Q1. (a) Some scientists thought that the waste water from a waste disposal factory contained **two** sodium halides.

They tested a sample of the waste water.

They added three reagents, one after the other, to the same test tube containing the waste water.

The table below shows their results.

Reagent added	Observations
1. Silver nitrate solution (acidified with dilute nitric acid)	A cream precipitate formed
2. Dilute ammonia solution	A yellow precipitate remained
3. Concentrated ammonia solution	The yellow precipitate did not dissolve

(i) Identify the yellow precipitate that did **not** dissolve in concentrated ammonia solution.
Write the **simplest** ionic equation for the formation of this precipitate from silver ions and the correct halide ion.
Identify the other sodium halide that must be present in this mixture of two sodium halides.

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(3)

(ii) Give **one** reason why the silver nitrate solution was acidified before it was used in this test.

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(1)

(iii) The method that the scientists used could **not** detect one type of halide ion.
Identify this halide ion.
Give **one** reason for your answer.

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(2)

(b) The scientists thought that the waste water also contained dissolved barium ions.
An aqueous solution of sodium sulfate can be used to test for the presence of dissolved barium ions.

Write the **simplest** ionic equation for the reaction between barium ions and sulfate ions to form barium sulfate.

State what is observed in this reaction.

Give a use for barium sulfate in medicine and explain why this use is possible, given that solutions containing barium ions are poisonous.

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(4)

(c) The scientists also analysed the exhaust gases from an incinerator used to destroy waste poly(ethene).
Mass spectrometry showed that there was a trace gas with a precise M_r = 28.03176 in the exhaust gases from the incinerator.

The table below contains some precise relative atomic mass data.

Atom	Precise relative atomic mass

^{12}C	12.00000
^{1}H	1.00794
^{16}O	15.99491

Use the data to show that the trace gas is ethene. Show your working.

Suggest why both ethene and carbon monoxide might have been identified as the trace gas if the scientists had used relative atomic masses to a precision of only one decimal place.

Write an equation for the incomplete combustion of ethene to form carbon monoxide and water only.

Ethene is used to make poly(ethene).
Draw the displayed formula for the repeating unit of poly(ethene).
Name this type of polymer.

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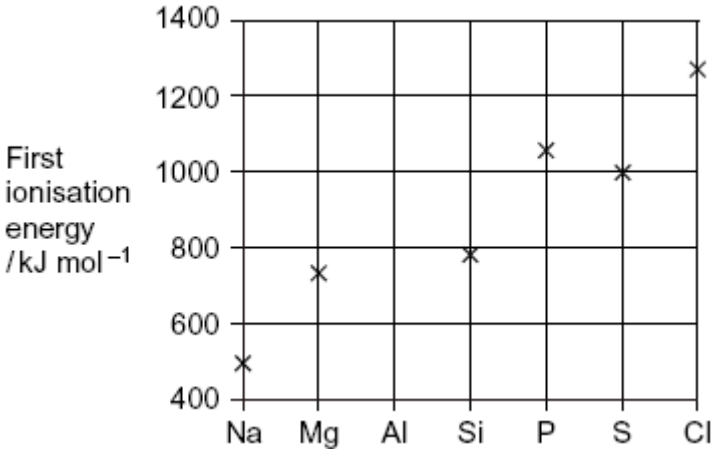
(5)
(Total 15 marks)

Q2. The following diagram shows the first ionisation energies of some Period 3 elements.



(a) Draw a cross on the diagram to show the first ionisation energy of aluminium.

(1)

(b) Write an equation to show the process that occurs when the first ionisation energy of aluminium is measured.

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(2)

(c) State which of the first, second or third ionisations of aluminium would produce an ion with the electron configuration $1s^2\ 2s^2\ 2p^6\ 3s^1$

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(1)

(d) Explain why the value of the first ionisation energy of sulfur is less than the value of the first ionisation energy of phosphorus.

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(2)

(e) Identify the element in Period 2 that has the highest first ionisation energy and give its electron configuration.

Element .....

Electron configuration .....

(2)

(f) State the trend in first ionisation energies in Group 2 from beryllium to barium. Explain your answer in terms of a suitable model of atomic structure.

Trend ….....

Explanation .....

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(3)
(Total 11 marks)

Q3. In an experiment to determine its solubility in water, solid barium hydroxide was added to 100cm^3 of water until there was an excess of the solid. The mixture was filtered and an excess of sulfuric acid was added to the filtrate. The barium sulfate produced was obtained from the reaction mixture, washed with cold water and dried. The mass of barium sulfate was then recorded.

(a) Explain why the mixture was filtered before the addition of sulfuric acid.

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(1)

(b) State how the barium sulfate produced was obtained from the reaction mixture.

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(1)

(c) Explain why the barium sulfate was washed before it was dried.

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(1)

(d) Write an equation for the reaction between barium hydroxide and sulfuric acid.

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(1)

(e) In an experiment, 4.25 g of barium sulfate were formed when an excess of sulfuric acid was added to 100 cm^3 of a saturated solution of barium hydroxide.

(i) Use data from the Periodic Table to calculate the M_r of barium sulfate. Give your answer to one decimal place.

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(1)

(ii) Calculate the amount, in moles, of $BaSO_4$ in 4.25 g of barium sulfate.

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(1)

(iii) Use your answer from part (ii) to calculate the mass of barium hydroxide(M_r = 171.3) present in 1 dm^3 of saturated solution. Show your working.

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(2)

(f) Barium sulfate is taken by mouth by patients so that an outline of a human digestive system can be viewed using X-rays. Explain why patients do **not** suffer any adverse effects from barium sulfate when it is known that solutions containing barium ions are toxic.

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(1)
(Total 9 marks)

Q4. Copper(II) sulfate solution, together with copper(II) carbonate ($CuCO_3$) powder, can be used to determine the identity of three solutions **A, B** and **C**. The three solutions are known to be hydrochloric acid, barium chloride, and sodium chloride.

In **Experiment 1** a small amount of copper(II) carbonate powder was added to each of the three solutions.

In **Experiment 2** a dropping pipette was used to add 2 cm^3 of copper(II) sulfate solution to each of the three solutions.

The results of these experiments are shown in the table below.

	Experiment 1 Addition of copper(II) carbonate powder	**Experiment 2** Addition of copper(II) sulfate solution
Solution **A**	no visible change	white precipitate
Solution **B**	no visible change	no visible change
Solution **C**	effervescence (bubbles of gas)	no visible change

(a) Use the observations in the table to deduce which of the solutions, **A, B** or **C** is

hydrochloric acid .....

barium chloride .....

(2)

(b) Explain why a precipitate was formed when copper(II) sulfate solution was added to solution **A**.
Write an equation for the reaction that occurred.

Explanation .....

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Equation .....

(2)

(c) Suggest the identity for the colourless gas produced when copper(II) carbonate powder was added to solution **C**.

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(1)

(d) Identify the two reagents that could be used in a test to confirm that the solutions contained chloride ions, **not** bromide ions. State what would be observed on addition of each reagent.

Reagent 1 .....

Observation 1 .....

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Reagent 2 .....

Observation 2 .....

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(4)

(e) Copper(II) sulfate is toxic. Suggest **one** safety precaution you would take to minimise this hazard when wiping up a spillage of copper(II) sulfate solution.

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(1)
(Total 10 marks)

Q5.(a) A solution of barium hydroxide is often used for the titration of organic acids. A suitable indicator for the titration is thymol blue. Thymol blue is yellow in acid and blue in alkali. In a titration a solution of an organic acid was added from a burette to a conical flask containing 25.0 cm^3 of a barium hydroxide solution and a few drops of thymol blue.

(i) Describe in full the colour change at the end-point of this titration.

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(1)

(ii) Thymol blue is an acid. State how the average titre would change if a few cm^3,

rather than a few drops, of the indicator were used by mistake in this titration.

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(1)

(iii) Barium hydroxide is toxic. Suggest **one** safety precaution you would take to minimise this hazard when wiping up a spillage of barium hydroxide solution.

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(1)

(iv) Suggest **one** reason why a 250 cm^3 conical flask is preferred to a 250cm^3 beaker for a titration.

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(1)

(v) Suggest **one** reason why repeating a titration can improve its reliability

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(1)

(b) Solubility data for barium hydroxide and calcium hydroxide are given in the table below.

Compound	Solubility at 20 °C / g dm^{-3}
barium hydroxide	38.9
calcium hydroxide	1.73

(i) Use the data given in the table to calculate the concentration, in mol dm^{-3}, of a saturated solution of calcium hydroxide (M_r = 74.1) at 20°C.

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(1)

(ii) Suggest **one** reason why calcium hydroxide solution is **not** used in the titration of a 0.200 mol dm^{-3} solution of an acid.

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(1)
(Total 7 marks)