1 (a) State the meaning of the term *mass number* of an isotope.

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(1 mark)

1 (b) Give the symbol of the element that has an isotope with a mass number of 68 and has 38 neutrons in its nucleus.

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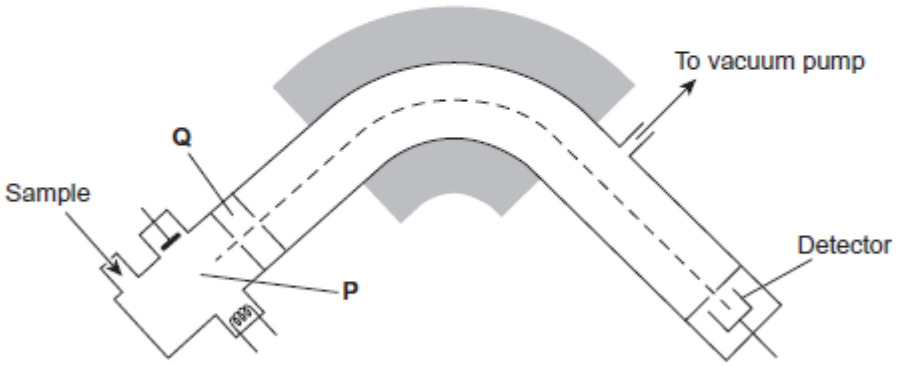
(1 mark)

1 (c) The following shows a simplified diagram of a mass spectrometer.



1 (c) (i) State what happens to the sample in the parts labelled **P** and **Q**.

P .....

Q .....

(2 marks)

1 (c) (ii) In a mass spectrometer, the isotopes of an element are separated.
Two measurements for each isotope are recorded on the mass spectrum.

State the **two** measurements that are recorded for each isotope.

Measurement 1 .....

Measurement 2 .....

(2 marks)

1 (d) A sample of element **R** contains isotopes with mass numbers of 206, 207 and 208 in a 1:1:2 ratio of abundance.

1 (d) (i) Calculate the relative atomic mass of **R**. Give your answer to one decimal place.

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(3 marks)

1 (d) (ii) Identify **R**.

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(1 mark)

1 (d) (iii) All the isotopes of **R** react in the same way with concentrated nitric acid.

State why isotopes of an element have the same chemical properties.

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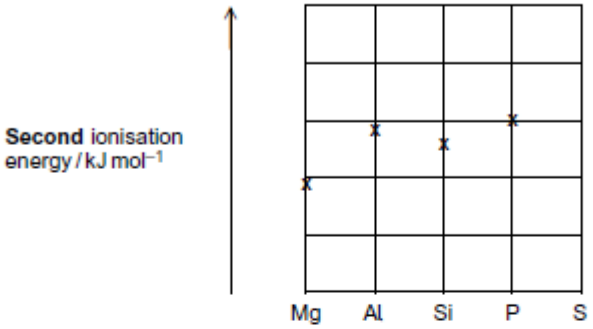
(1 mark)

(Extra space) .....

2 (a) Use your knowledge of electron configuration and ionisation energies to answer this question.
The following diagram shows the **second** ionisation energies of some Period 3 elements.



2 (a) (i) Draw an '**X**' on the diagram to show the **second** ionisation energy of sulfur.

(1 mark)

2 (a) (ii) Write the full electron configuration of the Al^{2+} ion.

.....

(1 mark)

2 (a) (iii) Write an equation to show the process that occurs when the **second** ionisation energy of aluminium is measured.

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(1 mark)

2 (a) (iv) Give **one** reason why the **second** ionisation energy of silicon is lower than the **second** ionisation energy of aluminium.

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(1 mark)

2 (b) Predict the element in Period 3 that has the highest **second** ionisation energy.
Give a reason for your answer.

Element .....

Reason .....

.....

.....

(2 marks)

2 (c) The following table gives the successive ionisation energies of an element in Period 3.

	First	Second	Third	Fourth	Fifth	Sixth
Ionisation energy / kJ mol^{-1}	786	1580	3230	4360	16 100	19 800

Identify this element.

.....

(1 mark)

2 (d) Explain why the ionisation energy of every element is endothermic.

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(1 mark)

(Extra space) .....

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3 The following table shows the electronegativity values of the elements from lithium to fluorine.

	Li	Be	B	C	N	O	F
Electronegativity	1.0	1.5	2.0	2.5	3.0	3.5	4.0

3 (a) (i) State the meaning of the term *electronegativity*.

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(2 marks)

(Extra space) .....

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3 (a) (ii) Suggest why the electronegativity of the elements increases from lithium to fluorine.

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(2 marks)

(Extra space) .....

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3 (b) State the type of bonding in lithium fluoride.
Explain why a lot of energy is needed to melt a sample of solid lithium fluoride.

Bonding .....

Explanation .....

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(3 marks)

(Extra space) .....

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4)

Ammonia is used to make nitric acid (HNO_3) by the Ostwald Process.
Three reactions occur in this process.

Reaction **1** $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

Reaction **2** $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

Reaction **3** $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$

(a) In one production run, the gases formed in Reaction **1** occupied a total volume of $4.31\ m^3$ at 25 °C and 100 kPa.

Calculate the amount, in moles, of NO produced.
Give your answer to 3 significant figures.
(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

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(4 marks)

(Extra space) .....

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(b) In another production run, 3.00 kg of ammonia gas were used in Reaction **1** and all of the NO gas produced was used to make NO_2 gas in Reaction **2**.

(b) (i) Calculate the amount, in moles, of ammonia in 3.00 kg.

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(2 marks)

(b) (ii) Calculate the mass of NO_2 formed from 3.00 kg of ammonia in Reaction **2** assuming an 80.0% yield.
Give your answer in kilograms.
(If you have been unable to calculate an answer for part **(b) (i)**, you may assume a value of 163 mol. This is **not** the correct answer.)

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(3 marks)

(Extra space) .....

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(c) Consider Reaction **3** in this process.

$$3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$$

Calculate the concentration of nitric acid produced when 0.543 mol of NO_2 is reacted with water and the solution is made up to 250 cm^3.

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(2 marks)

(Extra space) .....

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(d) Suggest why a leak of NO_2 gas from the Ostwald Process will cause atmospheric pollution.

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(1 mark)

(e) Give **one** reason why excess air is used in the Ostwald Process.

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(1 mark)

(f) Ammonia reacts with nitric acid as shown in this equation.

$$NH_3 + HNO_3 \longrightarrow NH_4NO_3$$

Deduce the type of reaction occurring.

.....

(1 mark)

5)

Chlorine can form molecules and ions that contain only chlorine, or that contain chlorine combined with another element.

(a) Use your understanding of the electron pair repulsion theory to draw the shape of the $AsCl_3$ molecule and the shape of the Cl_3^+ ion.
Include any lone pairs of electrons that influence the shape.

Name the shape made by the atoms in the $AsCl_3$ molecule and in the Cl_3^+ ion.

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(4 marks)

(Extra space) .....

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(b) Explain why the $AsCl_4^+$ ion has a bond angle of 109.5°

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(2 marks)

(Extra space) .....

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6)

Copper is extracted from the ore chalcopyrite ($CuFeS_2$) in a three-stage process.

(a) In the first stage of this extraction, the chalcopyrite is heated with silicon dioxide and oxygen.

(a) (i) Balance the following equation for this first stage in which copper(I) sulfide is formed.

……$CuFeS_2$ + ……SiO_2 + ……O_2 ⟶ Cu_2S + ……$FeSiO_3$ + ……SO_2

(1 mark)

(a) (ii) Give **one** environmental reason why the SO_2 gas formed in this reaction is not allowed to escape into the atmosphere.

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(1 mark)

(a) (iii) State **one** use for the sulfur dioxide formed in this reaction.

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(1 mark)

(b) In the second stage of this extraction, the copper(I) sulfide is converted into copper(II) oxide. This occurs by roasting the sulfide with oxygen at high temperature. Write an equation for this reaction.

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(1 mark)

(c) In the third stage of this extraction, copper(II) oxide is reduced to copper by its reaction with carbon. Write an equation for this reaction.

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(1 mark)

(d) Scrap iron can be used to extract copper from dilute aqueous solutions containing copper(II) ions.

(d) (i) Explain why this is a low-cost method of extracting copper.

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(1 mark)

(d) (ii) Write the **simplest ionic** equation for the reaction of iron with copper(II) ions in aqueous solution.

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(1 mark)