

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname StemUp Model Solution

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS CHEMISTRY (9620)

Unit 1: Inorganic 1 and Physical 1

Friday 5 January 2024

07:00 GMT

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- 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 70.

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



J A N 2 4 C H O 1 0 1

Answer **all** questions in the spaces provided.

0 1

Gallium (Ga) is a metal.

0 1 . 1

Describe the bonding in solid gallium.

[2 marks]

Metallic bonding: there is a strong electrostatic attraction between a lattice of positive gallium ions (Ga^{3+}) and the sea of delocalised electrons.

Gallium forms GaCl_3 molecules.

0 1 . 2

Write an equation for the formation of GaCl_3 from its elements.

[1 mark]



0 1 . 3

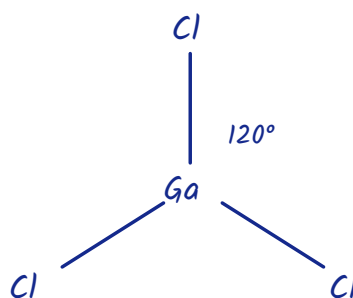
Draw the shape of a molecule of GaCl_3

Include any lone pairs of electrons, if any, that influence the shape.

Name the shape of the GaCl_3 molecule.

[2 marks]

Shape



(3 bonding pairs, no lone pairs on Ga)

Name of shape *trigonal planar*



0 1 . 4 A molecule of GaCl_3 reacts with a chloride ion to form a GaCl_4^- ion.

During this reaction a bond is formed.

Name the type of bond formed.

Describe how this bond is formed.

[2 marks]

Type of bond coordinate (dative covalent) bond

How bond is formed a lone pair of electrons on the chloride ion is donated to the gallium atom (into its empty orbital), so both shared electrons come from Cl^-

0 1 . 5 What is the difference, if any, between the Cl-Ga-Cl bond angle in GaCl_3 and in GaCl_4^- ?

Tick (✓) **one** box.

[1 mark]

The bond angle is bigger in GaCl_3

☒

The bond angle is the same

☐

The bond angle is smaller in GaCl_3

☐

8

Turn over for the next question

Turn over ►



0 2

This question is about reactions involving halide ions.

0 2 . 1

Give a reagent that could be used to distinguish between separate samples of aqueous potassium fluoride and aqueous potassium chloride.

Describe what you would observe for each solution.

[3 marks]

Reagent silver nitrate solution ($\text{AgNO}_3(\text{aq})$)

Observation with aqueous potassium fluoride no visible change

(stays a colourless solution)

Observation with aqueous potassium chloride a white precipitate forms (AgCl)

Aqueous bromine reacts with aqueous sulfur dioxide to form hydrobromic acid (HBr).

0 2 . 2

Write a half-equation for the reaction of bromine to form bromide ions.

[1 mark]



0 2 . 3

Write a half-equation for the reaction of an aqueous solution of sulfur dioxide to form hydrogen ions and sulfate(VI) ions.

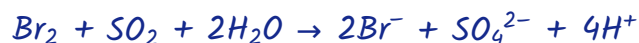
[1 mark]



0 2 . 4

Use your answers to Question 02.2 and Question 02.3 to deduce an overall equation for the reaction of bromine and aqueous sulfur dioxide to form hydrobromic acid.

[1 mark]



0 2 . 5

Identify the reducing agent in this reaction.

[1 mark]

sulfur dioxide (SO_2)



0 2 . 6

Chlorine gas is bubbled into an aqueous solution of potassium iodide.

Give **one** observation.

Write an equation for this reaction.

[2 marks]

Observation a black solid forms (the solution turns brown)

Equation



9

Turn over for the next question

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0 3

Time of flight (TOF) mass spectrometry is used to determine accurate relative atomic masses.

0 3 . 1

Define relative atomic mass.

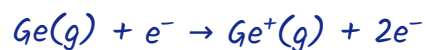
[2 marks]

*The average (weighted mean) mass of one atom of an element
compared with 1/12 of the mass of one atom of carbon-12.*

A sample of germanium (Ge) is ionised by electron impact.

0 3 . 2

Write an equation, including state symbols, for this ionisation.

[1 mark]

0 3 . 3

In a TOF mass spectrometer, some germanium ions are accelerated to a kinetic energy (KE) of 9.616×10^{-13} J

One germanium ion takes 3.739×10^{-7} s to travel along a 1.500 m flight tube.

$$KE = \frac{mv^2}{2}$$

m = mass of the ion / kg

v = velocity of ion / m s^{-1}

Calculate the mass, in g, of one mole of these germanium ions.

Use your answer to deduce the mass number of this germanium ion.

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

[5 marks]

$$v = d \div t = 1.500 \div (3.739 \times 10^{-7}) = 4.012 \times 10^6 \text{ m s}^{-1}$$

$$m = 2KE \div v^2 = (2 \times 9.616 \times 10^{-13}) \div (4.012 \times 10^6)^2$$

$$m = (1.9232 \times 10^{-12}) \div (1.6096 \times 10^{13}) = 1.195 \times 10^{-25} \text{ kg}$$

$$\text{mass of 1 mole} = 1.195 \times 10^{-25} \times 1000 \times 6.022 \times 10^{23}$$

$$= 71.96 \text{ g, so the mass number is 72}$$

Mass of one mole of germanium ions 71.96 g

Mass number 72

0 3 . 4

Explain why the atomic radius of ^{76}Ge is the same as the atomic radius of ^{74}Ge

[1 mark]

both isotopes have the same number of protons (same nuclear charge)

and the same number of electrons (same electron configuration)

9

Turn over for the next question

Turn over ►



0 4

This question is about compounds containing carbon.

0 4 . 1

Deduce the formula of silicon carbide.

[1 mark]

SiC

0 4 . 2

The C–F bond is polar.

Explain why CF₄ is a non-polar molecule.

[2 marks]

*CF₄ is a symmetrical (tetrahedral) molecule,
so the dipoles of the four polar C–F bonds cancel out and there is no
overall dipole.*

0 4 . 3

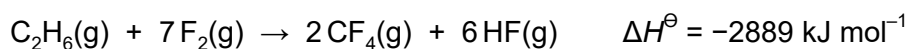
Ethane (C₂H₆) reacts with fluorine to form CF₄Table 1 gives some values of standard enthalpies of formation, $\Delta_f H^\ominus$

Table 1

Substance	C ₂ H ₆ (g)	F ₂ (g)	HF(g)
$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	–85	0	–269

Use the standard enthalpy change of the reaction and the data in Table 1
to calculate the standard enthalpy of formation, in kJ mol^{–1}, of CF₄(g)

[3 marks]

$$\Delta H = \Sigma \Delta_f H(\text{products}) - \Sigma \Delta_f H(\text{reactants})$$

$$-2889 = [2x + 6(-269)] - [(-85) + 7(0)]$$

$$2x = -2889 + 1614 - 85 = -1360$$

$$x = -1360 \div 2 = -680 \text{ kJ mol}^{-1}$$

Standard enthalpy of formation of CF₄(g) –680 kJ mol^{–1}



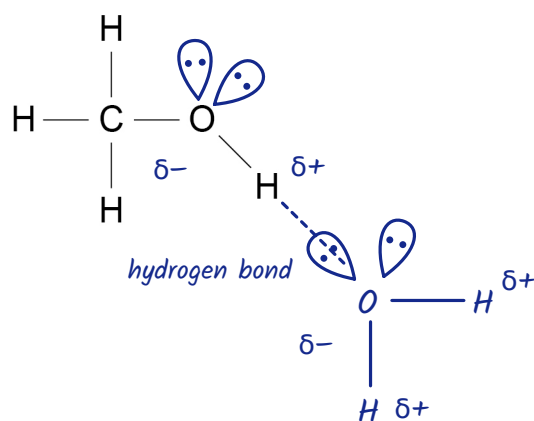
0 4 . 4

Methanol (CH_3OH) dissolves in water.

Name the strongest type of interaction between a molecule of methanol and a molecule of water.

Complete the diagram to show how one molecule of methanol interacts with one molecule of water.

Include all lone pairs and partial charges in your diagram.

[4 marks]Name hydrogen bond

0 5

This question is about a titration experiment.

0 5 . 1

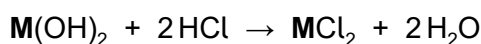
A student does a titration to identify a metal, **M**.

The student dissolves 2.43 g of the metal hydroxide, $\text{M}(\text{OH})_2$, in distilled water to make 250 cm^3 of an aqueous solution.

A 25.0 cm^3 sample of this $\text{M}(\text{OH})_2$ solution is titrated with $0.104 \text{ mol dm}^{-3}$ hydrochloric acid.

The mean titre is 27.30 cm^3

The equation for the reaction is



Calculate the relative atomic mass of **M**.

Give your answer to 1 decimal place.

Identify **M**.

[6 marks]

$$n(\text{HCl}) = 0.104 \times 27.30 \div 1000 = 0.00284 \text{ mol}$$

$$n(\text{M}(\text{OH})_2) \text{ in } 25.0 \text{ cm}^3 = 0.00284 \div 2 = 0.00142 \text{ mol}$$

$$n(\text{M}(\text{OH})_2) \text{ in } 250 \text{ cm}^3 = 10 \times 0.00142 = 0.0142 \text{ mol}$$

$$M_r(\text{M}(\text{OH})_2) = \text{mass} \div \text{moles} = 2.43 \div 0.0142 = 171.1$$

$$A_r(\text{M}) = 171.1 - 2(16.0 + 1.0) = 171.1 - 34.0 = 137.1$$

M forms a 2+ ion (Group 2) with A_r 137.1, so M is barium

Relative atomic mass of **M** 137.1

Identity of **M** barium (Ba)



The student makes the solution of the metal hydroxide in Question **05.1** as follows.

- Step 1** Weighs out the solid metal hydroxide and records the mass to 2 decimal places
- Step 2** Transfers the solid to a beaker
- Step 3** Dissolves the solid in distilled water
- Step 4** Transfers the solution, with washings from the beaker, to a suitable piece of equipment
- Step 5** Makes up the volume of solution with distilled water to exactly 250 cm^3

0 5 . 2

Describe what the student must do to make sure they know the exact mass of the solid metal hydroxide in **Step 1**.

[1 mark]

reweigh the weighing bottle after tipping the solid into the beaker and use the difference in mass (or wash all the solid from the weighing boat into the beaker)

0 5 . 3

Name a suitable piece of equipment the student would use in **Step 4**.

[1 mark]

a 250 cm^3 volumetric flask

0 5 . 4

Describe how the student would make the solution up to exactly 250 cm^3 in **Step 5**.

[1 mark]

add distilled water drop by drop (with a dropping pipette) until the bottom of the meniscus is exactly on the graduation line

Question 5 continues on the next page

Turn over ►



0 5 . 5 Table 2 shows the results of the experiment.

Table 2

	Rough	1	2	3
Final reading / cm³	29.20	29.55	29.35	30.95
Initial reading / cm³	1.50	2.20	1.85	3.70
Titre / cm³	27.70	27.35	27.50	27.25

Explain why the mean titre used in the calculation in Question **05.1** is 27.30 cm³

[1 mark]

titres 1 and 3 are concordant (within 0.10 cm³ of each other), so only these are averaged: $(27.35 + 27.25) \div 2 = 27.30 \text{ cm}^3$

0 5 . 6 Distilled water is used to wash down the sides of the conical flask near the end of the titration.

Give **one** reason why this washing is done.

Give **one** reason why distilled water is used.

[2 marks]

Reason for washing down the sides of the flask *to make sure all the reagents splashed onto the sides end up in the solution and react*

Reason why distilled water is used *water does not react with the acid or alkali, so the number of moles of reactants does not change*



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0 6

This question is about the elements in Group 2, from Mg to Ba, and their compounds.

0 6 . 1

State why the atomic radius of barium is larger than the atomic radius of calcium.

[1 mark]*barium has more electron shells (energy levels) than calcium***0 6 . 2**

Strontium reacts with hydrochloric acid.

When 0.123 g of strontium is added to hydrochloric acid, a gas is produced.

Write an equation for the reaction of strontium with hydrochloric acid.

Calculate the volume, in cm^3 , of the gas produced at 101 kPa and 25 °C
Give your answer to 3 significant figures.The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ **[6 marks]**Equation *$\text{Sr} + 2\text{HCl} \rightarrow \text{SrCl}_2 + \text{H}_2$*

$$n(\text{Sr}) = 0.123 \div 87.6 = 1.404 \times 10^{-3} \text{ mol} = n(\text{H}_2)$$

$$p = 101\,000 \text{ Pa} \quad T = 25 + 273 = 298 \text{ K}$$

$$V = nRT \div p = (1.404 \times 10^{-3} \times 8.31 \times 298) \div 101\,000$$

$$V = 3.44 \times 10^{-5} \text{ m}^3$$

$$V = 3.44 \times 10^{-5} \times 10^6 = 34.4 \text{ cm}^3 \text{ (3 s.f.)}$$

Volume 34.4 cm^3 

Two Group 2 metals, **Y** and **Z**, form chlorides **YCl₂** and **ZCl₂**
A student does some test tube reactions with solutions of **YCl₂** and **ZCl₂**
The observations are shown in **Table 3**.

Table 3

	Addition of potassium hydroxide solution	Addition of potassium sulfate solution
YCl₂	Colourless solution	White precipitate
ZCl₂	White precipitate	Colourless solution

0 6 . 3 Identify metal **Y** and metal **Z**.

[2 marks]

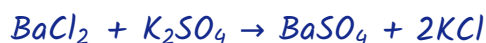
Metal **Y** barium (Ba) Metal **Z** magnesium (Mg)

0 6 . 4 Write equations to show the formation of each of the white precipitates.

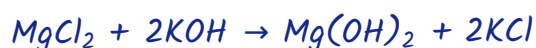
If you were unable to identify the metals **Y** and **Z**, you should use **YCl₂** and **ZCl₂** in your equations.

[2 marks]

Equation 1



Equation 2



0 6 . 5 A student dissolves 2.53 g of calcium chloride in water at 20.0 °C in a plastic cup. 50.0 cm³ of solution are formed and the temperature of the solution rises to 25.4 °C

Calculate a value for the enthalpy change, in kJ mol⁻¹, when calcium chloride dissolves in water.

Specific heat capacity of the solution is 4.18 J g⁻¹ K⁻¹
Assume that the density of the solution is 1.00 g cm⁻³

[3 marks]

$$Q = mc\Delta T = 50.0 \times 4.18 \times 5.4 = 1128.6 \text{ J} = 1.129 \text{ kJ}$$

$$n(\text{CaCl}_2) = 2.53 \div 111.1 = 0.0228 \text{ mol}$$

$$\Delta H = -1.129 \div 0.0228 = -49.5 \text{ kJ mol}^{-1}$$

Enthalpy change -49.5 kJ mol⁻¹

14**Turn over ►**

0 7

This question is about physical properties of elements in Period 3.

0 7 . 1

Identify the element in Period 3 with the lowest melting point.

[1 mark]

argon (Ar)

0 7 . 2

State the meaning of electronegativity.

[1 mark]

*the power of an atom to attract the pair of electrons in a covalent**bond*

0 7 . 3

Suggest why the electronegativity of the elements in Period 3 increases from sodium to chlorine.

[2 marks]

*Across the period the number of protons increases, so the nuclear charge increases.**The outer electrons are in the same shell, so the shielding is similar and the atoms get smaller, so the bonding pair is attracted more strongly.*

0 7 . 4

Table 4 shows successive ionisation energies of an element in Period 3.

Table 4

Ionisation number	1	2	3	4	5	6	7	8
Ionisation energy / kJ mol ⁻¹	1060	1900	2920	4960	6280	21 200	25 900	30 500

Identify this element.

[1 mark]

phosphorus (P)

07.5

Write an equation, including state symbols, to show the process that occurs when the **second** ionisation energy of sodium is measured.

[1 mark]

07.6

Explain why sodium has a higher **second** ionisation energy than magnesium.

[2 marks]

The second electron removed from sodium comes from the 2p sub-shell (second energy level), whereas for magnesium it comes from the 3s sub-shell.

The 2p electron is closer to the nucleus and less shielded, so it is attracted more strongly and more energy is needed to remove it.

8

END OF QUESTIONS

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2 4 1 X C H O 1

