

1 This question is about the elements with atomic numbers between 58 and 70.

(a) Cerium, atomic number 58, is a metal.

Complete the table to show the relative charge of each particle and the number of each particle found in a $^{140}\text{Ce}^{2+}$ ion.

Particle	Relative charge of each particle	Number of each particle present in a $^{140}\text{Ce}^{2+}$ ion
proton		
neutron		
electron		

[2]

(b) Cerium behaves as a typical metal when it reacts with dilute sulfuric acid to form the salt cerium(III) sulfate and a second product.

(i) Identify the second product.

..... [1]

(ii) Write the formula of cerium(III) sulfate and, explain what has happened to the cerium in this reaction in terms of the number of electrons transferred.

Formula

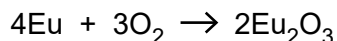
Explanation

..... [2]

(iii) How has a salt been formed in this reaction?

.....
..... [1]

(c) Europium, atomic number 63, reacts with oxygen at room temperature.



Calculate the volume of oxygen, in cm^3 , required to fully react with 9.12 g of europium at room temperature and pressure.

Volume = cm^3 [2]

(d) A compound of thulium, atomic number 69, has the following composition by mass:

O 30.7% S 15.4% Tm 53.9%

(i) State what is meant by the term *empirical formula*.

.....
..... [1]

(ii) Determine the empirical formula of the compound.

Show your working.

Empirical formula = [2]

(e) Ytterbium, atomic number 70, is the first element in the Periodic Table to have the first four shells full.

(i) State the number of electrons in the **fourth** shell of ytterbium.

..... [1]

(ii) How many orbitals are there in the **third** shell of ytterbium?

..... [1]

[Total: 13]

2 This question is about Group 7 elements.

(a) Chlorine can be made by the redox reaction below.



Using oxidation numbers, show what has been oxidised and what has been reduced in this reaction.

Oxidised

.....

Reduced

.....

[2]

(b) Complete the electron configuration of a manganese atom.

1s² [1]

(c) Chlorine gas can be added to a cold, dilute alkaline solution to form bleach.

Write the equation for this reaction.

..... [1]

(d) A student bubbles chlorine gas through aqueous potassium iodide. A reaction takes place.

(i) State what the student would observe.

..... [1]

(ii) Write the ionic equation for this reaction.

Include state symbols.

..... [1]

(e) Chlorine gas reacts with methane. One of the products is dichloromethane, CH_2Cl_2 .

(i) Chlorine is more electronegative than carbon and hydrogen, which have approximately equal electronegativity values.

Explain what is meant by the term *electronegativity*.

.....
.....
..... [2]

(ii) Draw a 3-D diagram of a molecule of CH_2Cl_2 .

Use partial charges to indicate polar bonds.

[2]

(iii) Explain why a CH_2Cl_2 molecule is polar.

.....
.....
..... [1]

(f) Bromine has two isotopes, Br-79 and Br-81. The relative atomic mass of bromine is 79.9.

Calculate the percentage of Br-79 atoms in a sample of bromine.

Answer = % [1]

[Total: 12]

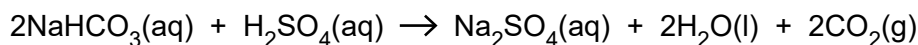
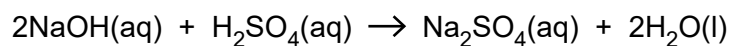
- 3 A student was given 200 cm³ of solution **X** in which sodium hydroxide, NaOH, and sodium hydrogencarbonate, NaHCO₃, had **both** been dissolved.

The student carried out **two different** titrations on samples of solution **X** using 0.100 mol dm⁻³ sulfuric acid, H₂SO₄.

- In the first titration, **both** NaOH **and** NaHCO₃ were neutralised.
- In the second titration, **only** NaOH was neutralised.

The student's results for the titrations of 25.0 cm³ samples of solution **X** are shown.

volume of H ₂ SO ₄ needed to neutralise both NaOH and NaHCO ₃	29.50 cm ³
volume of H ₂ SO ₄ needed to neutralise only NaOH	18.00 cm ³



- (a) (i) Calculate the amount, in mol, of H₂SO₄ used to neutralise **only** the NaOH in 25.0 cm³ of solution **X**.

Amount = mol **[1]**

- (ii) Calculate the concentration, in mol dm⁻³, of NaOH in solution **X**.

Concentration = mol dm⁻³ **[1]**

(b) (i) Calculate the amount, in mol, of NaHCO_3 in the 200 cm^3 of solution **X**.

Amount = mol [2]

(ii) Calculate the mass of NaHCO_3 in the 200 cm^3 of solution **X**.

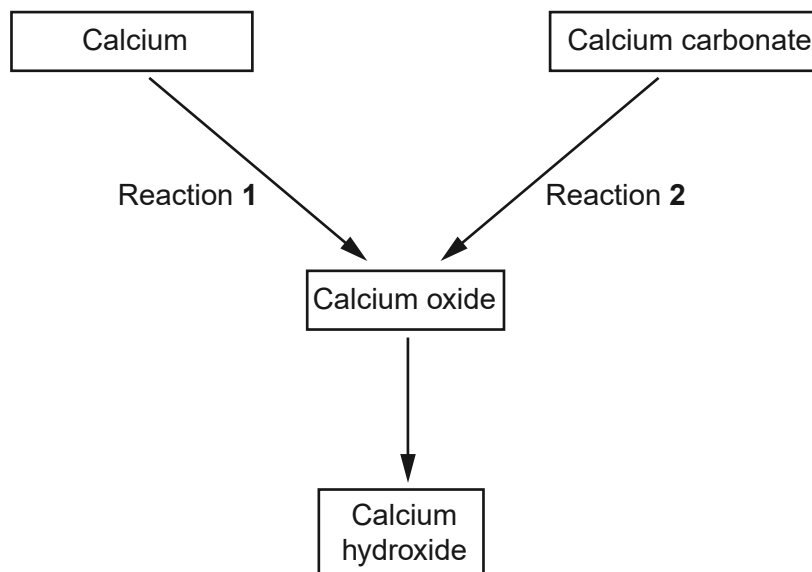
Give your answer to **three** significant figures.

Mass = g [1]

[Total: 5]

4 Calcium is in Group 2 of the Periodic Table.

The diagram shows some reactions of calcium and its compounds.



(a) Reactions 1 and 2 both form calcium oxide.

(i) Write the equation for reaction 1.

..... [1]

(ii) What type of reaction is reaction 2?

..... [1]

(b) Calcium hydroxide is both a base and an alkali. Refer to any relevant ions in your answer.

Explain what is meant by the terms *base* and *alkali*.

Base

.....

Alkali

..... [2]

- (c) A student prepared some calcium hydroxide by adding a small piece of calcium to a large excess of water.

Describe what the student would observe and write the equation for the reaction.

Observation

Equation [2]

- (d) A student prepares a solution of calcium nitrate from calcium carbonate.

What reagent would the student need to use?

Write the equation for the reaction.

Reagent

Equation [2]

[Total: 8]

5 Antimony, Sb, has atomic number 51.

(a) Complete the table below to show where antimony is found in the Periodic Table.

Period	Block

[1]

(b) Antimony exists as a mixture of isotopes.

(i) What is meant by the term *isotopes*?

.....
..... [1]

(ii) Different isotopes of antimony have the same chemical properties.

Explain why.

.....
..... [1]

(iii) Complete the table below to show the atomic structure of ^{121}Sb .

Protons	Neutrons	Electrons

[1]

(c) The relative atomic mass of antimony is 121.8.

(i) Define the term *relative atomic mass*.

.....
.....
.....
..... [3]

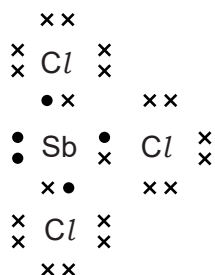
- (ii) A sample of antimony, $A_r = 121.8$, was analysed and was found to consist of 60% ^{121}Sb and one other isotope.

Determine the mass number of the other isotope in the sample of antimony.

mass number of the other antimony isotope = [1]

- (d) Antimony chloride, SbCl_3 , exists as simple covalent molecules.

A 'dot-and-cross' diagram of SbCl_3 is shown below.



- (i) Predict the shape of a molecule of SbCl_3 .

Explain your answer.

name of shape:

explanation:

.....

..... [3]

- (ii) SbCl_3 molecules are polar.

Explain why.

.....

.....

..... [2]

6 This question is about compounds used in fertilisers.

(a) A compound used as a fertiliser has the following composition by mass:

C, 20.00%; H, 6.67%; N, 46.67%; O, 26.66%.

Calculate the empirical formula of this compound.

empirical formula = [2]

(b) A salt used as a fertiliser has the empirical formula $\text{H}_4\text{N}_2\text{O}_3$.

Suggest the formulae of the ions present in this salt.

..... [2]

(c) Calcium phosphate(V), $\text{Ca}_3(\text{PO}_4)_2$, is another salt used in fertilisers.

Calcium phosphate(V) can be prepared by reacting together an acid and a base.

(i) Suggest the **formula** of the acid used to prepare $\text{Ca}_3(\text{PO}_4)_2$.

..... [1]

(ii) **Name** a base which could be used to prepare $\text{Ca}_3(\text{PO}_4)_2$.

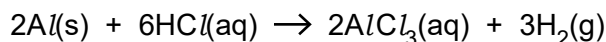
..... [1]

[Total: 6]

- 7 An aqueous solution of aluminium chloride can be prepared by the redox reaction between aluminium metal and dilute hydrochloric acid.

A student reacts 0.0800 mol of aluminium completely with dilute hydrochloric acid to form an aqueous solution of aluminium chloride.

The equation for this reaction is shown below.



- (a) In terms of electron transfer, explain whether aluminium is being oxidised or reduced.

..... [1]

- (b) Calculate the volume of hydrogen gas formed, in dm^3 , at room temperature and pressure.

volume of hydrogen gas formed = dm^3 [2]

- (c) Calculate the mass of $AlCl_3$ formed.

Give your answer to **three** significant figures.

mass of $AlCl_3$ formed = g [2]

- (d) Calculate the volume, in cm^3 , of 1.20 mol dm^{-3} hydrochloric acid needed to react completely with 0.0800 mol of aluminium.

volume = cm^3 [2]

[Total: 7]

8 Silicon and potassium are two elements found in the Earth's crust.

(a) Silicon and potassium both exist as several isotopes.

(i) Define the term *relative isotopic mass*.

.....
.....
..... [2]

(ii) Complete the table below for an atom and an ion of two different isotopes of potassium.

	Protons	Neutrons	Electrons
^{39}K	19
.....	22	18

[2]

(b) Complete the electron configuration of a silicon atom.

$1s^2$ [1]

(c) (i) Silicon reacts with chlorine to form molecules of silicon tetrachloride, SiCl_4 .

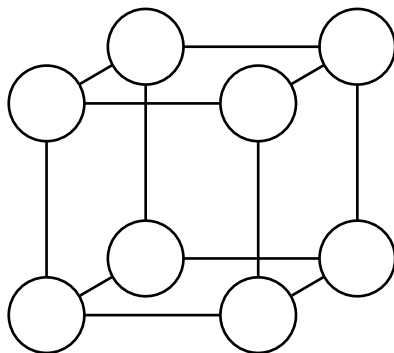
How many molecules are present in 8.505 g of SiCl_4 ?

answer = molecules [3]

(ii) Potassium reacts with chlorine to form an ionic lattice of potassium chloride, KCl .

A diagram of part of the potassium chloride lattice is shown below.

Add labels to each circle in the diagram to show the particles present in the lattice. The diagram assumes all particles have the same size.



[2]

[Total: 10]