and XeF_4

In your answer you should:

- **name the shape of each molecule**
- **explain the shape of each molecule**
- **explain the bond angle(s) in each molecule.**

[6 marks]

[Turn over]

[Turn over]

[Turn over]

6

0 6

This question is about halogens and halide ions.

0 6 . 1

Explain why the electronegativity of the halogens decreases down the group. [2 marks]

Concentrated sulfuric acid reacts with solid sodium chloride and with solid sodium bromide.

0 6 . 2

State ONE similarity in, and ONE difference between, these reactions. [2 marks]

Similarity ____

____

____

Difference ____

____

____

[Turn over]

0 6 . 3

Solid sodium iodide reacts with concentrated sulfuric acid to form hydrogen sulfide.

Give a half-equation to show the oxidation of iodide ions.

Give a half-equation to show the reduction of concentrated sulfuric acid to hydrogen sulfide.

Use your half-equations to deduce an overall equation for this reaction. [3 marks]

Half-equation 1

Half-equation 2

Overall equation

7

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[Turn over]

0 7

This question is about time of flight (TOF) mass spectrometry.

0 7 . 1

Compound X is dissolved in a polar, volatile solvent and is ionised by electrospray ionisation.
Each ion is accelerated so that it has a kinetic energy of 1.36×10^{-16} J

The kinetic energy of an ion is given by the equation $KE = \frac{1}{2}mv^2$ where:

KE = kinetic energy / J

m = mass / kg

v = speed / m s^{-1}

The time of flight along the 0.750 m flight tube is 2.48×10^{-5} s

Determine the mass, in g, of one mole of X.

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}
[5 marks]

Mass of one mole of X ____________________________ g

[Turn over]

A mixture of gases is analysed using TOF mass spectrometry.
The mixture contains argon, carbon dioxide, nitrogen and oxygen.
The mixture is ionised by electron impact.

0 7 . 2

State the meaning of the term electron impact ionisation. [1 mark]

____

____

____

0 7 . 3

Identify the ion formed from this mixture that reaches the detector last.

Justify your answer. [2 marks]

Ion that reaches detector last ____________________

____

Justification ______________________________

____

0 7 . 4

State how the ions are detected, and how the abundance of each ion is measured, in a TOF mass spectrometer. [2 marks]

How ions are detected ______________________________

How abundance is measured ______________________________

[Turn over]

10

0 8

This question is about the equilibrium mixture formed when A and B react.

$$A(aq) + 2B(aq) \rightleftharpoons C(aq) \qquad \Delta H = -32 \text{ kJ mol}^{-1}$$

0 8 . 1

A solution containing 0.60 mol of A is added to a solution containing 0.60 mol of B.
The amount of C formed at equilibrium is 0.28 mol

Deduce the amounts, in moles, of A and B in this mixture at equilibrium. [2 marks]

Amount of A ________________________________ mol

Amount of B ________________________________ mol

[Turn over]

0 8 . 2

Give an expression for the equilibrium constant (K_c) for this reaction. [1 mark]

K_c

08.3

The temperature of the equilibrium mixture is decreased.

Predict the effect, if any, on the value of K_c
Give a reason for your prediction. [3 marks]

Prediction ____

____

Reason ____

____

____

____

[Turn over]

0 8 . 4

In another mixture at equilibrium

[A] = 0.48 mol dm^{-3}
[C] = 0.62 mol dm^{-3}

For this reaction, the equilibrium constant
K_c = 7.8 mol^{-2} dm^{6}

Calculate [B] at equilibrium.
Give your answer to the appropriate number of significant figures. [3 marks]

[B] ______________________________ mol dm^{-3}

[Turn over]

9

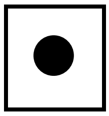
SECTION B

Answer ALL questions in this section.

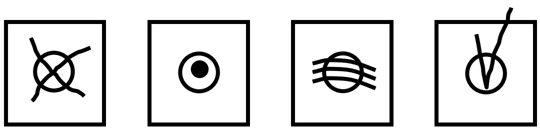
Only ONE answer per question is allowed.

For each question completely fill in the circle alongside the appropriate answer.

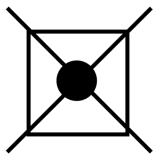
CORRECT METHOD



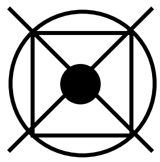
WRONG METHODS



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 9

Which atom contains the most neutrons? [1 mark]

- ○ **A** ^{54}Cr
- ○ **B** ^{55}Mn
- ○ **C** ^{57}Fe
- ○ **D** ^{58}Ni

[Turn over]

Use this information for Questions 10 and 11.

A student completes a titration to determine the concentration of ethanoic acid in vinegar.

25.0 cm^3 of vinegar are transferred to a conical flask using a pipette.
A few drops of phenolphthalein are added to the conical flask.
Sodium hydroxide solution is added from a burette to the conical flask.
The titration is repeated until concordant results are obtained.

1 0

Which suggestion improves the accuracy of the titres?
[1 mark]

○ **A** Rinsing the conical flask with vinegar between each titration.

○ **B** Rinsing the conical flask with sodium hydroxide solution between each titration.

○ **C** Rinsing the conical flask with water between each titration.

○ **D** Not rinsing the conical flask between each titration.

1 1

Which suggestion decreases the percentage uncertainty in the mean titre? [1 mark]

- ○ **A** Use a more dilute solution of sodium hydroxide in the burette.
- ○ **B** Use a more dilute solution of vinegar.
- ○ **C** Rinse the inside of the conical flask with distilled water during each titration.
- ○ **D** Rinse the tip of the burette with distilled water near the end point in each titration.

[Turn over]

12

Which reaction has the highest percentage atom economy for the production of hydrogen? [1 mark]

○ **A** $LiH + H_2O \longrightarrow LiOH + H_2$

○ **B** $CO + H_2O \longrightarrow CO_2 + H_2$

○ **C** $2Al + 3H_2O \longrightarrow Al_2O_3 + 3H_2$

○ **D** $CH_4 + H_2O \longrightarrow CO + 3H_2$

13

Which molecule has a permanent dipole? [1 mark]

○ **A** NCl_3

○ **B** CCl_4

○ **C** PF_5

○ **D** SF_6

[Turn over]

1 4

Which molecule can accept an electron pair during the formation of a coordinate bond? [1 mark]

- ○ **A** NH_3
- ○ **B** $AlCl_3$
- ○ **C** SiH_4
- ○ **D** PCl_3

15

Which reaction has an enthalpy change equal to the standard enthalpy of formation of potassium oxide?
[1 mark]

○ **A** $4K(s) + O_2(g) \longrightarrow 2K_2O(s)$

○ **B** $2K(s) + O(g) \longrightarrow K_2O(s)$

○ **C** $2K^+(g) + O^{2-}(g) \longrightarrow K_2O(s)$

○ **D** $2K(s) + \frac{1}{2}O_2(g) \longrightarrow K_2O(s)$

[Turn over]

16

In which species is chlorine in its highest oxidation state? [1 mark]

- ○ **A** ClF_2^-
- ○ **B** ClO_4^-
- ○ **C** ClO_2
- ○ **D** ClF_3

17

Which statement about this redox reaction is correct?

$$3\,Sn^{2+}(aq) + Cr_2O_7^{2-}(aq) + 2\,H^+(aq) \longrightarrow 2\,Cr^{3+}(aq) + 3\,SnO_2(s) + H_2O(l)$$

[1 mark]

○ **A** Sn^{2+} is the oxidising agent and it gains electrons.

○ **B** Sn^{2+} is the reducing agent and it gains electrons.

○ **C** $Cr_2O_7^{2-}$ is the oxidising agent and it gains electrons.

○ **D** $Cr_2O_7^{2-}$ is the reducing agent and it gains electrons.

[Turn over]

18

Which incomplete half-equation is balanced by adding two H^+ ions and one electron to the left-hand side?
[1 mark]

○ **A** $CH_3CHO \longrightarrow CH_3CH_2OH$

○ **B** $VO^{2+} \longrightarrow V^{3+} + H_2O$

○ **C** $HNO_2 \longrightarrow NO + H_2O$

○ **D** $O_2 \longrightarrow H_2O_2$

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[Turn over]

Use this information for Questions 19 to 23.

A student completes some test-tube reactions on five solutions, P, Q, R, S and T. The student completes each test on separate samples of each solution. Observations are shown in the table.

Solution	TEST 1 Add a few drops of $H_2SO_4(aq)$	TEST 2 Add $HNO_3(aq)$ then a few drops of $AgNO_3(aq)$	TEST 3 Add a few drops of $NaOH(aq)$	TEST 4 Add a few drops of $Cl_2(aq)$
P	White precipitate	Cream precipitate	No visible change	Orange solution
Q	Effervescence	Effervescence and white precipitate	No visible change	No visible change
R	No visible change	No visible change	White precipitate	No visible change
S	White precipitate		No visible change	Dark brown solution
T	No visible change	White precipitate	White precipitate	No visible change

Use the information in the table to answer Questions 19 to 23.

19

Which solution contains carbonate ions? [1 mark]

- ○ **A** Solution P
- ○ **B** Solution Q
- ○ **C** Solution R
- ○ **D** Solution S

[Turn over]

2 0

What could be the identity of the compound in solution P? [1 mark]

- [ ] **A** $MgBr_2$
- [ ] **B** $BaBr_2$
- [ ] **C** $MgCl_2$
- [ ] **D** $BaCl_2$

2 1

What observation is expected in TEST 2 for solution S? [1 mark]

- ○ **A** No visible change
- ○ **B** Effervescence
- ○ **C** White precipitate
- ○ **D** Pale yellow precipitate

[Turn over]

22

In TEST 2, the mixture formed by solution S is filtered.

Which substance is present in the filtrate? [1 mark]

- ○ **A** $AgBr$
- ○ **B** AgI
- ○ **C** $Ba(NO_3)_2$
- ○ **D** $Mg(NO_3)_2$

23

What could be the identity of the compound in solution T? [1 mark]

- ○ **A** $MgCl_2$
- ○ **B** $BaCl_2$
- ○ **C** $MgBr_2$
- ○ **D** $BaBr_2$

END OF QUESTIONS

/15

Additional page, if required.

Write the question numbers in the left-hand margin.

Additional page, if required.

Write the question numbers in the left-hand margin.

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For Examiner's Use	
Question	Mark
1	
2	
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8	
Section B	
TOTAL	

WP/M/SB/Jun23/7404/1/E2

2 3 6 A 7 4 0 4 / 1