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

Monday 18 May 2020    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 | |
| 8 | |
| 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 about 65 minutes on **Section A** and 25 minutes on **Section B**.

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## Section A

Answer **all** questions in this section.

**0 1** This question is about atomic structure.

**0 1 . 1** There is a general trend for an increase in ionisation energy across Period 3.
Give **one** example of an element that deviates from this trend.

Explain why this deviation occurs.

**[3 marks]**

Element ______________________________

Explanation ______________________________

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**0 1 . 2** Give an equation, including state symbols, to represent the process that occurs when the **third** ionisation energy of sodium is measured.

**[1 mark]**

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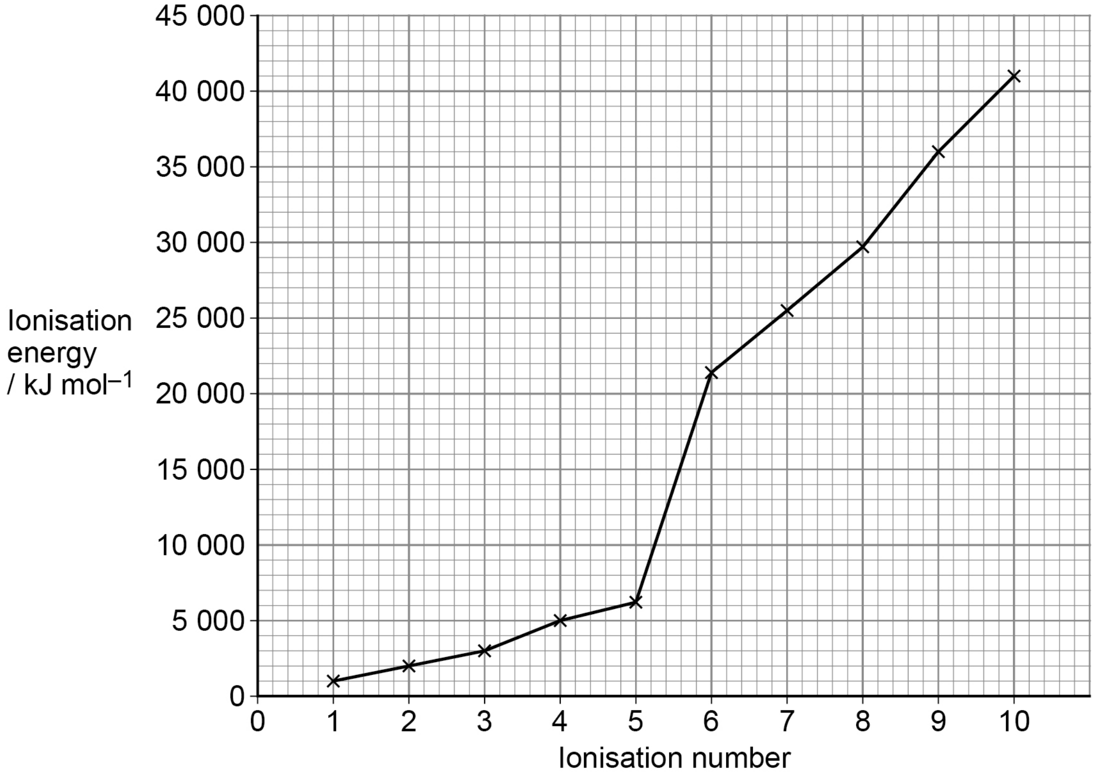
**0 1 . 3** **Figure 1** shows the successive ionisation energies of a Period 3 element, **X**.

**Figure 1**




Identify element **X**.
Explain your choice.

**[3 marks]**

Element ______________________________

Explanation ______________________________

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**7**

**Turn over for the next question**

**Turn over ►**

*Do not write outside the box*

**0 2** This question is about a titration.

A student dissolves an unknown mass of sodium hydroxide in water to make 200 $cm^3$ of an aqueous solution.

A 25.0 $cm^3$ sample of this sodium hydroxide solution is placed in a conical flask and is titrated with 0.150 mol $dm^{-3}$ sulfuric acid.

The equation for this reaction is shown.

$$2\,NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2\,H_2O(l)$$

**Table 1** shows the results of the titrations.

**Table 1**

| **Titration** | **Rough** | **1** | **2** | **3** |
|---|---|---|---|---|
| **Final reading / $cm^3$** | 20.75 | 40.35 | 21.05 | 40.60 |
| **Initial reading / $cm^3$** | 0.00 | 20.75 | 1.20 | 21.05 |
| **Titre / $cm^3$** | 20.75 | 19.60 | 19.85 | 19.55 |

**0 2 . 1** Calculate the mass of sodium hydroxide used to make the original solution.

**[5 marks]**

Mass of sodium hydroxide ______________________________ g

*Do not write outside the box*

**0 2 . 2** The student uses a funnel to fill the burette with sulfuric acid before starting the titration. After filling, the student forgets to remove the funnel from the top of the burette.

Suggest why this might affect the titre volume recorded.

**[1 mark]**

**0 2 . 3** State **one** advantage of using a conical flask rather than a beaker for the titration.

**[1 mark]**

**7**

**Turn over for the next question**

*Do not write outside the box*

**0 3** This question is about time of flight (TOF) mass spectrometry.

**0 3 . 1** Define the term relative atomic mass.

**[2 marks]**

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**0 3 . 2** A sample of krypton is ionised using electron impact.

The mass spectrum of this sample of krypton has four peaks.

**Table 2** shows data from this spectrum.

**Table 2**

| ***m/z*** | 82 | 83 | 84 | 86 |
|---|---|---|---|---|
| **Relative intensity** | 6 | 1 | 28 | 8 |

Calculate the relative atomic mass ($A_r$) of this sample of krypton.

Give your answer to 1 decimal place.

**[2 marks]**

$A_r$ ______________________________

Do not write outside the box

**0 3 . 3** In a TOF mass spectrometer, ions are accelerated to the same kinetic energy (*KE*).

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 / $m\,s^{-1}$

In a TOF mass spectrometer, each $^{84}Kr^{+}$ ion is accelerated to a kinetic energy of $4.83 \times 10^{-16}$ J and the time of flight is $1.72 \times 10^{-5}$ s

Calculate the length, in metres, of the TOF flight tube.

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

**[4 marks]**

Length of flight tube ______________________ m

8

**Turn over for the next question**

*Do not write outside the box*

**0 4** This question is about enthalpy changes.

**0 4 . 1** State the meaning of the term enthalpy change as applied to a chemical reaction.

**[1 mark]**

**0 4 . 2** A student determines the enthalpy change for the reaction between calcium carbonate and hydrochloric acid.

$$CaCO_3(s) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The student follows this method:

- measure out 50 $cm^3$ of 1.00 mol $dm^{-3}$ aqueous hydrochloric acid using a measuring cylinder and pour the acid into a 100 $cm^3$ glass beaker
- weigh out 2.50 g of solid calcium carbonate on a watch glass and tip the solid into the acid
- stir the mixture with a thermometer
- record the maximum temperature reached.

The student uses the data to determine a value for the enthalpy change.

Explain how the experimental method and use of apparatus can be improved to provide more accurate data.

Describe how this data from the improved method can be used to determine an accurate value for the temperature change.

**[6 marks]**

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**Question 4 continues on the next page**

**Turn over ►**

Do not write outside the box

**0 4 . 3** In a different experiment 50.0 $cm^3$ of 0.500 mol $dm^{-3}$ aqueous hydrochloric acid are reacted with 50.0 $cm^3$ of 0.500 mol $dm^{-3}$ aqueous sodium hydroxide.

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) \quad \Delta H = -57.1 \text{ kJ mol}^{-1}$$

The initial temperature of each solution is 18.5 °C

Calculate the maximum final temperature of the reaction mixture.

Assume that the specific heat capacity of the reaction mixture, $c$ = 4.18 J $K^{-1}$ $g^{-1}$

Assume that the density of the reaction mixture = 1.00 g $cm^{-3}$

**[5 marks]**

Final temperature ______________________________ °C

**0 4 . 4** Suggest how, without changing the apparatus, the experiment in Question **04.3** could be improved to reduce the percentage uncertainty in the temperature change.

**[1 mark]**

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**13**

*Do not write outside the box*

**0 5** This question is about Group 2 elements and their compounds.

**0 5 . 1** Explain why the melting point of magnesium is higher than the melting point of sodium.

**[2 marks]**

**0 5 . 2** Give an equation to show how magnesium is used as the reducing agent in the extraction of titanium.

Explain, in terms of oxidation states, why magnesium is the reducing agent.

**[2 marks]**

Equation

Explanation

**Question 5 continues on the next page**

*Do not write outside the box*

**0 5 . 3** State what is observed when dilute aqueous sodium hydroxide is added to separate solutions of magnesium chloride and barium chloride.

**[2 marks]**

Observation with magnesium chloride ____________________________________

Observation with barium chloride ____________________________________

**6**

*Do not write outside the box*

**0 6** This question is about shapes of molecules and ions.

Draw the shape of $NCl_3$ and of $NCl_4^+$

Include any lone pairs of electrons that influence the shape.

Name the shape of $NCl_3$

State and explain the bond angle in $NCl_4^+$

**[5 marks]**

**Shape of $NCl_3$** **Shape of $NCl_4^+$**

Name of shape of $NCl_3$ ______________________________

Bond angle in $NCl_4^+$ ______________________________

Explanation of bond angle in $NCl_4^+$ ______________________________

______________________________

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5

**Turn over for the next question**

*Do not write outside the box*

**0 7** This question is about Group 7 elements and their compounds.

**0 7 . 1** Chlorine is used to treat water even though it is toxic to humans.

Give **one** reason why water is treated with chlorine.

Explain why chlorine is added to water even though it is toxic.

Give an equation for the reaction of chlorine with cold water.

**[3 marks]**

Reason ____________________

____________________

Explanation ____________________

____________________

____________________

Equation

____________________

*Do not write outside the box*

**0 7 . 2** Solid sodium iodide reacts with concentrated sulfuric acid to form iodine and sulfur in a redox reaction.

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

Give a half-equation to show the conversion of sulfuric acid to sulfur.

Give an overall equation for this redox reaction.

Identify one other sulfur-containing reduction product formed when solid sodium iodide reacts with concentrated sulfuric acid.

**[4 marks]**

Half-equation for the conversion of iodide ions to iodine

_______________________________________________

Half-equation for the conversion of sulfuric acid to sulfur

_______________________________________________

Overall equation

_______________________________________________

Other sulfur-containing reduction product

_______________________________________________

**Question 7 continues on the next page**

*Do not write outside the box*

A student completes an experiment to determine the percentage by mass of sodium chloride in a mixture of sodium chloride and sodium iodide.

The student uses this method.

- 600 mg of the mixture are dissolved in water to form a solution.
- An excess of aqueous silver nitrate is added to the solution. This forms a precipitate containing silver chloride and silver iodide.
- Excess dilute ammonia solution is then added to the precipitate. The silver chloride dissolves.
- The silver iodide is filtered off from the solution, and is then washed and dried.

The mass of the silver iodide obtained is 315 mg

**0 7 . 3** Silver nitrate is added to the solution.

Suggest why an excess is used.

**[1 mark]**

______________________________________________

______________________________________________

______________________________________________

**0 7 . 4** Calculate the amount, in moles, of silver iodide obtained.

$M_r$(AgI) = 234.8

**[1 mark]**

Amount of silver iodide ____________________ mol

*Do not write outside the box*

**0 7 . 5** Calculate, using your answer to Question **07.4**, the mass, in grams, of sodium iodide in the mixture.

$M_r$(NaI) = 149.9

**[1 mark]**

Mass of sodium iodide ____________________ g

**0 7 . 6** Calculate, using your answer to Question **07.5**, the percentage by mass of sodium chloride in the mixture.

**[2 marks]**

Percentage of sodium chloride ____________________

12

**Turn over for the next question**

Do not write outside the box

**0 8** This question is about a volatile liquid, **A**.

**0 8 . 1** A student does an experiment to determine the relative molecular mass ($M_r$) of liquid **A** using the apparatus shown in **Figure 2**.

The student injects a sample of **A** into a gas syringe in an oven.

At the temperature of the oven, liquid **A** vaporises.

**Figure 2**

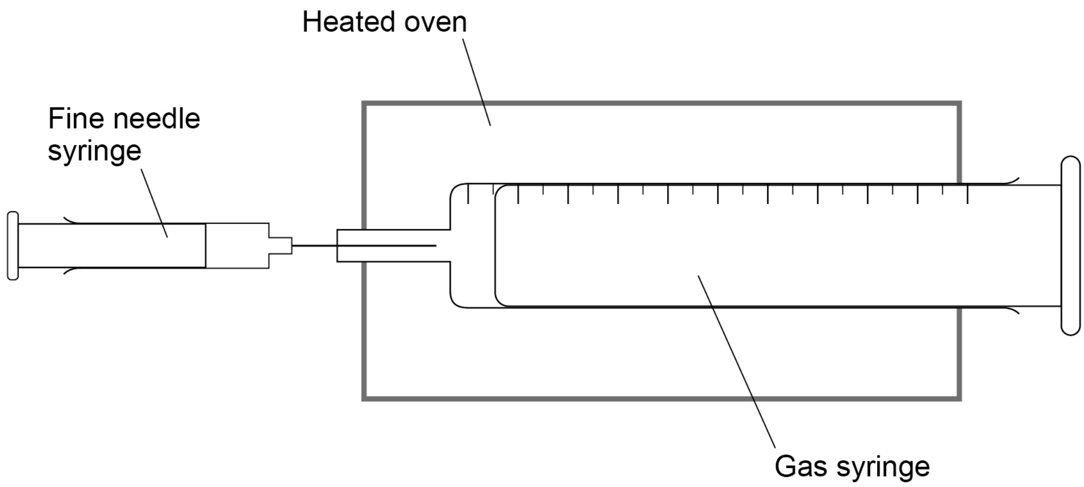


**Table 3** shows the student's results.

**Table 3**

| | |
|---|---|
| Mass of fine needle syringe and contents before injecting | 11.295 g |
| Mass of fine needle syringe and contents after injecting | 10.835 g |
| Volume reading on gas syringe before injecting | 0.0 $cm^3$ |
| Volume reading on gas syringe after injecting | 178.0 $cm^3$ |
| Pressure of gas in syringe | 100 kPa |
| Temperature of oven | 120 °C |

*Do not write outside the box*

Calculate the $M_r$ of **A**.

Give your answer to 3 significant figures.

The gas constant, $R$ = 8.31 J $K^{-1}$ $mol^{-1}$

**[4 marks]**

$M_r$ ____________________

**0 8 . 2** The student noticed that some of the liquid injected into the gas syringe did **not** vaporise.

Explain the effect that this has on the $M_r$ calculated by the student.

**[2 marks]**

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Question 8 continues on the next page**

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**Table 3** is repeated here.

**Table 3**

| | |
|---|---|
| Mass of fine needle syringe and contents before injecting | 11.295 g |
| Mass of fine needle syringe and contents after injecting | 10.835 g |
| Volume reading on gas syringe before injecting | 0.0 $cm^3$ |
| Volume reading on gas syringe after injecting | 178.0 $cm^3$ |
| Pressure of gas in syringe | 100 kPa |
| Temperature of oven | 120 °C |

**0 8 . 3** Each reading on the balance used to record the mass of the fine needle syringe and contents had an uncertainty of ±0.001 g

Calculate the percentage uncertainty in the mass of liquid **A** injected in this experiment.

**[1 mark]**

Percentage uncertainty ____________________________

**7**

*Do not write outside the box*

## Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.
For each answer 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 has the smallest number of neutrons?

**[1 mark]**

**A** $^{3}H$

**B** $^{4}He$

**C** $^{5}He$

**D** $^{4}Li$

**1 0** Which species contains bonds that have different polarities?

**[1 mark]**

**A** $NH_4^+$

**B** $CCl_4$

**C** $CH_3Cl$

**D** $H_3O^+$

**Turn over ►**

Do not write outside the box

**1 1** Which compound has hydrogen bonding?

**[1 mark]**

**A** NaH

**B** $NH_3$

**C** HI

**D** $SiH_4$

**1 2** Which reaction has an enthalpy change equal to the standard enthalpy of formation of lithium fluoride?

**[1 mark]**

**A** $Li(g) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$

**B** $Li^+(g) + F^-(g) \rightarrow LiF(s)$

**C** $Li^+(aq) + F^-(aq) \rightarrow LiF(s)$

**D** $Li(s) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$

**1 3** $NO_2^-$ ions can be reduced in acidic solution to NO

How many electrons are gained when each $NO_2^-$ ion is reduced?

**[1 mark]**

**A** 1

**B** 2

**C** 3

**D** 4

**1 4** Which is the electron configuration of an atom with **only two** unpaired electrons?

**[1 mark]**

**A** $1s^2 2s^2 2p^3$ ⬭

**B** $1s^2 2s^2 2p^4$ ⬭

**C** $1s^2 2s^2 2p^6 3s^2 3p^5$ ⬭

**D** $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ ⬭

**1 5** Which represents the correct order of increasing radius of the ions?

**[1 mark]**

**A** $F^-$ $O^{2-}$ $Li^+$ $Be^{2+}$ ⬭

**B** $Li^+$ $Be^{2+}$ $O^{2-}$ $F^-$ ⬭

**C** $Be^{2+}$ $Li^+$ $F^-$ $O^{2-}$ ⬭

**D** $O^{2-}$ $F^-$ $Li^+$ $Be^{2+}$ ⬭

**1 6** Which compound contains a co-ordinate bond?

**[1 mark]**

**A** HF ⬭

**B** $NH_3$ ⬭

**C** $CHCl_3$ ⬭

**D** $NH_4Cl$ ⬭

*Do not write outside the box*

**1 7** Which property increases down Group 7?

**[1 mark]**

**A** ability to oxidise a given reducing agent

**B** boiling point

**C** electronegativity

**D** first ionisation energy

**1 8** Which of these elements has the highest melting point?

**[1 mark]**

**A** Argon

**B** Chlorine

**C** Silicon

**D** Sulfur

**1 9** Which statement is **not** always correct for a reaction at equilibrium?

reactants $\rightleftharpoons$ products

**[1 mark]**

**A** The concentrations of the reactants and products are equal.

**B** The equilibrium can be achieved starting from the reactants.

**C** The equilibrium can be achieved starting from the products.

**D** The rate of the forward reaction is equal to the rate of the reverse reaction.

Do not write outside the box

**2 0** Two reactions of iron with oxygen are shown.

$$Fe(s) + \frac{1}{2}O_2(g) \rightarrow FeO(s) \qquad \Delta H = -272 \text{ kJ mol}^{-1}$$

$$2\,Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s) \qquad \Delta H = -822 \text{ kJ mol}^{-1}$$

What is the enthalpy change, in kJ mol$^{-1}$, for this reaction?

$$2\,FeO(s) + \frac{1}{2}O_2(g) \rightarrow Fe_2O_3(s)$$

**[1 mark]**

**A** +550

**B** –278

**C** –1094

**D** –1372

**2 1** Which compound contains chlorine in an oxidation state of +1?

**[1 mark]**

**A** $Cl_2O$

**B** $KClO_3$

**C** $ClF_3$

**D** $CCl_4$

**Turn over for the next question**

*Do not write outside the box*

**2 2** Which equation shows a redox reaction that does **not** occur?

**[1 mark]**

**A** $Br_2(aq) + 2KI(aq) \rightarrow I_2(aq) + 2KBr(aq)$

**B** $Cl_2(g) + 2KI(aq) \rightarrow I_2(aq) + 2KCl(aq)$

**C** $Cl_2(g) + 2KBr(aq) \rightarrow Br_2(aq) + 2KCl(aq)$

**D** $I_2(aq) + 2KBr(aq) \rightarrow Br_2(aq) + 2KI(aq)$

**2 3** Which molecule has a permanent dipole?

**[1 mark]**

**A** $CF_4$

**B** $PCl_5$

**C** $CO_2$

**D** $Cl_2O$

**15**

**END OF QUESTIONS**

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