

AQA A-LEVEL CHEMISTRY • 7405

CHEMISTRY



EXAM QUESTION PACK

3.2.2 GROUP 2, THE ALKALINE EARTH METALS

SCORE

/247

PERCENTAGE

%

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Q1.

Which substance is used to reduce titanium(IV) chloride in the extraction of titanium metal?

- A** Magnesium ☐
- B** Manganese ☐
- C** Vanadium ☐
- D** Zinc ☐

(Total 1 mark)

Q2.

Which statement about barium sulfate is correct?

- A** It is soluble in water at a temperature of 100 °C. ☐
- B** It is used in medicine because it does not dissolve in body fluids. ☐
- C** It is a pale yellow solid. ☐
- D** It reacts with acidified barium chloride solution. ☐

(Total 1 mark)

Q3.

Which compound is used to treat the symptoms of indigestion?

- A** MgO ☐
- B** Mg(OH)₂ ☐
- C** CaO ☐
- D** Ca(OH)₂ ☐

(Total 1 mark)

Q4.

This question is about s-block metals.

- (a) Give the full electron configuration for the calcium ion, Ca²⁺

(1)

- (b) Explain why the second ionisation energy of calcium is lower than the second ionisation energy of potassium.

(2)

- (c) Identify the s-block metal that has the highest first ionisation energy.

(1)

- (d) Give the formula of the hydroxide of the element in Group 2, from Mg to Ba, that is least soluble in water.

(1)

- (e) A student added 6 cm³ of 0.25 mol dm⁻³ barium chloride solution to 8 cm³ of 0.15 mol dm⁻³ sodium sulfate solution.

The student filtered off the precipitate and collected the filtrate.

Give an ionic equation for the formation of the precipitate.

Show by calculation which reagent is in excess.

Calculate the total volume of the other reagent which should be used by the student so that the filtrate contains only one solute.

Ionic equation _____

Reagent in excess _____

Total volume of other reagent _____

(3)

- (f) A sample of strontium has a relative atomic mass of 87.7 and consists of three isotopes, ⁸⁶Sr, ⁸⁷Sr and ⁸⁸Sr

In this sample, the ratio of abundances of the isotopes ⁸⁶Sr : ⁸⁷Sr is 1:1

State why the isotopes of strontium have identical chemical properties.

Calculate the percentage abundance of the ⁸⁸Sr isotope in this sample.

Why isotopes of strontium have identical chemical properties

Percentage abundance of ^{88}Sr _____ %

(4)

- (g) A time of flight (TOF) mass spectrum was obtained for a sample of barium that contains the isotopes ^{136}Ba , ^{137}Ba and ^{138}Ba

The sample of barium was ionised by electron impact.

Identify the ion with the longest time of flight.

(1)

- (h) A $^{137}\text{Ba}^+$ ion travels through the flight tube of a TOF mass spectrometer with a kinetic energy of $3.65 \times 10^{-16} \text{ J}$
This ion takes $2.71 \times 10^{-5} \text{ s}$ to reach the detector.

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

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

Calculate the length of the flight tube in metres.

Give your answer to the appropriate number of significant figures.

Length of flight tube _____ m

(5)

(Total 18 marks)

Q5.

Which products are formed when magnesium reacts with steam?

A Magnesium hydroxide and hydrogen

☐

B Magnesium hydroxide and oxygen

☐

C Magnesium oxide and hydrogen

☐

D Magnesium oxide and oxygen

☐

(Total 1 mark)

Q6.

An aqueous solution **Y** is known to contain one type of group 2 metal ion and one type of negative ion.

Aqueous solutions of sulfuric acid and magnesium nitrate are added to separate samples of solution **Y**. The observations are shown in the table.

Solution added	Observation with solution Y
Sulfuric acid	A white precipitate forms
Magnesium nitrate	A white precipitate forms

(a) Suggest the identity of the group 2 metal ion present in solution **Y**.

Write an ionic equation, including state symbols, for the reaction that takes place when sulfuric acid is added to solution **Y**.

Group 2 metal ion _____

Ionic equation _____

(2)

(b) Suggest the identity of the negative ion present in solution **Y**.

Write an ionic equation, including state symbols, for the reaction that takes place when magnesium nitrate is added to solution **Y**.

Negative ion _____

Ionic equation _____

(2)

(Total 4 marks)

Q7.

The ionic product of water, $K_w = 2.93 \times 10^{-15} \text{ mol}^2 \text{ dm}^{-6}$ at 10°C

(a) Which is the correct expression for K_w ?

Tick (✓) **one** box.

A $K_w = \frac{[H_2O]}{[H^+][OH^-]}$

B $K_w = [H^+][H_2O]$

C $K_w = [H^+][OH^-]$

D $K_w = \frac{[H^+][OH^-]}{[H_2O]}$

(1)

- (b) Calculate the pH of pure water at 10 °C
Give your answer to two decimal places.

pH of water _____

(2)

- (c) Suggest why this pure water at 10 °C is **not** alkaline.

(1)

- (d) Calculate the pH of a 0.0131 mol dm⁻³ solution of calcium hydroxide at 10 °C
Give your answer to two decimal places.

pH of solution _____

(3)

- (e) The 0.0131 mol dm⁻³ calcium hydroxide solution at 10 °C was a saturated solution.

A student added 0.0131 mol of magnesium hydroxide to 1.00 dm³ of water at 10 °C and stirred the mixture until no more solid dissolved.

Predict whether the pH of the magnesium hydroxide solution formed at 10 °C is larger than, smaller than or the same as the pH of the calcium hydroxide solution at 10 °C

Explain your answer.

pH of magnesium hydroxide compared to calcium hydroxide

Explanation _____

(2)

(Total 9 marks)

Q8.

This question is about ion testing.

- (a) Describe how a student could distinguish between aqueous solutions of potassium nitrate, KNO₃, and potassium sulfate, K₂SO₄, using one simple test-tube reaction.

Reagent _____

Observation with KNO₃(aq) _____

Observation with K₂SO₄(aq) _____

(3)

- (b) Describe how a student could distinguish between aqueous solutions of magnesium chloride, MgCl₂, and aluminium chloride, AlCl₃, using **one** simple test-tube reaction.

Reagent _____

Observation with MgCl₂(aq) _____

Observation with AlCl₃(aq) _____

(3)

(Total 6 marks)

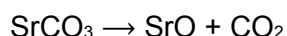
Q9.

A sample of strontium ore is known to contain strontium oxide, strontium carbonate and some inert impurities. To determine the mass of strontium carbonate present, a student weighed a sample of the solid ore and then heated it in a crucible for 5 minutes. The sample was allowed to cool and then reweighed. This heating, cooling and reweighing was carried out three times.

The results are set out in the table.

Mass of crucible / g	9.85
Mass of crucible and ore sample / g	16.11
Mass of crucible and sample after first heating / g	14.66
Mass of crucible and sample after second heating / g	14.58
Mass of crucible and sample after third heating / g	14.58

- (a) When strontium carbonate is heated it decomposes according to the following equation.



Give a reason why the mass of the solid sample changed during the experiment.

(1)

- (b) Use the data in the table to calculate the mass of strontium carbonate in the original ore sample. Give your answer to an appropriate precision.

Mass of strontium carbonate = ____ g

(5)

- (c) Each balance reading has an uncertainty of ± 5.00 mg.

Calculate the percentage error in the initial mass of ore used.

Percentage error = _____ %

(1)

- (d) The mass of inert impurities in the sample was 347 mg.

Deduce the mass of SrO in the sample and justify any assumption made in calculating your answer.

(If you have been unable to answer part (b), assume the mass of strontium carbonate was 4.85 g. This is **not** the correct answer.)

Mass of SrO = _____

(2)

- (e) Strontium metal can be extracted by heating strontium oxide with aluminium metal.

In this reaction, strontium vapour and solid aluminium oxide are formed.

Write an equation for the reaction and state the role of the aluminium in the process. Explain why strontium forms a vapour but aluminium oxide is formed as a solid.

Equation

Role of aluminium _____

Explanation _____

(5)

(Total 14 marks)

Q10.

This question is about the chemistry of some Group 2 elements.

- (a) Write an equation for the reaction of calcium with water at 25 °C and predict a possible value for the pH of the solution formed.

Equation

pH _____ (2)

- (b) State the trend in solubility, in water, of the Group 2 sulfates from magnesium to barium.

_____ (1)

- (c) State the trend in solubility, in water, of the Group 2 sulfates from magnesium to barium.

Reagent _____

Equation

_____ (2)

- (d) Explain why the melting point of calcium sulfate is high.

(2)

(Total 7 marks)

Q11.

This question is about the elements in Group 2 and their compounds.

- (a) Use the Periodic Table to deduce the full electron configuration of calcium.

_____ (1)

- (b) Write an ionic equation, with state symbols, to show the reaction of calcium with an excess of water.

_____ (1)

- (c) State the role of water in the reaction with calcium.

(1)

- (d) Write an equation to show the process that occurs when the first ionisation energy of calcium is measured.

(1)

- (e) State and explain the trend in the first ionisation energies of the elements in Group 2 from magnesium to barium.

Trend _____

Explanation _____

(3)

(Total 7 marks)

Q12.

The table below shows observations of changes from some test-tube reactions of aqueous solutions of compounds **Q**, **R** and **S** with five different aqueous reagents. The initial colours of the solutions are not given.

	BaCl₂ + HCl	AgNO₃ + HNO₃	NaOH	Na₂CO₃	HCl (conc)
Q	no change observed	pale cream precipitate	white precipitate	white precipitate	no change observed
R	no change observed	white precipitate	white precipitate, dissolves in excess of NaOH	white precipitate, bubbles of a gas	no change observed
S	white precipitate	no change observed	brown precipitate	brown precipitate, bubbles of a gas	yellow solution

- (a) Identify each of compounds **Q**, **R** and **S**.
You are **not** required to explain your answers.

Identity of **Q** _____

Identity of **R** _____

Identity of **S** _____

(6)

- (b) Write ionic equations for each of the positive observations with **S**.

(4)

(Total 10 marks)

Q13.

A student was given a powder made from a mixture of anhydrous barium chloride and anhydrous magnesium chloride. The student dissolved 1.056 g of the powder in water in a conical flask and added an excess of sulfuric acid.

A white precipitate formed and was filtered off, washed and dried.

The mass of this solid was 0.764 g.

Identify the white precipitate and calculate the percentage, by mass, of magnesium chloride in the powder.

(Total 4 marks)

Q14.

An experiment to investigate enthalpy was carried out with calcium instead of magnesium, and with 2.0 mol dm^{-3} sulfuric acid instead of 2.0 mol dm^{-3} hydrochloric acid. Both acids were in excess. At first the reaction of calcium with sulfuric acid was faster than the reaction of magnesium with hydrochloric acid. However, the reaction of calcium with sulfuric acid soon stopped even though some calcium remained. A white solid had formed.

- (a) Suggest **two** reasons why the reaction was faster at first with calcium and sulfuric acid than with magnesium and hydrochloric acid.

Reason 1 _____

Reason 2 _____

(2)

- (b) Identify the white solid and write an equation for its formation in this reaction.

Explain why the reaction of calcium with sulfuric acid stopped even though some calcium remained.

Identity of white solid _____

Equation _____

Explanation _____

(3)

(Total 5 marks)

Q15.

Which of these decreases down Group 2?

A First ionisation energy

☐

- B Atomic radius ☐
- C Number of protons ☐
- D Reactivity with water ☐

(Total 1 mark)

Q16.

Sulfur dioxide (SO_2) is produced when some fossil fuels are burned.

Which of the following statements is true?

- A Sulfur dioxide can be removed from waste gases in a power station by an acid-base reaction with calcium oxide. ☐
- B Sulfur dioxide is insoluble in water. ☐
- C Sulfur dioxide is a basic oxide. ☐
- D Sulfur dioxide is an ionic compound. ☐

(Total 1 mark)

Q17.

This question is about the Group 2 metals and their compounds.

- (a) Explain why the first ionisation energy of barium is less than the first ionisation energy of calcium.

(2)

- (b) Magnesium reacts readily with steam.

State **two** observations you would make when magnesium reacts with steam. Write an equation for the reaction.

Observation 1 _____

Observation 2 _____

Equation _____

(3)

- (c) Explain why different observations are made when aqueous barium chloride is

added separately to aqueous magnesium sulfate and to aqueous magnesium nitrate.

Write the simplest ionic equation, including state symbols, for any reaction that occurs.

Explanation _____

Equation _____

(2)

(Total 7 marks)

Q18.

The following pairs of compounds can be distinguished by simple test-tube reactions.

For each pair of compounds, give a reagent (or combination of reagents) that, when added separately to each compound, could be used to distinguish between them. State what is observed in each case.

- (a) Butan-2-ol and 2-methylpropan-2-ol

Reagent _____

Observation with butan-2-ol

Observation with 2-methylpropan-2-ol

(3)

- (b) Propane and propene

Reagent _____

Observation with propane

Observation with propene

(3)

- (c) Aqueous silver nitrate and aqueous sodium nitrate

Reagent _____

Observation with aqueous silver nitrate

Observation with aqueous sodium nitrate

(3)

- (d) Aqueous magnesium chloride and aqueous barium chloride

Reagent _____

Observation with aqueous magnesium chloride

Observation with aqueous barium chloride

(3)

(Total 12 marks)

Q19.

The elements in Group 2 from Mg to Ba can be used to show the trends in properties down a group in the Periodic Table.

- (a) State the trend in atomic radius for atoms of the elements down Group 2 from Mg to Ba
Give a reason for this trend.

Trend _____

Reason _____

(2)

(b) The Group 2 elements react with water.

- (i) State the trend in reactivity with water of the elements down Group 2 from Mg to Ba

(1)

- (ii) Write an equation for the reaction of strontium with water.

(1)

- (c) Give the **formula** of the hydroxide of the element in Group 2 from Mg to Ba that is most soluble in water.

(1)

(Total 5 marks)

Q20.

Zinc is similar to Group 2 metals and forms compounds containing Zn^{2+} ions.

Write an equation for the thermal decomposition of zinc carbonate to zinc oxide.

Calculate the percentage atom economy for the formation of zinc oxide from zinc carbonate in this reaction.

Equation _____

Percentage atom economy _____

(Total 3 marks)

Q21.

A laboratory technician discovered four badly-labelled bottles, each containing one pure white solid. Each bottle contained a compound of a different Group 2 metal (magnesium, calcium, strontium and barium).

Some tests were carried out on the solids or, if the compound was soluble, on the aqueous solution. The results are given in the table.

Test	Compound 1	Compound 2	Compound 3	Compound 4
------	------------	------------	------------	------------

Added to water	Dissolves	Insoluble	Dissolves	Dissolves
Solution or solid added to HCl(aq)	Solution remains colourless	Gives off carbon dioxide gas and a colourless solution forms	Solution remains colourless	Solution remains colourless and heat released
Solution or solid added to NaOH(aq)	Solution gives a white precipitate	Solid remains insoluble	Solution gives a slight white precipitate	Solution has no visible change
Solution or solid added to H ₂ SO ₄ (aq)	Solution has no visible change	Gives off carbon dioxide gas and a white solid remains	Solution slowly forms a slight white precipitate	Solution forms a white precipitate

- (a) One of the bottles has a very faint label that could be read as 'Magnesium Sulfate'.

Use the information in the table to deduce which **one** of the four compounds is magnesium sulfate and explain your answer.

Compound _____

Explanation _____

(3)

- (b) The bottle containing **Compound 2** has a 'TOXIC' hazard symbol.

Use the information in the table to identify **Compound 2**.

Explain both observations in the reaction with H₂SO₄(aq).

Identity of **Compound 2** _____

Explanation _____

(3)

- (c) Identify the compound that is strontium hydroxide.

Give an equation for the reaction of strontium hydroxide with sulfuric acid.

Compound _____

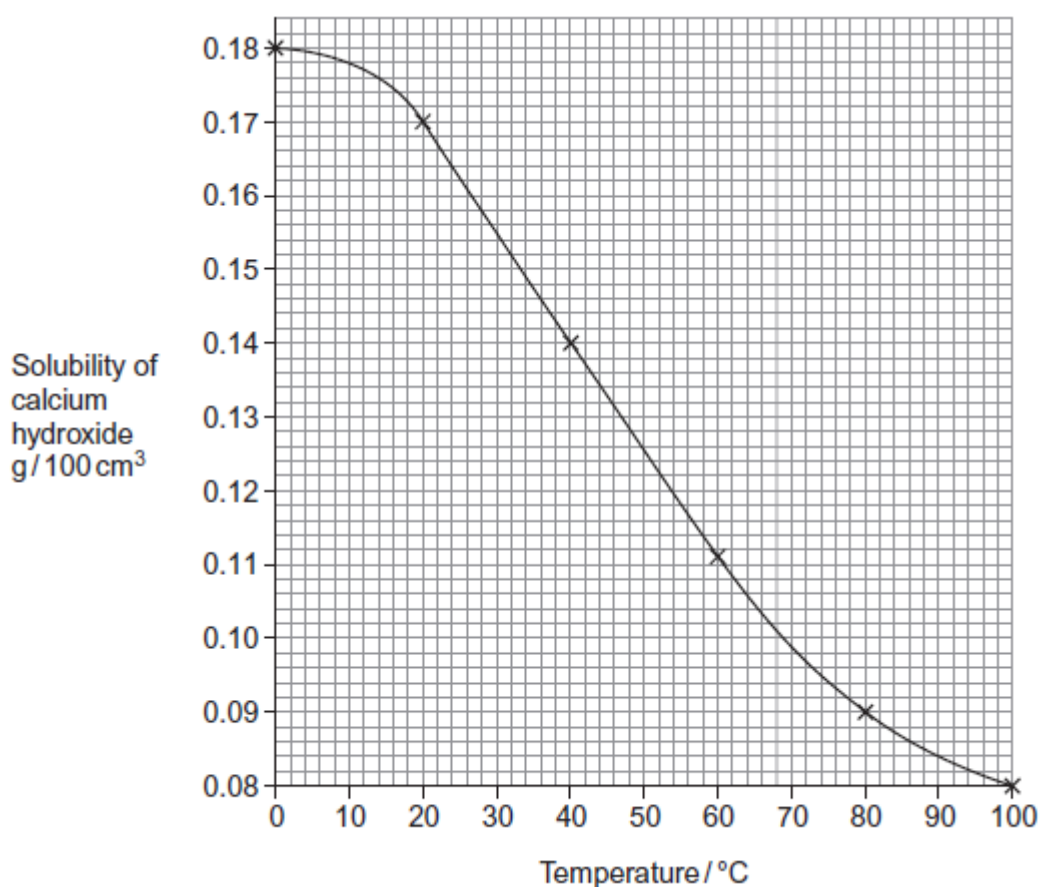
Equation _____

(2)
(Total 8 marks)

Q22.

Calcium hydroxide is slightly soluble in water at room temperature. As the temperature rises, the solubility decreases. When the maximum amount of solid has dissolved at a particular temperature the solution is said to be **saturated**.

In an experiment, the solubility of calcium hydroxide was measured over a range of temperatures. The results are shown in the graph.



- (a) Use data from the graph to calculate the concentration, in mol dm⁻³, of a saturated solution of calcium hydroxide at 30 °C. Give your answer to 3 significant figures.

Show your working.

(3)

- (b) You are given a sample of saturated calcium hydroxide solution. Outline the practical steps that you would take to determine the solubility of calcium hydroxide in this solution.

(3)

(Total 6 marks)

Q23.

There are many uses for Group 2 metals and their compounds.

- (a) State a medical use of barium sulfate.
State why this use of barium sulfate is safe, given that solutions containing barium ions are poisonous.

Use _____

Why this use is safe _____

(2)

- (b) Magnesium hydroxide is used in antacid preparations to neutralise excess stomach acid.

Write an equation for the reaction of magnesium hydroxide with hydrochloric acid.

(1)

- (c) Solutions of barium hydroxide are used in the titration of weak acids.

State why magnesium hydroxide solution could **not** be used for this purpose.

(1)

- (d) Magnesium metal is used to make titanium from titanium(IV) chloride.

Write an equation for this reaction of magnesium with titanium(IV) chloride.

(1)

- (e) Magnesium burns with a bright white light and is used in flares and fireworks.

Use your knowledge of the reactions of Group 2 metals with water to explain why water should **not** be used to put out a fire in which magnesium metal is burning.

(2)

(Total 7 marks)

Q24.

- (a) Strontium chloride is used in toothpaste for sensitive teeth.
Both strontium carbonate and strontium sulfate are white solids that are insoluble in water.

- (i) Write an equation for the reaction between strontium chloride solution and sodium sulfate solution.
Include state symbols in your equation.

(1)

- (ii) Strontium carbonate reacts with nitric acid to produce a solution of strontium nitrate.
Strontium sulfate does not react with nitric acid.

Describe briefly how you could obtain strontium sulfate from a mixture of strontium carbonate and strontium sulfate.
You are **not** required to describe the purification of the strontium sulfate.

(2)

- (b) A solution of magnesium sulfate is sometimes given as first aid to someone who has swallowed barium chloride.

Explain why drinking magnesium sulfate solution is effective in the treatment of barium poisoning.

(1)

- (c) Medicines for the treatment of nervous disorders often contain calcium bromide. Silver nitrate, acidified with dilute nitric acid, can be used together with another reagent to test for the presence of bromide ions in a solution of a medicine.

Describe briefly how you would carry out this test and state what you would observe.

(3)

(Total 7 marks)

Q25.

- (a) Anhydrous strontium chloride is not used in toothpaste because it absorbs water from the atmosphere. The hexahydrate, $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$, is preferred.

A chemist was asked to determine the purity of a sample of strontium chloride hexahydrate. The chemist weighed out 2.25 g of the sample and added it to 100 cm³ of water. The mixture was warmed and stirred for several minutes to dissolve all of the strontium chloride in the sample. The mixture was then filtered into a conical flask. An excess of silver nitrate solution was added to the flask and the contents swirled for 1 minute to make sure that the precipitation was complete.

The silver chloride precipitate was separated from the mixture by filtration. The precipitate was washed several times with deionised water and dried carefully. The chemist weighed the dry precipitate and recorded a mass of 1.55 g.

- (i) Calculate the amount, in moles, of AgCl in 1.55 g of silver chloride ($M_r = 143.4$).

(1)

- (ii) The equation for the reaction between strontium chloride and silver nitrate is



Use your answer from part (i) and this equation to calculate the amount, in moles, of SrCl_2 needed to form 1.55 g of silver chloride.

(1)

- (iii) Use data from the Periodic Table to calculate the M_r of strontium chloride hexahydrate. Give your answer to 1 decimal place.

(1)

- (iv) Use your answers from parts (a)(ii) and (a)(iii) to calculate the percentage by mass of strontium chloride hexahydrate in the sample. Show your working. Give your answer to the appropriate precision.

(2)

- (v) Several steps in the practical procedure were designed to ensure an accurate value for the percentage by mass of strontium chloride hexahydrate in the sample.

- 1 Explain why the solution of strontium chloride was filtered to remove insoluble impurities before the addition of silver nitrate.

(1)

- 2 Explain why the precipitate of silver chloride was washed several times with deionised water.

(1)

- (b) Magnesium hydroxide and magnesium carbonate are used to reduce acidity in the stomach. Magnesium hydroxide can be prepared by the reaction of solutions of magnesium chloride and sodium hydroxide.

- (i) Write the **simplest ionic** equation for the reaction that occurs between magnesium chloride and sodium hydroxide. Include state symbols in your equation.

(1)

- (ii) Other than cost, explain one advantage of using magnesium hydroxide rather than magnesium carbonate to reduce acidity in the stomach.

(1)

- (c) Calcium ethanoate, $(\text{CH}_3\text{COO})_2\text{Ca}$, is used in the treatment of kidney disease. Thermal decomposition of calcium ethanoate under certain conditions gives propanone and **one** other product.

Write an equation for the thermal decomposition of calcium ethanoate.

(1)

- (d) Salts containing the chromate(VI) ion are usually yellow in colour.
Calcium chromate(VI) is soluble in water.
Strontium chromate(VI) is insoluble in water, but will dissolve in a solution of ethanoic acid.
Barium chromate(VI) is insoluble in water and is also insoluble in a solution of ethanoic acid.

Describe a series of tests using solutions of sodium chromate(VI) and ethanoic acid that would allow you to distinguish between separate solutions of calcium chloride, strontium chloride and barium chloride.
State what you would observe in each test.

(3)

- (e) The strontium salt of ranelic acid is used to promote bone growth. Analysis of a pure sample of ranelic acid showed that it contained 42.09% of carbon, 2.92% of hydrogen, 8.18% of nitrogen, 37.42% of oxygen and 9.39% of sulfur by mass.

Use these data to calculate the empirical formula of ranelic acid.
Show your working.

(2)
(Total 15 marks)

Q26.

A student investigated how the initial rate of reaction between sulfuric acid and magnesium at 20 °C is affected by the concentration of the acid.

The equation for the reaction is



- (a) The student made measurements every 20 seconds for 5 minutes. The student then repeated the experiment using double the concentration of sulfuric acid.

State a measurement that the student should make every 20 seconds. Identify the apparatus that the student could use to make this measurement.

(2)

- (b) State **one** condition, other than temperature and pressure, that would need to be kept constant in this investigation.

(1)

- (c) When the student had finished the investigation, an excess of sodium hydroxide solution was added to the reaction mixture. This was to neutralise any unreacted sulfuric acid. The student found that a further reaction took place, producing magnesium hydroxide.

- (i) Draw a diagram to show how the student could separate the magnesium hydroxide from the reaction mixture.

(2)

- (ii) Suggest **one** method the student could use for removing soluble impurities from the sample of magnesium hydroxide that has been separated.

(1)

(Total 6 marks)

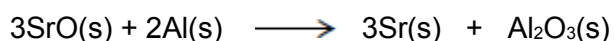
Q27.

Group 2 metals and their compounds are used commercially in a variety of processes.

- (a) Strontium is extracted from strontium oxide (SrO) by heating a mixture of powdered strontium oxide and powdered aluminium.

Consider these standard enthalpies of formation.

	SrO(s)	Al ₂ O ₃ (s)
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	– 590	– 1669



Use these data and the equation to calculate the standard enthalpy change for this extraction of strontium.

The use of powdered strontium oxide and powdered aluminium increases the surface area of the reactants.

Suggest **one** reason why this increases the reaction rate.

Suggest **one** major reason why this method of extracting strontium is expensive.

(5)

- (b) Explain why calcium has a higher melting point than strontium.

(2)

- (c) Magnesium is used in fireworks. It reacts rapidly with oxygen, burning with a bright white light. Magnesium reacts slowly with cold water.

Write an equation for the reaction of magnesium with oxygen.

Write an equation for the reaction of magnesium with cold water.

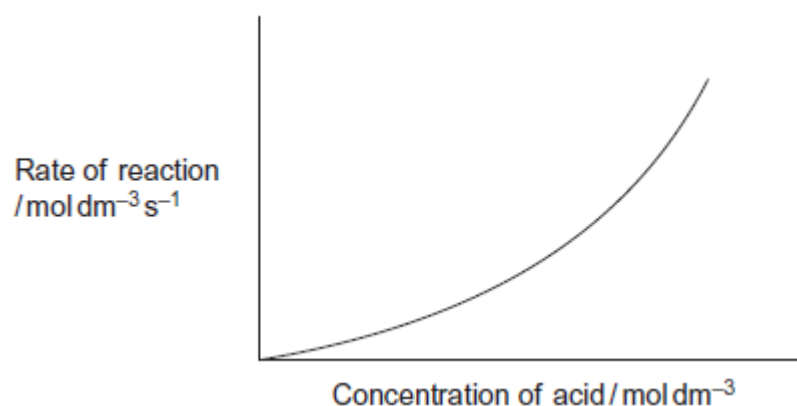
Give a medical use for the magnesium compound formed in the reaction of magnesium with cold water.

(3)

(Total 10 marks)

Q28.

- (a) In an investigation of the rate of reaction between hydrochloric acid and pure magnesium, a student obtained the following curve.



The reaction of magnesium with dilute hydrochloric acid is exothermic.

Use your understanding of collision theory to explain why the student did **not** obtain a straight line.

(3)

- (b) The magnesium used in a laboratory experiment was supplied as a ribbon. The ribbon was stored in an open plastic bag exposed to the air.

Explain why it is important to clean the surface of this magnesium ribbon when investigating the rate of its reaction with hydrochloric acid.

(2)

- (c) Magnesium ribbon reacts with hot water. Heated magnesium ribbon reacts with

steam. State **two** differences between these reactions.

Difference 1 _____

Difference 2 _____

(2)

- (d) Pure magnesium reacts completely with an excess of dilute sulfuric acid. The reaction of pure calcium with an excess of dilute sulfuric acid is very rapid initially. This reaction slows down and stops before all of the calcium has reacted.

Use your knowledge of the solubilities of Group 2 sulfates to explain why these reactions of magnesium and calcium with dilute sulfuric acid are so different.

(3)

(Total 10 marks)

Q29.

Barium chloride solution was added, dropwise, to magnesium sulfate solution until no more white precipitate was formed. The mixture was filtered.

Give the formulae of the **two** main ions in the filtrate.

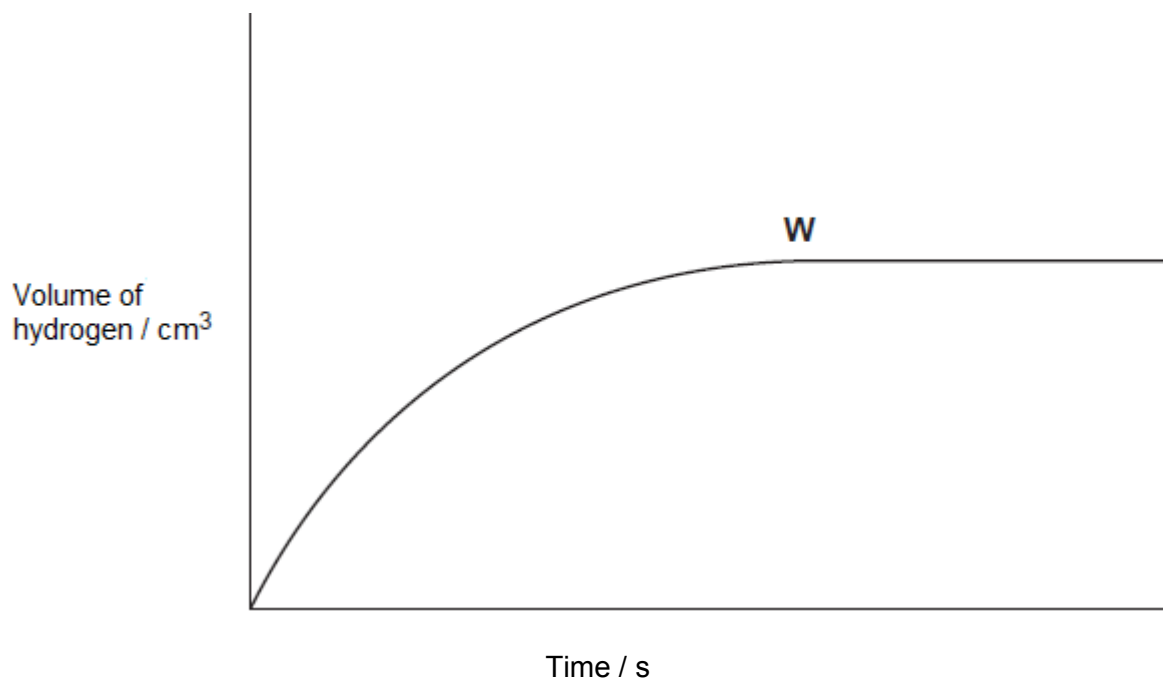
(Total 1 mark)

Q30.

- (a) **Figure 1** shows the volume of hydrogen gas collected when a sample of magnesium reacted with an excess of dilute hydrochloric acid.

The rate of this reaction can be studied by measuring the time it takes for a given volume of hydrogen to be collected.

Figure 1



- (i) State the meaning of the term *rate of reaction*.

(1)

- (ii) State and explain what has happened to the rate of this reaction at point **W** in **Figure 1**.

(2)

- (iii) In terms of collision theory explain why, at a fixed temperature, the rate of this reaction doubles when the concentration of the hydrochloric acid doubles.

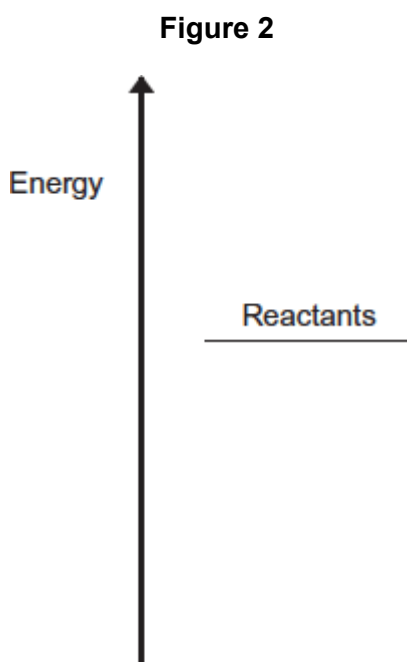
(2)

(b) In a study of the reaction in part (a), a student referred to activation energy.

(i) State the meaning of the term *activation energy*.

(1)

(ii) Complete **Figure 2** by drawing the shape of the reaction profile from reactants to products for an exothermic reaction. Show the position of the products. Show and label the activation energy.



(2)

(c) Barium metal reacts very quickly with dilute hydrochloric acid, but it reacts more slowly with water.

(i) Write an equation for the reaction of barium with water.

(1)

(ii) A solution containing barium ions can be used to show the presence of sulfate ions in an aqueous solution of sodium sulfate.

Write the **simplest ionic** equation for the reaction that occurs and state what is observed.

Simplest ionic equation

Observation

(2)

- (iii) State **one** use of barium sulfate in medicine.
Explain why this use is possible, given that solutions containing barium ions are poisonous.

Use _____

Explanation _____

(2)

(Total 13 marks)

Q31.

There are many uses for compounds of barium.

- (a) (i) Write an equation for the reaction of barium with water.

(1)

- (ii) State the trend in reactivity with water of the Group 2 metals from Mg to Ba

(1)

- (b) Give the formula of the **least** soluble hydroxide of the Group 2 metals from Mg to Ba

(1)

- (c) State how barium sulfate is used in medicine.
Explain why this use is possible, given that solutions containing barium ions are poisonous.

Use _____

Explanation _____

(2)

(Total 5 marks)

Q32.

Group 2 elements and their compounds have a wide range of uses.

- (a) For parts (a)(i) to (a)(iii), draw a ring around the correct answer to complete each

sentence.

- (i) From $\text{Mg}(\text{OH})_2$ to $\text{Ba}(\text{OH})_2$, the solubility in water

decreases.
increases.
stays the same.

(1)

- (ii) From Mg to Ba, the first ionisation energy

decreases.
increases.
stays the same.

(1)

- (iii) From Mg to Ba, the atomic radius

decreases.
increases.
stays the same.

(1)

- (b) Explain why calcium has a higher melting point than strontium.

(2)

- (c) Acidified barium chloride solution is used as a reagent to test for sulfate ions.

- (i) State why sulfuric acid should **not** be used to acidify the barium chloride.

(1)

- (ii) Write the **simplest ionic** equation for the reaction that occurs when acidified barium chloride solution is added to a solution containing sulfate ions.

(1)

Q33.

- (a) Give the **formula** of a Group 2 metal hydroxide used in agriculture.

_____ (1)

- (b) Identify a sodium halide that does **not** undergo a redox reaction when added as a solid to concentrated sulfuric acid.

_____ (1)

- (c) Chlorine gas reacts with cold dilute sodium hydroxide solution to form sodium chloride and another chlorine-containing compound, **X**.

Give the **formula** of **X**.

_____ (1)

- (d) Give the **formula** of the substance responsible for the orange colour when chlorine gas is bubbled through an aqueous solution of sodium bromide.

_____ (1)

- (e) Solid sodium iodide undergoes a redox reaction with concentrated sulfuric acid.

Give the **formula** for each of the following in this reaction.

Formula of the solid reduction product _____

Formula of the oxidation product _____

(2)

- (f) Draw the structure of each of the following organic compounds.

- (i) The hydrocarbon that is a chain isomer of methylpropene, but does **not** exhibit E–Z stereoisomerism.

(1)

- (ii) The alcohol that is a position isomer of butan-2-ol.

(1)

- (iii) The hydrocarbon that has a peak, due to its molecular ion, at $m/z = 44$ in its mass spectrum.

(1)

- (iv) The bromoalkane that reacts with sodium cyanide to produce propanenitrile.

(1)

(Total 10 marks)

Q34.

- (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.

(3)

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

(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.

(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.

(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
^1H	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.

(5)

(Total 15 marks)

Q35.

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 _____

Equation _____

(2)

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

(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 _____

Reagent 2 _____

Observation 2 _____

(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.

(1)

(Total 10 marks)

Mark schemes

Q1.

A

[1]

Q2.

B

[1]

Q3.

B

[1]

Q4.

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 (4s^0)$

1

(b) **M1** In $\text{Ca}^{(+)}$ (outer) electron(s) is further from nucleus

Or $\text{Ca}^{(+)}$ loses electron from a higher (energy) orbital

Or $\text{Ca}^{(+)}$ loses electron from a 4(s) orbital or 4th energy level or 4th energy shell and $\text{K}^{(+)}$ loses electron from a 3(p) orbital or 3rd energy level or 3rd energy shell

Must be comparative

Allow converse arguments

1

M2 More shielding (in Ca^{+})

1

(c) Be /Beryllium

1

(d) $\text{Mg}(\text{OH})_2$

1

(e) $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$

Ignore state symbols

1

$n \text{ BaCl}_2 (6/1000 \times 0.25) = 1.5 \times 10^{-3}$ and $n \text{ Na}_2\text{SO}_4 = (8/1000 \times 0.15) = 1.2 \times 10^{-3}$
and BaCl_2 /barium chloride in excess

Working required or 3×10^{-4} of BaCl_2

1

10 cm^3 (of 0.15 mol dm^{-3} sodium sulfate)

or 0.01 dm^3

1

(f) **M1** Same electronic configuration / same number of electrons (in outer shell) / all

have 37 electrons (1)

Ignore protons and neutrons unless incorrect numbers

Not just electrons determine chemical properties

1

M2
$$\frac{86x + 87x + 88(100-2x)}{100} = 87.7$$

Alternative M2:

$$\frac{86 + 87 + 88y}{1 + 1 + y} = 87.7$$

1

M3 $x = 10\%$ (or $x = 0.1$)

$M3 y = 8$

1

M4 (% abundance of 88 isotope is $100 - 2x10 = 80(.0)\%$)

M4 % of 88 isotope is $100 - 10y = 80(.0) \%$

Allow other alternative methods

1

(g) $^{138}\text{Ba}^+$

1

(h) **M1**
$$\text{mass} = \frac{137 \times 10^{-3}}{6.022 \times 10^{23}} = 2.275 \times 10^{-25} \text{ (kg)}$$

Calculation of m in kg

If not converted to kg, max 4

If not divided by L lose M1 and M5, max 3

1

M2
$$v^2 = \frac{2KE}{m} = \frac{2 \times 3.65 \times 10^{-16}}{2.275 \times 10^{-25}} = 3.2088 \times 10^9$$

For re-arrangement

1

M3
$$v = \sqrt{2KE/m} \quad (v = 5.6646 \times 10^4)$$

For expression with square root

1

M4 $v = d/t$ or $d = vt$ or with numbers

1

M5 $d = (5.6646 \times 10^4 \times 2.71 \times 10^{-5}) = 1.53 - 1.54 \text{ (m)}$

M5 must be to 3sf

If not converted to kg, answer = 0.0485-0.0486 (3sf). This scores 4 marks

1

Alternative method

M1
$$m = \frac{137 \times 10^{-3}}{6.022 \times 10^{23}} = 2.275 \times 10^{-25}$$

M1 Calculation of m in kg

1

M2 $v = d/t$

M2, M3 and M4 are for algebraic expressions or correct expressions with numbers

1

M3 $d^2 = \frac{KE \times 2t^2}{m}$

1

M4 $d = \sqrt{\frac{KE \times 2t^2}{m}} (= \sqrt{(3.65 \times 10^{-16} \times 2 \times (2.71 \times 10^{-5})^2 / 2.275 \times 10^{-25}))$

1

M5 $d = 1.53 - 1.54 \text{ (m)}$

M5 must be to 3sf

1

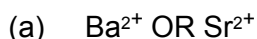
[18]

Q5.

C

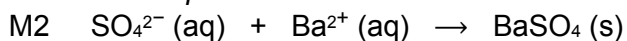
[1]

Q6.

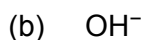


1

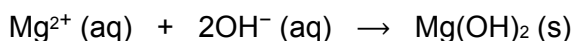
Award M1 if barium named in M1 then used Ba^{2+} in the equation



1



Award M1 if hydroxide named in M1 then used OH^- in the equation



1

1

[4]

Q7.

(a) Ans = C

1

(b) $[\text{H}^+] = \sqrt{K_w} = \sqrt{2.93 \times 10^{-15}} (= 5.41 \times 10^{-8})$

1

$\text{pH} = (-\log (5.41 \times 10^{-8})) = \underline{7.27}$

Must be 2dp

7.27 scores 2 marks

1

(c) $[H^+] = [OH^-]$
allow description in words
equal moles / quantities / numbers / ratio of H^+ and OH^-
 1

(d) $[OH^-] = 0.0131 \times 2 = 0.0262$
pH = 12.95 scores 3 marks
pH = 12.42 scores 2 marks ($K_w = 1 \times 10^{-14}$)
pH = 12.65 scores 1 mark (not multiplied by 2)
pH = 12.35 scores 1 mark (divided by 2)
pH = 12.12 scores 0 marks (no $\times 2$ and wrong K_w)
 1

$[H^+] = (K_w / [OH^-]) = 2.93 \times 10^{-15} / 0.0262 (= 1.118 \times 10^{-13})$
 1

$pH = (-\log (1.118 \times 10^{-13})) = 12.9514 = 12.95$
 Or
 $[OH^-] = 0.0131 \times 2 = 0.0262$
 $pOH = (-\log 0.0262) = 1.5817$
 $pH = (-\log K_w - pOH = -\log 2.93 \times 10^{-15} - 1.58 = 14.53 - 1.58) = 12.95$
allow to 2dp or more
 1

(e) smaller / lower pH / less alkaline / more acidic
If not smaller CE = 0/2
Allow pH number between 8 and 12
 1

(magnesium hydroxide) is less soluble / sparingly soluble/ solubility of hydroxide increases down group II
M2 dependent on M1 but if blank mark on
Ignore concentration and dissociation
Ignore incorrect formula
Do not allow $Mg(OH)_2$ is insoluble
 1

[9]

Q8.

(a) $BaCl_2$ / $Ba(OH)_2$ / $Ba(NO_3)_2$ / BaX_2 or names
Ignore acidification but CE = 0/3 if H_2SO_4
If reagent incorrect or blank then CE = 0/3
If Ba^{2+} or wrong formula, lose M1 and mark on
 1

colourless solution / no (visible) change (nvc) / no ppt / no (visible) reaction
Ignore nothing happens and no observation
 1

white precipitate / white solid
 1

(b) NaOH / sodium hydroxide / other Group 1 hydroxides

*If reagent incorrect or blank then CE =0/3
If reagent incomplete, lose M1 and mark on*

1

white precipitate / white solid

1

(white) ppt which dissolves in excess (NaOH)

If reagent is excess NaOH, allow colourless solution for M3

1

Alternative Method

Name or formula of Group 1 carbonate

1

white precipitate / white solid

1

(white) precipitate and effervescence

1

[6]

Q9.

(a) CO₂ gas escapes or is lost

1

(b) Mass CO₂ = 16.11 – 14.58 = 1.53 g

1

$M_r \text{ CO}_2 = 44.0$

$\text{Mol CO}_2 = 1.53 / 44.0 = 3.48 \times 10^{-2}$

1

$\text{Mol SrCO}_3 = 3.48 \times 10^{-2}$

1

$\text{Mass SrCO}_3 = \text{mol} \times M_r = 3.48 \times 10^{-2} \times 147.6$

$\text{Mass SrCO}_3 = 5.13 \text{ (g)}$

1 mark for the answer and 1 for 3 sf precision

Allow 5.14 g (as a result of rounding)

2

(c) Percentage error = $\frac{0.01}{6.26} \times 100$

= 0.160 (%)

1

(d) Original Mass SrO = 6.26 – 0.347 – 5.13

= 0.783 g (or 783 mg)

OR 6.26 – 0.347 – 4.85 = 1.063 g

Allow 0.773 g or 773 mg (from rounding error in part (b))

1

Justification: All SrCO_3 reacted because heated to constant mass.

1



1

Al acts as a reducing agent

1

Sr is collected as a vapour because

1

Al_2O_3 is an ionic lattice and so has strong ionic attractions

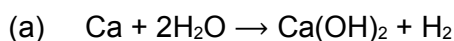
1

Than Sr which is a metallic structure with (relatively) weaker bonding

1

[14]

Q10.



1

8 – 12

1

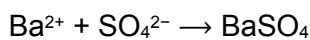
(b) Decrease

1

(c) BaCl_2

Allow $\text{Ba}(\text{NO}_3)_2$ or other soluble barium salt

1



Allow equation if state symbols missing but penalise if state symbols are incorrect

1

(d) Strong attraction

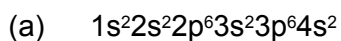
1

Between positive and negative ions

1

[7]

Q11.



Allow correct numbers that are not superscripted

1

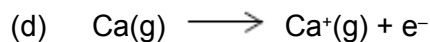


State symbols essential

1

(c) Oxidising agent

1



State symbols essential

Allow 'e' without the negative sign

1

(e) Decrease

If answer to 'trend' is not 'decrease', then chemical error = 0 / 3

1

Ions get bigger / more (energy) shells

Allow atoms instead of ions

1

Weaker attraction of ion to lost electron

1

[7]

Q12.

(a) **Q** is calcium or magnesium

1

bromide

1

R is aluminium

1

chloride

1

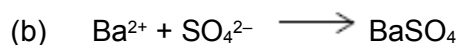
S is iron(III)

1

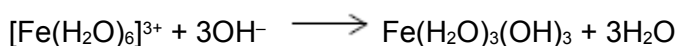
sulfate

1

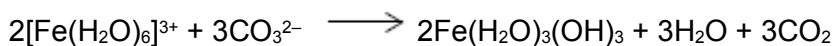
Mark this question independently



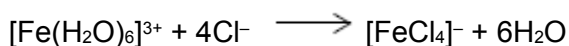
1



1



1



1

[10]

Q13.

Identifies precipitate as being BaSO_4

1

Moles of Barium sulfate = mass/Mr

$$\begin{aligned}
 & (= 0.764 / 233.4) \\
 & = 0.003273 \text{ moles}
 \end{aligned}$$

Allow conseq if Mr BaSO₄ or BaCl₂ incorrect

$$\text{Mass of Barium chloride} = 208.3 \times 0.003273 = 0.6818 \text{ g}$$

$$\text{Percentage of Magnesium chloride} = \frac{1.056 - 0.6818}{1.056} \times 100$$

Do NOT penalise incorrect precision here

Allow range 33.7-35.5% (rounding errors penalised elsewhere in paper)

1

1

1

[4]

Q14.

- (a) Sulfuric acid has 2 × the H⁺ ion concentration

Larger concentration of H⁺ is sufficient.

1

Calcium is more reactive (than magnesium)

Allow reference to a greater surface area for calcium.

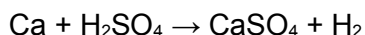
Do not allow any references to temperature variations.

1

- (b) Calcium sulfate

Accept CaSO₄

1



Accept Ca²⁺ + SO₄²⁻ → CaSO₄

Allow multiples or fractions of these equations.

Ignore state symbols.

1

Calcium sulfate is insoluble or has (very) low solubility

Accept "an insoluble layer is formed".

Answer must refer to the low solubility.

1

[5]

Q15.

A

[1]

Q16.

A

[1]

Q17.

- (a) More (electron) shells / (outer) electrons further from the nucleus / larger atoms /

more shielding

If 'molecules' mentioned CE = 0

It = Ba

Mark independently

ALLOW energy levels for shells

Both ideas must be comparative

1

So weaker attraction of nucleus/protons for (outer) electrons

NOT hold/pull/bonded for 'attraction'

Idea of nucleus or protons must be clear

ALLOW M2 if electrons implied from mention in M1

ALLOW converse if it is clear that answer refers to Ca

1

(b) White solid / white ash

ALLOW 'white smoke/powder'

IGNORE 'product'

NOT ppt

IGNORE fumes

IGNORE tube/glass goes black

1

Bright light / white light

ALLOW glow/flame for light

1

$\text{Mg} + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{H}_2$

IGNORE state symbols

1

(c) BaSO_4 is insoluble but $\text{Ba}(\text{NO}_3)_2$ is soluble

OR

BaSO_4 precipitates but $\text{Ba}(\text{NO}_3)_2$ product(s) of second reaction is soluble/remains in solution

OR

BaSO_4 is insoluble but no reaction occurs in second case

NOT just 'no observation' in second case

Comparison of solubilities must be implied

NOT Barium is soluble/insoluble

Correct state symbols required

1

$\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$

1

[7]

Q18.

(a) **M1** acidified potassium dichromate or $\text{K}_2\text{Cr}_2\text{O}_7$ / H_2SO_4

OR $\text{K}_2\text{Cr}_2\text{O}_7$ / H^+ **OR** acidified $\text{K}_2\text{Cr}_2\text{O}_7$

M2 (orange to) green solution **OR** goes green

M3 (solution) remains orange or no reaction or no (observed) change

If no reagent or incorrect reagent in M1, CE = 0 and no marks for M1, M2 or M3

If incomplete / inaccurate attempt at reagent e.g. "dichromate" or "dichromate(IV)" or incorrect formula or no acid, penalise M1 only and mark on

For M2 ignore dichromate described as "yellow" or "red"

For M3 ignore "nothing (happens)" or "no observation"

Alternative using $\text{KMnO}_4 / \text{H}_2\text{SO}_4$

M1 acidified potassium manganate(VII) / potassium permanganate or $\text{KMnO}_4 / \text{H}_2\text{SO}_4$

OR $\text{KMnO}_4 / \text{H}^+$ **OR** acidified KMnO_4

M2 colourless solution **OR** goes colourless

M3 (solution) remains purple or no reaction or no (observed) change

For M1

If incomplete / inaccurate attempt at reagent e.g.

"manganate" or "manganate(IV)" or incorrect formula or no acid, penalise M1 only and mark on

Credit alkaline KMnO_4 for possible full marks but M2 gives brown precipitate or solution goes green

3

(b) **M1** (Shake with) Br_2 **OR** bromine (water) **OR** bromine (in CCl_4 / organic solvent)

M2 (stays) orange / red / yellow / brown / the same

OR no reaction **OR** no (observed) change

M3 decolourised / goes colourless / loses its colour / orange to colourless

If no reagent or incorrect reagent in M1, CE = 0 and no marks for M1, M2 or M3

If incomplete / inaccurate attempt at reagent (e.g. Br), penalise M1 only and mark on

No credit for combustion observations; CE = 0

For M2 in every case

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear"

OR as alternatives

Use $\text{KMnO}_4 / \text{H}_2\text{SO}_4$

M1 acidified potassium manganate(VII) / potassium permanganate **OR** $\text{KMnO}_4 / \text{H}_2\text{SO}_4$

OR $\text{KMnO}_4 / \text{H}^+$ **OR** acidified KMnO_4

M2 (stays) purple or no reaction or no (observed) change

M3 decolourised / goes colourless / loses its colour

Use iodine

M1 iodine or I₂ / KI or iodine solution

M2 no change

M3 decolourised / goes colourless / loses its colour

Use concentrated sulfuric acid

M1 concentrated H₂SO₄

M2 no change

M3 brown

For M1, it must be a whole reagent and / or correct formula

For M1 penalise incorrect attempt at correct formula, but mark M2 and M3

With potassium manganate(VII)

If incomplete / inaccurate attempt at reagent e.g.

*“manganate” or “manganate(IV)” or incorrect formula or no acid, **penalise M1 only and mark on***

Credit alkaline / neutral KMnO₄ for possible full marks but M3 gives brown precipitate or solution goes green

Apply similar guidance for errors in the formula of iodine or concentrated sulfuric acid reagent as those used for other reagents.

3

(c) **M1** Any soluble chloride including hydrochloric acid (ignore concentration)

M2 white precipitate or white solid / white suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 Any soluble iodide including HI

M2 yellow precipitate or yellow solid / yellow suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 Any soluble bromide including HBr

M2 cream precipitate or cream solid / cream suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 NaOH or KOH or any soluble carbonate

M2 brown precipitate or brown solid / brown suspension with NaOH / KOH
(white precipitate / solid / suspension with carbonate)

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If no reagent or incorrect reagent or insoluble chloride in **M1**,
CE = 0 and no marks for **M1**, **M2** or **M3***

Allow chlorine water

*If incomplete reagent (e.g. chloride ions) or inaccurate attempt at formula of chosen chloride, or chlorine, **penalise M1 only and mark on***

*For **M2** require the word “white” and some reference to a solid. Ignore “cloudy solution” OR “suspension” (similarly for the alternatives)*

*For **M3***

Ignore “nothing (happens)”

Ignore “no observation”

Ignore “clear” on its own

Ignore “dissolves”

3

(d) **M1** Any soluble sulfate including (dilute or aqueous) sulfuric acid

M2 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

M3 white precipitate or white solid / white suspension

*If no reagent or incorrect reagent or insoluble sulfate in **M1**,
CE = 0 and no marks for **M1**, **M2** or **M3***

Accept MgSO_4 and CaSO_4 but not barium, lead or silver sulfates

*If concentrated sulfuric acid or incomplete reagent (e.g. sulfate ions) or inaccurate attempt at formula of chosen sulfate, **penalise M1 only and mark on***

*For **M3** (or **M2** in the alternative) require the word “white” and some reference to a solid.*

Ignore “cloudy solution” OR “suspension”

*For **M2** (or **M3** in the alternative)*

Ignore “nothing (happens)”

Ignore “no observation”

Ignore “clear” on its own

Ignore “dissolves”

OR as an alternative

M1 NaOH or KOH

M2 white precipitate or white solid / white suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If incomplete reagent (e.g. hydroxide ions) or inaccurate attempt at formula of chosen hydroxide, **penalise M1 only and mark on***

*If **M1** uses NH_3 (dilute or concentrated) **penalise M1 only and mark on***

3

[12]

Q19.

- (a) **M1** Increases / gets bigger

*If **M1** is incorrect **CE = 0** for the clip*

*If **M1** is blank, mark on and seek to **credit the correct information in the text***

M2 requires a correct **M1**

M2** requires correct **M1

More shells or sub-shells or (main) levels or sub-levels or orbitals (of electrons)

*If “molecules” penalise **M2***

Not simply “more electrons”

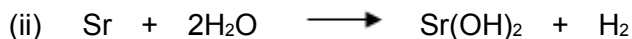
Not “more outer shells”

Ignore reference to nuclear charge and shielding

2

- (b) (i) Increases / gets more reactive / reacts more vigorously / violently (down the Group)

1



Credit multiples and correct ionic equations

Ignore state symbols

1

- (c) $\text{Ba}(\text{OH})_2$

*This **MUST** be a formula so ignore the name*

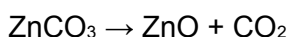
Credit $\text{Ba}^{2+} 2\text{OH}^-$

Ignore state symbols

1

[5]

Q20.



Ignore state symbols.

If equation incorrect, allow one mark only for correct atom economy method.

1

Percentage atom economy =

Mark consequentially for incorrect formula mass(es)

1

$$\frac{81.4}{125.4} \times 100 = 64.9$$

Accept answer to at least 2 significant figures

1

[3]

Q21.

(a) Compound 1

If M1 incorrect, CE = 0

M1
1

No visible change with H₂SO₄

M2
1

Gives white ppt with NaOH

M3
1

(b) BaCO₃

1

The carbonate ion releases CO₂

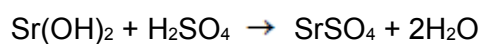
1

but the BaSO₄ formed is highly insoluble.

1

(c) Compound 4

1



Allow ionic equation; ignore state symbols

1

[8]

Q22.

(a) 0.155 g per 100 cm³

M1

Allow 0.153 – 0.157

1

$$(0.155 / 74.1) \times 10 = 0.0209 \text{ mol dm}^{-3}$$

M2

Allow 0.0206 – 0.0212

1

Answer to 3 significant figures

The correct answer only loses M1

1

- (b) Take a known volume of the saturated solution

1

Evaporate the filtrate to dryness

Allow titrate with dilute HCl or HNO₃

1

Weigh the residue

.....of known / specified concentration

Ignore any references to indicators

1

[6]

Q23.

- (a) **M1** Used in a barium meal / barium swallow / barium enema

OR (used to absorb) X-rays

*Credit a correct reference to **M1** written in the explanation in **M2** unless contradictory.*

M2 BaSO₄ / barium sulfate / it is insoluble

*For **M2** penalise obvious reference to barium or to barium ions being insoluble.*

2

- (b) $\text{Mg}(\text{OH})_2 + 2\text{HCl} \longrightarrow \text{MgCl}_2 + 2\text{H}_2\text{O}$

Or multiples.

Ignore state symbols.

1

- (c) It / magnesium hydroxide is insoluble / insufficiently soluble / sparingly soluble / less soluble than barium hydroxide / forms low concentration solutions

Weak alkali alone is insufficient.

Formation of a precipitate needs explanation.

1

- (d) $\text{TiCl}_4 + 2\text{Mg} \longrightarrow 2\text{MgCl}_2 + \text{Ti}$

Or multiples.

Ignore state symbols.

1

- (e) **M1** Hydrogen / H₂ produced

OR an equation to produce hydrogen / H₂

(eg $\text{Mg} + 2\text{H}_2\text{O} \longrightarrow \text{Mg}(\text{OH})_2 + \text{H}_2$)

(eg $\text{Mg} + \text{H}_2\text{O} \longrightarrow \text{MgO} + \text{H}_2$)

*For **M1***

Do not penalise an incorrect equation; the mark is for H₂ or

hydrogen.

Award one mark only for 'exothermic reaction with steam / H_2O ' for a student who has not scored **M1**

M2 requires correct **M1**

risk of explosion

OR forms explosive mixture (with air)

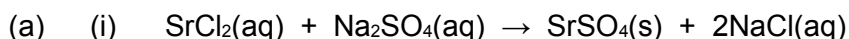
OR (highly) flammable

Ignore 'violent' reaction.

2

[7]

Q24.



Allow multiples, including fractions.

Allow ionic equations.

Lose this mark if any of the state symbols are missing or incorrect.

1

(ii) Add nitric acid to the mixture (until in excess)

Do not allow any suggestion that the solution is an emetic.

1

Filter (to isolate strontium sulfate)

1

(b) Insoluble barium sulfate is formed

Allow 'removes barium ions as a precipitate'.

1

(c) Add silver nitrate, then dilute ammonia (solution) **M1**

Do not allow answers which imply silver nitrate and ammonia are added at the same time.

Allow 'add silver nitrate, then concentrated ammonia (solution)'.

Can score **M1** in the answer for **M3**

1

Cream precipitate **M2**

Allow 'off white precipitate'.

1

No visible change or precipitate dissolves slightly in dilute ammonia **M3**

Allow 'soluble / colourless solution / precipitate dissolves in concentrated ammonia'.

Allow 3 marks for:

Add dilute ammonia (solution), then silver nitrate **M1**

No visible change **M2**

Cream / off white precipitate with silver nitrate **M3**

1

Q25.

- (a) (i)
- 1.08×10^{-2}

Do not penalise precision but must be to at least 2 significant figures.

Do not accept 1×10^{-2}

1

- (ii)
- $5.4(0) \times 10^{-3}$

Allow (i) / 2

Do not penalise precision but must be to at least 2 significant figures.

1

- (iii) 266.6

Lose this mark if answer not given to 1 decimal place.

1

- (iv) mass =
- $5.4(0) \times 10^{-3} \times 266.6 = 1.44 \text{ g}$
- M1**

Allow (ii) $\times$ (iii).

1

percentage = $1.44 \times 100 / 2.25 = 64.0$ **M2**

*Allow consequential answer from **M1***

Lose this mark if answer not given to 3 significant figures.

*Correct answer with no working scores **M2** only.*

1

- (v) 1 Would give an
- incorrect / too large mass
- (of silver chloride)

Do not allow 'to get an accurate result' without qualification.

1

- 2
- To remove soluble impurities
- /
- excess silver nitrate
- (solution) /
- strontium nitrate
- (solution)

Do not allow 'to remove impurities'.

Do not allow 'to remove excess strontium chloride solution'.

1

- (b) (i)
- $\text{Mg}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Mg}(\text{OH})_2(\text{s})$

Allow $\text{Mg}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{OH})_2(\text{s})$

Allow multiples, including fractions.

Lose mark if state symbols are missing or incorrect.

Lose mark if incorrect charge on an ion.

1

- (ii) Does not produce
- CO_2
- / gas which distends stomach / does not produce wind / does not increase pressure in stomach

Allow 'prevents flatulence' and 'prevents burping'.

Do not allow 'gas' without qualification.

1

- (c)
- $(\text{CH}_3\text{COO})_2\text{Ca} \rightarrow \text{CH}_3\text{COCH}_3 + \text{CaCO}_3$

Allow multiples.

Allow propanone as C_3H_6O

Allow $(CH_3COO^-)_2Ca^{2+} \rightarrow CH_3COCH_3 + Ca^{2+}CO_3^{2-}$

1

- (d) Ca (salt) - no visible change with sodium chromate(VI) **M1**

Allow 'yellow solution formed' or 'no ppt. forms'.

Allow **M1** and **M2** in any order.

1

Sr and Ba (salts) give (yellow) precipitate with sodium chromate(VI) **M2**

Lose this mark if precipitate has an incorrect colour.

1

Sr precipitate (chromate(VI)) dissolves in ethanoic acid / Ba precipitate (chromate(VI)) does not dissolve in ethanoic acid **M3**

If ethanoic acid is added first, allow access to **M1** and **M3**.

1

- (e) C 42.09 / 12, H 2.92 / 1, N 8.18 / 14, O 37.42 / 16 and S 9.39 / 32.1

Accept any other correct method of working.

If relative atomic mass has been divided by the percentage composition is used then CE = 0 / 2

1

$C_{12}H_{10}N_2O_8S$

Correct answer with no working scores 1 mark only.

1

[15]

Q26.

- (a) (Measure the) volume of gas / mass of the container + contents

1

Suitable named piece of equipment

Gas syringe (or inverted burette or measuring cylinder, as long as student has referred to the cylinder being filled with water) / balance.

Equipment must be correct for the measurement stated.

1

- (b) Any **one** of:

- Mass of magnesium
Allow amount of magnesium.
- Surface area of magnesium

1

- (c) (i) Gravity: Conical flask or beaker and funnel /

Vacuum: Sealed container with a side arm and Buchner or Hirsch funnel

Must be either gravity filtration (with a V-shaped funnel) or vacuum filtration (with a side-arm conical flask) appropriately drawn.

1

Filter paper

Must show filter paper as at least two sides of a triangle (V-shaped) for gravity filtration or horizontal filter paper for vacuum filtration.

1

- (ii) Wash with / add (a small amount of cold) water
Ignore filtering.

1

[6]

Q27.

- (a) **M1 (could be scored by a correct mathematical expression)**

*Correct answer to the calculation gains all of **M1**, **M2** and **M3***

M1 $\Delta H = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants})$

Credit 1 mark for $-101 \text{ (kJ mol}^{-1}\text{)}$

OR a correct cycle of balanced equations

$$\begin{aligned} \text{M2} &= -1669 - 3(-590) \\ &= -1669 + 1770 \\ &\text{(This also scores M1)} \end{aligned}$$

M3 = + **101** (kJ mol⁻¹)

Award 1 mark ONLY for -101

For other incorrect or incomplete answers, proceed as follows

- check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (**M1** and **M2**)
- If no AE, check for a correct method; this requires either a correct cycle with 3Sr and 2Al **OR** a clear statement of **M1** which could be in words and scores only M1

M4 - Using powders

Any **one** from

- To increase collision frequency / collisions in a given time / rate of collisions
- To increase the surface contact / contact between the solids / contact between (exposed) particles

Ignore dividing final answer by 3

*Penalise **M4** for reference to molecules.*

5

M5 Major reason for expense of extraction

Any **one** from

- Aluminium is extracted by electrolysis **OR** aluminium extraction uses (large amounts of) electricity
- Reaction / process / It / the mixture requires heat

- It is endothermic

- (b) Calcium has a higher melting point than strontium, because
Ignore general Group 2 statements.

Correct reference to size of cations / proximity of electrons

M1 (For Ca) delocalised electrons closer to cations / positive ions / atoms / nucleus

OR cations / positive ions / atoms are smaller

OR cation / positive ion / atom or it has fewer (electron) shells / levels

Penalise M1 if either of Ca or Sr is said to have more or less delocalised electrons OR the same nuclear charge.

Ignore reference to shielding.

Relative strength of metallic bonding

M2 (Ca) has stronger attraction between the cations / positive ions / atoms / nucleus and the delocalised electrons

OR

stronger metallic bonding

(assume argument refers to Ca but credit converse argument for Sr)

CE= 0 for reference to molecules or Van der Waals forces or intermolecular forces or covalent bonds.

2

- (c) **M1** $2\text{Mg} + \text{O}_2 \longrightarrow 2\text{MgO}$

M2 $\text{Mg} + 2\text{H}_2\text{O} \longrightarrow \text{Mg}(\text{OH})_2 + \text{H}_2$

Credit multiples of the equations.

M3 Magnesium hydroxide is used as an antacid / relieve indigestion (heartburn) / neutralise (stomach) acidity / laxative

Not simply "milk of magnesia" in M3

3

[10]

Q28.

- (a) As concentration increases the amount of heat given out increases / temperature increases (**M1**)

Any order.

Ignore references to an exothermic reaction.

1

More successful collisions or reactions in a given time **OR** more particles have the activation energy (**M2**)

Allow could be a second / n^{th} order reaction.

1

(An increase in temperature or more heat given out) increases the rate of a reaction (**M3**)

1

- (b) The magnesium is coated with an oxide / MgO (**M1**)

Allow magnesium hydroxide.

1

MgO / the coating / the corrosion product has to be removed before Mg will react
OR Mg and MgO / the coating / the corrosion product react at different rates
OR Initially MgO / the coating / the corrosion product reacts not Mg (**M2**)
Ignore inert coating.

1

- (c) Any **two** from:

Any order.

Slower with hot water or faster with steam

The hot water produces $\text{Mg}(\text{OH})_2$ / the hydroxide **OR** steam produces MgO / the oxide

(Slow) bubbling with hot water **OR** bright white light / flame / white solid with steam

2 max

- (d) Magnesium sulfate is soluble and calcium sulfate is insoluble / slightly soluble / magnesium sulfate is more soluble / calcium sulfate is less soluble / correct trend in solubility (**M1**)

Any order.

M1 requires a comparison of the two solubilities.

Calcium sulfate coats the surface of the calcium (**M2**)

Coating prevents further contact with / reaction by the acid (**M3**)

'Calcium sulfate forms a protective coating' scores M2 only.

3

[10]

Q29.

Mg^{2+} and Cl^-

Do not allow names.

[1]

Q30.

- (a) (i) Change in concentration (of a substance / reactant / product) in unit time / given time / per (specified) unit of time

*This may be written mathematically **OR** may refer to the gradient of a graph of concentration / volume against time*

OR

Amount of substance formed / used up in unit time / given time / per (specified) unit of time

Ignore additional information including reference to collisions

1

- (ii) At **W**

M1 (QoL)

The rate / it is zero

M2

The magnesium has all reacted / has been used up
Ignore reference to the acid being used up

OR

No more collisions possible between acid and Mg

OR

Reaction is complete / it has stopped

OR

No more hydrogen / product is produced

2

(iii) M1

Twice / double as many particles / hydrogen ions (in a given volume)
Penalise reference to (hydrochloric acid) molecules in M1
Penalise reference to "HCl particles" in M1

OR

Twice / double as much hydrochloric acid

M2

Twice / double as many effective / successful collisions (in a given time)

OR

Twice / double as many collisions with either sufficient energy to react
OR with $E \geq E_a$

OR

double the successful / effective collision frequency

2

(b) (i) The activation energy is the minimum energy for a reaction to go / start

OR

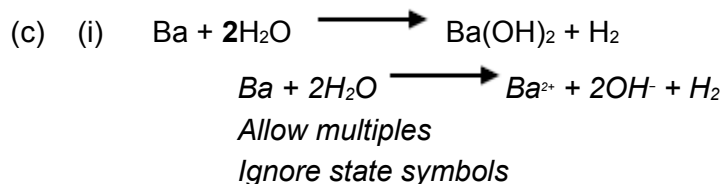
Minimum energy for a successful/ effective collision

1

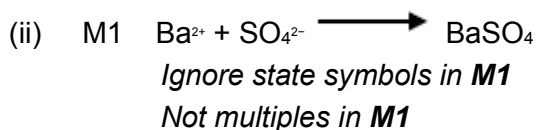
(ii) M1 Products lower than reactants on the profile
Mark independently

M2 Activation energy (E_a) shown and labelled correctly from reactants
to peak of curve
Mark independently

2



1



M2 White precipitate / solid
 Extra ions must be cancelled
 Penalise contradictory observations in **M2**

2

(iii) M1 Barium meal / barium swallow / barium enema
 Accept a correct reference to **M1** written in the explanation in **M2**, unless contradictory

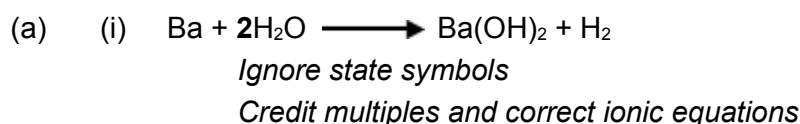
OR used in X-rays **OR** to block X-rays **OR** X-ray contrast medium **OR** CT scans

M2 BaSO₄ / barium sulfate is insoluble (and therefore not toxic)
 For **M2** NOT barium ions
 NOT barium
 NOT barium meal and NOT "It"
 Ignore radio-tracing

2

[13]

Q31.



1

(ii) (Reactivity with water) increase(s) / increasing / increased (down the Group / from Mg to Ba)
 Accept "greater" or "gets more" or similar words to that effect.
 Ignore reference to "increase in solubility / gets more soluble"

1

(b) Mg(OH)_2
 Accept $\text{Mg}^{2+}(\text{OH})_2$ / $\text{Mg}(\text{HO})_2$
 Insist on brackets and correct case

1

(c) **M1** Barium meal / barium swallow / barium enema or (internal) X-ray or to block X-rays

M2 BaSO₄ / barium sulfate is insoluble (and therefore not toxic)
 Accept a correct reference to **M1** written in the explanation in **M2**, unless contradictory
 For **M2** NOT barium ions
 NOT barium
 NOT barium meal and NOT "It"
 Ignore radio-tracing

2

[5]

Q32.

- (a) (i) Increases 1
- (ii) Decreases 1
- (iii) Increases 1
- (b) Calcium has a higher melting point than strontium, because
CE = 0 for reference to molecules or intermolecular forces or covalent bonds

Correct reference to size of cations/proximity of electrons

M1 (For Ca) delocalised electron(s) closer to cations / positive ions / nucleus
 Ignore "Van der Waals forces (between atoms)" but penalise if between "molecules"

OR cations / positive ions / atoms are smaller

OR cation / positive ion / atom or it has fewer (electron) shells / levels
 Ignore general Group 2 statements
 Answers must be specific

Relative strength of metallic bonding

M2 (For Ca) has stronger attraction between the cations / positive ions / nucleus and the delocalised electron(s)
 Penalise M1 if Ca or Sr is said to have more or less delocalised electrons

OR

stronger metallic bonding

(assume argument refers to Ca but accept converse argument for Sr)
 Ignore reference to shielding

2

- (c) (i) Sulfuric acid / it contains sulfate ions / SO₄²⁻

OR

Do not penalise an additional but incorrect formula for sulfate ion.

Sulfuric acid would form a (white) precipitate

If only the formula of the sulfate ion is given, it must be correct

1



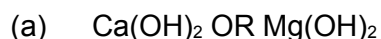
Ignore state symbols

No multiples

1

[7]

Q33.



Ignore name

Could be ionic

1



OR



Either formula or name can score

Do not penalise the spelling "fluoride"

When both formula and name are written,

- penalise contradictions
- if the attempt at the correct **formula** is incorrect, ignore it and credit **correct name** for the mark unless contradictory
- if the attempt at the correct name is incorrect, ignore it and credit **correct formula** for the mark unless contradictory

1



Ignore name (even when incorrect)

The correct formula must be clearly identified if an equation is written

1



Only the correct formula scores;

penalise lower case "b", penalise upper case "R", penalise superscript

Ignore name

The correct formula must be clearly identified if an equation is written

1



M2 I₂ (ONLY)

Ignore names

penalise lower case "i" for iodine,

penalise superscripted numbers

Mark independently

The correct formula must be clearly identified in each case if an equation is written

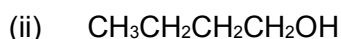
2



Structure of but-1-ene. Ignore name

Credit "sticks" for C-H bonds

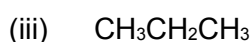
1



Structure of butan-1-ol. Ignore name

Credit "sticks" for C-H bonds

1



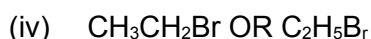
Structure of propane. Ignore name

Ignore calculations and molecular formula

Credit "sticks" for C-H bonds

Ignore the molecular ion

1



Structure of bromoethane.

Ignore name and structure of nitrile

Credit "sticks" for C-H bonds

1

[10]

Q34.

- (a) (i) **M1** (yellow precipitate is) silver iodide OR AgI (which may be awarded from the equation)

M2 $\text{Ag}^+ + \text{I}^- \rightarrow \text{AgI}$ (Also scores M1 unless contradicted)

M3 sodium chloride OR NaCl

For M2

Accept multiples

Ignore state symbols

Allow crossed out nitrate ions, but penalise if not crossed out

3

- (ii) The silver nitrate is acidified to

- react with / remove ions that would interfere with the test
- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test

- remove (other) ions that react with the silver nitrate
- react with / remove carbonate / hydroxide / sulfite (ions)
Ignore reference to “false positive”

1

(iii) **M1 and M2 in either order**

M1 Fluoride (ion) OR F⁻

- M2**
- Silver fluoride / AgF is soluble / dissolves (in water)
 - no precipitate would form / no visible / observable change
*Do not penalise the spelling “fluoride”,
Penalise “fluride” once only
Mark M1 and M2 independently*

2

(b) **M1** $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$

(or the ions together)

M2 white precipitate / white solid / white suspension

M3 Barium meal or (internal) X-ray or to block X-rays

M4 BaSO₄ / barium sulfate is insoluble (and therefore not toxic)

For M1, ignore state symbols

Allow crossed out sodium ions, but penalise if not crossed out

For M2, ignore “milky”

If BaSO₃ OR BaS used in M1 and M4, penalise once only

For M3 Ignore radio-tracing

For M4 NOT barium ions

NOT barium

NOT barium meal

NOT “It” unless clearly BaSO₄

4

(c) **M1** $2(12.00000) + 4(1.00794) = 28.03176$

M2 Ethene and CO or “they” have an imprecise **M_r** of 28.0 / 28

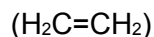
OR

Ethene and CO or “they” have the same M_r to one d.p.

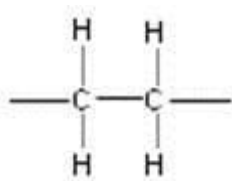
OR

These may be shown by two clear, simple sums identifying both compounds

M3 $\text{C}_2\text{H}_4 + 2\text{O}_2 \rightarrow 2\text{CO} + 2\text{H}_2\text{O}$



M4 Displayed formula



M5 Type of polymer = Addition (polymer)

M1 must show working using 5 d.p. for hydrogen

Penalise "similar" or "close to", if this refers to the imprecise value in M2, since this does not mean "the same"

For M3, accept $CH_2=CH_2$ OR CH_2CH_2

For M4, all bonds must be drawn out including those on either side of the unit.

Penalise "sticks"

*Ignore brackets around **correct** repeating unit but penalise "n"*

Penalise "additional"

5

[15]

Q35.

(a) Hydrochloric acid = **C**

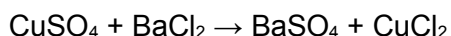
1

Barium chloride = **A**

1

(b) Barium sulfate is insoluble

1



Accept multiples.

Accept ionic equation.

Do not penalise lack of state symbols, but if used they must be correct.

1

(c) CO_2 / Carbon dioxide

1

(d) Reagent 1 silver nitrate (solution)

Ignore lack of reference to acidifying prior to addition of silver nitrate solution.

1

Observation 1 White precipitate

1

Reagent 2 (dilute) ammonia solution / aqueous ammonia

*Do not accept addition of **ammonia** only.*

Observation 2 (Colourless) solution

Allow ppt dissolves.

Do not allow 'goes colourless' or 'goes clear'.

Chlorine and no visible change or solution does not become orange scores M3 and M4.

1

(e) Gloves / wash hands after use

Ignore 'eye protection'.

Do not accept 'do not ingest the chemicals', 'wipe up spillages', 'use a fume cupboard', 'wear a lab coat' (list principle).

1

[10]

Examiner reports

Q1.

The majority of students (74%) were able to recall correctly the reducing agent in this process.

Q2.

Many students (81.2%) got this correct and appreciated the use of barium sulfate in medicine.

Q3.

Most students (69.2%) got this question correct but many confused the uses of magnesium hydroxide and calcium hydroxide.

Q4.

- (a) The electron configuration was well known (88.9% correct).
- (b) Only the best students gained both marks here (19%); many students focused on whether the electron was being removed from a full or partially full orbital instead of considering why the attraction between the nucleus and the electron might be different.
- (c) Less than half of the students (39.5%) could give the correct answer here; lithium was a common error.
- (d) The majority of students (76.3%) answered this correctly, although there were quite a number who gave the incorrect formula.
- (e) The ionic equation was generally correct and many students could also calculate that barium chloride was in excess. Just under a third of students managed to score all three marks.
- (f) Most students could state why isotopes have the same chemical properties. In the calculation, many students gave an algebraic equation with two unknowns and could not proceed any further. The students who gave a correct algebraic expression with one unknown could work through the calculation and generally gained full marks. Some students answered the question by trial and error and this was also given full credit. Pleasingly, 43.7% of students gained all four marks available.
- (g) Most students deduced that the mass number of the ion would be 138 but less than 30% of students could give the correct formula for the ion including its charge.
- (h) Some students answered this part very well (with 36.6% scoring full marks), but most students scored partial marks or no marks; common errors included failure to use the Avogadro constant, not converting mass to kg, and incorrect rearrangement of expressions.

Q5.

Although 73.5% of students chose the correct response, A was a significant distractor, suggesting confusion with the reaction between magnesium and cold water.

Q6.

- (a) The correct ion was identified quite often but the equation was much less well answered.
- (b) Even good students struggled with this question. The context of the ion test was the reverse of the common way of asking the question and, as such, poorly understood.

Q7.

- (a) This question was answered well (89.5% correct).
- (b) Many students scored both marks here, although some did not give the answer to two decimal places and thereby lost a mark; some students failed to take the square root of K_w .
- (c) The answer to this question was generally well known, although some students appeared to believe that a pH of 7.27 was not sufficiently alkaline.
- (d) This question differentiated well. Many students failed to appreciate that calcium hydroxide is dibasic and an answer of 12.65 was common. Some students used $K_w = 1.00 \times 10^{-14}$ and a few students failed to give the answer to two decimal places.
- (e) The idea that magnesium hydroxide is less soluble than calcium hydroxide was appreciated by only a few students. Many thought the pH value should be the same. Some who gave a lower pH followed this with a discussion about the magnesium ion's greater polarising power.

Q8.

- (a) Many students gave incomplete reagents or the wrong formula. Barium itself was an occasional wrong answer. Most students gained the observation mark for potassium sulfate, but not for potassium nitrate.
- (b) Good answers to this question were rarely seen. Sodium hydroxide was the most common correct reagent, but students then failed to realise that an excess of sodium hydroxide was needed to distinguish between the two metal ions. A few students suggested sodium carbonate as the reagent but then failed to give full observations.

Q13.

This question was very poorly answered with few getting to the correct overall answer. The unstructured nature of this calculation proved too difficult for most especially following the requirement to identify correctly BaSO_4 as the precipitate formed. Only the very best students scored well here.

Q14.

A common mistake in (a) was to allow the answer that sulfuric was a stronger acid than hydrochloric without reference to the correct answer relating to concentration of acid ions. In (b) there was good discrimination but many markers ignored the underlined terms in the Marking Guidelines that had to be present in a correct answer.

Q15.

Usually well answered.

Q17.

Two-thirds of the marks in this enthalpy-based question involved students being able to carry out calculations based on Hess' Law and, as always, there was a divide between those who could cope with such questions and those who couldn't.

In part (a) the importance of learning definitions was illustrated. Many students failed to make clear that all reactants and products need to be in their standard states.

In questions such as part (b) students are strongly advised to start with a clear and complete indication of the expression relating the enthalpy change of the reaction to the data given or to draw out a clearly labelled cycle. Students who relied on the use of a learned expression often got this wrong way round, possibly due to confusion with the use of enthalpies of formation whereas, in this case, the data provided were enthalpies of combustion.

In a question like part (c) students are strongly advised to sketch out the displayed formulae of all reactants and products when working with bond energies. Failing to do so in many cases meant that bonds were omitted or miscounted (3 x C-C in propan-1-ol was often seen) by students.

Q18.

This was a high demand question, since it requires application of chemistry from the specification and a failure to provide a suitable test reagent leads to the loss of three marks in each part. The number of possible answers to distinguish silver nitrate in part (c) was considerable and partial credit was awarded for test reagents that were unsuitable for test-tube tests, but which led to correct chemical observations. Less than one third of students scored all three marks on part (c) and part (d), whereas three quarters scored full marks on part (b).

Q19.

This covered aspects of Group 2 chemistry and in part (a), the trend in atomic radius down the Group was usually correct, but the simple reason that one more main level of electrons was being added for each element in the Group was seen less than might have been expected. As has happened in the past, the failure to be able to work out the formula of Group 2 compounds resulted in the loss of marks for some students.

Q20.

This question was well done with a few of the weaker students having problems with correct formulae.

Q21.

All parts of this question were good discriminators with, poor expression of the chemical ideas the major problem. Over-generous marking was particularly evident in parts (a) and (b).

Q22.

In part (a) Centres often ignored the requirement for 3 s.f. in the answers and were lenient in marking part (b). It is the sequence of steps here that is important and the omission of a 'known volume' the usual error. Centres must not give credit for 'evaporate' as part of a method that is clearly unworkable.

Q23.

Incorrect formulae of Group 2 compounds and that of titanium(IV) chloride were common and it was problems with these that contributed to only about two-thirds of students scoring the mark in parts (b) and (d), respectively. Just over half of students scored both marks in part (e).

Q24.

- (a) (i) In this part, it was disappointing to note that there were many instances of missing or incorrect state symbols that were missed or ignored by the marker.
- (ii) The logic required in this part again required a careful and sequenced expression of ideas that some found challenging.

The information and test in part (b) and (c) were well known and usually well expressed with occasional confusion regarding the concentration of the ammonia solution used.

Q25.

- (a) The calculations in parts (i) to (iv) of this part were generally well done although there was some confusion regarding the number of significant figures (both in answers and the marking) and with some lower-scoring students experiencing difficulties in part (iv). However, the ideas underlying part (v) gave a greater challenge and many partial answers were seen (and sometimes incorrectly credited).
- (b) In part (b) and (c) were well answered in the main with the usual caveat about state symbols. The formula of propanone was generally well known either as the molecular or structural formula.
- (c) In part (b) and (c) were well answered in the main with the usual caveat about state symbols. The formula of propanone was generally well known either as the molecular or structural formula.
- (d) The ideas in this part were found to be quite challenging to all but the highest-scoring students and a great deal of confusion was seen regarding colours, solutions and precipitates. In the marking, it is important to appreciate that to gain partial marks the procedure described must be chemically correct; M3 could not be awarded unless there is some correct work up to this point. Answers were often jumbled and contradictory. Many students failed to add sodium chromate solution at the start and so could not gain any marks. Where this addition was done, some students mentioned the formation of a precipitate with the calcium ion solution that then dissolved on addition of water. Many students did not appreciate that the substances were already in solution at the start of the procedure.
- (e) As usual, the empirical formula in this part was well done with a few arithmetic errors only.

Q26.

- (a) In this part, 'amount' was not sufficient. Many students simply referred to measuring the mass of the reagents but, since this is not practically possible without including the container too, it was not credited. Surprisingly, many students incorrectly wanted to measure the temperature.
- (b) In this part, 'reagents' was insufficient since it is the magnesium that is critical.

Although the quality of the diagram was not part of the assessment, poor diagrams often failed to show a clear filter funnel and a visible filter paper; this was penalised. For some reason, a large number of students decided incorrectly that distillation was the required process. The final question simply needed 'wash with water' and yet attracted some very complicated answers.

Q27.

The whole of this question was relatively straightforward and it was pleasing to see the majority of students gain at least 3 marks in part (a) and over 40% gain both marks in part (b).

In part (c), too many students failed to balance their equations or could not write the correct formula for magnesium hydroxide. Fewer than half of all students gained all three marks.

Q28.

- (a) This part was found demanding. Few students were able to relate correctly an increase in concentration to an increase in temperature. Many answers contained no reference to temperature at all. In addition, some teachers tended to mark this question generously. Many students should have not been awarded the second mark as they did not state that there would be more successful collisions in a given time. Some students were incorrectly given full credit without making any reference to the extra heat generated by the reaction affecting the rate of this reaction.
- (b) In this part, a surprising number of students did not realise that the surface coating was magnesium oxide, and an even larger number thought that magnesium oxide would not react with hydrochloric acid. This chemical error often went unpunished.
- (c) This part was answered well, although many students gave only one difference, spreading the explanation across all four answer lines.
- (b) In this part, a large number of students referred to solubility of the metals themselves rather than the sulfates. A solubility comparison was often lacking and few students appreciated that the insoluble calcium sulfate would prevent further contact between the acid and the metal.

Given the increasing pressure on schools and colleges to deliver the teaching programme, this was, overall, a very positive session. Teachers are once again thanked for the trouble taken with the coursework. Their efforts continue to be much appreciated by the moderator team.

Q29.

The final question, proved too difficult for most students. It is clear that many did not understand the term 'filtrate' and quoted the ions in barium sulfate. A considerable number of students gave a selection from a variety of correct and incorrect species to answer this deceptively simple question.

Q30.

In part (a)(i), many students were unable to state that the rate is zero at point W. There were many qualitative answers to part (a)(iii) even though the word "double" is used twice in the question. In part (b), students often failed to label their reaction profile with sufficient clarity and only 45% scored both marks.

Q31.

Much of Group 2 chemistry requires learning and this question was no exception. The usual errors were seen although there were many very good answers.

Q32.

Part (a) involved a simple format but the chemical demand did not diminish and only 70% of the students wrote the correct response in part (a)(i). The correct use of chemical names and terminology was required in part (b). Part (c) was generally well answered.

Q33.

This question covered a wide range of the specification content. Halogen chemistry is not well-known by students and even when they may know some chemistry they can miss the mark by being unable to write the correct formula. Indicative of this was part (e) with only 18% scoring both marks and 56% scoring zero. The organic structures in part (f) were answered better, although part (f)(i) proved demanding and only 26% obtained this mark.

Q34.

Inorganic chemistry is a weakness for many candidates and this question proved challenging for some. Not surprisingly sodium bromide was a common incorrect response in part (a)(i).

Only the better candidates knew the reason for acidifying the silver nitrate solution in part (a)(ii) but the inability of this reagent to detect fluoride ions in part (a)(iii) was reasonably well known. Part (b) was a good discriminator; the relatively easy equation and observation marks eluded some. In part (c) most candidates could use the data to arrive at the correct precise Mr value but were less effective in explaining that the Mr values are the same when using one decimal place. The equation for complete combustion of ethene was done well but neither the displayed formula for the repeating unit nor the type of polymer scored highly.

Q35.

In part (a) only the highest-scoring candidates scored both marks. Weaker candidates seemed to be guessing.

In this part (b) was, perhaps, the most demanding question of all. Many candidates could not equate the appearance of a precipitate with insolubility, and even the better candidates could not write a correct equation for a very familiar reaction.

The better candidates scored full marks in this part (d). A few lost a mark because they were vague about the concentration of the ammonia solution to be used. A surprising number got the tests the wrong way around, losing two marks. Centres are reminded that if a candidate chooses an incorrect test reagent the mark for the observation can also not be awarded.

The above notes are intended for the small minority of centres experiencing difficulty in meeting the coursework criteria. They must not be allowed to detract unduly from the very healthy overall picture. Given the pressures on centres to deliver the teaching programme, this was once again a very positive and encouraging session. Centres are again warmly commended for the trouble taken to assemble a sample which proved to be easy to moderate. Their efforts continue to be much appreciated by the moderator team.