

OCR A-LEVEL CHEMISTRY A • H432

CHEMISTRY



EXAM QUESTION PACK

2.1.3 AMOUNT OF SUBSTANCE

SCORE

/276

PERCENTAGE

%

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- 1 A sample of a compound **M** contains 1.46 g of carbon, 0.482 g of hydrogen and 1.69 g of nitrogen.

What is the empirical formula of **M**?

- A CH_2N
- B C_4HN_4
- C CH_4N
- D $\text{C}_2\text{H}_4\text{N}$

Your answer

[1]

- 2 A student mixes 100 cm^3 of 0.200 mol dm^{-3} NaCl(aq) with 100 cm^3 of 0.200 mol dm^{-3} $\text{Na}_2\text{CO}_3\text{(aq)}$.

What is the total concentration of Na^+ ions in the mixture formed?

- A 0.100 mol dm^{-3}
- B 0.200 mol dm^{-3}
- C 0.300 mol dm^{-3}
- D 0.400 mol dm^{-3}

Your answer

[1]

- 3 Which mass of substance contains the greatest number of atoms?

- A 3.00 g of ammonia, NH_3
- B 3.00 g of chloromethane, CHCl_3
- C 4.00 g of hydrogen sulfide, H_2S
- D 4.00 g of hydrogen chloride, HCl

Your answer

[1]

4 Which reagent would exactly neutralise 100 cm³ of 1.00 mol dm⁻³ H₂SO₄(aq)?

- A 0.100 mol Al(OH)₃
- B 0.100 mol NH₃
- C 0.100 mol Ba(OH)₂
- D 0.100 mol NaOH

Your answer

[1]

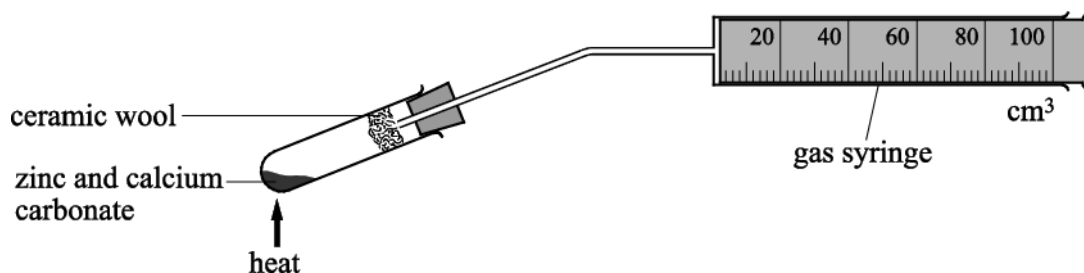
5 Which volume of oxygen gas, at room temperature and pressure, is required for complete combustion of 1.25 × 10⁻³ mol of propan-1-ol?

- A 105 cm³
- B 120 cm³
- C 135 cm³
- D 120 cm³

Your answer

[1]

- 6 A student carried out the reaction of zinc (Zn) and calcium carbonate (CaCO_3) in a fume cupboard. The student measured the volume of gas produced.



A mixture containing 0.27 g of powdered zinc and 0.38 g of powdered CaCO_3 was heated strongly for two minutes. The volume of gas collected in the 100 cm^3 syringe was then measured. The experiment was then repeated.

- (i) Calculate the maximum volume of carbon monoxide, measured at room temperature and pressure, that could be produced by heating this mixture of Zn and CaCO_3 .

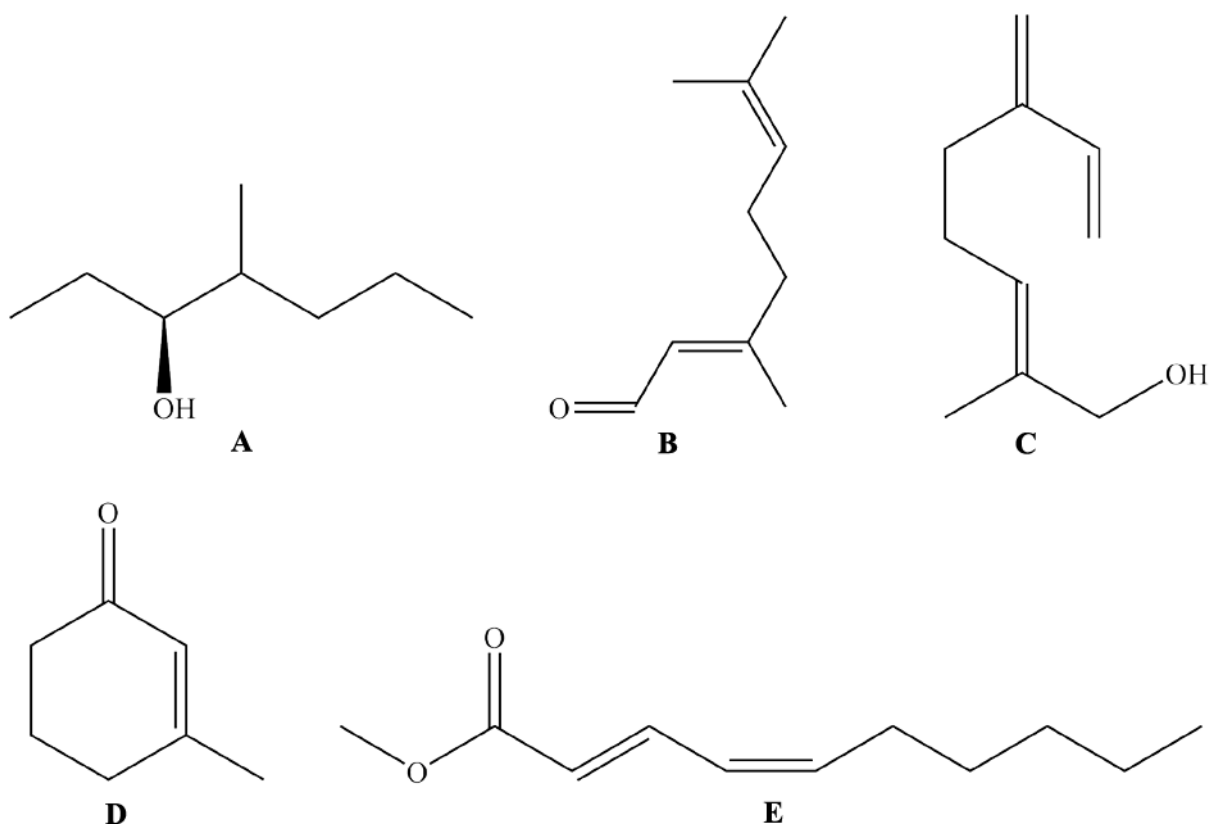
Show **all** your working.

volume of carbon monoxide = _____ cm^3 [2]

- (ii) The student did **not** obtain the volume of gas predicted in (i) using this procedure.

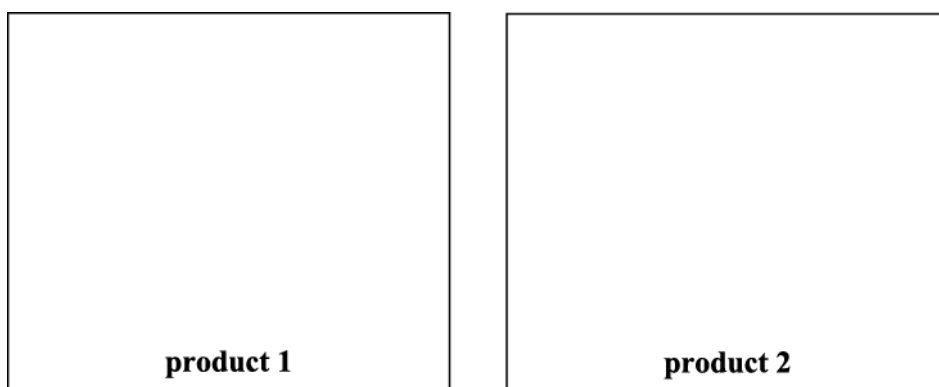
Apart from further repeats, suggest **two** improvements to the practical procedure that would allow the student to obtain a more accurate result.

7(a) The organic compounds labelled A to E below are all produced by living organisms.



Compound D reacts readily with hydrogen chloride in an addition reaction. Two products are formed in this reaction, but one of the products is formed in much greater amounts than the other.

(i) Draw the structure of **both** possible addition products of this reaction.



[2]

(ii) State and explain which of the two possible products will be formed in greater amounts.

Include a diagram of the intermediate in the mechanism of this reaction in your answer.

----- [2]

- (iii) 4.125 g of compound **D** is reacted with an excess of hydrogen chloride. The mixture of products contains 95% by mass of one product and 5% by mass of the other product.

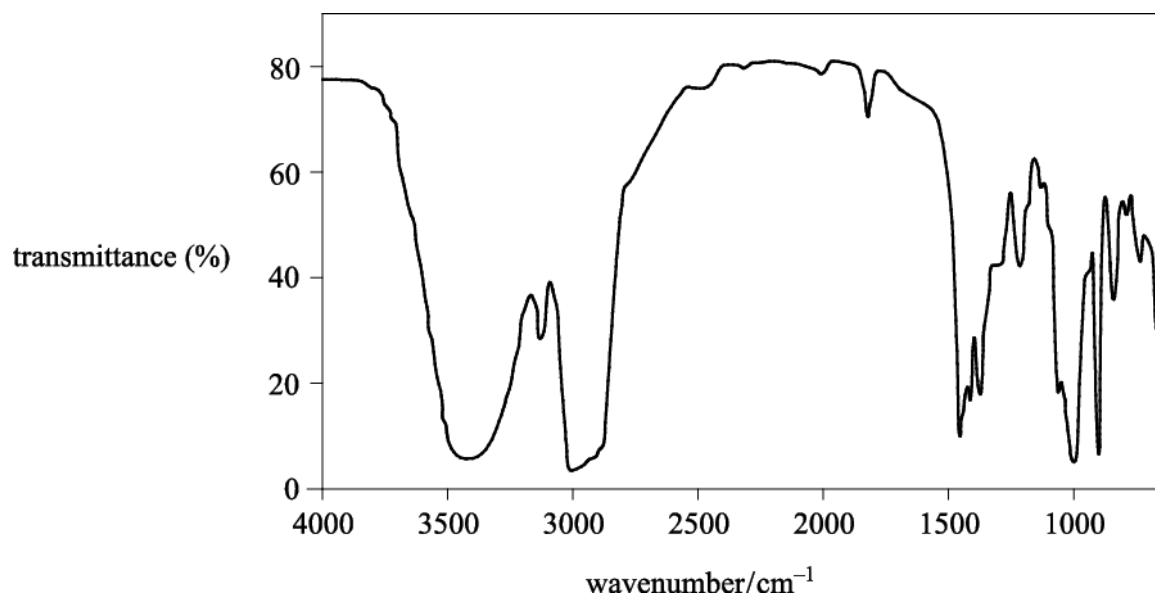
Calculate the mass of each product formed.

[2]

- (b) Analysis of one of the compounds **A** to **E** is shown below.

Percentage composition by mass: C, 78.94%; H, 10.53%; O 10.53%

Infrared spectrum:

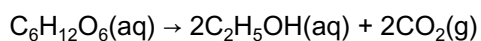


Use this information to identify the compound.

Explain your reasoning, referring to **all** the evidence provided.

[3]

- 8 An increasing amount of ethanol is made by the fermentation of glucose from plants, rather than by the hydration of ethene. Fermentation is catalysed by enzymes from yeast at a temperature of 40 °C and a pressure of 100 kPa.



Compare the sustainability of each process for the manufacture of ethanol, by considering their:

- atom economies
- raw materials
- reaction conditions.

Suggest which process is the more sustainable.

[4]

- 9 0.010 mol of barium is added to 500 cm³ of water. The equation is shown below:



The volume of water does not change during the reaction.

Which statement is correct?

- A The number of hydroxide ions formed is $0.010 \times 6.02 \times 10^{23}$.
- B The volume of hydrogen gas produced is 0.24 cm³, measured at room temperature and pressure.
- C The concentration of Ba(OH)₂(aq) formed is 0.020 mol dm⁻³.
- D 0.0050 mol of water reacts.

Your answer

☐

[1]

- 10 A chemist collects 1.00×10^{-6} m³ of a gaseous compound at 295 K and 1.01×10^5 Pa.

What is the correct expression for the amount, in mol, of the gaseous compound

A
$$\frac{8.314 \times 295}{(1.01 \times 10^5) \times (1.00 \times 10^{-6})}$$

B
$$\frac{(1.00 \times 10^{-6}) \times 295}{8.314 \times (1.01 \times 10^5)}$$

C
$$\frac{8.314 \times (1.00 \times 10^{-6})}{(1.01 \times 10^5) \times 295}$$

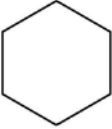
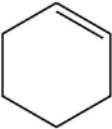
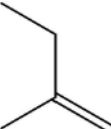
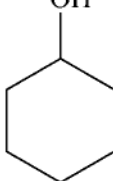
D
$$\frac{(1.01 \times 10^5) \times (1.00 \times 10^{-6})}{8.314 \times 295}$$

Your answer

☐

[1]

11(a) The organic compounds in the table below can be termed, aliphatic, alicyclic or aromatic.

E 	F 	G 
H 	I 	J 

Identify, using letters E, F, G, H, I, J, the compound(s) which are the following types.

Each response may contain more than one letter.

aliphatic _____

alicyclic _____

aromatic _____

[3]

(b) Compound I has one alkyl group.

What is the general formula of alkyl groups?

_____ [1]

(c) Compound H can be prepared in an elimination reaction by heating compound J with an acid catalyst.

A student carries out this preparation using 7.65 g of compound J.

The student obtains 2.05 g of compound H.

(i) Write an equation for this reaction, using molecular formulae.

Calculate the percentage yield of compound H.

Give your answer to **one** decimal place.

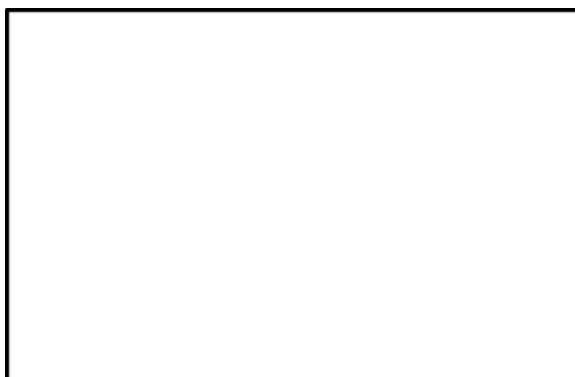
percentage yield = _____ % [4]

- (ii) Describe a simple test that the student could carry out to confirm the presence of the functional group in compound H.

Draw the structure of the organic product from the test.

test: _____

organic product =



[2]

12(a) Calculate the number of europium atoms in 0.0019 g of europium.

Give your answer in **standard form** to an **appropriate** number of significant figures.

= _____ atoms [2]

(b) Europium reacts with dilute sulfuric acid, forming a solution of europium sulfate and hydrogen gas.

A chemist reacts 0.608 g of europium with an excess of $\text{H}_2\text{SO}_4(\text{aq})$ and collects 144 cm^3 of hydrogen gas at room temperature and pressure.

Analyse the chemist's results to write the overall equation for the reaction between europium and sulfuric acid.

Show **all** your working.

equation:

----- [6]

13(a) This question looks at neutralisation reactions.

A student carries out an experiment to determine the enthalpy change for a neutralisation reaction.

The student measures out 35.0 cm^3 of 2.40 mol dm^{-3} KOH and 35.0 cm^3 of 1.20 mol dm^{-3} H_2SO_4 .

The temperature of each solution is 19.5°C .

The student mixes the solutions. The KOH is all neutralised and the maximum temperature reached is 36.0°C .

(i) Write the overall equation for the reaction that takes place.

[1]

(ii) Calculate the enthalpy change for the reaction between 1 mol KOH and 1 mol HCl.

Assume that the density of the mixture is 1.00 g cm^{-3} and that the specific heat capacity for the solution is the same as for water.

$\Delta H =$ _____ kJ [3]

(iii) Explain, why the answer to (ii) is the enthalpy change of neutralisation.

----- [1]

(iv) In this experiment, the student uses a thermometer with an uncertainty of $\pm 0.5^\circ\text{C}$ in each reading.

Calculate the percentage uncertainty in the temperature rise.

percentage uncertainty = _____ % [1]

(b) In an experiment, a scientist prepared a 0.500 g sample of a salt made by neutralisation.

Analysis of the sample gave the following data.

Element	Mass present / g
hydrogen	0.025
oxygen	0.300
nitrogen	0.175

(i) Calculate the empirical formula of the salt.

empirical formula = _____ [2]

(ii) Suggest the formula of the acid and base that the scientist used to prepare this salt.

acid: _____

base: _____

[1]

- 14 Bromine is a reactive element. It combines with other non-metals to form covalent compounds. Phosphorus tribromide, PBr_3 , and iodine monobromide, IBr , are examples of covalent compounds used in organic synthesis.

PBr_3 can be prepared by heating bromine with phosphorus, P_4 .

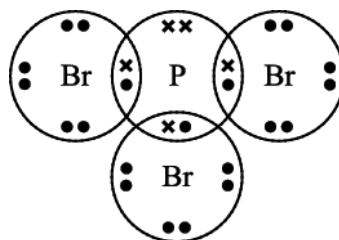
- (i) Write an equation for this reaction.

----- [1]

- (ii) How many molecules are present in 1.3535 g of PBr_3 ?

number of molecules = ----- [3]

- (iii) The 'dot-and-cross' diagram of a molecule of PBr_3 is given below.



Name the shape of this molecule and explain why the molecule has this shape.

name: -----

explanation: -----

[3]

- 15 1.00 tonne of ammonia is reacted with carbon dioxide to prepare the fertiliser urea, NH_2CONH_2 .



1.35 tonnes of urea are formed.

Calculate the percentage yield of urea.

Show **all** your working.

yield = _____ % [3]

- 16 Alcohols can be converted into haloalkanes in a substitution reaction.

Plan an experiment to prepare approximately 0.1 mol of 2-bromopentane, $\text{CH}_3\text{CHBrCH}_2\text{CH}_2\text{CH}_3$, from pentan-2-ol, $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{CH}_3$.

Your plan should include a calculation of the mass of alcohol required and details of the chemicals to be used in the reaction.

----- [2]

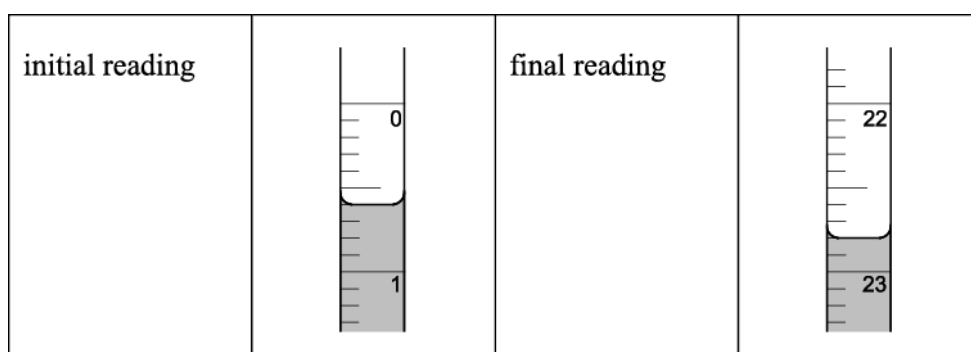
17(a) A student carries out an experiment to identify an unknown carbonate.

- The student weighs a sample of the solid carbonate in a weighing bottle.
- The student tips the carbonate into a beaker and weighs the empty weighing bottle.
- The student prepares a 250.0 cm^3 solution of the carbonate.
- The student carries out a titration using 25.0 cm^3 of this solution measured using a pipette with 0.100 mol dm^{-3} hydrochloric acid in the burette.

The student carries out the final part of the experiment by adding 0.100 mol dm^{-3} hydrochloric acid to a burette and performing a titration using a 25.0 cm^3 sample of the aqueous carbonate.

The student reads the burette to the nearest 0.05 cm^3 .

The diagrams below show the initial burette reading and the final burette reading.



(i) Record the student's readings and the titre.

[1]

(ii) Describe what the student should do next to obtain reliable results for the titration.

----- [1]

(b) The equation below represents the reaction between the carbonate and hydrochloric acid.



(i) Calculate the amount, in mol, of M_2CO_3 used in the titration.

$$n(\text{M}_2\text{CO}_3) = \text{----- mol [2]}$$

(ii) The student's mass readings are recorded below.

Mass of weighing bottle + carbonate / g	14.92
Mass of weighing bottle / g	13.34

Use the student's results to identify the carbonate, M_2CO_3 .

Show **all** your working.

[4]

- 18 An alcohol **A** contains carbon, hydrogen and oxygen only. The alcohol is a liquid at room temperature and pressure but can easily be vaporised.

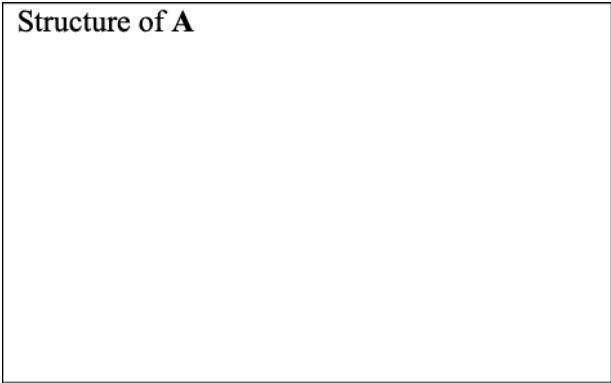
1.15 g of **A** produces 761 cm^3 of gas when vaporised, measured at 100 kPa and 366 K.

Determine the molar mass of compound **A** and draw a possible structure for **A**.

Show all your working.

molar mass = _____ g mol^{-1}

Structure of **A**



[5]

19 A student carries out a titration to determine the molar mass of an unknown acid, **A**.

- The student dissolves 2.24 g of acid **A** in distilled water and makes the solution up to 250.0 cm³.
- The student titrates a 25.0 cm³ portion of this solution with 0.120 mol dm⁻³ NaOH.
- 25.25 cm³ of 0.120 mol dm⁻³ NaOH are required to reach the end point.

The acid reacts with NaOH in a 1 : 1 molar ratio.

Calculate the molar mass of acid **A**.

molar mass of acid **A** = _____ g mol⁻¹ [3]

20 This question looks at groups in the periodic table.

Calcium and strontium are Group 2 metals. They both react with water.

A chemist reacts 0.200 g of strontium with 250 cm³ water, leaving a colourless solution containing strontium ions. The volume remains at 250 cm³.

- (i) Write an equation for the reaction between strontium and water.

Include state symbols.

----- [1]

- (ii) Calculate the concentration, in mol dm⁻³, of strontium ions in the resulting solution.

concentration of strontium ions = ----- mol dm⁻³ [2]

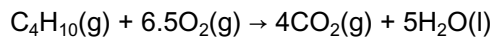
- (iii) A student plans to carry out this experiment using 0.200 g of calcium instead of 0.200 g of strontium.

Predict the difference, if any, between the volume of gas produced by calcium and strontium.

Explain your reasoning and include a calculation in your answer.

----- [3]

21(a) Butane, C₄H₁₀, is a highly flammable gas, used as a fuel for camping stoves. Butane reacts with oxygen as in the equation below:



- (i) The use of portable heaters in enclosed spaces can result in potential dangers if incomplete combustion takes place.

Explain the potential danger of incomplete combustion.

-----[1]

- (ii) A portable heater is lit to heat a room.

The heater burns 600 g of butane and consumes 1.50 m³ of O₂, measured at room temperature and pressure.

Determine whether this portable heater is safe to use.

Show **all** your working.

conclusion, with reason: -----

-----[3]

(b) Alkane X can be used as a fuel.

Complete combustion of 0.0117 mol of X produces $2.00 \times 10^{-3} \text{ m}^3$ of carbon dioxide gas, measured at 24.0 °C and 101 kPa.

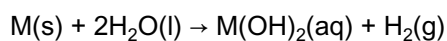
Determine the molecular formula of X.

Show **all** your working.

molecular formula of X = _____ [4]

22(a) Group 2 elements are metals that react with oxygen and water.

A student reacts a Group 2 metal, M, with water.



The student measures the volume of hydrogen gas produced.

0.162 g of the metal produces 97.0 cm³ of gas measured at room temperature and pressure.

(i) Draw a labelled diagram of the apparatus that can be used to carry out this experiment.

[2]

(ii) Identify the Group 2 metal, M.

Show your working.

Group 2 metal = _____ [3]

(b) The student plans to repeat the experiment using the same mass of a Group 2 metal from further down the group.

Predict whether the volume of hydrogen produced would be greater than, less than or the same as the volume in the first experiment.

Explain your answer.

[1]

23 Nitrogen forms several different oxides.

N_2O is a useful anaesthetic and NO has been linked to the depletion of ozone in the stratosphere.

N_2O is supplied as a compressed gas in steel cylinders for use as an anaesthetic.

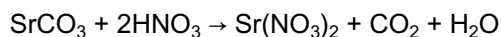
The cylinders are stored at $20.0\text{ }^\circ\text{C}$.

Calculate the gas pressure, in Pa, in a 2.32 dm^3 steel cylinder containing 187 g of N_2O gas.

Give your answer in standard form to **three** significant figures.

pressure = _____ Pa [4]

24(a) A student investigates the reaction between strontium carbonate and dilute nitric acid.



The rate of reaction is determined from the loss in mass over a period of time.

- (i) Explain why there is a loss in mass during the reaction.

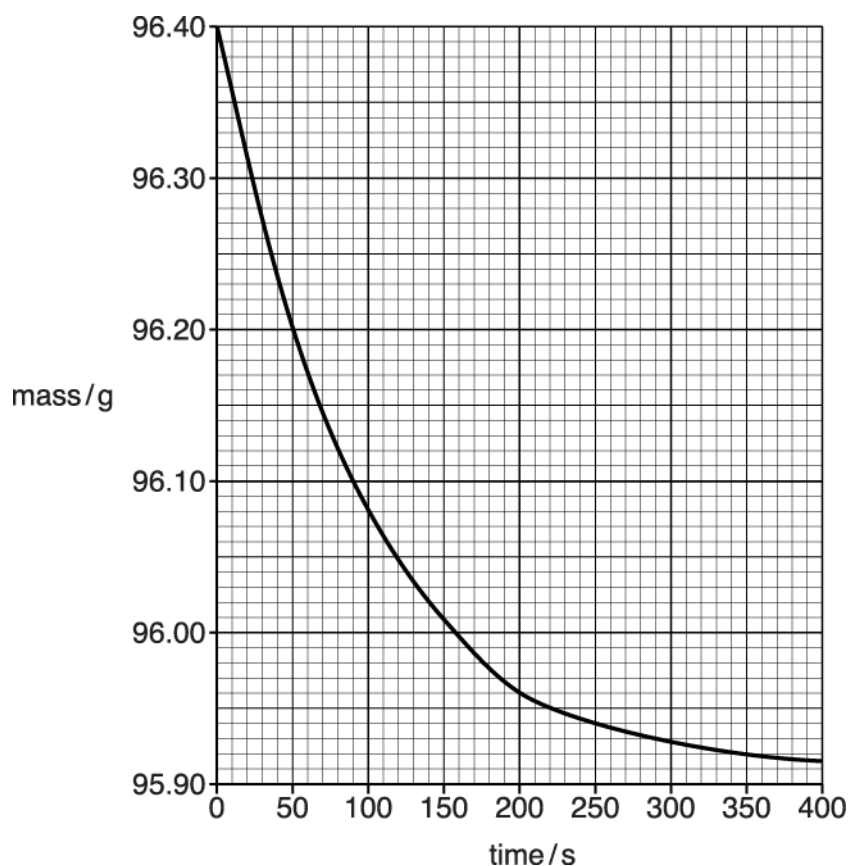
----- [1]

- (ii) An excess of strontium carbonate, SrCO_3 , is mixed with 20.0 cm^3 of 1.25 mol dm^{-3} nitric acid, HNO_3 .

Calculate the mass of SrCO_3 that reacts with the HNO_3 .

mass = ----- g [3]

(b) The student plots a graph of total mass (reagents + container) against time.



(i) Describe and explain the change in the rate of the reaction during the first 200 seconds of the experiment.

----- [2]

(ii) Using the graph, calculate the rate of reaction, in g s^{-1} , at 200 seconds.

Show your working on the graph.

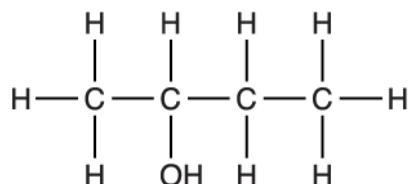
rate of reaction = _____ g s⁻¹ [2]

- (c) Outline a method that could be used to obtain the results that are plotted on the graph.

Your answer should include the apparatus required and the procedure for the experiment.

----- [3]

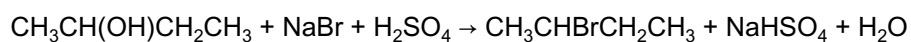
25 This question is about the properties and reactions of butan-2-ol.



Some properties of butan-2-ol are listed in the table.

Melting point	-115 °C
Boiling point	99.5 °C

20.2 g of butan-2-ol is reacted with excess sodium bromide and sulfuric acid.



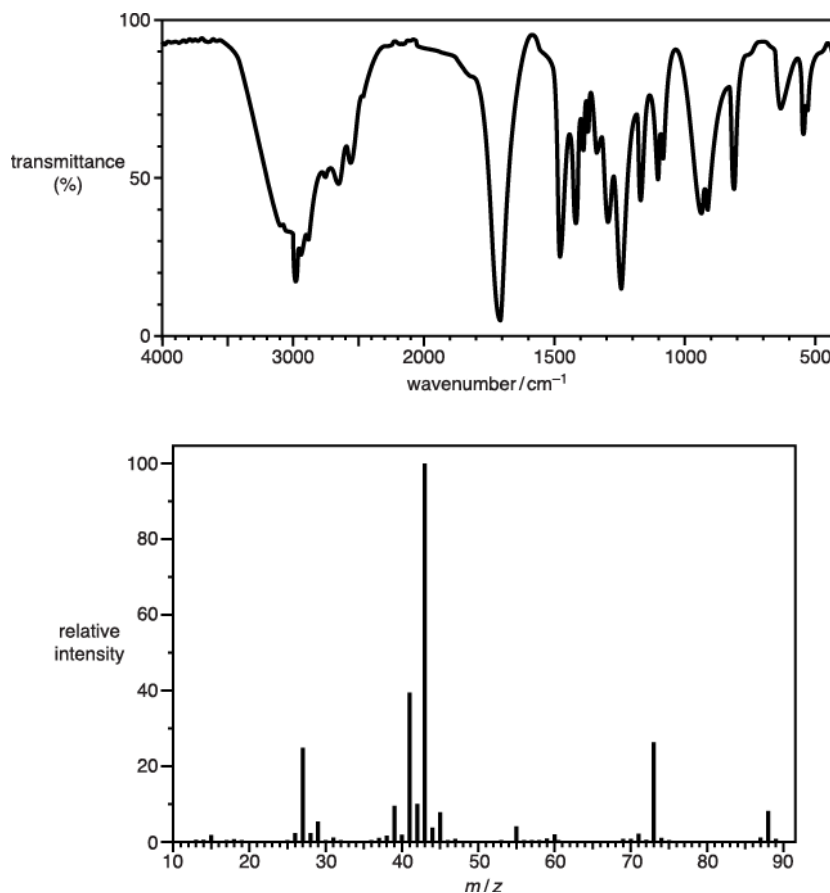
25.2g of $\text{CH}_3\text{CHBrCH}_2\text{CH}_3$ is formed.

Calculate the percentage yield of $\text{CH}_3\text{CHBrCH}_2\text{CH}_3$.

percentage yield = _____ % [3]

- 26 * Organic compound C has the following percentage composition by mass:
C, 54.5%; H, 9.1%; O, 36.4%.

The infrared spectrum and mass spectrum of compound C are shown below.



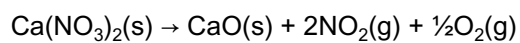
In the mass spectrum, a secondary carbocation is responsible for the peak with the greatest relative intensity.

Identify compound C.

In your answer you should make clear how your conclusion is linked to all the evidence.

[6]

27 Calcium nitrate, $\text{Ca}(\text{NO}_3)_2$, decomposes when heated, as shown below.



A student decomposes 0.00500 mol of $\text{Ca}(\text{NO}_3)_2$ and collects the gas that is produced.

Calculate the volume of gas that the student should expect to collect, measured at room temperature and pressure.

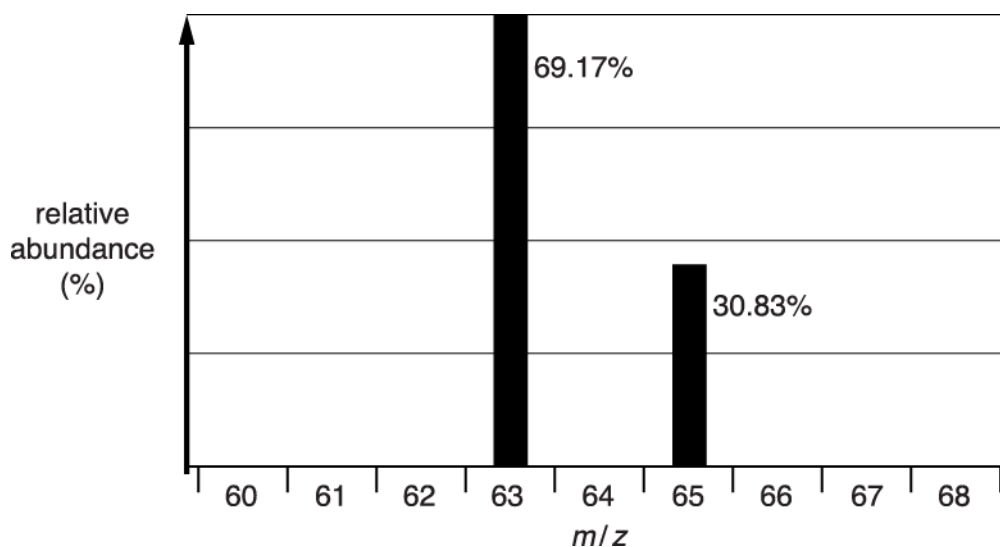
- A 60 cm^3
- B 120 cm^3
- C 240 cm^3
- D 300 cm^3

Your answer

[1]

28 A twenty pence coin contains copper and nickel.

The copper used to make a batch of coins is analysed by mass spectrometry. The mass spectrum is shown below.



(i) Calculate the relative atomic mass of the copper used to make the coins.

Give your answer to **two** decimal places.

relative atomic mass = _____ [2]

(ii) One coin has a mass of 5.00 g and contains 84.0% of copper, by mass.

Calculate the number of copper atoms in one coin.

Give your answer in standard form and to **three** significant figures.

number of copper atoms = _____ [2]

29(a) This question is about several salts.

A hydrated salt, compound A, is analysed and has the following percentage composition by mass:

Cr, 19.51%; Cl, 39.96%; H, 4.51%; O, 36.02%.

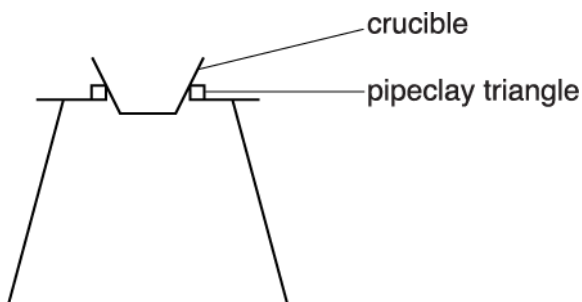
Calculate the formula of compound A, showing clearly the water of crystallisation.

Show your working.

formula of compound A = _____ [3]

- (b) A student carries out an experiment to determine the amount of water of crystallisation in the formula of another hydrated salt. The student intends to remove the water by heating the hydrated salt.

A diagram of the apparatus used by the student is shown below.



- The student adds the hydrated salt to the crucible and weighs the crucible and contents.
- The student heats the crucible and contents and allows them to cool.
- The student weighs the crucible and residue.

The student's results are shown below.

Mass of crucible + hydrated salt / g	16.84
Mass of crucible + residue after heating / g	16.26

- (i) The maximum error in each mass measurement using the balance is ± 0.005 g.

Calculate the percentage error in the mass of water removed.

percentage error = _____ % [1]

- (ii) Suggest **one** modification that the student could make to their method to reduce the percentage error in the mass of water removed.

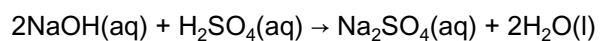
 ----- [1]

- (iii) The student is not sure that all the water of crystallisation has been removed.

How could the student modify the experiment to be confident that all the water of crystallisation has been removed?

 ----- [1]

- (c) A student prepares a solution of sodium sulfate, Na_2SO_4 , by adding $6.25 \times 10^{-2} \text{ mol dm}^{-3}$ sulfuric acid, H_2SO_4 , from a burette to 25.0 cm^3 of $0.124 \text{ mol dm}^{-3}$ NaOH in a conical flask.

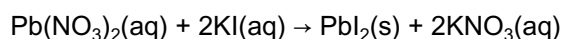


Calculate the minimum volume of the H_2SO_4 that the student would need to completely react with the NaOH present.

volume of H_2SO_4 = _____ cm^3 [3]

30(a) Aqueous lead(II) nitrate, $\text{Pb}(\text{NO}_3)_2(\text{aq})$, and aqueous potassium iodide, $\text{KI}(\text{aq})$, react together.

The equation is shown below.



A student carries out an experiment to determine the enthalpy change of reaction, $\Delta_r H$, of this reaction.

The student follows the method outlined below.

- Add 50.0 cm^3 of 1.50 mol dm^{-3} $\text{Pb}(\text{NO}_3)_2(\text{aq})$ to a polystyrene cup.
- Measure out 50.0 cm^3 of a solution of $\text{KI}(\text{aq})$, which is in excess.
- Measure the temperature of both solutions.
- Add the $\text{KI}(\text{aq})$ to the polystyrene cup, stir the mixture and record the maximum temperature.

Temperature readings

Initial temperature of both solutions = 19.5°C

Maximum temperature of mixture = 30.0°C

Calculate $\Delta_r H$, in kJ mol^{-1} , for the reaction shown in the equation above.

Give your answer to an **appropriate** number of significant figures.

Assume that the density of all solutions and specific heat capacity, c , of the reaction mixture is the same as for water.

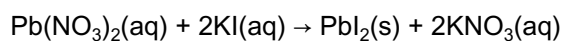
$\Delta_r H =$ _____ kJ mol^{-1} [4]

(b) Write an ionic equation for the reaction that the student carries out.

Include state symbols.

----- [1]

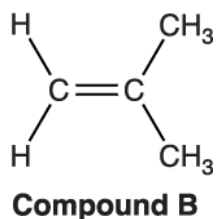
- (c) The 50.0 cm^3 of KI(aq) used in the experiment contains 10% more KI than is needed to react with 50.0 cm^3 of $1.50 \text{ mol dm}^{-3} \text{ Pb(NO}_3)_2\text{(aq)}$.



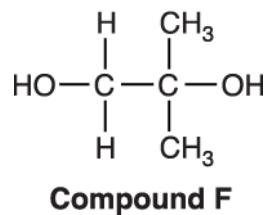
Calculate the concentration, in mol dm^{-3} , of KI that the student used.

concentration of KI = _____ mol dm^{-3} [2]

31 Compound **B**, shown below, can be used to synthesise organic compounds with different functional groups.



The structure of compound **F** is shown below.



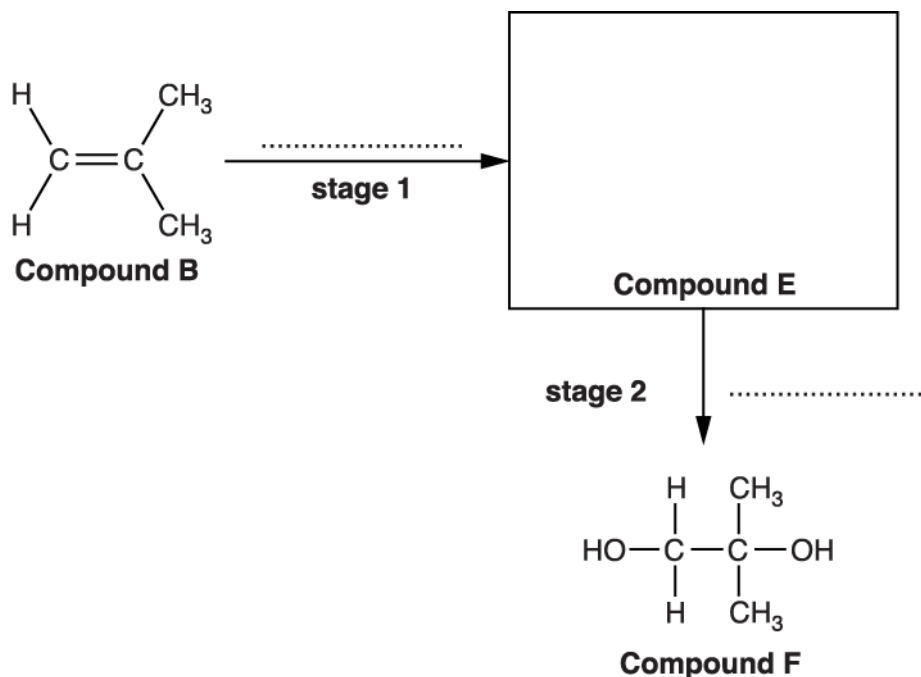
- (i) What is the empirical formula of compound **F**?

-----[2]

- (ii) A student plans a two-stage synthesis for preparing compound **F** from compound **B**.

The synthesis first prepares compound **E**, as shown in the flowchart.

Draw the structure of compound **E** in the box and state the reagents for each stage on the dotted lines.



[3]

32

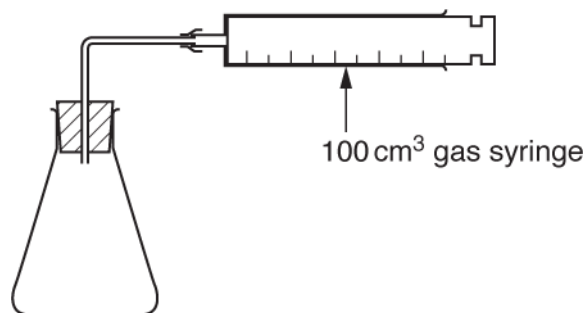


A student was asked to carry out an experiment to determine the initial rate of reaction of zinc and hydrochloric acid.

The student plans to collect a total of about 72 cm³ of hydrogen at RTP and to use an excess of zinc.

The student selects the following apparatus:

- the apparatus shown in the diagram
- 100 cm³ measuring cylinder
- stop clock
- 2 decimal place balance



Outline how the student could carry out the experiment and explain how the results could be processed graphically.

Show all working in your calculations.

This image shows a blank sheet of white paper with ten horizontal dashed lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There is no text or other content on the page.

C, 53.33 %; H, 11.11%; O, 35.56%.

A $C_4H_8O_2$

C C₂H₄O

Your answer

Your answer

34 Samples of four hydrocarbons are completely burnt under the same conditions of temperature and pressure.

Which sample produces the greatest volume of CO_2 ?

- A 0.4 mol C_2H_6
- B 0.3 mol C_3H_8
- C 0.2 mol C_4H_{10}
- D 0.1 mol C_5H_{12}

Your answer

[1]

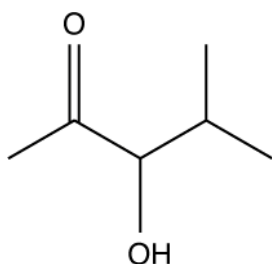
35 Which reaction produces the smallest atom economy of BaCl_2 ?

- A $\text{BaCl}_2 \cdot 2\text{H}_2\text{O} \rightarrow \text{BaCl}_2 + 2\text{H}_2\text{O}$
- B $\text{BaO} + 2\text{HCl} \rightarrow \text{BaCl}_2 + \text{H}_2\text{O}$
- C $\text{BaCO}_3 + 2\text{HCl} \rightarrow \text{BaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$
- D $\text{Ba} + 2\text{HCl} \rightarrow \text{BaCl}_2 + \text{H}_2$

Your answer

[1]

36 The skeletal formula of an organic compound is shown below.



What is the molecular formula of the organic compound?

- A $\text{C}_6\text{H}_{10}\text{O}_2$
- B $\text{C}_6\text{H}_{11}\text{O}_2$
- C $\text{C}_6\text{H}_{12}\text{O}_2$
- D $\text{C}_6\text{H}_{13}\text{O}_2$

Your answer

[1]

37(a) Barium combines with oxygen, chlorine and nitrogen to form ionic compounds.

Barium oxide, BaO, has a giant ionic lattice structure.

(i) State what is meant by the term *ionic bond*.

----- [1]

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in barium oxide.

Show outer electrons only.

[2]

(iii) Calculate the number of barium ions in 1.50 g of barium oxide.

Give your answer in standard form and to **three** significant figures.

number of barium ions = ----- [2]

(b) Barium chloride, BaCl₂, is soluble in water.

- Explain your answer in terms of the particles involved.

[2]

- [2]

- Show your working.

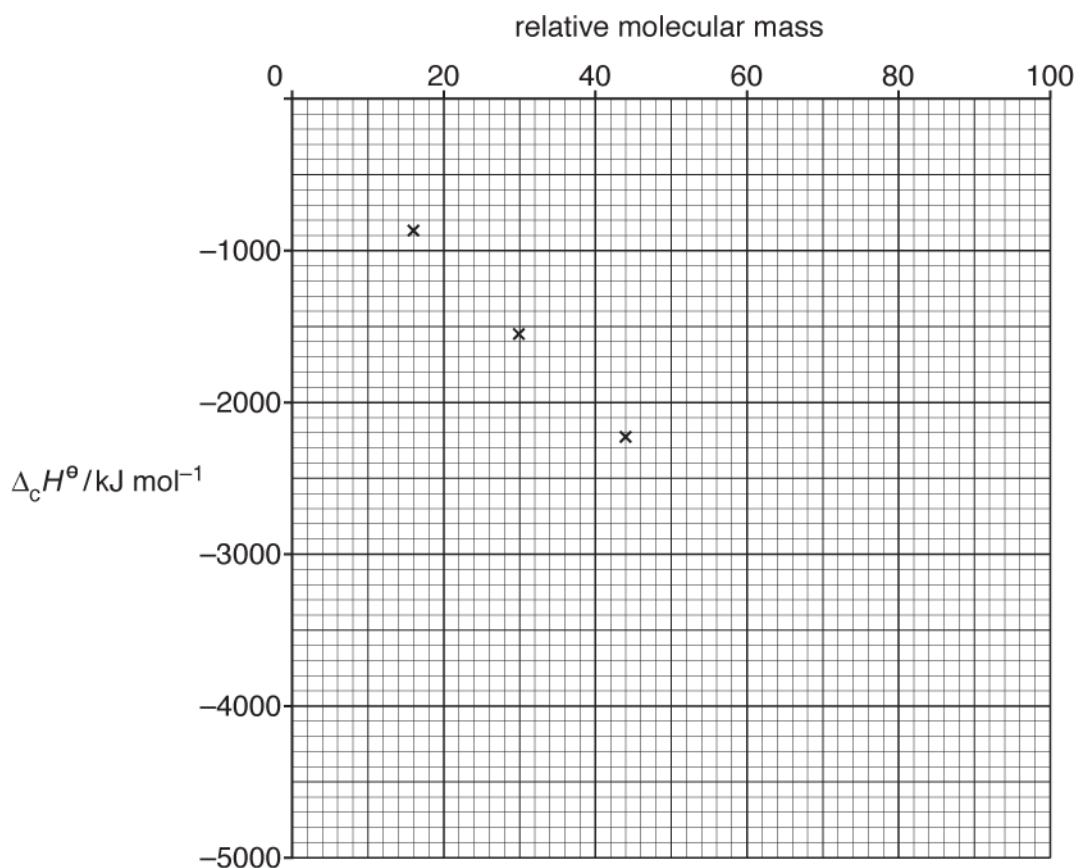
$x =$ _____ [2]

- 38 Data book values for the standard enthalpy changes of combustion, $\Delta_c H^\theta$, of the first four alkanes are shown in the table.

Alkane	methane	ethane	propane	butane
$\Delta_c H^\theta / \text{kJ mol}^{-1}$	-890	-1560	-2219	-2877

- (i) The values for the first three alkanes are plotted on the graph below.

Plot the value for butane on the graph.



[1]

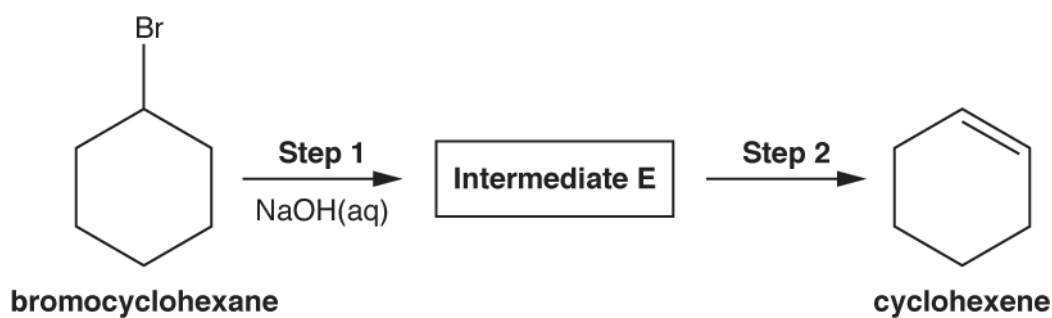
- (ii) Use the graph to estimate the energy released during complete combustion of 1.80 g of pentane.

Show relevant working below and on the graph.

energy released = _____ kJ [3]

39 Organic compounds can be prepared in the laboratory using synthetic routes with two or more stages.

A student devises a two-stage synthesis of cyclohexene from bromocyclohexane.



- (i) Suggest the structure of **intermediate E** and the reagent(s) and conditions for **step 2**.

reagent(s) and conditions ----- [2]

- (ii) The student carries out this synthesis and obtains 1.23 g of pure cyclohexene from 5.50 g of bromocyclohexane.

Calculate the percentage yield of cyclohexene.

Give your final answer to an **appropriate** number of significant figures.

percentage yield = ----- % [3]

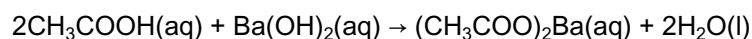
- 41 A student plans to determine the concentration, in mol dm^{-3} , of ethanoic acid, CH_3COOH , in a bottle of vinegar. The student will carry out a titration with aqueous barium hydroxide, $\text{Ba}(\text{OH})_2(\text{aq})$.

The student's method is outlined below.

- Dilute 10.0 cm^3 of vinegar from the bottle with distilled water and make the solution up to 250.0 cm^3 .
- Add the diluted vinegar to the burette.
- Titrate 25.0 cm^3 volumes of $0.0450 \text{ mol dm}^{-3} \text{ Ba}(\text{OH})_2$ with the diluted vinegar.

The mean titre of the diluted vinegar is 25.45 cm^3 .

The reaction in the student's titration is shown below.



- (i) Calculate the concentration, in mol dm^{-3} , of CH_3COOH in the original bottle of vinegar.
Show your working.

concentration of $\text{CH}_3\text{COOH} = \text{-----} \text{ mol dm}^{-3}$ [4]

- (ii) Suggest **one** assumption that the student has made that might mean that their calculated concentration of ethanoic acid in the vinegar is invalid.
Predict, with a reason, how the experimental result would differ from the actual concentration of CH_3COOH if the assumption were **not** correct.

----- [2]

42 An alkene **D** is a liquid at room temperature and pressure but can easily be vaporised.

When vaporised, 0.1881 g of **D** produces 82.5 cm³ of gas at 101 kPa and 373 K.

Determine the molar mass and molecular formula of alkene **D**.

Show all your working.

molar mass = _____ g mol⁻¹

molecular formula = _____ [5]

43(a) A student carries out a titration to determine the molar mass and structure of a weak acid **A**.

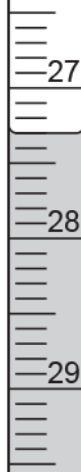
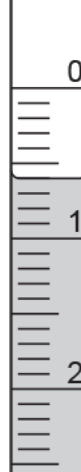
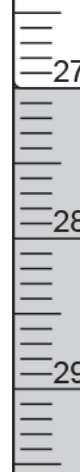
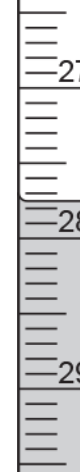
The student follows the method below.

- Dissolve a weighed mass of **A** in 100 cm³ of distilled water and make the solution up to 250 cm³ in a beaker.
- Add the solution of **A** to a burette.
- Titrate the solution of **A** with a standard solution of sodium hydroxide, NaOH.

The student carries out a trial, followed by three further titrations.

The diagram shows the initial and final burette readings for the three **further** titrations.

The student measures all burette readings to the nearest 0.05 cm³.

Titration 1		Titration 2		Titration 3	
Initial reading	Final reading	Initial reading	Final reading	Initial reading	Final reading
					

(i) Record the student's readings and the titres in the table below.

Calculate the mean titre, to the nearest 0.05 cm³, that the student should use for analysing the results.

	Titration 1	Titration 2	Titration 3
Final reading/cm ³			
Initial reading/cm ³			
Titre/cm ³			

mean titre = ----- cm^3 [4]

- (ii) The uncertainty in each burette reading is $\pm 0.05 \text{ cm}^3$.

Calculate the percentage uncertainty for the titre in **Titration 1**.

percentage uncertainty = ----- % [1]

- (iii) The student realised that the solution of **A** had not been prepared correctly.

How should the student have made up the solution?

----- [1]

(b) A student repeats the titration to determine the molar mass and structure of **A**.

- The student prepares a 250.0 cm³ solution from 1.513 g of **A**.
- The solution of **A** is added to the burette and titrated with 25.0 cm³ volumes of 0.112 mol dm⁻³ NaOH(aq).
- 1 mol of **A** reacts with 2 mol of NaOH.
- The student obtains a mean titre of 27.30 cm³.

(i) Calculate the molar mass of **A** from these results.

Give your answer to the nearest whole number.

Show your working.

molar mass of **A** = ----- g mol⁻¹ [4]

(ii) **A** is an organic acid, containing C, H and O only.

One molecule of **A** contains two COOH groups.

Suggest the structure of **A**.

[1]

44 Selenium is in the same group of the periodic table as sulfur.

(i) Complete the full electron configuration of a selenium atom.

$1s^2$ [1]

(ii) Sodium selenide reacts with hydrochloric acid to form a toxic gas, **B**, with a relative molecular mass of 81.0.

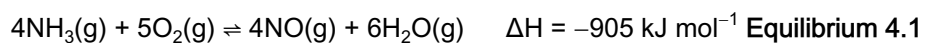
Identify gas **B** and write an equation for this reaction.

Gas B

Equation [2]

45 The reaction of ammonia, NH_3 , with oxygen to form nitrogen monoxide, NO , is an important industrial process.

The equation for this reaction is shown in **equilibrium 4.1** below.

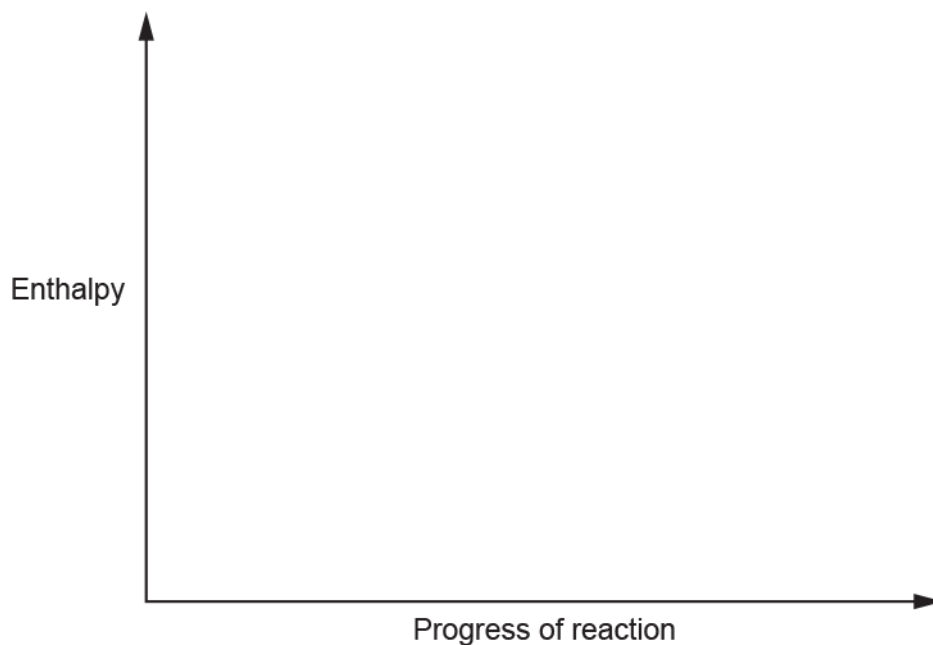


The forward reaction in **equilibrium 4.1** converts NH_3 into NO .

(i) Complete the enthalpy profile diagram for this reaction.

On your diagram:

- Label the activation energy, E_a
- Label the enthalpy change of reaction, ΔH
- Include the formulae of the reactants and products.



[2]

(ii) 5.10 tonnes of NH_3 are converted into NO.

Calculate the energy released, in kJ, for this conversion.

Give your answer in **standard form** and to an **appropriate** number of significant figures.

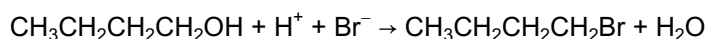
energy released = ----- kJ [4]

46(a)

1-Bromobutane is an organic liquid with a boiling point of 102 °C.

A student prepares 1-bromobutane by reacting butan-1-ol with sulfuric acid and sodium bromide. The student boils the mixture for one hour.

The equation is shown below.



The student obtains a reaction mixture containing an organic layer (density = 1.27 g cm⁻³) and an aqueous layer (density = 1.00 g cm⁻³).

- (i) * Draw a labelled diagram to show how you would safely set up apparatus for the preparation. Outline a method to obtain a pure sample of 1-bromobutane from the reaction mixture.

----- [6]

- (ii) The student used 0.150 mol of butan-1-ol. The student obtained a 61.4% percentage yield of 1-bromobutane.

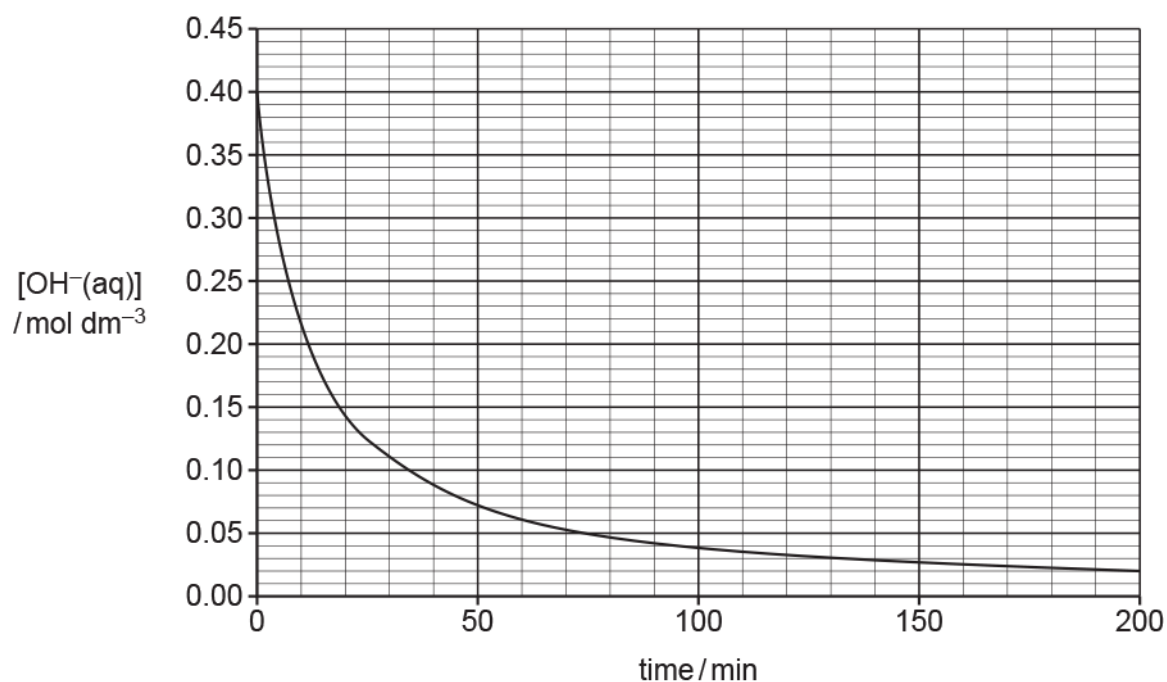
Calculate the mass of 1-bromobutane obtained.

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

mass = ----- g [2]

(b) A student investigates the rate of reaction of 1-bromobutane with aqueous hydroxide ions.

The graph shows how the hydroxide ion concentration, $[\text{OH}^-(\text{aq})]$, changes during the reaction.



Using the graph, calculate the rate of reaction, in $\text{mol dm}^{-3} \text{ min}^{-1}$, at 30 minutes.

Show your working on the graph and in the space below.

rate of reaction = ----- $\text{mol dm}^{-3} \text{ min}^{-1}$ [2]

47 What is the number of oxygen atoms in 88.0 g of CO₂?

A 3.01×10^{23}

B 1.20×10^{24}

C 2.41×10^{24}

D 4.82×10^{24}

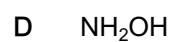
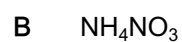
Your answer

[1]

48 A compound has the composition by mass:

H, 5.00%; N, 35.00%; O, 60.00%.

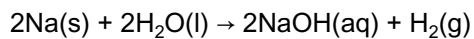
Which compound has this composition?



Your answer

[1]

49 Sodium reacts with water as shown below.



Which mass of sodium reacts with water to produce 960 cm^3 of hydrogen gas at RTP?

A 0.46 g

B 0.92 g

C 1.84 g

D 3.68 g

Your answer

[1]

50 1 mol of a compound reacts with 8 mol O_2 for complete combustion.

What is the formula of the compound?

A C_4H_8

B $\text{C}_4\text{H}_9\text{OH}$

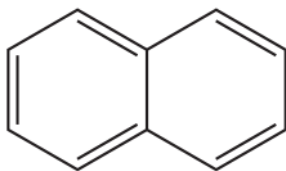
C $\text{C}_5\text{H}_{11}\text{OH}$

D C_5H_{12}

Your answer

[1]

51 The structure of naphthalene is shown below.



What is the molecular formula of naphthalene?

A C_{10}H_8

B $\text{C}_{10}\text{H}_{10}$

C $\text{C}_{12}\text{H}_{10}$

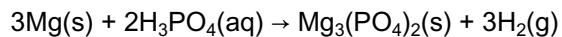
D $\text{C}_{12}\text{H}_{12}$

Your answer

[1]

52(a) This question is about compounds of magnesium and phosphorus.

A student plans to prepare magnesium phosphate using the redox reaction of magnesium with phosphoric acid, H_3PO_4 .



- (i) In terms of the number of electrons transferred, explain whether magnesium is being oxidised or reduced.

----- [1]

- (ii) The student plans to add magnesium to 50.0 cm^3 of $1.24 \text{ mol dm}^{-3} \text{ H}_3\text{PO}_4$.

Calculate the mass of magnesium that the student should add to react exactly with the phosphoric acid.

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

mass of Mg = ----- g [3]

- (iii) How could the student obtain a sample of magnesium phosphate after reacting magnesium with phosphoric acid?

----- [2]

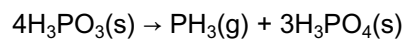
(iv) Magnesium phosphate can also be prepared by reacting phosphoric acid with a compound of magnesium.

Choose a suitable magnesium compound for this preparation and write the equation for the reaction.

Formula of compound -----

Equation ----- [2]

(b) Phosphine, PH_3 , is a gas formed by heating phosphorous acid, H_3PO_3 , in the absence of air.



(i) 3.20×10^{-2} mol of H_3PO_3 is completely decomposed by this reaction.

Calculate the volume of phosphine gas formed, in cm^3 , at 100 kPa pressure and 200 °C.

volume of PH_3 = _____ cm^3 [4]

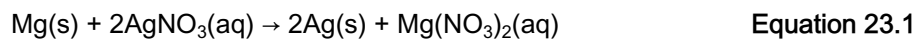
(ii) When exposed to air, phosphine spontaneously ignites, forming P_4O_{10} and water.

Construct an equation for this reaction.

-----[1]

53 This question is about energy changes and rate of reaction.

Magnesium reacts with aqueous silver nitrate, $\text{AgNO}_3(\text{aq})$, as in **equation 23.1**.



A student carries out an experiment to determine the enthalpy change of this reaction, $\Delta_r H$.

- The student adds 25.0 cm^3 of $0.512 \text{ mol dm}^{-3}$ AgNO_3 to a polystyrene cup.
- The student measures the temperature of the solution.
- The student adds a small spatula measure of magnesium powder, stirs the mixture and records the maximum temperature

Temperature readings

Initial temperature	= 19.5°C
Maximum temperature	= 47.5°C

(i) Calculate $\Delta_r H$, in kJ mol^{-1} , for the reaction shown in **equation 23.1**.

Give your answer to an **appropriate** number of significant figures.

Assume that the density and specific heat capacity, c , of the solution are the same as for water and that all the aqueous silver nitrate has reacted.

$\Delta_r H =$ kJ mol^{-1} [4]

- (ii) At the end of the experiment, the student adds a few drops of aqueous sodium chloride to the reaction mixture in the polystyrene cup to test whether all the aqueous silver nitrate has reacted.

Explain how the results would show whether all the aqueous silver nitrate has reacted. Include an equation with state symbols in your answer.

----- [2]

(b) Compounds **A**, **B** and **C** all react with chlorine in the presence of ultraviolet radiation to form organic compounds with the formula $C_5H_{11}Cl$.

(i) Name the mechanism for this reaction.

----- [1]

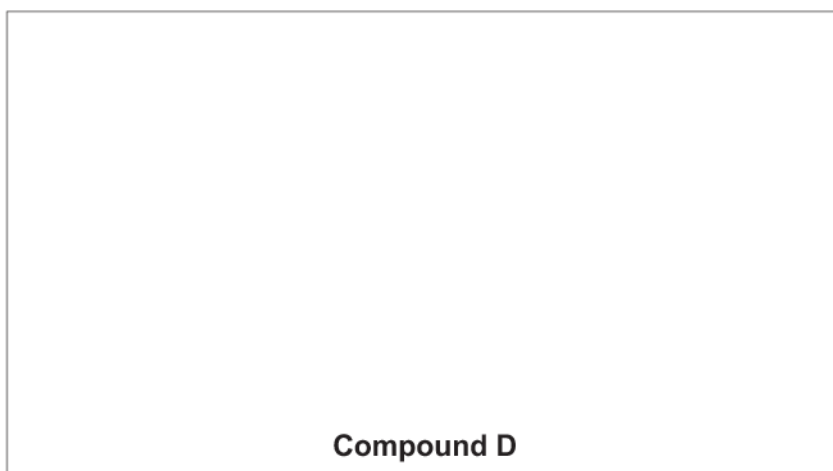
(ii) Complete the table to show the number of structural isomers of $C_5H_{11}Cl$ that could be formed from the reaction of chlorine with **A** and **B**.

	A	B
Number of structural isomers		

[2]

(iii) The reaction of compound **A** with excess chlorine forms a compound **D**, which has a molar mass of 175.5 g mol^{-1} .

Draw a possible structure for compound **D** and write the equation for its formation from compound **A**. Use molecular formulae in the equation.



Equation ----- [2]

55 What is the percentage composition by mass of nitrogen in $(\text{NH}_4)_2\text{CO}_3$?

- A 14.58%
- B 17.95%
- C 29.17%
- D 37.50%

Your answer

[1]

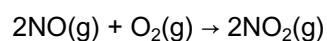
56 Which chemical process is the most sustainable in terms of the atom economy of the organic product?

- A $\text{CO}_2 + 3\text{H}_2 \rightarrow \text{CH}_3\text{OH} + \text{H}_2\text{O}$
- B $\text{CH}_3\text{CH}_2\text{OH} + \text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{CH}_3\text{CH}_2\text{Cl} + \text{NaHSO}_4 + \text{H}_2\text{O}$
- C $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2 + \text{H}_2\text{O}$

Your answer

[1]

57 8.0 dm^3 of NO is mixed with 6.0 dm^3 of O_2 at room temperature and pressure (RTP).
The reaction below takes place until one of the reactants is used up.



What is the volume of the mixture at RTP after the reaction has taken place?

- A 8.0 dm^3
- B 10.0 dm^3
- C 12.0 dm^3
- D 14.0 dm^3

Your answer

[1]

58 What is the volume of 0.0100 mol of N_2 at 350 °C and 200 kPa?

A 145 cm^3

B 259 cm^3

C 145 dm^3

D 259 dm^3

Your answer

[1]

59 0.24 g of an element, X, is reacted with 0.0100 mol Cl_2 to form a chloride with the formula XCl_2 .
What is element X?

A carbon

B magnesium

C molybdenum

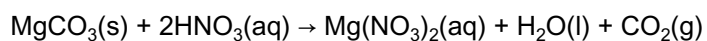
D titanium

Your answer

[1]

- 60 A solution of magnesium nitrate can be prepared by reacting magnesium carbonate, MgCO_3 , with nitric acid, $\text{HNO}_3(\text{aq})$.

The equation is shown below.

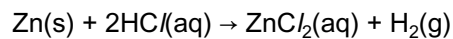


Calculate the minimum volume, in cm^3 , of 1.75 mol dm^{-3} HNO_3 that is needed to prepare a solution containing 5.00 g of $\text{Mg}(\text{NO}_3)_2$.

Give your answer to 3 significant figures.

volume = ... cm^3 [3]

61 Zinc reacts with hydrochloric acid, HCl(aq) , as shown in the following equation.



A student investigates the rate of this reaction.

The student plans to react 50.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ HCl with 0.200 g of zinc (an excess).

Calculate the volume, in cm^3 , of hydrogen that should be produced at RTP.

volume = ... cm^3 [3]

- 62 When hydrated strontium chloride is heated, the water of crystallisation is removed, leaving a residue of anhydrous strontium chloride.

A student carries out an experiment to find the value of x in the formula of hydrated strontium chloride, $\text{SrCl}_2 \cdot x\text{H}_2\text{O}$.

The student's method is outlined below.

Step 1

Weigh an empty crucible.

Add $\text{SrCl}_2 \cdot x\text{H}_2\text{O}$ to the crucible and reweigh.

Step 2

Heat the crucible and contents for 10 minutes.

Allow to cool and reweigh.

Step 3

Heat the crucible and residue for another 5 minutes.

Allow to cool and weigh the crucible and residue.

Repeat step 3 a further two times.

The student's results are shown below:

Mass of empty crucible / g	15.96
Mass of crucible + $\text{SrCl}_2 \cdot x\text{H}_2\text{O}$ / g	18.65
First mass of crucible + residue / g	17.66
Second mass of crucible + residue / g	17.61
Third mass of crucible + residue / g	17.58
Fourth mass of crucible + residue / g	17.58

- (i) Calculate the value of x in $\text{SrCl}_2 \cdot x\text{H}_2\text{O}$.

Give your answer to 2 significant figures.

(ii) Suggest why the student takes four readings of the mass of the crucible and residue.

----- [1]

(iii) Suggest **two** modifications to the method that would reduce the percentage uncertainty in the mass of the residue.

1 -----

2 -----

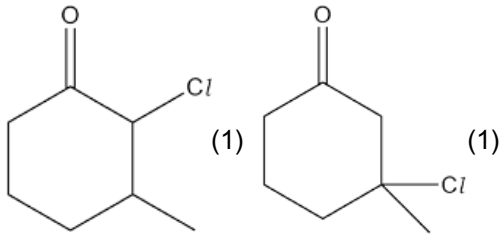
[2]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	1	
2			C	1	
			Total	1	
3			A	1	
			Total	1	
4			C	1	
			Total	1	
5			C	1	
			Total	1	
6		i	<i>Determining limiting factor</i> $n(\text{Zn}) \ 0.27/65.4 = 0.0041 \text{ mol}$ AND $n(\text{CaCO}_3) = 0.38/100.1 = 0.0038 \text{ mol}$ so Zn is in excess (1) <i>Determining volume of CO</i> ratio 1:1, so $n(\text{CO}) = 0.0038 \text{ (mol)}$ vol. CO = $0.0038 \times 24.0 = 0.091 \text{ dm}^3 = 91 \text{ (cm}^3\text{)} \text{ (1)}$	2	evidence of 0.27/65.4 is required (or using the mass ratio to predict 0.116g of CO from 0.27g Zn) or use of the mass ratio to predict 0.106g CO from 0.38g CaCO₃, and dividing by 28.0 to get 0.0038 mol CO allow 2 sig figs up to calculator answer allow second and third marks for correct final answer with no working allow 2 marks for 99 cm³ from excess Zn mass
		ii	heat until syringe stops moving / no further gas produced (1) wait until the gas has cooled (to room temperature) before measuring the volume of gas (1)	2	allow heat for longer than two minutes allow heat a greater mass
			Total	4	

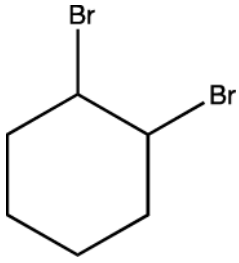
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7	a	i		2	allow any unambiguous structure or formula. allow ecf on the second structure for hydrogen atom errors if candidate tries to convert to a displayed / structural formula, but the carbon skeleton must be correct.
		ii	correct structure of either possible carbocation intermediate shown (1) the tertiary halogenoalkane (which will be labelled as either product 1 or product 2) is identified as the one formed in greater amounts ... because the carbocation more stable on C3 than C2 <i>owtte</i> (1)	2	If both carbocations are drawn, only one needs to be correct to score the mark. allow ecf from (i) for correct justification of product formed in greater amount based on incorrect structures.
		iii	Amount of D that reacts $M(D: C_7H_{16}O) = 110 \text{ (g mol}^{-1}\text{)}$ AND $n(C_7H_{16}O) =$ $\frac{4.125}{110} =$ 0.0375 (mol) (1) Masses of two products formed $M(\text{product: } C_7H_{17}OCl) = 146.5 \text{ (g mol}^{-1}\text{)}$ AND Mass of 95% product = $0.0375 \times \frac{95}{100} \times 146.5 = 5.22 \text{ g}$ AND	2	

Mark Scheme

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		iii	Mass of 5% product = $0.0375 \times \frac{5}{100} \times 146.5 = 0.27 \text{ g}$ (1)		allow mass of both products $= 0.0375 \times 146.5 = 5.49 \text{ g}$ Mass of 95% product = $\frac{95}{100} \times 5.49 = 5.22 \text{ g}$ Mass of 5% product = $\frac{5}{100} \times 5.49 = 0.27 \text{ g}$ allow 'product 1' and 'product 2' if linked to correct mass given labelling in (i) and reasoning in (ii) (allow ecf from (ii)).
	b		(broad) peak at 3300–3600 (cm^{-1}) for O–H (therefore A or C) (1) molar ratio: C : H : O $\frac{78.94}{12.0} : \frac{10.53}{1.0} : \frac{10.53}{16.0}$ OR 6.58 : 10.53 : 0.658 (1) 10 : 16 : 1 OR $\text{C}_{10}\text{H}_{16}\text{O}$, therefore C (1)	3	allow 3200–3600 cm^{-1} ignore references to the peak at ~2900 for C–H allow annotation of the spectrum to identify the bond responsible for the peak instead of quoting the wavenumber. Conclusion may also follow from empirical formula followed by IR data.
			Total	9	
8			atom economy suggests hydration is more sustainable (1) (but ...) <i>Any two from:</i> the CO_2 given off is taken in by plants as they grow (1) (ethene from) crude oil is non-renewable / glucose is renewable (1) fermentation does not require high temperatures / pressures, so lower energy demand (1) so on balance fermentation is more sustainable <i>owtte</i> (1)	4	ignore references to global warming or 'carbon neutral' there must be a conclusion for this mark
			Total	4	
9			C	1	
			Total	1	
10			D	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
11	a		Aliphatic = E, H, I, J (1) Alicyclic = E, H, J (1) Aromatic = F, G (1)	3	
	b		C_nH_{2n+1}	1	do not allow C_nH_{2n+1}
	c	i	<i>Equation:</i> $C_6H_{12}O \rightarrow C_6H_{10} + H_2O$ (1) <i>Calculation:</i> FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 32.7 (%) award 3 marks theoretical yield = $7.65 / 100 = 0.0765$ (mol) (1) actual yield = $2.05 / 82 = 0.025$ (mol) (1) % yield = $(0.025 / 0.0765) \times 100\% = 32.7(\%)$ (1)	4	ignore state symbols allow $C_6H_{11}OH$ for $C_6H_{12}O$ If there is an alternative answer, check to see if there is any ECF credit possible using working below % yield must be to 1 dp allow theoretical and actual yield calculated in mass theoretical yield = $0.0765 \times 82 = 6.273$ g % yield = $(2.05 / 6.273) = 32.7(\%)$ allow ecf from calculated actual and theoretical yields
		ii	bromine water is decolourised (1)  (1)	2	allow bromine water turns colourless ignore 'goes clear' allow correct structural OR displayed OR skeletal formula OR mixture of the above
			Total	10	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
12	a		$n(\text{Eu}) = 0.0019 / 152.0 = 1.25 \times 10^{-5} \text{ (1)}$ Atoms of Eu = $1.25 \times 10^{-5} \times 6.02 \times 10^{23} = 7.5 \times 10^{18} \text{ (1)}$	2	allow 0.0000125 Must be standard form AND two significant figures allow ecf from incorrect amount allow 2 marks for correct answer without working
	b		$n(\text{H}_2) = 144 / 24000 = 6(.00) \times 10^{-3} \text{ (mol)}$ (1) $n(\text{Eu}) = 0.608 / 152.0 = 4(.00) \times 10^{-3} \text{ (mol)}$ AND ratio $n(\text{Eu}) : n(\text{H}_2) = 2 : 3 \text{ (1)}$ $2\text{Eu} + 3\text{H}_2\text{SO}_4 \rightarrow \text{Eu}_2(\text{SO}_4)_3 + 3\text{H}_2 \text{ (1)}$	3	Look for evidence of 2 : 3 anywhere. <i>Could be within an attempted equation.</i> ignore state symbols
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance						
13	a	i	$\text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$ (1)	1	allow multiples						
		ii	<i>Energy (into water) mark</i> $70.0 \times 4.18 \times 16.5 = 4827.9$ (J) or 4.8279 (kJ) (1) <i>amount of substance mark</i> $n(\text{H}_2\text{O}) = \frac{35.0}{1000} \times 2.40 = 0.084(0)$ (mol) <i>$\Delta_{\text{neut}}H$ mark</i> $(-)4.8279 / 0.084(0) =$ $(-)57.475$ OR $(-)57.48$ OR $(-)57.5$ (1) Correctly rounded to at least 3 significant figures	3	allow rounding to 4828 OR 4830 allow amount of substance mark to be based upon either HCl or NaOH allow ecf for <u>Energy (into water) mark</u> Amount of substance mark						
		iii	1 mole of water had been formed (1)	1							
		iv	$\frac{2 \times 0.5}{16.5} \times 100 = 6\%$ (1)	1							
	b	i	<i>Amount of each element mark</i> <table><tr><td>H</td><td>O</td><td>N</td></tr><tr><td>$\frac{0.025}{1.0}$</td><td>$\frac{0.300}{16.0}$</td><td>$\frac{0.175}{14.0}$</td></tr></table> $= 0.025 \quad 0.01875 \quad 0.0125$ (1) <i>Simplest whole number ratio empirical formula</i> $\frac{0.025}{0.0125} = 2 \quad \frac{0.01875}{0.0125} = 1.5 \quad \frac{0.0125}{0.0125} = 1$ AND $\text{H}_4\text{O}_3\text{N}_2$ (1)	H	O	N	$\frac{0.025}{1.0}$	$\frac{0.300}{16.0}$	$\frac{0.175}{14.0}$	2	allow 2 marks for correct answer without working
H	O	N									
$\frac{0.025}{1.0}$	$\frac{0.300}{16.0}$	$\frac{0.175}{14.0}$									
		ii	acid: HNO_3 AND base: NH_3 (1)	1	allow atoms within HNO_3 and NH_3 in any order						
			Total	9							

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
14		i	$P_4 + 6Br_2 \rightarrow 4PBr_3$	1	ignore state symbols
		ii	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 3.01×10^{21} award 3 marks $M_r(PBr_3) = 270.7 \text{ (g mol}^{-1}\text{)} \text{ (1)}$ $n(PBr_3) = 1.3535 / 270.7 = 5.000 \times 10^{-3} \text{ mol (1)}$ number of molecules = $5.000 \times 10^{-3} \times 6.02 \times 10^{23} = 3.01 \times 10^{21} \text{ molecules (1)}$	3	If there is an alternative answer, check to see if there is any ecf credit possible using working below. allow in working shown as $28.1 + 35.5 \times 4$ allow ecf from incorrect molar mass of PBr_3 allow 0.005(00) (mol) for two marks allow ecf for incorrect amount of PBr_3 allow calculator value or rounding to 3 significant figures or more but ignore 'trailing' zeroes, e.g. 0.200 allowed as 0.2 do not allow any marks for: $1.3535 \times 6.02 \times 10^{23} = 8.15 \times 10^{23}$
		iii	Pyramidal (1) (because there are) 3 bonded pairs and 1 lone pair (around the central phosphorus atom) (1) and electron pairs repel each other as far apart as possible so will take on a tetrahedral arrangement (giving a pyramidal shape overall) (1)	3	
			Total	7	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
15			FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 76.5 (%) award 3 marks $n(\text{NH}_3) = (1 \times 10^6) / 17 = 5.88 \times 10^4$ (58824) (mol) AND <i>Theoretical yield:</i> $n(\text{NH}_2\text{CONH}_2) = 5.88 \times 10^4 / 2 = 2.94 \times 10^4$ (29412) (mol) (1) <i>Actual yield:</i> $n(\text{NH}_2\text{CONH}_2) = 1.35 \times 10^6 / 60 = 2.25 \times 10^4$ (22500) (mol) (1) % yield = $(2.94 \times 10^4 / 2.25 \times 10^4) \times 100\%$ = 76.5(%) (1)	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below allow up to full calculator display For 2nd and 3rd marks, allow calculation in mass. <i>Theoretical mass yield:</i> $m(\text{NH}_2\text{CONH}_2) = 60 \times 5.88 \times 10^4 / 2 = 1.764 \text{ tonne}$ % yield = $(1.35 / 1.764) \times 100 = 76.5\%$ allow 76% (2 sig figs) up to calculator answer correctly rounded from previous values allow ecf from calculated actual and theoretical yields
			Total	3	
16			(Minimum) $n(\text{pentan-2-ol})$ required = $0.1 \times 88 = 8.8 \text{ g}$ (1) React the alcohol with a mixture of NaBr AND H_2SO_4 AND warm (to distil off the product) (1)	2	allow HBr
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
17	a	i	Initial reading = 0.60 (cm ³) Final reading = 22.80 (cm ³) Titre = 22.20 cm ³ Initial and final values recorded to two decimal places AND titre recorded to the nearest 0.05 cm ³ with correct units	1	
		ii	Suggests repeating the titration to obtain consistent / concordant results (those that agree to within 0.1 cm ³) AND calculating the mean titre	1	
	b	i	$n(\text{HCl}) = (0.100)(\text{answer to (c)(i)}/1000) = 0.00222 \text{ (mol) (1)}$ $n(\text{M}_2\text{CO}_3) = 0.00222/2 = 0.00111 \text{ (mol) (1)}$	2	allow ecf from (b)(i)
		ii	$n(\text{M}_2\text{CO}_3) \text{ in total} = 0.00111 \times 10 = 0.0111 \text{ mol (1)}$ Molar mass = $1.58/0.0111 = 142.3 \text{ g mol}^{-1} \text{ (1)}$ Mass of M = $(142.3 - 60)/2 = 41.15 \text{ (= K) (1)}$ $\text{K}_2\text{CO}_3 \text{ (1)}$	4	Note: molar mass is between K_2CO_3 (138.2) and SrCO_3 (147.6); only possible match for a Group 1 carbonate is K_2CO_3 .
			Total	8	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
18	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 46.0 (g mol⁻¹) award 4 marks for calculation <i>Rearranging ideal gas equation to make n subject</i> $n = \frac{pV}{RT} \quad (1)$ <i>Substituting all values taking into account conversion to Pa and m³</i> $n = \frac{(100 \times 10^3) \times (761 \times 10^{-6})}{8.314 \times 366} \quad (1)$ $n = 0.0250 \text{ mol} \quad (1)$ <i>Calculation of M</i> $M = \frac{m}{n} = \frac{1.15}{0.0250} = 46.0 \text{ (g mol}^{-1}\text{)} \quad (1)$ <i>Identification of A (1)</i> <pre> H H H — C — C — OH H H </pre>	5	If there is an alternative answer, check to see if there is any ECF credit possible using working below. 1st mark may be implicit in direct substitution of correct values into rearranged equation. allow any unambiguous structure allow C₂H₅OH do not allow C₂H₆O
	Total	5	
19	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 73.9 or 73.93 (g mol⁻¹) award 3 marks for calculation $n(\text{NaOH}) = (25.25/1000) \times 0.120 = 3.03 \times 10^{-3} \text{ (mol)} \quad (1)$ $n(\text{acid in } 250 \text{ cm}^3 \text{ flask}) = 3.03 \times 10^{-3} \times 10 = 3.03 \times 10^{-2} \text{ (mol)} \quad (1)$ molar mass of unknown acid = $2.24 / 3.03 \times 10^{-2} = 73.9 \text{ (g mol}^{-1}\text{)} \quad (1)$	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below
	Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
20		i	$\text{Sr(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Sr(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$ Note: all state symbols required	1	allow multiples
		ii	$n(\text{Sr}) = n(\text{Sr}^{2+}) = 0.200 / 87.6 = 2.28 \times 10^{-3}$ (1) $[\text{Sr}^{2+}] = 2.28 \times 10^{-3} \times 1000 / 250 = 9.13 \times 10^{-3}$ (mol dm ⁻³) (1)	2	allow ecf
		iii	Greater volume with Ca AND larger amount / more moles of Ca OR A_r Ca is smaller (1) $n(\text{Ca}) = 0.200/40.1 = 0.005(0)$ (mol) (1) volume H ₂ with Sr = 55 cm ³ AND volume with Ca = 120 cm ³ OR 65 cm ³ more H ₂ with Ca (1)	3	ora allow values up to calculator values allow volumes $\pm 1 \text{ cm}^3$
			Total	6	

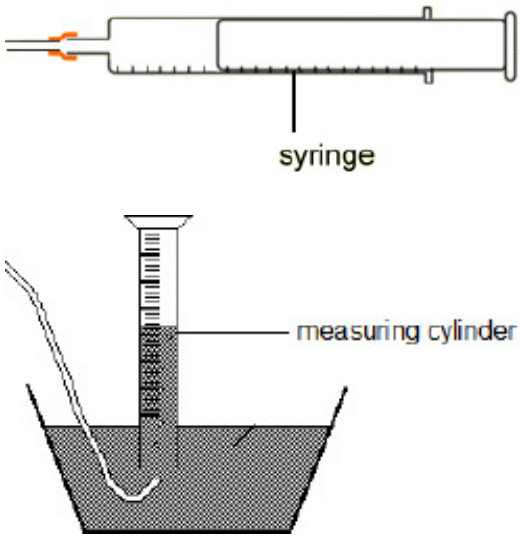
Mark Scheme

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21	a	i	CO is toxic	1	allow responses linked to effect of CO in blood
		ii	<i>Calculation:</i> $n(\text{butane}) = 600/58.0 = 10.34 \text{ (mol)}$ AND $n(\text{O}_2) \text{ required} = 6.5 \times 10.34 = 67.2 \text{ (mol) (1)}$ $n(\text{O}_2) \text{ consumed} = 1.50 \times 10^3 / 24.0 = 62.5 \text{ (mol)}$ OR volume O₂ required for complete combustion = $67.2 \times 24.0/1000 = 1.61 \text{ m}^3 \text{ (1)}$ <i>Conclusion:</i> incomplete combustion / stove not safe to use AND $62.5 < 67.2$ OR $1.61 > 1.50 \text{ (1)}$	3	using 1 : 6.5 ratio allow number rounding to 67
	b		<i>Rearranging ideal gas equation to make n subject</i> $n = pV / RT \text{ (1)}$ <i>Substituting all values taking into account conversion of units</i> $n = \frac{(101 \times 10^3) \times (2.00 \times 10^{-3})}{8.314 \times 297} \text{ (1)}$ $n = 0.0818 \dots \text{ (mol) (1)}$ number of C atoms in alkane = $0.0818/0.0117 = 7$ alkane = C₇H₁₆ (1)	4	allow 3SF up to calculator value of 0.08180595142, correctly rounded allow ecf from incorrect n
			Total	8	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
22	a	i	Diagram of labelled reaction vessel for reaction ✓	1	ALLOW (conical) flask, test-tube or boiling tube. DO NOT ALLOW volumetric flask, beaker, measuring cylinder DO NOT ALLOW delivery tube below reacting solution ALLOW any of these diagrams.  ALLOW a single line for the tube IGNORE Sealed end of delivery tube

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
i	Labelled (gas) syringe OR diagram of gas collection over water in a labelled measuring cylinder / inverted burette. AND closed system with a tube connecting reaction vessel to gas collection apparatus ✓	1	 DO NOT ALLOW measuring tube Examiner's Comments Clearly candidates were not expecting to be asked about how to set up the apparatus to measure the volume of a gas produced in an experiment. The specification states that candidates can be assessed on the techniques and procedures required during experiments requiring the measurement of mass, volumes of solutions and gas volumes. Many diagrams were unlabelled or suggested apparatus that was totally unsuitable for the set task. Some provided unsealed systems which would lead to gas being lost which would be inappropriate.
ii	FIRST CHECK CALCULATED VALUE FOR MOLAR / ATOMIC MASS OF CALCIUM IF answer = 40.1 OR 40.08 is seen anywhere award first two marks		DO NOT ALLOW $pV = nRT$ for the calculation of the amount in moles for marking point 1.
ii	$n(\text{H}_2)$ OR $n(\text{Group 2 metal})$ $= \frac{97.0}{24\,000} = 4.04 \times 10^{-3} \text{ (mol)} \quad \checkmark$	1	ALLOW 3 SF up to calculator value correctly rounded (0.004041666)
ii	molar mass / atomic mass of Group 2 metal $= \frac{0.162}{0.00404} = 40.1 \text{ (g mol}^{-1}\text{)} \quad \checkmark$	1	ALLOW 3 SF up to calculator value correctly rounded (40.08247423) ALLOW ECF from incorrectly calculated amount in moles

Mark Scheme

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		ii	Group 2 metal: calcium / Ca ✓	1	DO NOT ALLOW Calcium if no working ALLOW ECF as element in Group 2 closest to the value calculated Examiner's Comments On the whole candidates were able to carry out this calculation to a satisfactory conclusion obtaining the relative atomic mass of the unknown metal and then suggesting that this was calcium. With an increased emphasis on the mathematical requirements within the specification, it is important that candidates are aware of suitable rounding within answers. A rounding error in the first part of this calculation frequently resulted in the atomic mass being calculated as 40.5 which did not gain credit. Although the mark for locating the metal as calcium was still awarded as an error carried forward. Answer = 40.1
	b		Less (volume / products) AND Smaller amount / fewer moles / fewer atoms of the metal OR element reacting ✓	1	IGNORE higher relative atomic mass / molar mass ALLOW a calculation showing that moles and volume are less $n(\text{H}_2) = 0.162/87.6 = 0.0018493156$ Volume = $0.0018493156 \times 24000 = 44(.4)$ cm³ Examiner's Comments This question was not well answered. Most candidates did not specify that there would be fewer moles of the metal. Many candidates were unable to grasp the concept that the amount of substance was linked to mass and relative atomic mass and that a larger atomic mass would lead to a smaller number of moles of the metal and hence a decrease in the volume of hydrogen produced.
			Total	6	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
23	FIRST CHECK ANSWER ON THE ANSWER L IF answer = 4.46×10^6 (Pa) award 4 marks Amount of N₂O $n(\text{N}_2\text{O}) = \frac{187}{44}$ OR 4.25 (mol) ✓ Unit conversion Volume conversion to m³ = 2.32×10^{-3} (m³) ✓ Ideal gas equation / temperature conversion $p = \frac{nRT}{V}$ OR $p = \frac{4.25 \times 8.314 \times 293}{2.32 \times 10^{-3}}$ AND Use of $T = 293$ K ✓ Final answer $p = 4.46 \times 10^6$ (Pa) ✓ <i>Must be calculated in standard form AND to 3 SF</i>	1 1 1 1	If there is an alternative answer, check to see if there is any ECF credit possible ALLOW ECF from incorrect amount of N₂O e.g. use of incorrect M_r for N₂O could still score 3 marks ----- Common Errors (3 marks) <i>No temperature conversion</i> $p = \frac{4.25 \times 8.314 \times 20}{2.32 \times 10^{-3}} = 3.05 \times 10^5$ <i>Incorrect volume conversion</i> $p = \frac{4.25 \times 8.314 \times 293}{2.32 \times 10^{-6}} = 4.46 \times 10^9$ <i>No volume conversion</i> $p = \frac{4.25 \times 8.314 \times 293}{2.32} = 4.46 \times 10^3$ <i>No standard form</i> = 4460000 Examiner's Comments This was a new addition to the OCR specification as part of the curriculum changes. The vast majority of candidates made a good attempt at this calculation which required both the rearrangement of a formula and the conversion of units of temperature and volume. The conversions and calculation did not prove that difficult for many candidates however answers were often not given to three significant figures or quoted in standard form resulting in the loss of one mark. Candidates clearly need to develop their mathematical skills in order to access the 20% of marks available for quantitative work. Answer = $4.46 \times 10_6(\text{Pa})$

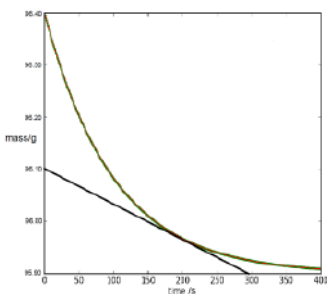
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			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
24	a	i	carbon dioxide lost/evolved/given off/or produced as a gas ✓	1	DO NOT ALLOW water or steam or CO₂ evaporates Examiner's Comments Candidates who failed to state that the gas being lost was CO₂ could not access the mark for this question. Vague answers relating to water being produced, products being gases, products being lost or a gas evolved were often given by Candidates.
		ii	FIRST CHECK ANSWER ON THE ANSWER LINE IF answer = 1.85 OR 1.845 g award 3 marks ----- $n(\text{HNO}_3)$ $= 1.25 \times \frac{20.0}{1000} = 0.0250 \text{ mol } \checkmark$ $n(\text{SrCO}_3)$ $= \frac{0.0250}{2} = 0.0125 \text{ mol } \checkmark$ $m(\text{SrCO}_3)$ $= 0.0125 \times 147.6 = 1.845 \text{ g OR } 1.85 \text{ g } \checkmark$	3	If there is an alternative answer, check to see if there is any ECF credit possible ALLOW ECF from incorrect $n(\text{HNO}_3)$ molar mass of SrCO₃ = 147.6 (g mol⁻¹) ALLOW ECF from incorrect $n(\text{SrCO}_3)$ Examiner's Comments The vast majority of candidates were able to complete this calculation arriving at the correct answer to score all three available marks. The most common error was in calculating the amount, in moles, of the SrCO₃ from the stoichiometry given in the equation. This resulted in an answer which was twice that expected however two marks could still be obtained by applying error carried forward. Answer = 1.845 g or 1.85 g
	b	i	rate of reaction decreases AND concentration decreases / reactants are used up ✓	1	ALLOW reaction slows down ALLOW concentration of reactants decreases.

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		i	less frequent collisions ✓	1	ALLOW fewer collisions per unit time OR collisions less often OR decreased rate of collision IGNORE less successful collisions / less collisions less chance of collisions Examiner's Comments Very few candidates were able to explain the change in the rate of the reaction during the first 200 seconds of the experiment. This relatively straightforward question required a statement that the rate decreases as the concentration of the reactants decreases due to there being less frequent collisions. Although a large number of candidates were able to state that the rate decreases few were able to explain why. This was possibly due to candidates having to apply their understanding in an unfamiliar context rather than from a lack of knowledge
		ii	Attempted tangent on graph drawn to line at approximately $t = 200$ s ✓	1	ALLOW 1 SF up to calculator value, in range 5×10^{-4} to 8×10^{-4} IGNORE units IGNORE sign Examiner's Comments This was the first time AS level candidates have been required to calculate a rate of reaction from a graph and many found this quite testing. Although many knew that a tangent was required only the most able candidates were able to arrive at a value for the gradient that was within the expected range. Candidates sometimes took as their values the point at which their tangent cut the axes rather than calculating the change in mass or change in time. Acceptable range 5×10^{-4} to 8×10^{-4}
		ii	Gradient (y/x) e.g. $\frac{0.20}{290} = 6.9 \times 10^{-4}$ ✓ 	1	

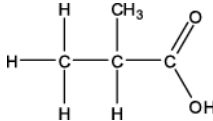
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	c		Flask OR beaker AND balance AND stopwatch OR stop clock OR other timing device ✓	1	DO NOT ALLOW round-bottomed flask. IGNORE weighing scales
			Records mass at time intervals ✓	1	ALLOW 'weigh at time intervals'
			Time interval quoted between 10-50s ✓	1	Examiner's Comments This was the second question that required candidates to describe an experiment that they could have carried out as part of their course. Even if this experiment had not been completed in class, candidates should be able to recognise that mass needs to be measured over a period of time. As the reaction was between an acid and a carbonate a suitable named reaction vessel such as a beaker or flask was required. A balance was needed for mass measurement and a timing device to monitor time. A simple statement that mass should be recorded at a given time interval scored two marks with one mark being allocated to suitable apparatus. At this level it is expected that candidates will be familiar with the correct names for the apparatus required to carry out an investigation.
			Total	11	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
25			FIRST CHECK ANSWER ON THE ANSWER LINE IF answer = 67.4% award all 3 marks for calculation $n(\text{butan-2-ol}) (m/M)$ $= 20.2/74$ OR $= 0.273 \text{ mol } \checkmark$ $n(\text{2-bromobutane } (m/M)$ $= 25.2/136.9$ OR $= 0.184 \text{ mol } \checkmark$ % yield $= (0.184/0.273) \times 100 = 67.4\% \checkmark$	1 1 1	If there is an alternative answer, check to see if there is any ECF credit possible ALLOW 3 SF: 0.273 up to calculator value of 0.272972973 correctly rounded ALLOW 3 SF: 0.184 up to calculator value of 0.184075967 correctly rounded ALLOW $(25.2/137) = 0.183941605$ ALLOW 67% if evidence shows 67.4% in answer ALLOW 67.4% up to calculator value correctly rounded. Common ECFs (2 marks) Incorrect M_r resulting in incorrect moles of butan-2-ol or 2-bromobutane ALLOW calculation in mass for 2nd and 3rd marks $m(\text{CH}_3\text{CHBrCH}_2\text{CH}_3) = 0.273 \times 136.9 = 37.4 \text{ g}$ % yield = $(25.2/37.4) \times 100 = 67.4\%$ Examiner's Comments Many good quality answers were given by candidates. Marks were sometimes dropped where answers were incorrectly rounded at the intermediate stage resulting in a percentage yield outside the acceptable range. Answer 67.4
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																				
26			<i>Please refer to marking instructions on page 4 of mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) A comprehensive description with all three scientific points explained thoroughly. C identified as a carboxylic acid containing four carbon atoms linked to the peak in the mass spectrum at 43. <i>The explanation makes use of all the evidence including the secondary carbocation in justifying the correct structure of C.</i> Level 2 (3–4 marks) Attempts all three scientific points but explanations may be incomplete. OR Explains two scientific points thoroughly with few omissions. <i>The analysis is clear and includes some interpretation o IR and MS peaks.</i> Level 1 (1–2 marks) A simple explanation based on at least two of the main scientific points. OR Explains one scientific point thoroughly with few errors. <i>The analysis is communicated in an unstructured way and includes interpretation of peaks from IR OR MS spectrum</i> 0 marks – No response worthy of credit.	6	LOOK ON THE SPECTRA for labelled peaks. Indicative scientific points may include: 1. Molecular formula <table><tr><td>Element</td><td>% mass</td><td>Ar</td><td>moles</td><td>ratio</td></tr><tr><td>C</td><td>54.5</td><td>12</td><td>4.54</td><td>2</td></tr><tr><td>H</td><td>9.1</td><td>1</td><td>9.1</td><td>4</td></tr><tr><td>O</td><td>36.4</td><td>16</td><td>2.28</td><td>1</td></tr></table> - empirical formula = C₂H₄O - molecular ion peak <i>m/z</i> or Mr = 88 - molecular formula = C₄H₈O₂ 2. Infrared spectrum - peak at 2500-3500 (cm⁻¹) is O–H - peak at 1630-1820 (cm⁻¹) is C=O - C is a carboxylic acid ALLOW stated values within the ranges above IGNORE references to C–O peaks 3. Identifying the carboxylic acid (CH₃CH₂CH₂COOH OR (CH₃)₂CHCOOH) - Mass spectrum peak at <i>m/z</i> = 43 = C₃H₇(⁺) - secondary carbocation: CH₃C⁺HCH₃ - compound C: (CH₃)₂CHCOOH  IGNORE name of carboxylic acid if structure given Examiner's Comments The final question on the paper was a six mark level of response question which required candidates to identify a molecule	Element	% mass	Ar	moles	ratio	C	54.5	12	4.54	2	H	9.1	1	9.1	4	O	36.4	16	2.28	1
Element	% mass	Ar	moles	ratio																					
C	54.5	12	4.54	2																					
H	9.1	1	9.1	4																					
O	36.4	16	2.28	1																					

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					from a range of data. Most candidates were able to process the percentage composition data to arrive at an empirical formula but less able candidates then failed to use the data from the mass spectrum to arrive at the molecular formula. Candidates were generally able to use the infrared spectrum to identify the presence of –OH and C=O and could link this to the carboxyl functional group. The best candidates were able to identify the peak in the mass spectrum at 43 and to link this to a C_3H_7^+ fragment which led to the assumption that the carboxylic acid was butanoic acid. Many outstanding candidates were able to discuss the peak at 43 being that of a branched chain secondary carbocation and linked this to the correct branched product. Some answers were unstructured and disorganised and candidates should be encouraged when analysing data to organise their answer sequentially and discuss each piece of data in turn.
			Total	6	
27			D	1	<u>Examiner's Comments</u> Many candidates were unable to identify the correct molar ratio, with B being a common incorrect answer. Many candidates chose C rather than D, overlooking oxygen in the equation.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
28		i	FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 63.62 award 2 marks $\frac{(63 \times 69.17) + (65 \times 30.83)}{100}$ OR 63.6166 OR 63.617 ✓ = 63.62 (to 2 DP) ✓ <i>IGNORE any units with A_r</i>	2	ALLOW ECF for a correct calculation to 2 DP if: %s have been used with wrong isotopes i.e. $\frac{(63 \times 30.83) + (65 \times 69.17)}{100} \rightarrow 64.38$ OR - decimal places for ONE % have been transposed, i.e. 69.71 → 63.96; 30.38 → 63.32 Examiner's Comments This part was mostly correct. Low-scoring candidates sometimes produced errors in averaging or rounding. Most final answers were given to the required two decimal places. Answer = 63.62
		ii	FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 3.97×10^{22} (from 63.62) award 2 marks If answer = 3.98×10^{22} (from 63.5) award 2 marks Using 63.62: correct A_r of Cu from 21(b)(i) See bottom of answer zone $n(\text{Cu}) = \frac{5.00 \times 0.840}{63.62} = \frac{4.2}{63.62} = 0.066(0) \text{ (mol)} \checkmark$ Cu atoms = $0.0660 \times 6.02 \times 10^{23} = 3.97 \times 10^{22} \checkmark$ <i>Must be calculated in standard form AND to 3 SF</i> OR _____	2	If there is an alternative answer, check to see if there is any ECF credit possible SEE answer from 21b(i) at bottom of answer zone ALLOW correct answer from 3 SF up to calculator value of 0.06601697579 ALLOW incorrect $n(\text{Cu}) \times 6.02 \times 10^{23}$ correctly calculated to 3 SF AND in standard form For ECF, A_r <i>must</i> have been used for $n(\text{Cu})$

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance								
			Using 63.5: A_r of Cu from periodic table $n(\text{Cu}) = \frac{5.00 \times 0.840}{63.5} = \frac{4.2}{63.5} = 0.0661 \text{ (mol)} \checkmark$ Cu atoms = $0.0661 \times 6.02 \times 10^{23} = 3.98 \times 10^{22} \checkmark$ <i>Must be calculated in standard form AND to 3 SF</i>		ALLOW correct answer from 3 SF up to calculator value of 0.06614173228 ALLOW incorrect $n(\text{Cu}) \times 6.02 \times 10^{23}$ correctly calculated to 3 SF AND in standard form <i>For ECF, A_r must have been used for $n(\text{Cu})$</i> Common errors Using 63.62: <table><tr><td>3.984×10^{22}</td><td>1 mark (SF)</td></tr><tr><td>4.73×10^{22}</td><td>1 mark (ECF: omitting 0.840)</td></tr></table> Using 63.5: <table><tr><td>3.982×10^{22}</td><td>1 mark (SF)</td></tr><tr><td>4.74×10^{22}</td><td>1 mark (ECF: omitting 0.840)</td></tr></table> <u>Examiner's Comments</u> This part was generally well answered with most candidates processing the data correctly. Candidates sometimes failed to consider 84% or rounded incorrectly in places. Answer = 3.97×10^{22} atoms	3.984×10^{22}	1 mark (SF)	4.73×10^{22}	1 mark (ECF: omitting 0.840)	3.982×10^{22}	1 mark (SF)	4.74×10^{22}	1 mark (ECF: omitting 0.840)
3.984×10^{22}	1 mark (SF)												
4.73×10^{22}	1 mark (ECF: omitting 0.840)												
3.982×10^{22}	1 mark (SF)												
4.74×10^{22}	1 mark (ECF: omitting 0.840)												
			Total	4									

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
29	a		<i>Initial ratios</i> Cr, $\frac{19.51}{52.0}$; Cl, $\frac{39.96}{35.5}$; H, $\frac{4.51}{1.0}$; O, $\frac{36.02}{16.0}$ OR Cr, 0.375; Cl, 1.126; H, 4.51; O, 2.25 ✓ <i>Whole number ratios</i> Cr, 1; Cl, 3; H, 12; O, 6 ✓ <i>Formula with water of crystallisation</i> $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ ✓	3	NOTE: If only the correct answer of $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ is seen with no working, award 1 mark only IF there is no whole number ratio, ALLOW empirical formula: $\text{CrCl}_3\text{H}_{12}\text{O}_6$ ALLOW ECF from incorrect whole number ratio, provided ONLY Cl incorrect AND $6\text{H}_2\text{O}$, e.g. $\text{CrCl}_2 \cdot 6\text{H}_2\text{O}$ <u>Examiner's Comments</u> Many candidates were able to calculate the empirical formula of the hydrated salt. While the majority went on to shown the formula as $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ to score all three marks, a significant minority failed to convert 12 H and 6 O into $6\text{H}_2\text{O}$.
	b	i	$\frac{2 \times 0.005}{0.58} \times 100 = 1.72\% \checkmark$	1	ALLOW 2% OR 1.7% up to calculator value of 1.724137931 <u>Examiner's Comments</u> This part was poorly answered. Candidates rarely seemed to understand the relationship between the precision of the balance and the uncertainty in taking two readings – hence 0.86%, half of 1.72%, was a common error. Answer = 1.72%

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	Use balance weighing to 3/more decimal places OR Use a larger mass/amount □ ✓	1	ALLOW more precise/more accurate/ more sensitive/higher resolution/smaller division IGNORE 'less error/smaller interval balance' IGNORE any reference to lid on crucible (<i>water can't escape</i>) IGNORE 'weigh straight after heating' IGNORE idea of repeating the experiment/ taking an average/ getting concordant results /larger sample size, etc. <u>Examiner's Comments</u> Correct answers suggested using a larger mass of the salt or a more accurate balance with more decimal places. Many responses instead discussed repeating the experiment and taking an average, or using a lid.
		iii	Heat to constant mass ✓	1	ALLOW response that implies heating to constant mass, e.g. Heat again until the mass does not change IGNORE 'heat for longer' <i>Needs link to constant mass</i> <u>Examiner's Comments</u> This was a good question to distinguish practical ability. Many candidates suggested simply 'heating for longer' or 'until no further colour change' but didn't link this to the idea of heating to constant mass.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 24.8 (cm³) award 3 marks $n(\text{NaOH}) = 0.124 \times \frac{25.0}{1000} = 3.1(0) \times 10^{-3} \text{ (mol) } \checkmark$ $n(\text{H}_2\text{SO}_4) = \frac{3.10 \times 10^{-3}}{2} = 1.55 \times 10^{-3} \text{ (mol) } \checkmark$ $V(\text{H}_2\text{SO}_4) = 1.55 \times 10^{-3} \times \frac{1000}{6.25 \times 10^{-2}} = 24.8 \text{ (cm}^3\text{) } \checkmark$	3	ALLOW ECF from $\frac{n(\text{NaOH})}{2}$ ALLOW ECF from $n(\text{H}_2\text{SO}_4) \times \frac{1000}{6.25 \times 10^{-2}}$ <u>Examiner's Comments</u> This part was answered well with the majority of candidates scoring all 3 marks. Where a mark was lost, it was generally either incorrect use of the mole ratio, or incorrect use of the moles of H₂SO₄ to calculate concentration. It was good to see how well many candidates were able to tackle an unstructured titration calculation.
			Total	9	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
30	a	FIRST, CHECK THE ANSWER ON ANSWER LINE IF $\Delta_r H = -58.5 \text{ (kJ mol}^{-1}\text{)}$ award 4 marks <i>Energy released in J OR kJ</i> $= 100.0 \times 4.18 \times 10.5 = 4389 \text{ (J) OR } 4.389 \text{ (kJ) } \checkmark$ <i>Correctly calculates $n(\text{Pb}(\text{NO}_3)_2)$</i> $= 1.50 \times \frac{50}{1000} = 0.075(0) \text{ (mol) } \checkmark$ ΔH value in J OR kJ Answer MUST divide energy by $n(\text{Pb}(\text{NO}_3)_2)$ $(-) \frac{4389}{0.0750} \text{ OR } (-)58520 \text{ (J)}$ OR $(-) \frac{4.389}{0.0750} \text{ OR } (-)58.52 \text{ (kJ) } \checkmark$ <i>(Sign ignored and/or more than 3 SF)</i> Correct $\Delta_r H$ in kJ AND – sign AND 3 SF $= -58.5 \text{ (kJ mol}^{-1}\text{)} \checkmark$	4	FULL ANNOTATIONS MUST BE USED ----- ALLOW 4390 J; 4.39 kJ DO NOT ALLOW less than 3 SF IGNORE units <i>i.e. ALLOW correctly calculated number in J OR kJ</i> ALLOW ECF from $n(\text{Pb}(\text{NO}_3)_2)$ AND/OR Energy ALLOW 58500 (from 4390) IGNORE absence of – sign and 3 SF requirement Final mark requires – sign, kJ AND 3 SF Note: From 4390 J, $\Delta_r H = -58.5 \text{ (kJ mol}^{-1}\text{)}$ (SAME) ----- Common error –29.3 3 marks (50 g instead of 100 g in $mc\Delta T$) <u>Examiner's Comments</u> Although similar in style to unstructured direct enthalpy calculations on the legacy specification, this question was harder for two reasons. Firstly, two volumes of 50 cm³ had to be added together to generate m as 100 g for $mc\Delta T$. Secondly, candidates were asked to quote their final answer to an ‘appropriate’ number of significant figures. This will be the least accurate measurement (to 3 significant figures in this example). Many incorrect answers used <i>m</i> as 50 g or

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					quoted a final numerical value to more than 3 significant figures. Even after obtaining a correct final value for ΔH, this was often not given a negative sign to indicate the exothermic change. It is important for candidates to show clear working so that markers can see what is intended and able to apply credit using error carried forward. Answer: $\Delta H = -58.5 \text{ kJ mol}^{-1}$
	b		$\text{Pb}^{2+}(\text{aq}) + 2\text{I}^{-}(\text{aq}) \rightarrow \text{PbI}_2(\text{s}) \checkmark$ State symbols required	1	ALLOW $\text{Pb}^{+2}(\text{aq})$ IGNORE spectator ions, $\text{K}^{+}(\text{aq})$ and $2\text{NO}_3^{-}(\text{aq})$ on both sides Examiner's Comments Only the best candidates were able to construct the required equation. Even when written correctly, state symbols (asked for in the question) were often omitted or shown incorrectly. Although very similar to the ionic equation for formation of silver halides, this equation was beyond most candidates at this stage of their chemistry studies.

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
	c	FIRST, CHECK ANSWER ON ANSWER LINE IF [KI(aq)] rounds to 3.3 mol dm⁻³ e.g. 3.30, 3.33, 3.3 recurring ----- Method 1 [KI(aq)] for complete reaction $= 2 \times 0.0750 = 0.150 \text{ mol} \times \frac{1000}{50} = 3 \text{ (mol dm}^{-3}\text{)} \checkmark$ 10% greater gives $3 \times 1.1 = 3.3(0) \checkmark$ OR----- Method 2 $n(\text{KI(aq)})$ required = $2.2 \times 0.0750 = 0.165 \text{ mol} \checkmark$ $[\text{KI(aq)}] = 0.165 \times \frac{1000}{50} = 3.3(0) \text{ (mol dm}^{-3}\text{)} \checkmark$	2	ALLOW ECF from incorrect $n(\text{Pb(NO}_3)_2)$ from 24(a) BUT if (a) is incorrect but 0.0750 used here, treat as a fresh start and IGNORE response from 24(a) ALLOW 2 marks for 3.3/3.3 recurring <i>Attempt at increasing concentration by 10%</i> $= 2 \times 0.0750 = 0.150 \text{ mol} \times \frac{1000}{45} = 3.33 \text{ (mol dm}^{-3}\text{)}$ ALLOW ECF from incorrect $n(\text{KI})$ <u>Common errors</u> 3 1 mark (Correct for KI with no extra 10%) 1.6 1 mark (no factor of 2 used for KI) 5 2.7 1 mark (10% less rather than 10% more) 2.7 1 mark (10% increase in volume: 55 3/2. cm³) 72 <u>Examiner's Comments</u> This part was well attempted with many candidates able to score at least one of the two marks. Errors related to use of an incorrect mole ratio, applying 10% incorrectly, or ignoring 10% altogether. Answer: 3.30 mol dm⁻³
		Total	7	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
31		i	C ₂ H ₅ O ✓	1	ALLOW elements in any order DO NOT ALLOW any other answer <u>Examiner's Comments</u> This part was answered well by most candidates. Some candidates however wrote the molecular rather than the empirical formula, or attempted to show the empirical formula as C₂H₄OH instead of C₂H₅O.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	Compound E: <pre> H CH₃ Br — C — C — Br H CH₃ ✓ </pre> Stage 1: Compound E: Bromine/Br₂ ✓ Stage 2: NaOH/KOH OR OH⁻ ✓ <i>Only award if intermediate contains at least one halogen atom</i>	3	For structures: ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above ALLOW dichloro/diiodo compound IGNORE connectivity of bonds to CH₃ ALLOW chlorine/Cl₂ OR iodine/I₂ IGNORE conditions, e.g. u.v. DO NOT ALLOW H₂O IGNORE conditions NOTE: Max of 2 marks available for monobrominated intermediate 1 mark Reagent: HBr AND Intermediate: CH₃C(CH₃)₂Br OR BrCH₂CH(CH₃)₂ 1 mark Intermediate: CH₃C(CH₃)₂Br OR BrCH₂CH(CH₃)₂ AND Reagent: NaOH <u>Examiner's Comments</u> This demanding part was answered poorly by weaker candidates and was good for differentiating higher ability candidates. The mark scheme allowed some credit for using a hydrogen halide to obtain a monosubstituted haloalkane for compound E. Surprisingly, reaction mechanism names were often given instead of reagents. Many candidates seemed to guess, sometimes showing the same reagents for both stages in the hope of getting a mark. Many showed an intermediate containing no halogen atom.
			Total	4	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
32	<i>Please refer to marking instructions on page 5 of mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) All three scientific points are covered in detail and explained thoroughly. <i>The method is logically structured and clear calculations are shown for an appropriate mass of metal and suitable volume of acid. The drawing of a tangent and determination of the gradient is communicated well.</i> Level 2 (3–4 marks) Candidates cover all three scientific points but explanations may be incomplete. OR Two of the scientific points are described thoroughly with no omissions. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence. e.g. there are clear calculations to justify mass and acid volume supported by some working and units; a simple description for determining initial rate related to tangent but no detail of how to measure gradient..</i> Level 1 (1–2 marks) There is a description based on at least two of the main scientific points OR The candidate explains one scientific point thoroughly with few omissions. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant. e.g. 'add zinc and acid and measure volume (no mass, volume or time intervals); calculations that have little structure, absent units and little working.</i>	6	Indicative scientific points 1. Method • measure mass of (excess) zinc (using 2 decimal place balance) • measure volume of hydrochloric acid (using measuring cylinder) • mix zinc and acid in flask • measure gas volume at time intervals 2. Calculations • moles of hydrogen $72/24000 = 0.00300 \text{ mol}$ • minimum mass of zinc $0.003 \times 65.4 = 0.20 \text{ g}$ • moles of hydrochloric acid $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$ $0.00300 \times 2 = 0.00600 \text{ mol}$ • volume / concentration of acid If $[\text{HCl}(\text{aq})] = 0.1 \text{ mol dm}^{-3}$ appropriate volume of acid = $0.006 \times 1000/0.1 = 60 \text{ cm}^3$ If $[\text{HCl}(\text{aq})] \geq 0.3 \text{ mol dm}^{-3}$, too low ($\leq 20 \text{ cm}^3$) If $[\text{HCl}(\text{aq})] \leq 0.03 \text{ mol dm}^{-3}$ too high ($\geq 200 \text{ cm}^3$) 3. Processing results • Plot a graph of volume against time • Draw a tangent at $t = 0$ • Gradient of tangent = initial rate • Gradient = volume / time

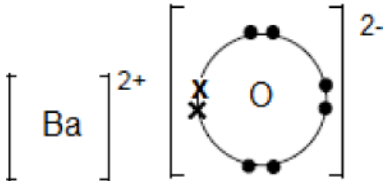
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			0 marks <i>No response or no response worthy of credit.</i>		Examiner's Comment: This question was marked using a level of response mark scheme and relatively few candidates were able to achieve Level 3. Many vague and rambling responses failed to mention the basic requirement to measure the volume of gas at regular time intervals. Some preferred to record the change in mass and ignored the diagram with a labelled gas syringe, while some carried out the experiment in a measuring cylinder. The question advises candidates to show working in their calculations but many omitted calculations from their answer. The question asked for an explanation of how the results could be processed graphically but this section was often lacking detail. Level 1 responses usually included the measurement and mixing of reactants and an attempt at processing the results by plotting a graph but further detail was missing. Candidates achieving Level 2 usually included a calculation of the moles of reactants and a more detailed description of how to process the results. Some excellent Level 3 responses included a full calculation of the mass of zinc and volume of hydrochloric acid required for the experiment.
			Total	6	
33			D	1	Examiner's Comments Most candidates answered this question correctly with only the weakest candidates losing the mark. Some candidates incorrectly identified the answer as B, which has the same ratio but was not the simplest whole number ratio.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
34			B	1	Examiner's Comments Able candidates answered this question correctly, with answer option A being a common distractor.
			Total	1	
35			C	1	Examiner's Comments This question was generally answered well. Answer option D was a common distractor.
			Total	1	
36			C	1	Examiner's Comments Most successful candidates showed rough working at the side with the formula displayed.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
37	a	i	<u>Electrostatic attraction</u> between positive and negative ions ✓	1	ALLOW oppositely charged ions ALLOW cations and anions ALLOW '+' for positive and '-' for negative IGNORE references to metal and non-metal IGNORE references to transfer of electrons Examiner's Comments The specification describes ionic bonding as an electrostatic attraction and a small proportion of answers were missing this key phrase.
		ii	 Ba shown with either 0 or 8 electrons AND O shown with 8 electrons with 6 dots and 2 crosses (or vice versa) ✓ Correct charges on both ions ✓	2	For first mark, if eight electrons are shown around Ba, the 'extra' electrons around O must match the symbol chosen for the electrons for Ba. IGNORE inner shells Circles not required Brackets not required Examiner's Comments Covalent bonding diagrams were not common and this question was well answered by the vast majority of candidates.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 5.89×10^{21} award 2 marks for calculation <i>Moles of barium oxide</i> $n(\text{BaO}) = 1.50/153.3$ OR 9.78×10^{-3} ✓ <i>Number of barium ions</i> $(9.78 \times 10^{-3} \times 6.02 \times 10^{23}) = 5.89 \times 10^{21}$ ✓ 3 SF AND standard form required	2	ALLOW 0.00978 up to calculator value 0.009784735 ALLOW ECF from incorrect moles of BaO Common incorrect answers are shown below IF 137.3 is used for the molar mass ALLOW 1 mark total for 6.58×10^{21} (0.010924981 mol) OR 6.56×10^{21} (0.0109 mol) IF 153 is used for the molar mass ALLOW 1 mark total for 5.90×10^{21} Examiner's Comments Use of the relative mass of barium to calculate moles of barium oxide was a common error but these candidates were usually able to pick up one mark for correctly multiplying their moles by the Avogadro constant. Some candidates correctly calculated moles but then divided by two thus losing the final mark.

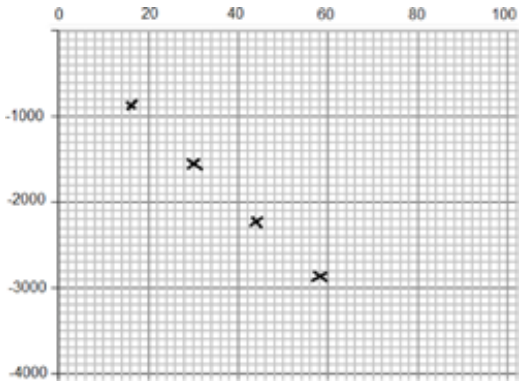
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	Barium chloride does not conduct electricity when solid AND because it has ions which are fixed (in position / in lattice) ✓ Barium chloride conducts when in aqueous solution AND because it has mobile ions	2	IGNORE use of 'free' instead of 'mobile' ALLOW ions are not free to move ALLOW ions are held (in position / in lattice) ALLOW ions are not mobile IGNORE charge carriers DO NOT ALLOW electrons moving ALLOW one mark for comparison that does not identify (s) and (aq). Examiner's Comments Many precise answers gained full marks by describing the fixed position of ions in a lattice and the mobility of ions in aqueous solution. Delocalised or free electrons were occasionally mentioned. Vague answers often used the terms 'free' instead of mobile, 'charge carrier' instead of ion and 'carry a charge' instead of conduct electricity.
		ii	Test for sulfate / SO_4^{2-} ✓ <u>White</u> precipitate forms (when barium chloride solution is mixed with a solution containing sulfate ions) ✓	2	IGNORE hydrochloric acid ALLOW white solid IGNORE cloudy DO NOT ALLOW test result linked to incorrect anion Examiner's Comments There was some confusion with the displacement reactions of halogens, the test for halide ions and the use of silver nitrate but the majority of students could recall the use of aqueous barium chloride to test for sulfate ions. Occasionally candidates described the use of dilute hydrochloric acid to remove carbonate ions from solution before their creditworthy description of the sulfate test.

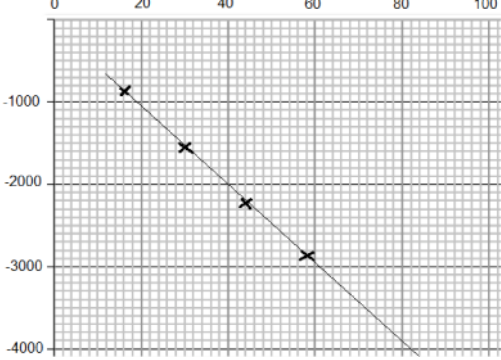
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 2 award 2 marks $M(\text{BaCl}_2) = ((137.3 + (35.5 \times 2))$ ✓ $= \underline{208.3} \text{ (g mol}^{-1}\text{)}$ $244.3 - 208.3 = 36$ AND $36/18 = 2$ ✓	2	ALLOW 208 (g mol⁻¹) ALLOW ECF for incorrectly calculated molar mass provided the final answer is rounded to nearest whole number Examiner's Comments Very well answered, the majority of candidates scored full marks for this simple calculation.
			Total	11	

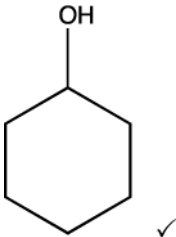
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
38		i	Value for butane plotted accurately on the graph ✓	3	relative molecular mass = 58 $\Delta_c H^\ominus = -2877 \text{ kJ mol}^{-1}$  Check accuracy: • There must be a visible point • Vertically: touching the 58 line • Horizontally: between 2800 and 2900 Examiner's Comments Most, but not all, candidates were able to plot the value for butane accurately on the graph.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST, CHECK THE ANSWER ON ANSWER LINE IF energy released = 87.5 (minimum) to 90 (maximum) AND line is extrapolated to 72 (molar mass) award 3 marks IF energy released <87.5 OR > 90.0 check the estimated value of $\Delta_c H^\ominus$ from the graph <i>Estimation of $\Delta_c H^\ominus$</i> extrapolated (straight) line of best fit (see graph) AND correctly estimated value $\Delta_c H^\ominus$ from graph ✓ <i>Calculation of energy released</i> $n(\text{C}_5\text{H}_{12}) = 0.0250 \text{ mol}$ ✓ <i>energy released</i> $= 0.0250 \times \text{correctly estimated value of } \Delta_c H^\ominus$ ✓	3	relative molecular mass = 72 $\Delta_c H^\ominus = -3509 \text{ KJ mol}^{-1}$  Expected value within range: (-)3500 to (-)3600 (kJ mol^{-1}) moles = $1.80/72.0$ IGNORE sign ALLOW ECF from incorrectly calculated moles of pentane OR incorrectly estimated $\Delta_c H^\ominus$ Examiner's Comment: A good proportion of candidates scored full marks for their estimate but some did not extrapolate the line on the graph and many did not calculate the amount of pentane. This restricted their answer to an estimate of the energy released by one mole of pentane and this could only score one mark.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
39		i	 Acid (catalyst) AND heat ✓	2	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous ALLOW (heat under) reflux ALLOW H_3PO_4 OR H_2SO_4 OR H^+ DO NOT ALLOW other named acids IGNORE concentration / pressure IGNORE water / steam Examiner's Comments Candidates who were able to give the structure of the intermediate were not always able to state the conditions for the elimination of water from an alcohol. The presence of an acid catalyst and heat are stated in the specification. Some candidates confused this reaction with addition reactions of alkenes suggesting that a Ni catalyst or the presence of steam is required.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 44.4(%) award all 3 marks for calculation <i>Amount cyclohexene (m / M)</i> = 1.23/82 OR 0.0150 mol ✓ <i>Amount of bromocyclohexane (m / M)</i> = 5.50/162.9 OR 0.0338 mol ✓ % yield = (0.0150/0.0338) × 100 = 44.4(%) ✓ Final answer must be to 3 significant figures	3	If there is an alternative answer, check to see if there is any ECF credit possible ALLOW 3 SF: 0.0338 up to calculator value of 0.033763044 correctly rounded Common ECFs (2 marks) • Incorrect M_r → incorrect moles of cyclohexene • Incorrect M_r → incorrect moles of 2- bromocyclohexane e.g. ALLOW two marks for use of incorrect mass of bromocyclohexane with other calculations correct e.g. (5.50/163) = 0.033742331 → 44.5% ALLOW calculation in mass <i>Theoretical mass yield:</i> $m(\text{C}_6\text{H}_{10}) = 0.0338 \times 82 = 2.77 \text{ g}$ % yield = (1.23/2.77) × 100 = 44.4% Examiner's Comment: Although some candidates simply calculated 1.23/5.50, most followed an effective strategy for the calculation of percentage yield. Many gained full marks but a large number of candidates relied on the application of error carried forward when they made one or more careless errors during the calculation of molar mass and / or moles. Intermediate answers were sometimes rounded to 2 significant figures and marks were lost by candidates who presented their final answer to 2 or 4 significant figures.
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
40			Observations linked to anion identifications Bubbles/effervescence/fizzing/gas AND carbonate ✓ (white OR precipitate) AND sulfate ✓ Use of molar mass in reasoning Molar mass used ONCE with carbonate OR sulfate ✓ Identification B: K_2CO_3 ✓ C: Na_2SO_4 ✓	5	FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED For bubbles, ALLOW carbon dioxide/CO_2 BUT DO NOT ALLOW hydrogen/H_2 For carbonate, ALLOW CO_3 For sulfate, ALLOW SO_4 e.g. Carbonate: $140 - (12 + 48)$; $140 - 60$ Sulfate: $140 - (32.1 + 64)$; $140 - 96.1$ $K_2CO_3 = 138.1$ $Na_2SO_4 = 142.1$ ALLOW ONE of the two identification marks for: • Correct names: B potassium carbonate AND C sodium sulfate • Incorrect formulae i.e. B KCO_3 AND C $NaSO_4$ <i>Communicates the same as names</i> Examiner's Comments This was a challenging question that discriminated extremely well. The more able candidates derived the anions from the two chemical tests and identified the cations using the molar masses of the salt and the anions. Weak candidates seemed to have little idea on how to approach such a question and they often achieved no credit. It was disappointing that many candidates were unable to identify a carbonate and sulfate from their chemical tests. Common errors included incorrectly identifying the gas with dilute acid as hydrogen, and identifying the white precipitate with barium ions as characteristic of a chloride. Candidates who used the provided molar mass of 140 usually went on to show that the cations contributed masses of approximately 80 for the carbonate and 44 for the sulfate. Candidates then needed to divide each value by 2 to obtain formulae

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					of K_2CO_3 and Na_2SO_4. Many did not divide by 2 and instead concluded that the compounds were $RbCO_3$, KSO_4 or $CaSO_4$. Strangely, some candidates thought they were identifying Group 1 metals and not salts.
			Total	5	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
41	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 2.21 (mol dm⁻³) award 4 marks TITRATION M1 $n(\text{Ba}(\text{OH})_2)$ in 25.0 cm³ $= 1.125 \times 10^{-3}$ (mol) ✓ M2 $n(\text{CH}_3\text{COOH})$ in 25.45 cm³ diluted vinegar $= 2 \times 1.125 \times 10^{-3} = 2.25 \times 10^{-3}$ (mol) ✓ SCALING ALLOW ECF from $n(\text{CH}_3\text{COOH})$ M3 $[\text{CH}_3\text{COOH}]$ in diluted vinegar $= \frac{2.25 \times 10^{-3} \times 1000}{25.45} = 0.0884$ (mol dm⁻³) ✓ Calculator: 0.0884086 M4 $[\text{CH}_3\text{COOH}]$ in original vinegar $= \frac{0.0884 \times 250}{10.0} = 2.21$ (mol dm⁻³) ✓	4	FULL ANNOTATIONS MUST BE USED ALLOW 3 SF or more correctly rounded throughout Apply ECF where appropriate ALLOW ECF from $n(\text{Ba}(\text{OH})_2)$ ALTERNATIVE APPROACHES FOR M3 AND M4: M3 $n(\text{CH}_3\text{COOH})$ in 25.45 cm³ original vinegar $= \frac{2.25 \times 10^{-3} \times 250}{10.0} = 0.05625$ (mol) ✓ M4 $[\text{CH}_3\text{COOH}]$ in original vinegar $= \frac{0.05625 \times 1000}{25.45} = 2.21$ (mol dm⁻³) ✓ M3 $n(\text{CH}_3\text{COOH})$ in 250 cm³ diluted vinegar $= \frac{2.25 \times 10^{-3} \times 250}{25.45} = 0.0221$ (mol) ✓ M4 $[\text{CH}_3\text{COOH}]$ in original vinegar $= 0.0221 \times \frac{1000}{250} \times \frac{250}{10.0} = 2.21$ (mol dm⁻³) ✓ Examiner's Comments This was a challenging unstructured titration calculation for AS level. Very able candidates rose to the challenge to secure all four marks. Many obtained the correct concentration of 0.0884 mol dm⁻³ for the diluted vinegar, but did not then use the dilution factor to convert this to the concentration of the original vinegar. Weaker candidates often obtained two relatively straightforward marks for the amounts of barium hydroxide and ethanoic acid used in the titration. Some otherwise good responses were not awarded full marks by excessive intermediate rounding, e.g. 0.0884 to 0.088, which then gave a rounding error in the final answer. Answer: 2.21 mol dm⁻³

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	Assumption: Vinegar contains (ethanoic acid and) no other acids ✓ Prediction: Experimental result is greater than conc of CH₃COOH OR conc of CH₃COOH is less than experimental result ✓	2	For credit, the response must refer to other acids IGNORE impurities, solution is pure, etc ONLY award the 'prediction' mark if 'assumption' mark is correct Examiner's Comments This question proved to be the most difficult on the paper. Very few candidates realised the key assumption that ethanoic acid was the only acid in the vinegar. Most candidates responded with mistakes made in the procedure such as overshooting the end point, the meniscus not being read properly, faulty apparatus, etc.
			Total	6	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
42	FIRST check the molar mass on answer line MUST be derived from $pV = nRT$, Award 4 marks for calculation for: • answer = 70 • OR answer that rounds to 69.9 OR 70.0 Rearranging ideal gas equation to make n subject $n = \frac{pV}{RT} \checkmark$ Substituting all values including conversion to Pa and m^3 $n = \frac{(101 \times 10^3) \times (82.5 \times 10^{-6})}{8.314 \times 373} \checkmark$ $n = 2.68693073 \times 10^{-3} \rightarrow 2.69 \times 10^{-3} \text{ (mol)} \checkmark$ unrounded rounded to 3 SF Calculation of molar mass, M $M = \frac{m}{n} = \frac{0.1881}{2.68693073 \times 10^{-3}} = 70(.0) \text{ (g mol}^{-1}\text{)}$ $\rightarrow \frac{0.1881}{2.69 \times 10^{-3}} = 69.9 \text{ (g mol}^{-1}\text{)} \checkmark$ Molecular formula of D $C_5H_{10} \checkmark$ IF candidate has failed to derive suitable value of n, ALLOW value of M from 0.1881 AND 24000 with alkene closest to calculated value for last 2 marks See Guidance column.	5	FULL ANNOTATIONS MUST BE USED If there is an alternative answer, check to see if there is any ECF credit possible using working below 1st mark may be implicit by direct substitution of correct values below into rearranged equation. ONLY award this mark if n has been derived from correct rearranged ideal gas equation ALLOW 3 SF up to calculator value, correctly rounded NOTE: ALLOW 69.9 $\rightarrow$ 70.0 AND 70 (2 SF) Calculator from unrounded: 70.00552634 ALLOW any unambiguous structure ALLOW ECF provided that formula given is an alkene and matches M calculated from 0.1881 AND $pV = nRT$ $M = \frac{0.1881}{82.5/24000} \text{ OR } \frac{0.1881}{3.4375 \times 10^{-3}}$ $= 54.72 \text{ OR } 54.7 \text{ OR } 55 \checkmark$ ALLOW 54.68 from use of 3.44×10^{-3} From 54.72, ONLY ALLOW = $C_4H_8 \checkmark$ Examiner's Comments Most candidates realised the need to use the ideal gas equation. The equation was usually rearranged correctly, with substituted values for p, V, R and T being added. Pressure and volume were not always converted correctly into Pa and m^3, creating problems for subsequent parts. Many candidates attempted to convert

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					from cm^3 to m^3 by multiplying by 10^{-3} rather than 10^{-6}. Candidates usually obtained a value for n, although those who had struggled with unit conversion obtained values that differed by powers of 10. Finally, candidates needed to derive the molar mass using their value of n and the mass of the alkene. Some candidates over-rounded their value of n, introducing an error in calculating the molar mass. Surprisingly, an appreciable number of candidates wrote their value of n on the answer line rather than the molar mass indicated by the answer prompt. This suggested that some candidates do not understand the term molar mass. Candidates who had obtained a molar mass of 70.0 usually determined that the alkene had the formula C_5H_{10}. Answer: 70.0 g mol^{-1}
			Total	5	

Mark Scheme

Question			Answer/Indicative content				Marks	Guidance									
43	a	i	<table><tr><td>Final reading/ cm³</td><td>27.30</td><td>27.00</td><td>27.75</td></tr><tr><td>Initial reading/ cm³</td><td>0.45</td><td>0.60</td><td>1.25</td></tr><tr><td>Titre/cm³</td><td>26.85</td><td>26.40</td><td>26.50</td></tr></table> Initial and final readings All burette readings (×6) correct ✓ Titres recorded to two decimal places with the last figure either 0 or 5 Correct subtractions to obtain final titre values ✓ Mean titre calculated from concordant results Correct mean titre = 26.45 (cm³) ✓ Mean titre recorded to accuracy of burette Final answer recorded to two decimal places with the last figure either 0 or 5 ✓	Final reading/ cm ³	27.30	27.00	27.75	Initial reading/ cm ³	0.45	0.60	1.25	Titre/cm ³	26.85	26.40	26.50	4	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC ALLOW missing zeroes for burette readings i.e. 0.6 for 0.60 27 OR 27.0 for 27.00 ALLOW ECF from incorrect burette readings IF MEAN IS CALCULATED FROM ECF, IT MUST BE FROM CLOSEST TITRES ALLOW ecf from incorrect mean DO NOT ALLOW 26.5 cm³ <i>Question asks for nearest 0.05 cm³</i> <u>Examiner's Comments</u> Most candidates were able to accurately record the burette readings and made the correct subtractions. Despite the examination question requesting the mean titre to be recorded to the accuracy of the burette, many candidates did not do this. A common error was taking a mean of all three readings instead of only the concordant results; this led the candidates to give an answer of 26.58 which lost them 2 marks.
Final reading/ cm ³	27.30	27.00	27.75														
Initial reading/ cm ³	0.45	0.60	1.25														
Titre/cm ³	26.85	26.40	26.50														
		ii	$\frac{2 \times 0.05}{26.85} \times 100 = 0.37(2) (\%) \checkmark$	1	ALLOW 0.4 up to full calculation display of 0.372439478 ALLOW ECF FOR CORRECT CALCULATION FROM 1 (c) (i) OR USE OF ANY TITRE <u>Examiner's Comments</u> A good attempt by many candidates but some did not know how to calculate this or did not multiply by 2.												

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	Use a (250 cm ³) volumetric flask (instead of a beaker)✓	1	IGNORE graduated flask <u>Examiner's Comments</u> Although there were some excellent descriptions of the correct processes, such as inverting the apparatus to ensure mixing and then making the solution up to the mark, many candidates could not name a volumetric flask.
	b	i	FIRST CHECK ANSWER ON ANSWER LINE If answer = 118 (g mol⁻¹) award 4 marks If answer = 108 (g mol⁻¹) award 3 marks $n(\text{NaOH})$ $= 0.112 \times \frac{25.0}{1000} = 0.00280 \text{ (mol)} \checkmark$ $n(\text{A})$ in 25.0 cm³ $= \frac{0.00280}{2} = 0.00140 \text{ (mol)} \checkmark$ $n(\text{A})$ in 250 cm³ $= 0.00140 \times \frac{250.0}{27.30} = 0.0128 \text{ (mol)} \checkmark$ Molar mass, $M(\text{A})$ to nearest whole number. $= \frac{1.513}{0.0128} = 118 \text{ (g mol}^{-1}\text{)} \checkmark$	4	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC Throughout: IGNORE trailing zeroes in intermediate working, e.g. For $n(\text{NaOH})$ ALLOW 0.0028 for 0.00280 ALLOW ECF from incorrect $n(\text{NaOH})$ ALLOW ECF from incorrect $n(\text{A})$ OR $n(\text{NaOH})$ ALLOW 3 sig fig up to full calculator display correctly rounded (0.012820512) ALLOW ECF from incorrect $n(\text{NaOH})$ Possible ECFs for 3 marks $1.513 \div (0.00140 \times 250/25) = 108$ $1.513 \div 0.00140 = 1081$ No $\div 2$ for $n(\text{A})$ - Molar mass A = 59 (g mol⁻¹) Using mean titre of 26.45 cm³ from 1c(i) - Molar mass A = 114 (g mol⁻¹) Using 27.3×0.112 in M1 and then 25.0 in M3 - Molar mass A = 99 (g mol⁻¹) <u>Examiner's Comments</u> Although there were some excellent descriptions of the correct processes, such as inverting the apparatus to ensure mixing and then making the solution up to the mark, many candidates could not name a volumetric flask.

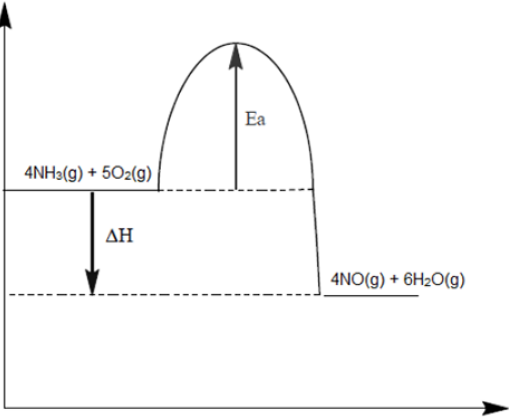
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	Structure of dicarboxylic acid $\text{HOOCCH}_2\text{CH}_2\text{COOH}$ OR $\text{HOOCCH}(\text{CH}_3)\text{COOH}$ ✓ STRUCTURE MUST MATCH M_r from answer to 1 d) i) (within 10 AMU)	1	ALLOW correct structural OR skeletal OR displayed formulae OR a combination ALLOW incorrect connectivity e.g. _HO ALLOW ECF from incorrect molar mass in (d)(i) but only if $2 \times \text{COOH}$ possible and M_r is a close match to (d) (i) within 10 AMU <u>Examiner's Comments</u> Most candidates that obtained a sensible value for the previous question managed to draw a creditable structure. Allowing error carried forward meant that feasibly derived structures could be credited a mark.
			Total	11	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
44		i	$(1s^2) 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$ ✓ Look carefully at $(1s^2) 2s^2 2p^6 3s^2 3p^6$ – there may be a mistake	1	ALLOW subscripts ALLOW in any order i.e. $3d^{10}$ after $4s^2$ or after $4p^4$ ALLOW upper case D, etc and subscripts, e.g. 3S ₂ 3P ⁶ DO NOT ALLOW [Ar] as shorthand for $1s^2 2s^2 2p^6 3s^2 3p^6$ <u>Examiner's Comments</u> Most candidates answered this correctly. The most common error seen was $4p^6$ instead of $4p^4$
		ii	Gas B H_2Se / Hydrogen selenide / Selenium hydride ✓ Equation $Na_2Se + 2HCl \rightarrow 2NaCl + H_2Se$ All formulae and balancing ✓	2	ALLOW SeH_2 ALLOW correct multiples IGNORE STATE SYMBOLS DO NOT ALLOW H_2S for gas B BUT ALLOW ECF from H_2S for equation: $Na_2S + 2HCl \rightarrow 2NaCl + H_2S$ <u>Examiner's Comments</u> The majority of candidates obtained 1 or 2 marks on this question. The most common errors seen were identifying the gas as H_2S or incorrect balancing.
			Total	3	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
45	i  Reactants, products and E_a Reactants on LHS $4\text{NH}_{3(g)} + 5\text{O}_{2(g)}$ AND Products on RHS $4\text{NO}_{(g)} + 6\text{H}_2\text{O}_{(g)}$ AND Activation energy correctly labelled / E_a ✓ ΔH ΔH labelled with product below reactant AND Arrow downwards ✓	2	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC IGNORE state symbols ALLOW 1 mark for a correctly labelled endothermic diagram E_a ALLOW no arrowhead or arrowheads at both end of E_a line. E_a line must reach maximum (or near to maximum) on curve For E_a, ALLOW AE OR A_E ΔH DO NOT ALLOW $-\Delta H$ DO NOT ALLOW double headed arrow on ΔH ALLOW ΔH arrow even with small gap at the top and bottom, i.e. line does not quite reach reactant or product line. ALLOW -905 for ΔH <u>Examiner's Comments</u> Most candidates were able to gain the first mark, but many lost the second mark by putting a double headed arrow or $-\Delta H$.

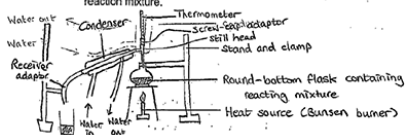
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK ON ANSWER LINE If answer = 6.79×10^7 (kJ) award 4 marks If answer = 2.72×10^8 (kJ) award 3 marks (no $\div 4$) $n(\text{NH}_3)$ $= \frac{5.1 \times 10^6}{17} = 3.00 \times 10^5$ (mol) ✓ Stoichiometry and ΔH 1 mol NH_3 releases $\frac{905}{4}$ OR 226.25 (kJ) ✓ Energy released $(3.00 \times 10^5) \times \frac{905}{4}$ OR 67875000 (kJ) ✓ Final answer to 3SF AND standard form $= 6.79 \times 10^7$ (kJ) ✓ <i>standard form AND 3 SF required</i>	4	IGNORE (-) SIGN Throughout: IGNORE trailing zeroes in intermediate working, e.g. For $n(\text{NH}_3)$ ALLOW 3×10^5 for 3.00×10^5 ALLOW ECF from incorrect $n(\text{NH}_3)$ OR 905/4 ALLOW 3 SF up to calc value correctly rounded. Value will depend on intermediate rounding Common Errors 1.09×10^9 ($\times 4$ instead of $\div 4$) 3 marks 2.72×10^8 (no $\div 4$) 3 marks 6.79×10^1 (no tonnes $\rightarrow$ g) 3 marks <u>Examiner's Comments</u> Most candidates were able to convert from tonnes to moles and then went on to complete the majority of the calculation steps. Many omitted to divide by 4 and were credited 3 marks. Some candidates lost marks by not stating the answer to standard form or quoted their answer to more than 3 significant figures. A number of candidates attempted to use $Q = mc\Delta T$ and did not get very far in the calculation.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
46	a	i	<i>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) Correctly labelled diagram of reflux apparatus that works, with no safety problems AND An appreciation of most of the purification steps required to gain a pure sample <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Labelled diagram of apparatus (either reflux or distillation) but with safety/procedural problems OR clear diagram of reflux apparatus without labelling AND Some details of further purification steps <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Diagram of apparatus (reflux OR separation OR distillation) drawn with no labelling OR labelled diagram with significant safety/procedural AND / OR Few or imprecise details about further purification stages <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit.	6	Indicative scientific points may include: Apparatus set up for reflux: • round-bottom/pear shaped flask • heat source • condenser <i>Detail: water flow in condenser bottom to top; open system.</i> Purification • Use of a separating funnel to separate organic and aqueous layers <i>Detail: Collect lower organic layer density greater</i> • Drying with an anhydrous salt, <i>Detail: e.g. MgSO_4, CaCl_2, etc.</i> • Redistillation <i>Detail: Collect fraction distilling at 102°C.</i> <u>Examiner's Comments</u> Candidates were not prepared to answer this type of question and the diagrams were hard to give credit to. Many had significant safety implications such as open beakers of butan-1-ol being heated by a Bunsen burner. Most mis-read the question and just outlined the method for purification and struggled to recall the practical details. Very few candidates mentioned the use of anhydrous salts, referring instead to 'boiling off' the water.

Mark Scheme

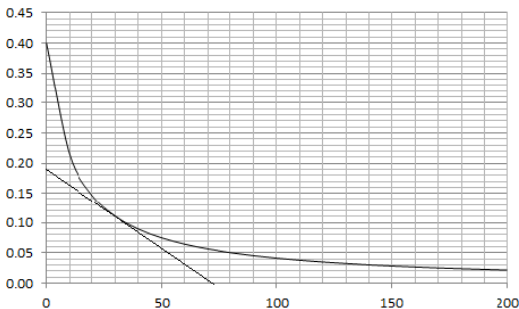
Question	Answer/Indicative content	Marks	Guidance
			Exemplar 4 $\text{Alcohol} \xrightarrow[\text{10}]{\text{Reflux}} \text{Halalkane}$ 5 (a) 1-Bromobutane is an organic liquid with a boiling point of 102°C. A student prepares 1-bromobutane by reacting butan-1-ol with sulfuric acid and sodium bromide. The student boils the mixture for one hour. The equation is shown below. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + \text{H}^+ + \text{Br}^- \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{H}_2\text{O}$ The student obtains a reaction mixture containing an organic layer (density = 1.27 g cm⁻³) and an aqueous layer (density = 1.00 g cm⁻³). (i)* Draw a labelled diagram to show how you would safely set up apparatus for the preparation. Outline a method to obtain a pure sample of 1-bromobutane from the reaction mixture.  Heat under reflux. Do perform a distillation. Heat the reaction mixture in a round-bottom flask at just over 100°C. The butan-1-ol will react with sulfuric acid and sodium bromide to form 1-bromobutane, which evaporates and condenses and is collected in a flask. Water has a boiling point of 100°C so also evaporates and condenses and collects in the flask. Add the mixture in the collecting flask to a separating funnel. The organic layer should settle below the aqueous layer as it is denser. To confirm, add distilled water to the separating funnel, invert the funnel, and allow the layers to settle. The layer that gets bigger is the aqueous layer. Open the tap and run off the lower organic layer into a conical flask. Add drying agent to remove traces of water.

This candidate was credited 4 marks for this level 2 answer. Although they have drawn distillation apparatus instead of reflux, they have considered the boiling point of the product, detailed using a separating funnel, a drying agent and that the lower organic layer would be drawn off first.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 12.6 (g) award 2 marks • $n(1\text{-bromobutane}) = 0.150 \times \frac{61.4}{100} = 0.0921 \text{ (mol)} \checkmark$ • Mass 1-bromobutane = $0.0921 \times 136.9 = 12.6 \text{ (g)} \checkmark$ 3 SF required	2	Common errors: 33.4 ($0.150 \times 100/61.4 = 0.244 \times 136.9$) 1 mark ALLOW ECF for incorrect moles or incorrect M_r of 1-bromobutane (provided answer is to 3 SF) DO NOT ALLOW 6.82 (using M_r of butan-1-ol) ALLOW calculation using masses, e.g. • Theoretical = $0.150 \times 136.9 = 20.535 \text{ (g)} \checkmark$ (ALLOW 20.535 rounded back to 20.5) • Actual mass = $20.535 \times \frac{61.4}{100} = 12.6 \text{ (g)} \checkmark$ (20.5 also gives 12.6) <u>Examiner's Comments</u> This question was well answered, but a significant number of candidates incorrectly used the M_r of butan-1-ol when calculating the mass of 1-bromobutane.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b		Tangent on graph drawn at approximately $t = 30$ min (± 10 mins) ✓ Calculation of rate = Gradient (y/x) of tangent drawn e.g. $\frac{0.19}{72} = 2.64 \times 10^{-3} / 0.00264 \text{ (mol dm}^{-3}\text{min}^{-1})$ ✓ 	2	DO NOT ALLOW interpolation (taking a direct reading from graph), answer must be derived from taking a gradient ALLOW ecf from incorrectly drawn tangent Tolerance: Readings from y axis should be $\pm 0.01 \text{ mol dm}^{-3}$ (i.e. within 1 square) Readings from x axis should be ± 5 minutes (i.e. within 0.5 of a square) IGNORE units IGNORE sign <u>Examiner's Comments</u> Most candidates knew they had to draw a tangent to the curve but calculating the gradient led to careless errors. Many drew tiny triangles and mis-read readings of coordinates. It is far easier, and more accurate, to use large triangles using the axes for coordinates. Lower ability candidates just interpolated the graph at 30s and were not credited marks for this.
			Total	10	
47			C	1	<u>Examiner's Comments</u> Candidates found this question difficult with comparatively few obtaining the correct response of C. Many candidates selected B instead, the number of CO_2 or O_2 molecules, and not the number of O atoms. Good advice is to read the question carefully and to underline any key features.
			Total	1	
48			B	1	<u>Examiner's Comments</u> Nearly all candidates responded with the correct response of B.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
49			C	1	<u>Examiner's Comments</u> This part discriminated well, with most able candidates selecting the correct answer of C. A sizeable number selected B, presumably by not considering the 2:1 stoichiometric ratio in the equation.
			Total	1	
50			D	1	<u>Examiner's Comments</u> Most candidates selected A or D, with D being the correct option. Presumably, A was chosen by halving the '8' in C_4H_8 without considering that each H_2O molecule contains two H atoms. The successful answer of D usually resulted from the candidate constructing equations.
			Total	1	
51			A	1	<u>Examiner's Comments</u> Many candidates added H atoms to the structure to aid their choice. Most candidates selected the correct response of A, with a sizeable number selecting B (by adding two H atoms where the two rings join).
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
52	a	i	Oxidised AND (Mg) transfers/loses/donates 2 electrons ✓ 2 essential	1	ALLOW Mg loses 6 electrons: 3 Mg in equation ALLOW $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ IGNORE oxidation numbers (even if wrong) <u>Examiner's Comments</u> Despite the question clearly asking for a response in terms of the number of electrons transferred, most candidates answered in terms of oxidation number changes. Candidates are recommended to read the question and to answer in terms of its requirements. Underlining 'number of electrons' may have helped candidates to answer the question that had been set.

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
	ii FIRST CHECK ANSWER ON THE ANSWER LINE IF answer = 2.26 (3 SF) award 3 marks $n(\text{H}_3\text{PO}_4) = \frac{1.24 \times 50.0}{1000} = 0.062(0) \text{ (mol)}$ ✓ $n(\text{Mg}) = \frac{3}{2} \times 0.062(0) = 0.093(0) \text{ (mol)} \quad \checkmark$ mass of Mg = $0.0930 \times 24.3 = 2.26 \text{ (g)}$ ✓ 3 SF required	3	At least 3SF needed throughout BUT ALLOW no trailing zeroes (e.g. 0.062 for 0.0620) ALLOW ECF from $n(\text{H}_3\text{PO}_4)$ ALLOW ECF from $n(\text{Mg})$ COMMON ERRORS for 2 marks 3:2 ratio omitted → $n(\text{Mg}) = 0.062(0) \rightarrow 1.51 \text{ (g)}$ Inverted 2:3 ratio → $n(\text{Mg}) = 0.0413 \rightarrow 1.00 \text{ (g)}$ <u>Examiner's Comments</u> Most candidates are competent at answering questions based on the mole. Almost all candidates were able to calculate the amount of H_3PO_4 as 0.062 mol. Candidates then needed to use the 2:3 mole stoichiometric ratio to show that 0.093 mol of Mg reacts, which has a mass of 2.26 g to the required 3 significant figures. The commonest errors were use of the inverse 3:2 ratio to obtain 1.00 g Mg, or to omit the ratio to obtain 1.51 g Mg, as shown in the exemplar. Candidates are advised to show clear working so that credit can be awarded for such responses by applying error carried forward. Exemplar 1 (ii) The student plans to add magnesium to 50.0 cm^3 of $1.24 \text{ mol/dm}^3 \text{ H}_3\text{PO}_4$. Calculate the mass of magnesium that the student should add to react exactly with the phosphoric acid. Give your answer to three significant figures. $n = cv$ $50 \text{ cm}^3 = 0.05 \text{ dm}^3$ $1.24 \times 0.05 = 0.062 \text{ mol}$ $0.062 \times 24.3 = 1.5066$ $M = n \times m$ mass of Mg = <u>1.51</u> g [3]

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	Separation of solid Filter to obtain solid/precipitate ✓ <i>Requires realisation that solid is filtered off.</i> <i>Solid may be stated within in 'removal of water'</i> Removal of water Dry (solid) OR Evaporate (water/solution/liquid) ✓	2	ALLOW Removal of water Evaporate/ distil water/solution/liquid ✓ IGNORE 'distil' if product OR H₂ is distilled Collection of remaining solid ✓ <i>Requires realisation that solid remains</i> IGNORE 'Leave to crystallise' (<i>already solid</i>) <u>Examiner's Comments</u> Candidates often struggle with questions based on practical work. There were many random responses to this question, with relatively few candidates identifying that solid magnesium phosphate could be obtained by filtration, followed by drying.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iv	Formula MgO OR Mg(OH)₂ OR MgCO₃ OR soluble Mg salt ✓ Equation $3\text{MgO} + 2\text{H}_3\text{PO}_4 \rightarrow \text{Mg}_3(\text{PO}_4)_2 + 3\text{H}_2\text{O}$ OR $3\text{Mg}(\text{OH})_2 + 2\text{H}_3\text{PO}_4 \rightarrow \text{Mg}_3(\text{PO}_4)_2 + 6\text{H}_2\text{O}$ OR $3\text{MgCO}_3 + 2\text{H}_3\text{PO}_4 \rightarrow \text{Mg}_3(\text{PO}_4)_2 + 3\text{CO}_2 + 3\text{H}_2\text{O}$	2	In equation: NO ECF from incorrect formula ALLOW multiples IGNORE state symbols (even if incorrect) Soluble Mg salts include MgCl₂, MgSO₄, Mg(NO₃)₂, MgBr₂, MgI₂ If unsure, check with TL e.g. $3\text{MgCl}_2 + 2\text{H}_3\text{PO}_4 \rightarrow \text{Mg}_3(\text{PO}_4)_2 + 6\text{HCl}$ <u>Examiner's Comments</u> Candidates were expected to identify a suitable reagent for this reaction, with most choosing magnesium oxide, hydroxide or carbonate. Credit was also given for using a soluble magnesium salt such as its sulfate, chloride or nitrate. The correct equation often followed, but errors sometimes appeared in the form of incorrect formulae, such as MgOH for magnesium hydroxide. The exemplar shows a good clear response, using MgO as the reagent. Exemplar 2 (iv) Magnesium phosphate can also be prepared by reacting phosphoric acid with a compound of magnesium. Choose a suitable magnesium compound for this preparation and write the equation for the reaction. Formula of compound MgO ✓ Equation $3\text{MgO} + 2\text{H}_3\text{PO}_4 \rightarrow \text{Mg}_3(\text{PO}_4)_2 + 3\text{H}_2\text{O}$ [2]

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	FIRST CHECK ANSWER ON THE ANSWER LINE IF answer = 315 (cm³) award 4 marks Amount of PH₃ $n(\text{PH}_3) = \frac{3.20 \times 10^{-2}}{4}$ OR $8(.00) \times 10^{-3}$ (mol) ✓ Unit conversions p conversion → Pa = 100×10^3 (Pa) AND T conversion → K = 473 (K) ✓ Evidence of use of rearranged gas equation OR $V = \frac{nRT}{p}$ OR $V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 473}{100 \times 10^3}$ OR $V = 3.15 \times 10^{-4}$ ✓ Calculator: $= 3.1460176 \times 10^{-4}$ V conversion of m³ → cm³ ✓ $V = 3.15 \times 10^{-4} \times 10^6 = 315 \text{ cm}^3$ ✓ Calculator from unrounded cm³: 314.60176 cm³ Requires 3 OR MORE SF, correctly rounded ALLOW use of $R = 8.31 \rightarrow 314.4504 \rightarrow 314$ to 3SF	4	If there is an alternative answer, check to see if there is any ECF credit possible ALLOW ECF throughout Common Errors (3 marks) Use of $n(\text{H}_3\text{PO}_4) = 3.20 \times 10^{-2}$ (Very common) $V = \frac{3.2(0) \times 10^{-2} \times 8.314 \times 473}{100 \times 10^3} \times 10^6$ = 1258.40704 cm³ (1260 to 3 SF) No temperature conversion from °C to K $V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 200}{100 \times 10^3} \times 10^6$ = 133 cm³ No p conversion from kPa to Pa $V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 473}{100} \times 10^6$ = 315000 cm³ No volume conversion from m³ to cm³ $V = 3.15 \times 10^{-4}$ IGNORE use of 24/24000 for molar volume e.g. $3.2(0) \times 10^{-3} \times 24000 = 768$ scores zero $8(.00) \times 10^{-3} \times 24000 = 292$ scores 1st mark only Examiner's Comments Almost all candidates realised that the calculation required the ideal gas equation. Most candidates correctly rearranged the equation and used the data from the question to obtain a value for the volume of phosphine. The most common errors were with conversion of units into Pa and m³. It is recommended that candidates learn how to carry out these conversions. In their calculations, many candidates used the amount of phosphoric acid, 3.20×10^{-3} mol, rather than 8.00×10^{-3} mol of

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					phosphine, obtaining a volume of 1258 cm³. Error carried forward ensured that 3 of the available 4 marks could be credited, provided that the working was clear. The exemplar shows such a response. Answer = 315 cm³ Exemplar 3 (b) Phosphine, PH₃, is a gas formed by heating phosphorous acid, H₃PO₃, in the absence of air. $4\text{H}_3\text{PO}_3(\text{s}) \rightarrow \text{PH}_3(\text{g}) + 3\text{H}_3\text{PO}_4(\text{s})$ (i) 3.20 × 10⁻² mol of H₃PO₃ is completely decomposed by this reaction. Calculate the volume of phosphine gas formed, in cm³, at 100 kPa pressure and 200 °C. <i>Handwritten working:</i> $PV = nRT$ $P = 100 \text{ kPa}$ $V = ? \text{ dm}^3$ $n = 3.2 \times 10^{-2} \text{ mol}$ $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ $T = 200 + 273 = 473 \text{ K}$ $100 \times V = (3.2 \times 10^{-2}) \times 8.314 \times 473$ $100 \times V = 125.840704$ $V = 1.25840704$ $= 1.26 \text{ dm}^3 \times 1000$ $= 1258.41 \text{ cm}^3$ volume of PH₃ = 1258.41 cm³ [4]
		ii	4PH ₃ + 8O ₂ → P ₄ O ₁₀ + 6H ₂ O ✓	1	ALLOW multiples Examiner's Comments Most candidates were able to write a correctly balanced equation for this reaction.
			Total	13	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
53	FIRST, CHECK THE ANSWER ON ANSWER LINE IF $\Delta_r H = -457$ OR -458 (kJ mol^{-1}) award 4 marks IF $\Delta_r H = \pm 229$ OR 457 (kJ mol^{-1}) award 3 marks ----- <i>Energy released in J OR kJ</i> $= 25.0 \times 4.18 \times 28.0 = 2926$ (J) OR 2.926 (kJ)✓ <i>Correctly calculates $n(\text{AgNO}_3)$</i> $= 0.512 \times \frac{25.0}{1000} = 1.28 \times 10^{-2}$ (mol) ✓ ΔH per mole AgNO_3 in kJ AND 3 SF Answer <i>MUST</i> divide energy by $n(\text{AgNO}_3)$ $\pm \frac{2.926}{1.28 \times 10^{-2}} = \pm 228.59375$ $= \pm 229$ (kJ) ✓ 3 SF needed Sign NOT needed ΔH for 2 mol AgNO_3 AND – sign AND 3 SF $\Delta H_r = 2 \times -228.59375 = -457$ (kJ mol^{-1}) OR $2 \times -229 = -458$ (kJ mol^{-1}) ✓	4	FULL ANNOTATIONS MUST BE USED ----- ALLOW ECF throughout ----- ALLOW 2930 J OR 2.93 kJ DO NOT ALLOW < 3 SF IGNORE any sign and units i.e. ALLOW correctly calculated number in J OR kJ ----- Alternative approach using 1 mol Mg Energy released = 2926 (J) OR 2.926 (kJ) ✓ $n(\text{AgNO}_3) = 1.28 \times 10^{-2}$ (mol) ✓ $n(\text{Mg}) = \frac{1.28 \times 10^{-2}}{2} = 6.4 \times 10^{-3}$ (mol) ✓ $\Delta H_r = \frac{2.926}{6.4 \times 10^{-3}} = -457$ (kJ mol^{-1}) – sign AND 3 SF needed Examiner's Comments Candidates are well-versed with the relationship $q = mc\Delta T$ and most were able to calculate that 2.926 kJ of energy was released in this reaction. It was also common to see the amount of AgNO_3 correctly calculated as 1.28×10^{-3} mol. Candidates were expected to determine the amount of energy released from 1 mol AgNO_3 as 229 kJ and finally to multiply this value by 2 for the molar quantities in the equation to match the 'enthalpy change of reaction'. It was common to see –229 given as the final answer but this was rarely multiplied by 2. The question also required the final answer to be given to an appropriate number of significant figures. Many candidates seemed to be unaware that this reflects the least significant figure provided in the data, in this case 3

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					significant figures. The exemplar shows a typical response for 3 of the available 4 marks. Many omitted the negative sign in their ΔH value to consider the exothermicity of the reaction. Candidates are also advised to only round at the end of a multi-step calculation. Rounding of intermediate values introduces rounding errors in the final answer. Answer = -457 kJ mol^{-1} Exemplar 4 (i) Calculate ΔH, in kJ mol^{-1}, for the reaction shown in equation 23.1. Give your answer to an appropriate number of significant figures. Assume that the density and specific heat capacity, c, of the solution are the same as for water and that all the aqueous silver nitrate has reacted. $c = 4.18$ density = 1.00 g cm^{-3} $Q = mc\Delta T$ $\Delta T =$ $Q = 25 \times 4.18 \times 28$ $n = \frac{m}{M_r}$ $n = CV$ $Q = 2926 \text{ J}$ $n = \frac{25}{1000} \times 0.512$ $Q = 2.926 \text{ kJ}$ $n = 0.0128$ $\frac{2.926}{0.0128} = 228.60$ 228.59375 $\Delta H = 229 \text{ kJ mol}^{-1}$ [4]
		ii	$\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ ✓ State symbols required White precipitate AND $\text{AgNO}_3/\text{Ag}^+$ NOT ALL reacted OR NO white precipitate AND $\text{AgNO}_3/\text{Ag}^+$ ALL reacted ✓	2	ALLOW $\text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{NaNO}_3(\text{aq})$ Observation needs to be linked to conclusion Examiner's Comments Most candidates recognised that silver nitrate and chloride ions react together to form a white precipitate, but many did not make the link between this observation and whether any silver nitrate was left unreacted. Many candidates did not give a correct equation, with missing or incorrect state symbols being common. This question discriminated extremely well.
			Total	6	

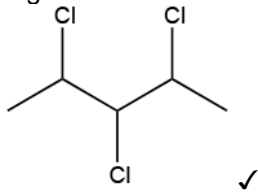
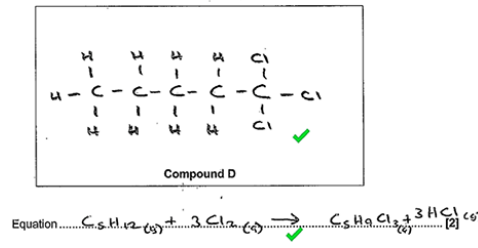
Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
54	a	Structural isomers: <i>1 mark</i> Different structural formulae AND same molecular formula ✓ Common molecular formula: <i>1 mark</i> C_5H_{12} for all 3 hydrocarbons ✓ Boiling point and branching: <i>1 mark</i> Boiling point decreases with more branching OR more methyl/alkyl groups/side chains OR shorter carbon chain ✓ Branching and London forces: <i>1 mark</i> <i>Could be seen anywhere within response</i> More branching gives less (surface) contact AND fewer/weaker London forces ✓ Energy and intermolecular forces: <i>1 mark</i> Less energy to break London forces/intermolecular forces/intermolecular bonds/ ✓	5	For 'structural': ALLOW different structure OR different displayed/ skeletal formula DO NOT ALLOW any reference to spatial/space/3D Same formula is not sufficient (no 'molecular') Different arrangement of atoms is not sufficient (no 'structure'/'structural') ALLOW 5 carbons and 12 hydrogens ALLOW for 2 marks: Different structural formulae AND same molecular formula ✓ of C_5H_{12} ✓ Comparisons needed throughout ORA throughout ALLOW comparison between any alcohols, e.g. A is least branched and has highest b pt C is most branched and has lowest b pt ALLOW induced dipole(–dipole) interactions IGNORE van der Waals'/vdw forces ALLOW SA for surface area ALLOW 'harder to overcome' intermolecular forces ALLOW more energy to separate the molecules IGNORE just 'bonds' <i>intermolecular/London forces required</i> <u>Examiner's Comments</u> This question discriminated well and resulted in a full range of marks. Most candidates were aware that structural isomers have different structural formulae

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance				
					but the same molecular formulae. It was common though for candidates to refer to different arrangements of atoms in space, clearly confusing with stereoisomerism. The best candidates used the structures (as in the question) to show that the common molecular formula was C5H12. Candidates were expected to link the amount of surface contact between molecules with induced dipole–dipole forces or London forces. ‘Contact’ or the name of the intermolecular forces was often omitted. Finally, candidates were expected to link the amount of branching to the strength of the intermolecular forces and the energy needed to change state. Lower ability candidates often let themselves down by being unable to construct a well-reasoned response. There was often a gulf between the clear responses of able candidates and those of lower ability candidates.				
	b	i	Radical substitution ✓	1	ALLOW Free radical substitution <u>Examiner’s Comments</u> Most candidates identified this reaction as radical substitution.				
		ii	<table><tr><td>A</td><td>B</td></tr><tr><td>3 ✓</td><td>2 ✓</td></tr></table>	A	B	3 ✓	2 ✓	2	<u>Examiner’s Comments</u> Most candidates achieved at least one mark, particularly for isomer A. Successful candidates often drew structures of the isomers alongside the table to help with their response.
A	B								
3 ✓	2 ✓								

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
iii	Structure of D Structure of a trichloro isomer of A, e.g.  ALLOW any trichloro isomer of A CHECK carefully Equation $C_5H_{12} + 3Cl_2 \rightarrow C_5H_9Cl_3 + 3HCl$ ✓ Molecular formulae required NO ECF from incorrect structure of D	2	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) IGNORE molecular formula ALLOW multiples, e.g. $2C_5H_{12} + 6Cl_2 \rightarrow 2C_5H_9Cl_3 + 6HCl$ Examiner's Comments Many candidates correctly drew the structure of compound D but comparatively few were able to construct a correct equation. For this equation, candidates needed to apply their knowledge and understanding of monosubstitution of alkanes to substitution of three H atoms by three Cl atoms. This task proved to be one of the most difficult questions on this paper. The exemplar shows an excellent response. The candidate has drawn a trisubstituted structure that fits the molar mass of 175.5 g mol^{-1} and a correct equation for its formation. Many attempts at this equation showed H_2 as the second product rather than HCl. Exemplar 6 (iii) The reaction of compound A with excess chlorine forms a compound D, which has a molar mass of 175.5 g mol^{-1}. Draw a possible structure for compound D and write the equation for its formation from compound A. Use molecular formulae in the equation. 

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	10	
55			C	1 (AO1.2)	
			Total	1	
56			D	1 (AO1.2)	<u>Examiner's Comments</u> This part discriminated extremely well. Many scripts showed clear working of the atom economy of each process, the usual result being the correct response of D. Candidates choosing an incorrect process (usually A), often showed no working suggesting the response was a guess. The advice here is obviously to work through calculations before choosing the answer.
			Total	1	
57			B	1 (AO2.6)	<u>Examiner's Comments</u> This question proved to be the most difficult of the multiple-choice questions. Candidates clearly did not use the clue in the question: 'until one of the reactants is used up'. Many then responded with C, the volume of NO₂ formed from complete reaction of 6 dm³ of O₂. D was another common error, which is simply the sum of the volumes of NO and O₂ provided in the question. The correct answer of B required candidate to identify that NO is in excess, reacting with 4 dm³ of the O₂ to form 8 dm³ NO₂ and leaving behind 2 dm³ of O₂, and contributing to a total volume of 10 dm³ of gas.
			Total	1	
58			B	1 (AO2.2)	<u>Examiner's Comments</u> After the difficulties with Question 6, most candidates were able to use the ideal gas equation (annotated on many scripts) to obtain either 259 cm³ or 259 dm³. The correct value of B (259 cm³) revealed the difficulties of unit conversions experienced by many candidates.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
59			B	1 (AO2.6)	
			Total	1	
60			FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 38.5 cm³ award 3 marks ----- $n(\text{Mg}(\text{NO}_3)_2) = \frac{5.00}{148.3} = 0.0337 \dots\dots\dots (\text{mol}) \checkmark$ $n(\text{HNO}_3) = 2 \times 0.0337 \dots\dots\dots = 0.0674 \dots\dots\dots (\text{mol}) \checkmark$ $\text{volume} = 0.0674 \dots\dots\dots \times \frac{1000}{1.75} = 38.5 (\text{cm}^3) \checkmark$ 3 SF required	3(AO2.8×3)	Calculator: 0.03371544167 ALLOW ECF from $n(\text{Mg}(\text{NO}_3)_2)$ Calculator: 0.06743088334 ALLOW ECF from $n(\text{HNO}_3)$ <u>Examiner's Comments</u> This question was answered well, with the majority of the candidates obtaining 3 marks.
			Total	3	
61			FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 60 cm³ award 3 marks ----- $n(\text{HCl}) = \frac{50.0}{1000} \times 0.100 = 5.00 \times 10^{-3} (\text{mol}) \checkmark$ $n(\text{H}_2) = \frac{5.00 \times 10^{-3}}{2} = 2.50 \times 10^{-3} (\text{mol}) \checkmark$ Volume = $2.5(0) \times 10^{-3} \times 24.0 \times 1000 = 60(.0) \text{ cm}^3 \checkmark$	3(AO2.6×3)	ALLOW 120 cm³ for 2 marks (no ÷ 2) ALLOW 240 cm³ for 2 marks (× 2 not ÷ 2) IGNORE absence of trailing zeroes, e.g. for 0.100, ALLOW 0.1 ALLOW ECF from $n(\text{HCl})$ ALLOW ECF from $n(\text{HCl})$ and/or $n(\text{H}_2)$ <u>Examiner's Comments</u> This was a well answered question, with the majority of candidates obtaining all 3 marks
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
62		i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 5.8 award 3 marks ----- $n(\text{SrCl}_2) = \frac{1.62}{158.6} = 0.0102\ldots\text{ (mol) } \checkmark$ $n(\text{H}_2\text{O}) = \frac{1.07}{18} = 0.0594\ldots\text{ (mol) } \checkmark$ $x = \text{SrCl}_2 : \text{H}_2\text{O} = \frac{0.0594\ldots}{0.0102\ldots}$ $= 5.8 \checkmark$	3 (AO3.1x 2) (AO3.2)	Calculator: 0.01021437579 Calculator: 0.05944444444 ALLOW ECF from $n(\text{SrCl}_2)$ and/or $n(\text{H}_2\text{O})$ Answer must be to TWO significant figures ALLOW 2 marks for 5.83 (answer must be to 2 SF) <u>Examiner's Comments</u> Most students managed to gain some marks on this question. The most common error was rounding to 6, something they have been taught to do for water of crystallisation. This caused them to lose a mark as the question asked for two significant figures. Many rounded too early so a variety of responses were seen.
		ii	To make sure all the water had been removed ✓	1(AO3.4)	IGNORE just 'to weigh to constant mass' <u>Examiner's Comments</u> The majority of candidates answered this correctly, the main incorrect answer was "to achieve constant mass".

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	Use balance that weighs to 3/more decimal places ✓ Use a larger mass (of hydrated strontium chloride) ✓	2(AO3.4× 2)	ALLOW more precise/more accurate/ more sensitive/higher resolution/smaller division/weigh to 0.001 IGNORE 'less error/smaller interval balance' IGNORE any reference to lid on crucible (water can't escape) IGNORE 'weigh straight after heating' IGNORE idea of repeating the experiment/ taking an average/ getting concordant results /larger sample size, etc. <u>Examiner's Comments</u> Most candidates identified either using a larger mass or a more accurate balance, not many stated both. The most common incorrect answers involved heating for longer or taking less measurements.
			Total	6	