

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

A-level CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

Tuesday 4 June 2019

Afternoon

Time allowed: 2 hours

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.
- 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 105.

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



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

0 1

Figure 1 shows an incomplete Born–Haber cycle for the formation of caesium iodide. The diagram is not to scale.

Figure 1

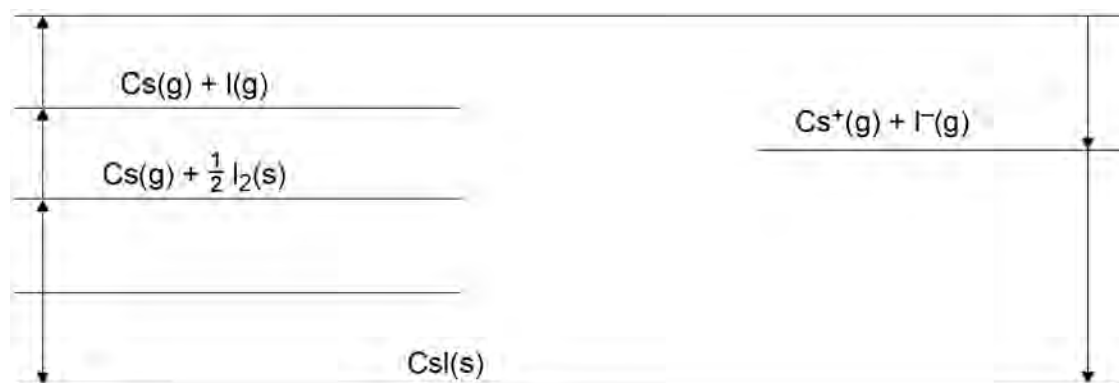


Table 1 gives values of some standard enthalpy changes.

Table 1

Name of enthalpy change	$\Delta H^\ominus / \text{kJ mol}^{-1}$
Enthalpy of atomisation of caesium	+79
First ionisation energy of caesium	+376
Electron affinity of iodine	-314
Enthalpy of lattice formation of caesium iodide	-585
Enthalpy of formation of caesium iodide	-337

0 1 . 1

Complete **Figure 1** by writing the formulas, including state symbols, of the appropriate species on each of the two blank lines.

[2 marks]

0 1 . 2

Use **Figure 1** and the data in **Table 1** to calculate the standard enthalpy of atomisation of iodine.

[2 marks]

Standard enthalpy of atomisation of iodine _____ kJ mol^{-1}



- 0 1 . 3** The enthalpy of lattice formation for caesium iodide in **Table 1** is a value obtained by experiment.
The value obtained by calculation using the perfect ionic model is -582 kJ mol^{-1}

Deduce what these values indicate about the bonding in caesium iodide.

[1 mark]

- 0 1 . 4** Use data from **Table 2** to show that this reaction is **not** feasible at 298 K

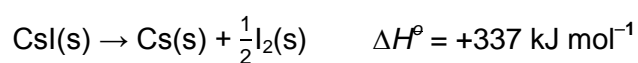


Table 2

	CsI(s)	Cs(s)	I₂(s)
S[∘] / J K⁻¹ mol⁻¹	130	82.8	117

[4 marks]

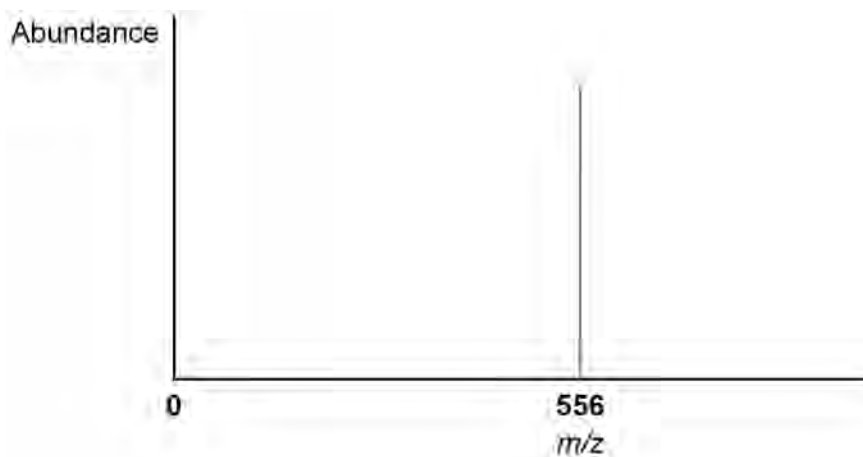


0 2

Time of flight (TOF) mass spectrometry can be used to analyse large molecules such as the pentapeptide, leucine enkephalin (**P**).

P is ionised by electrospray ionisation and its mass spectrum is shown in **Figure 2**.

Figure 2



0 2 . 1

Describe the process of electrospray ionisation.

Give an equation to represent the ionisation of **P** in this process.

[4 marks]

Description _____

Equation



0 2 . 2

What is the relative molecular mass of **P**?Tick (✓) **one** box.

[1 mark]

555

556

557

0 2 . 3

A molecule **Q** is ionised by electron impact in a TOF mass spectrometer.The **Q**⁺ ion has a kinetic energy of $2.09 \times 10^{-15} \text{ J}$ This ion takes $1.23 \times 10^{-5} \text{ s}$ to reach the detector.

The length of the flight tube is 1.50 m

Calculate the relative molecular mass of **Q**.

$$KE = \frac{1}{2}mv^2 \quad \text{where } m = \text{mass (kg) and } v = \text{speed (m s}^{-1}\text{)}$$

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

[5 marks]

Relative molecular mass _____

10

Turn over ►



0 3 This question is about periodicity, the Period 4 elements and their compounds.

0 3 . 1 State the meaning of the term periodicity.

[1 mark]

0 3 . 2 Identify the element in Period 4 with the highest electronegativity value.

[1 mark]

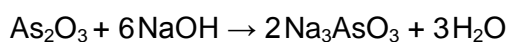
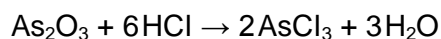
0 3 . 3 Identify the element in Period 4 with the largest atomic radius.
Explain your answer.

[3 marks]

Element _____

Explanation _____

0 3 . 4 The equations for two reactions of arsenic(III) oxide are shown.



Name the property of arsenic(III) oxide that describes its ability to react in these two ways.

[1 mark]

0 3 . 5 Complete the equation for the formation of arsenic hydride.

[1 mark]

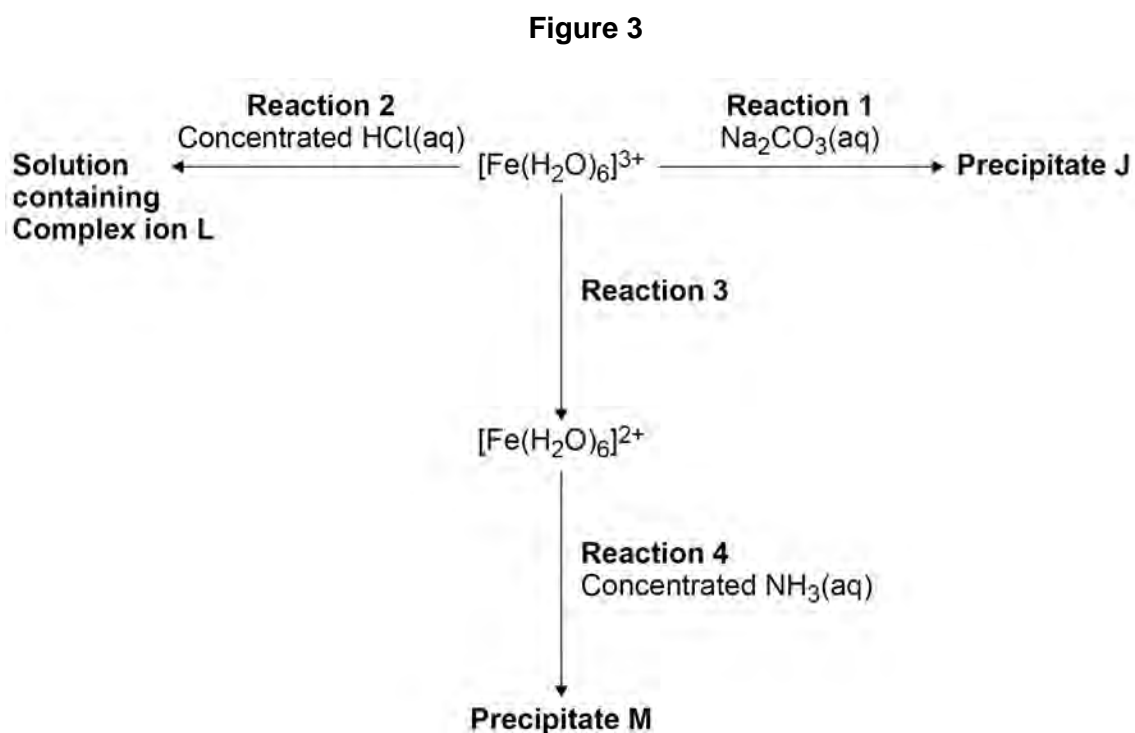


7



0 4

Figure 3 shows some reactions of aqueous iron ions.



0 4 . 1

Give the formula of **Precipitate J** and state its colour.
Give an equation for **Reaction 1**.

[3 marks]

Formula of **J** _____

Colour _____

Equation _____

0 4 . 2

Give the formula of **L** and an equation for **Reaction 2**.

[2 marks]

Formula of **L** _____

Equation _____

0 4 . 3

Suggest a reagent for **Reaction 3**.

[1 mark]

Turn over ►



0 5

This question is about some Group 7 compounds.

0 5 . 1

Solid sodium chloride reacts with concentrated sulfuric acid.

Give an equation for this reaction.

State the role of the sulfuric acid in this reaction.

[2 marks]

Equation

Role

0 5 . 2

Fumes of sulfur dioxide are formed when sodium bromide reacts with concentrated sulfuric acid.

For **this** reaction

- give an equation
- give **one** other observation
- state the role of the sulfuric acid.

[3 marks]

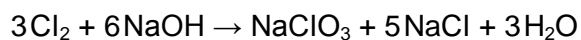
Equation

Observation

Role

0 5 . 3

Chlorine reacts with hot aqueous sodium hydroxide as shown in the equation.

Give the oxidation state of chlorine in NaClO_3 and in NaCl **[1 mark]** NaClO_3

 NaCl



0 5 . 4 State, in terms of redox, what happens to chlorine in the reaction in Question **05.3**.
[1 mark]

0 5 . 5 Solution **Y** contains **two** different negative ions.

To a sample of solution **Y** in a test tube a student adds

- silver nitrate solution
- then an excess of dilute nitric acid
- finally an excess of concentrated ammonia solution.

The observations after each addition are recorded in **Table 3**.

Table 3

Reagent added to solution Y	Observation
silver nitrate solution	cream precipitate containing compound D and compound E
excess dilute nitric acid	cream precipitate D and bubbles of gas F
excess concentrated ammonia solution	colourless solution containing complex ion G

Give the formulas of **D**, **E** and **F**.

Give an **ionic** equation to show the formation of **E**.

Give an equation to show the conversion of **D** into **G**.

[6 marks]

Formula of **D** _____

Formula of **E** _____

Formula of **F** _____

Ionic equation to form **E**

Equation to show the conversion of **D** into **G**



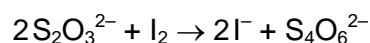
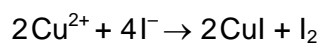
0 6

A student does an experiment to determine the percentage of copper in an alloy.

The student

- reacts 985 mg of the alloy with concentrated nitric acid to form a solution (all of the copper in the alloy reacts to form aqueous copper(II) ions)
- pours the solution into a volumetric flask and makes the volume up to 250 cm³ with distilled water
- shakes the flask thoroughly
- transfers 25.0 cm³ of the solution into a conical flask and adds an excess of potassium iodide
- uses exactly 9.00 cm³ of 0.0800 mol dm⁻³ sodium thiosulfate (Na₂S₂O₃) solution to react with all the iodine produced.

The equations for the reactions are

**0 6 . 1**

Calculate the percentage of copper by mass in the alloy.

Give your answer to the appropriate number of significant figures.

[6 marks]

% copper _____



0 6 . 2

Suggest **two** ways that the student could reduce the percentage uncertainty in the measurement of the volume of sodium thiosulfate solution, using the same apparatus as this experiment.

[2 marks]

1 _____

2 _____

0 6 . 3

State the role of iodine in the reaction with sodium thiosulfate.

[1 mark]

0 6 . 4

Give the full electron configuration of a copper(II) ion.

[1 mark]

0 6 . 5

Copper(I) iodide is a white solid.

Explain why copper(I) iodide is white.

[2 marks]

Question 6 continues on the next page**Turn over ►**

0 6 . 6 Iodine vaporises easily.

Calculate the volume, in cm^3 , that 5.00 g of iodine vapour occupies at $185\text{ }^\circ\text{C}$ and 100 kPa

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

Give your answer to 3 significant figures.

[4 marks]

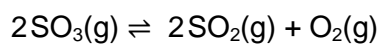
Volume _____ cm^3

16



0 7

Sulfur trioxide decomposes on heating to form an equilibrium mixture containing sulfur dioxide and oxygen.

**0 7 . 1**

A sample of sulfur trioxide was heated and allowed to reach equilibrium at a given temperature.

The equilibrium mixture contained 6.08 g of sulfur dioxide.

Calculate the mass, in g, of oxygen gas in the equilibrium mixture.

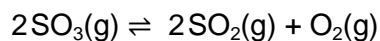
[2 marks]

Mass _____ g

Question 7 continues on the next page**Turn over ►**

07.2

A different mass of sulfur trioxide was heated and allowed to reach equilibrium at 1050 K



The amounts of each substance in the equilibrium mixture are shown in **Table 4**.

Table 4

Substance	Amount at equilibrium / mol
sulfur trioxide	0.320
sulfur dioxide	1.20
oxygen	0.600

For this reaction at 1050 K the equilibrium constant, $K_p = 7.62 \times 10^5 \text{ Pa}$

Calculate the mole fraction of each substance at equilibrium.

Give the expression for the equilibrium constant, K_p

Calculate the total pressure, in Pa, of this equilibrium mixture.

[4 marks]

Mole fraction SO_3 _____

Mole fraction SO_2 _____

Mole fraction O_2 _____

K_p

Total pressure _____ Pa



0 7 . 3

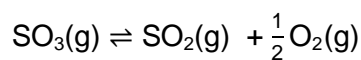
For this reaction at 1050 K the equilibrium constant, $K_p = 7.62 \times 10^5 \text{ Pa}$
 For this reaction at 500 K the equilibrium constant, $K_p = 3.94 \times 10^4 \text{ Pa}$

Explain how this information can be used to deduce that the forward reaction is endothermic.

[2 marks]

0 7 . 4

Use data from Question **07.3** to calculate the value of K_p , at 500 K, for the equilibrium represented by this equation.
 Deduce the units of K_p

**[2 marks]** K_p _____

Units _____

10**Turn over for the next question****Turn over ►**

0 8

This question is about structure and bonding.

0 8 . 1

Draw a diagram to show the strongest type of interaction between two molecules of ethanol ($\text{C}_2\text{H}_5\text{OH}$) in the liquid phase.

Include all lone pairs and partial charges in your diagram.

[3 marks]

0 8 . 2

Methoxymethane (CH_3OCH_3) is an isomer of ethanol.

Table 5 shows the boiling points of ethanol and methoxymethane.

Table 5

Compound	Boiling point / °C
ethanol	78
methoxymethane	-24

In terms of the intermolecular forces involved, explain the difference in boiling points.

[3 marks]



Extra space _____

0 8 . 3

Draw the shape of the POCl_3 molecule and the shape of the ClF_4^- ion.
Include any lone pairs of electrons that influence the shapes.

In a POCl_3 molecule the oxygen atom is attached to the phosphorus atom by a double bond that uses two electrons from phosphorus.

Name each shape.

Suggest a value for the bond angle in ClF_4^-

Shape of POCl_3

Shape of ClF_4^-

[5 marks]

Name of shape of POCl_3 _____

Name of shape of ClF_4^- _____

Bond angle in ClF_4^- _____

11

Turn over for the next question

Turn over ►



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0 9

This question is about different pH values.

0 9 . 1

For pure water at 40 °C, pH = 6.67
A student thought that the water was acidic.

Explain why the student was incorrect.

Determine the value of K_w at this temperature.

[4 marks]

Explanation _____

K_w _____ $\text{mol}^2 \text{dm}^{-6}$

Question 9 continues on the next page

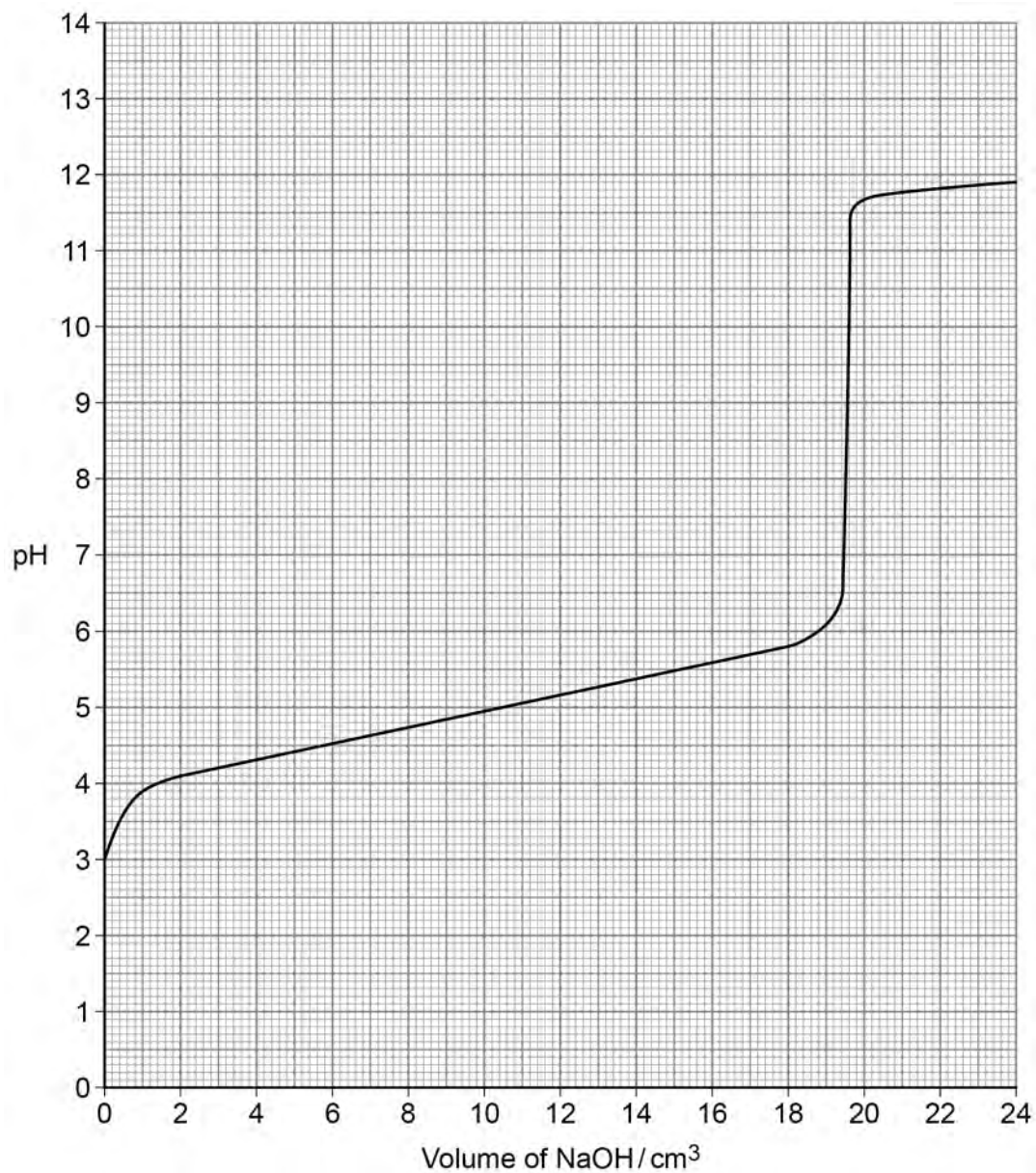
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09.2

Sodium hydroxide solution was added gradually from a burette to 25 cm³ of 0.080 mol dm⁻³ propanoic acid at 25 °C
The pH was measured and recorded at regular intervals.

The results are shown in **Figure 4**.

Figure 4



Use **Figure 4** to determine the value of K_a for propanoic acid at 25 °C

Show your working.

[3 marks]

K_a _____ mol dm⁻³

0 9 . 3

Suggest which indicator is the most appropriate for the reaction in Question **09.2?**

Tick (✓) **one** box.

[1 mark]

Indicator	pH range	Tick (✓) one box
methyl orange	3.1 – 4.4	
bromothymol blue	6.0 – 7.6	
cresolphthalein	8.2 – 9.8	
indigo carmine	11.6 – 13.0	

Question 9 continues on the next page

Turn over ►



0 9 . 4

A student prepared a buffer solution by adding 0.0136 mol of a salt KX to 100 cm³ of a 0.500 mol dm⁻³ solution of a weak acid HX and mixing thoroughly.

The student then added 3.00×10^{-4} mol of potassium hydroxide to the buffer solution.

Calculate the pH of the buffer solution after adding the potassium hydroxide.

For the weak acid HX at 25 °C the value of the acid dissociation constant, $K_a = 1.41 \times 10^{-5}$ mol dm⁻³.

Give your answer to two decimal places.

[6 marks]

pH _____



09.5

A buffer solution has a constant pH even when diluted.

Use a mathematical expression to explain this.

[1 mark]

15

END OF QUESTIONS



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2 8



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