PEARSON EDEXCEL A-LEVEL CHEMISTRY · 9CH0

CHEMISTRY



EXAM QUESTION PACK

TOPIC 4: INORGANIC CHEMISTRY AND THE PERIODIC TABLE

SCORE	PERCENTAGE
/212	%

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Q1. This is a question about Group 2 compounds.

Limewater is a solution of calcium hydroxide, commonly used in the identification of carbon dioxide gas. Since calcium hydroxide is only sparingly soluble in water, technicians often make the solution by adding an excess of the solid calcium hydroxide to the required volume of deionised water, shaking the container and then leaving the mixture to settle. In this way, a saturated solution is produced but it can be of variable concentration.

Two students were each given a sample of limewater, from the same batch, in order to determine its concentration. Using 50.0 cm^3 portions of the limewater, they carried out titrations using 0.100 mol dm^{-3} hydrochloric acid. One of the students obtained the following results:

Titration	Trial	1	2
Final Volume /cm^3	14.50	28.60	42.70
Initial Volume /cm^3	0.00	14.50	28.60
Volume Added /cm^3	14.50	14.10	14.10

The student decided that the mean titre was 14.10 cm^3

The equation for the reaction is:

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

(a) (i) Calculate the number of moles of hydrochloric acid that reacted.

(1)

(ii) Calculate the number of moles of calcium hydroxide, $Ca(OH)_2$, that reacted with the acid.

(1)

(iii) the concentration of $Ca(OH)_2$, in mol dm^{-3}, in this sample of limewater.

(1)

(iv) Calculate the concentration of $Ca(OH)_2$, in g dm^{-3}, in this sample of limewater. Use the Periodic Table as a source of data.

(2)

(v) This student did not include the trial value when calculating the mean titre. Explain why.

(1)

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(vi) The second student obtained a different mean titre value for the experiment and thought that this difference may be due to the use of a faulty pipette.

Suggest a simple method, involving distilled water and a balance, by which the accuracy of the pipette in measuring out exactly 50.0 cm^3 could be checked.

(2)

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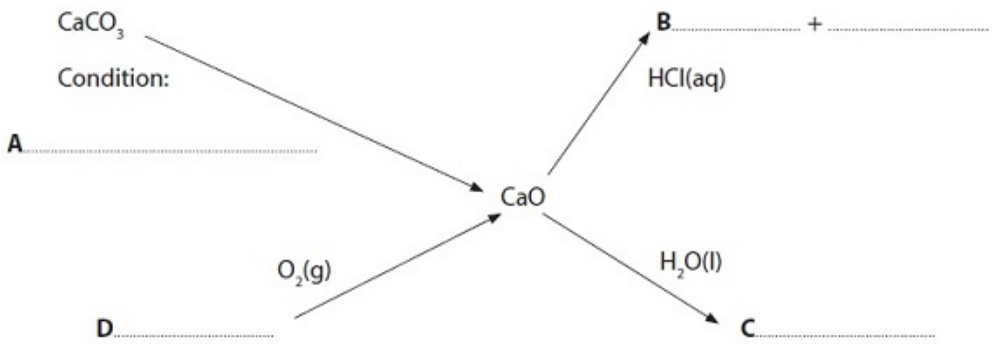
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(b) Complete the missing details from the reaction flowchart shown below, giving the condition for **A** and using chemical formulae for answers **B**, **C** and **D**. State symbols are not required.

(4)



(c) In certain areas of the UK, calcium and magnesium carbonates tend to be deposited as an off-white solid on the inside surface of pipes and the surface of heating elements in kettles. These deposits can be removed by treatment with a weak acid. An equation for this is shown below.

$$CaCO_3(s) + 2HA(aq) \rightarrow CaA2(aq) + H_2O(l) + CO_2(g)$$

State **one** observation, other than the solid disappearing, that would be made when the above reaction is carried out.

(1)

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(d) The thermal stability of these carbonates depends on a combination of factors, including the size of their lattice energies.

Explain why the lattice energy of calcium carbonate is less exothermic than that of magnesium carbonate.

(2)

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(e) Calcium and magnesium ions can be distinguished by the use of a flame test. State the difference in the flame colour and explain how colours in a flame are produced in terms of electronic transitions.

(3)

Calcium

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Magnesium

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Colour produced by

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(Total for Question = 18 marks)

Q2.

This question is about halogens and redox reactions.

The boiling temperatures of three halogens are shown in the table.

Halogen	Boiling temperature / °C
chlorine	–35
bromine	59
iodine	184

Explain why the boiling temperatures increase from chlorine to iodine.

(2)

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(Total for question = 2 marks)

Q3.

Compound **A** is a green solid containing one cation and one anion. It dissolves in water to form a green solution.

(a) Give the formulae of **two** cations which could be responsible for the green colour in the solid.

(2)

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(b) A student adds dilute sodium hydroxide solution, drop by drop, to an aqueous solution of **A**. A green precipitate forms, which dissolves in excess sodium hydroxide solution to form a dark green solution.

(i) Give the formula of the cation in **A**.

(1)

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(ii) Give a formula for the green precipitate.

(1)

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(iii) Give a formula for the species present in the dark green solution.

(1)

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(c) The student adds a few drops of acidified potassium manganate(VII) solution to another

sample of a solution of **A** in a test tube.

State the colour change that occurs.

(1)

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(d) The student acidifies 2 cm^3 of a solution of **A** with dilute nitric acid in a test tube and then adds a few drops of aqueous silver nitrate. A white precipitate is formed.

(i) Give the formula of the anion in **A**.

(1)

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(ii) This test is usually followed by the addition of ammonia solution to test the solubility of the precipitate.

Explain why this procedure in not suitable to confirm the identity of the anion in **A**.

(2)

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Q4.

This question is about some redox reactions of chlorine, bromine and iodine.

Chlorine undergoes disproportionation when it reacts with **hot** aqueous sodium hydroxide solution.

(i) Complete the ionic equation for this reaction. State symbols are not required.

(1)

..... Cl_2 + ... OH^- → ..... Cl^- + ... ClO_3^- + ... H_2O

(ii) Explain, in terms of oxidation numbers, why this is a disproportionation reaction.

(2)

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(Total for question = 3 marks)

Q5.

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

Explain how the thermal stability of magnesium carbonate compares with that of calcium carbonate.

(4)

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Q6.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new

answer with a cross ☒ .

The halogens are elements in Group 7 of the Periodic Table.

The halogens can be identified by their colour in an organic solvent such as hexane or cyclohexane.

Which sequence of colours is correct for chlorine, bromine and iodine dissolved in an organic solvent?

(1)

	Chlorine	Bromine	Iodine
☒ **A**	orange	red-brown	black
☒ **B**	pale green	orange	black
☒ **C**	orange	red-brown	purple
☒ **D**	pale green	orange	purple

(Total for question = 1 mark)

Q7.

An inorganic salt **A** contains one cation and one anion.
The results of two tests on salt **A** are shown in the table.

Test	Observation
Add aqueous sodium hydroxide to solid **A**. Warm the mixture. Test any gas evolved with damp red litmus paper.	A gas was evolved. The gas turned red litmus paper blue.
Add dilute nitric acid followed by aqueous silver nitrate to an aqueous solution of **A**.	A cream precipitate formed.

Describe additional tests, with the results, that will confirm the identity of the **anion** in the cream precipitate.

(2)

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(Total for question = 2 marks)

Q8.

Compound **C** is a pink crystalline solid containing two cations and one anion.

Three tests were carried out on **C**. The observation made for each test was recorded in the table.

Test	Observation	Inference
Test 1 Aqueous sodium hydroxide was added to solid **C** and the mixture warmed The gas evolved was tested with damp red litmus paper	The red litmus paper turned blue	The gas evolved was ..... One of the cations in **C** is .....
Test 2 Concentrated hydrochloric acid was added to an aqueous solution of **C**	The pink solution turned blue	The other cation in **C** is ..... The formula of the complex ion in the blue solution is .....
Test 3 Dilute hydrochloric acid and aqueous barium chloride were added to an aqueous solution of **C**	A white precipitate formed	The white precipitate is ..... The anion in **C** is .....

Give a reason why dilute hydrochloric acid is needed in **Test 3**.

(1)

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(Total for question = 1 mark)

Q9.

This question is about halogens and redox reactions.

Potassium halides react with concentrated sulfuric acid to form potassium hydrogensulfate and the different products shown in the table.

Potassium halide	Products
potassium chloride	hydrogen chloride
potassium bromide	hydrogen bromide, bromine and sulfur dioxide
potassium iodide	hydrogen iodide, iodine, hydrogen sulfide and sulfur

By referring to any changes in oxidation numbers when these halides react with concentrated sulfuric acid, explain which halide is the strongest reducing agent.

(3)

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(Total for question = 3 marks)

Q10.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Barium ions can be identified by their flame colour.

A flame test was carried out on a mixture of barium chloride and magnesium chloride.

How does the presence of magnesium ions affect the appearance of the flame colour of barium ions?

(1)

☒ **A** the colour is more intense

☒ **B** a bright white colour completely masks the barium colour

☒ **C** there is no change

☒ **D** the barium colour is decreased by the white magnesium flame colour

(Total for question = 1 mark)

Q11.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Barium ions can be identified by their flame colour.

What colour do barium ions give in a flame test?

(1)

☒ **A** green

☒ **B** lilac

☒ **C** red

☒ **D** yellow

(Total for question = 1 mark)

Q12.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Barium ions can be identified by their flame colour.

Which of the following should be used for a flame test on barium carbonate?

(1)

☒ **A** iron wire and water

☒ **B** iron wire and concentrated hydrochloric acid

☒ **C** nichrome wire and water

☒ **D** nichrome wire and concentrated hydrochloric acid

(Total for question = 1 mark)

Q13.

This question is about flame tests for Group 1 and 2 metal ions.

(i) State the colour of the flame produced by separate samples of potassium and strontium ions.

(1)

Potassium ions
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Strontium ions

.....

(ii) Give a reason why carrying out a flame test on a mixture of potassium chloride and strontium chloride does not
clearly show that two different metal ions are present.

(1)

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(Total for question = 2 marks)

Q14.

This question is about flame tests for Group 1 and 2 metal ions.

In the first stage of the flame test, the nichrome wire is dipped into concentrated hydrochloric acid and then heated in a Bunsen flame.

In the second stage, this nichrome wire is dipped into fresh hydrochloric acid and then into the metal salt to be tested before being reheated in the Bunsen flame.

(i) Give **two** reasons why the wire is made of nichrome and not iron.

(2)

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(ii) Give a reason why the wire is dipped into acid and then heated in the first stage.

(1)

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(iii) State why **fresh** concentrated hydrochloric acid is used in the second stage of the flame test.

(1)

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(iv) State why **hydrochloric acid** is used in the second stage of the flame test.

(1)

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(Total for question = 5 marks)

Q15.

This question is about the chemistry of hydrated magnesium nitrate, $Mg(NO_3)_2.xH_2O$.

Group 2 nitrates decompose when heated.

(i) State **two** observations you would see when hydrated magnesium nitrate is heated.

(2)

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(ii) Explain the trend in thermal stability of Group 2 nitrates.

(3)

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(Total for question = 5 marks)

Q16.

An inorganic salt **A** contains one cation and one anion.
The results of two tests on salt **A** are shown in the table.

Test	Observation
Add aqueous sodium hydroxide to solid **A**. Warm the mixture. Test any gas evolved with damp red litmus paper.	A gas was evolved. The gas turned red litmus paper blue.
Add dilute nitric acid followed by aqueous silver nitrate to an aqueous solution of **A**.	A cream precipitate formed.

Deduce the **name** of salt **A**.

(2)

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(Total for question = 2 marks)

Q17.

Compound **C** is a pink crystalline solid containing two cations and one anion.

Three tests were carried out on **C**. The observation made for each test was recorded in the table.

Test	Observation	Inference
Test 1 Aqueous sodium hydroxide was added to solid **C** and the mixture warmed The gas evolved was tested with damp red litmus paper	The red litmus paper turned blue	The gas evolved was ..... One of the cations in **C** is .....
Test 2 Concentrated hydrochloric acid was added to an aqueous solution of **C**	The pink solution turned blue	The other cation in **C** is ..... The formula of the complex ion in the blue solution is .....
Test 3 Dilute hydrochloric acid and aqueous barium chloride were added to an aqueous solution of **C**	A white precipitate formed	The white precipitate is ..... The anion in **C** is .....

(b) Write the **ionic** equation for the reaction between the cation in **C** and sodium hydroxide producing the gas in **Test 1**.

State symbols are not required.

(1)

(Total for question = 1 mark)

Q18.

The halogens are elements in Group 7 of the Periodic Table.

Halide ions can be identified by their reaction with silver nitrate.

(i) Write the **ionic** equation for the reaction between aqueous solutions of sodium iodide and silver nitrate.
Include state symbols.

(2)

(ii) A solution containing 0.010 mol of a halide ion was reacted with excess silver nitrate and produced 1.88 g of precipitate.

Identify the halide ion.
Justify your answer.

(2)

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(Total for question = 4 marks)

Q19.

Tests are carried out on aqueous solutions of two salts, **X** and **Y**.

X contains one cation and one anion.

The observations for each test are recorded in the table.

(i) Complete the table by writing the names or formulae of the species.

(2)

Test	Observation	Inference
Test 1 Add aqueous sodium hydroxide to an aqueous solution of **X**	A green precipitate forms The precipitate turns brown on the top after a few minutes	The cation in **X** is .....
Test 2 To an aqueous solution of **X**, add dilute hydrochloric acid followed by aqueous barium chloride	A white precipitate forms	The anion in **X** is .....

(ii) Write the ionic equation for the reaction between the cation in **X** and aqueous sodium hydroxide in **Test 1**. Include state symbols.

(2)

(iii) Give a reason why the green precipitate turns brown on the top after a few minutes.

(1)

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(iv) Give a reason why dilute hydrochloric acid is needed in **Test 2**.

(1)

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(Total for question = 6 marks)

Q20.

This question is about some halogens and their compounds.

The intermolecular attractions between halogen molecules are London forces.

(i) Describe how London forces form between halogen molecules.

(3)

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(ii) The boiling temperatures of chlorine and bromine are shown in the table.

Halogen	Boiling temperature / °C
chlorine	−34
bromine	59

Explain why bromine has a higher boiling temperature than chlorine.

(2)

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(Total for question = 5 marks)

Q21.

This question is about the identification of a Group 2 carbonate.

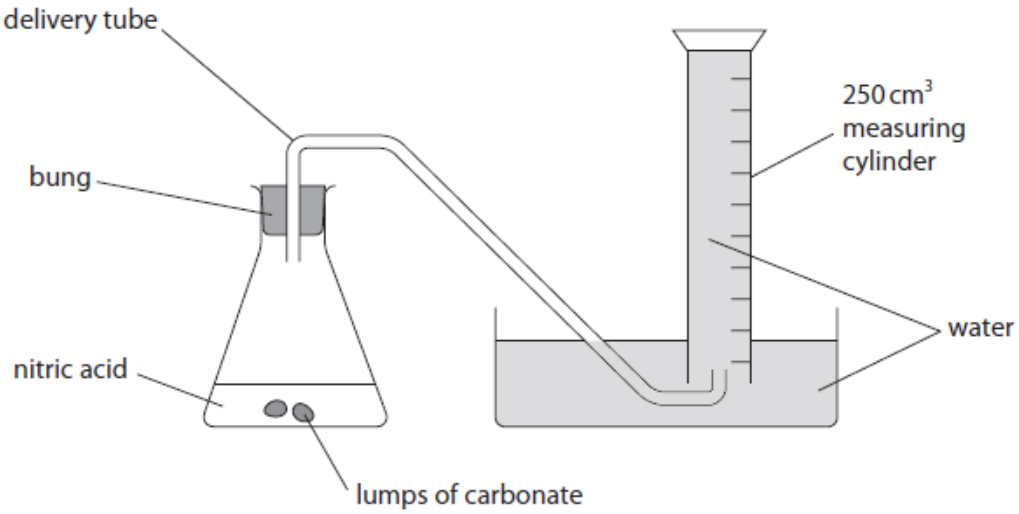
A chemistry teacher found a bottle containing lumps of a white solid. The original label was missing from the bottle. However, someone had written 'Group 2 carbonate' on the bottle. The lumps of the anhydrous white solid were pure and dry.

The chemistry teacher tried to identify the carbonate with the help of three students.
The three students worked under identical conditions and shared the same weighing balance.

Student **1** recognised that if an acid is added to a carbonate, carbon dioxide is evolved. The student decided to measure the volume of carbon dioxide evolved when the Group 2 carbonate reacts with excess nitric acid.

The student knew that 1 mol of a Group 2 carbonate produces 1 mol of carbon dioxide.

Student **1** set up the apparatus shown below.



- Student **1** weighed out some of the Group 2 carbonate and added it to a 250 cm^3 conical flask.
- Student **1** then added 100 cm^3 of 0.200 mol dm^{-3} nitric acid to the conical flask and replaced the bung.
- Student **1** measured the volume of gas collected in the inverted measuring cylinder at room temperature and pressure (r.t.p.) when all the Group 2 carbonate had reacted.
- Student **1** obtained the results shown in Table 1.

Measurement		Value
Mass of weighing bottle and carbonate	/ g	13.247
Mass of empty weighing bottle	/ g	12.431
Mass of carbonate used	/ g	.....
Volume of acid used	/ cm^3	100
Volume of gas collected	/ cm^3	225

Table 1

(a) Complete Table 1 to show the mass of the carbonate used.

(1)

(b) Calculate the amount, in moles, of carbon dioxide collected in the measuring cylinder at r.t.p.

(1)

(c) Calculate the molar mass of the Group 2 carbonate to an appropriate number of significant figures and hence deduce the identity of the Group 2 metal.

(4)

(d) Student **2** carried out the same experiment as Student **1**, using the same mass of the Group 2 carbonate.

Student **2** made no errors in their measurements or calculations but obtained a value for the

molar mass which was 10 g mol^{-1} greater than the value obtained by Student **1**.

(i) Explain **one** procedural error which could have resulted in Student **2** obtaining a molar mass greater than that of Student **1**.

(2)

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(ii) It was later discovered that Student **2** had used 110 cm^3 of 0.200 mol dm^{-3} dilute nitric acid, instead of 100 cm^3 of 0.200 mol dm^{-3} dilute nitric acid.

Give a reason why this mistake would **not** have affected Student **2**'s result.

No calculation is required.

(1)

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(iii) The teacher noticed that Student **2** had used the Group 2 carbonate in powdered form rather than in lumps.

Explain how, if at all, this would affect the rate of reaction and the final volume of gas produced in the reaction.

(2)

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(e) Student **3** suggested a different experiment.

Student **3** realised that, by heating the carbonate, carbon dioxide would be lost and an oxide would remain.

Student **3** decided to measure the change in mass of the carbonate and to use this information to calculate its molar mass.

- Student **3** weighed an empty test tube.
- Using a spatula, Student **3** added some of the carbonate to the test tube.
- The test tube containing the carbonate was then weighed.
- The test tube and its contents were heated to constant mass.
- The results obtained by Student **3** are shown in Table 2.

Measurement		Value
Mass of carbonate + test tube	/ g	20.447
Mass of oxide + test tube	/ g	20.205
Mass of empty test tube	/ g	19.996

Table 2

(i) Write an equation, including state symbols, for the thermal decomposition of a Group 2 carbonate, MCO_3, where M represents the metal.

(1)

(ii) Using Student **3**'s results, calculate the molar mass of the Group 2 carbonate.

(3)

(f) Student **3** used the same balance as Student **1**.

Give a reason why the mass of the carbonate measured by Student **3** has a greater percentage uncertainty than that measured by Student **1**.

(1)

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(g) Student **3** noticed that on heating the test tube some solid was lost.

Explain how this would affect the calculated value for the molar mass of the Group 2 carbonate.

(2)

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(Total for question = 18 marks)

Q22.

Compound **C** is a pink crystalline solid containing two cations and one anion.

Three tests were carried out on **C**. The observation made for each test was recorded in the table.

(i) Complete the statements in the inference column by writing the names or formulae of the species.

(6)

Test	Observation	Inference
Test 1 Aqueous sodium hydroxide was added to solid **C** and the mixture warmed The gas evolved was tested with damp red litmus paper	The red litmus paper turned blue	The gas evolved was ..... One of the cations in **C** is .....
Test 2 Concentrated hydrochloric acid was added to an aqueous solution of **C**	The pink solution turned blue	The other cation in **C** is ..... The formula of the complex ion in the blue solution is .....
Test 3 Dilute hydrochloric acid and aqueous barium chloride were added to an aqueous solution of **C**	A white precipitate formed	The white precipitate is ..... The anion in **C** is .....

(ii) Use the results of the tests in (i) to give a formula of **C**.

Do not include water of crystallisation.

(1)

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(Total for question = 7 marks)

Q23.

Magnesium nitrate decomposes on heating as shown by the equation.

$$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$$

Calcium nitrate decomposes in a similar way to magnesium nitrate, but requires a higher temperature for decomposition.

Explain this observation in terms of the charge and size of the cations.

(3)

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(Total for question = 3 marks)

Q24.

This question is about some halogens and their compounds.

A student carries out experiments to determine the order of reactivity of three halogens: bromine, chlorine and iodine.

The student is provided with aqueous solutions of the following five substances:

- bromine
- iodine
- potassium chloride
- potassium bromide
- potassium iodide.

The student has **no** access to chlorine gas or chlorine water.
The student uses cyclohexane, an organic solvent, to identify the halogen present at the end of each experiment.

The student carries out the **smallest** number of experiments required to determine the order of reactivity of the halogens.

Describe the experiments and the expected observations.

Include in your answer **ionic** equations for any reactions that occur.

State symbols are **not** required.

(5)

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(Total for question = 5 marks)

Q25.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

The halogens are elements in Group 7 of the Periodic Table.

Sodium chlorate(I) is a bleaching agent.

(i) Sodium chlorate(I) can be made by the reaction of chlorine with sodium hydroxide.

Show, by using oxidation numbers, that this reaction is disproportionation.

$$2NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$$

(2)

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(ii) A different bleaching agent can be made by the reaction of chlorine with sodium hydroxide under different conditions.

Balance this equation.

$$.....NaOH + ...Cl_2 \rightarrow NaClO_3 + ...NaCl + ...H_2O$$

(1)

(iii) What conditions are required for the reaction in (b)(ii)?

(1)

☒ **A** cold and dilute alkali

☒ **B** cold and concentrated alkali

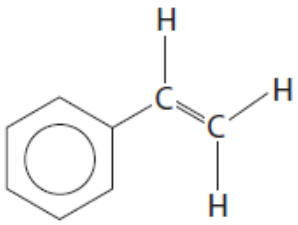
☒ **C** hot alkali

☒ **D** excess chlorine

(Total for question = 4 marks)

Q26.

The compound phenylethene (styrene) is used in the manufacture of polymers.



A simple test for the alkene functional group, such as that in styrene, is the addition of a small amount of bromine dissolved in cyclohexane.

(i) State the colour change you would expect to see in this test.

(1)

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(ii) Explain what happens to the bromine molecule as it gets close to the alkene functional group.

(2)

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(iii) Give the type of reaction that occurs and draw the structure of the product formed in the test for the alkene functional group.

(2)

Type of reaction

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Structure

(iv) Draw the repeat unit of the polymer formed from phenylethene.

(1)

Q27.

1-bromobutane can be prepared from butan-1-ol and hydrogen bromide.

$$CH_3CH_2CH_2CH_2OH + HBr \rightarrow CH_3CH_2CH_2CH_2Br + H_2O$$

Hydrogen bromide can be made from sodium bromide and 50% concentrated sulfuric acid.

(a) The steps for the preparation of impure 1-bromobutane are summarised.

Step **1** Dissolve the sodium bromide in distilled water in a pear-shaped flask and then add 20.0 cm^3 of butan-1-ol.

Step **2** Surround the flask with an ice bath to **cool the mixture**, before adding concentrated sulfuric acid drop by drop.

Step **3** Remove the flask from the ice bath and add a few **anti-bumping granules** to the reaction mixture.

Step **4** Set up the apparatus for **heating under reflux**. Heat the mixture in the flask for 30 minutes and then allow the apparatus to cool.

Step **5** Rearrange the apparatus for distillation and heat the mixture until no more 1-bromobutane distils over.

(i) Parts of the method are given in **bold** type in Steps **2**, **3** and **4**.

Give a reason why each of these parts is necessary.

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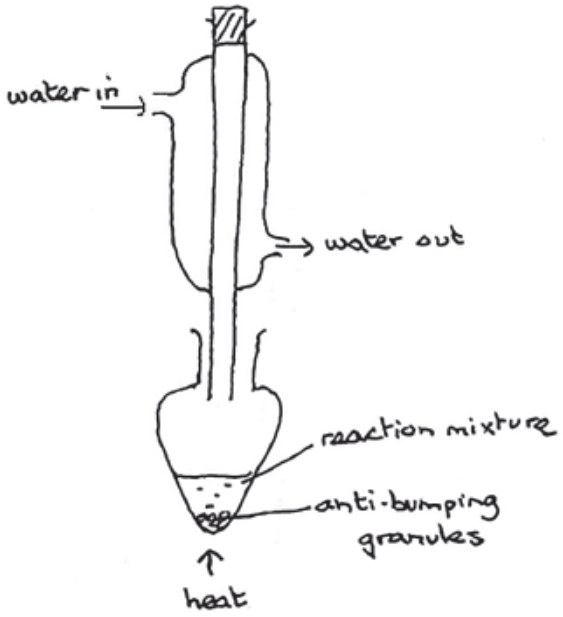
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(ii) A student drew a diagram of the apparatus used for heating under reflux in Step **4**. There are three errors in the apparatus shown in the diagram.
Assume the apparatus is suitably clamped.



Identify the three errors, including the effect of each error.

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(iii) The student corrected the errors.

While the mixture was heating under reflux, the student noticed a small amount of a brown vapour was formed.

Explain why the brown vapour forms.

(2)

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(b) The distillate collected in Step **5** is a mixture consisting of two layers.

There is an aqueous layer and a layer containing impure 1-bromobutane.

Data

Densities:

water	$1.00\,g\,cm^{-3}$
butan-1-ol	$0.81\,g\,cm^{-3}$
1-bromobutane	$1.27\,g\,cm^{-3}$

Boiling temperature of 1-bromobutane = 102 °C

The steps for the purification of the 1-bromobutane are summarised.

Step **6** Transfer the mixture from Step **5** to a separating funnel and remove the aqueous layer.

Step **7** Wash the impure 1-bromobutane with concentrated hydrochloric acid in the separating funnel.

Remove the aqueous layer.

Step **8** Add aqueous sodium hydrogencarbonate to the impure 1-bromobutane in the separating funnel.

Step **9** Shake the mixture in the separating funnel and, from time to time, invert the funnel and open the tap.

Step **10** Collect the 1-bromobutane layer from Step **9** in a small conical flask.

Add anhydrous sodium sulfate and swirl the flask until the liquid becomes clear.

Step **11** Decant the 1-bromobutane into a clean pear-shaped flask and redistil it. Measure the volume of 1-bromobutane produced.

(i) State the position of the aqueous layer in the separating funnel at the start of Step **6**. Justify your answer.

(1)

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(ii) Concentrated hydrochloric acid is used to remove any unreacted butan-1-ol in the mixture in Step **7**.

Give the reasons for carrying out Steps **8**, **9** and **10**.

(3)

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(iii) Give a suitable temperature **range** over which to collect the pure 1-bromobutane in the redistillation in Step **11**.

(1)

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(iv) The volume of 1-bromobutane collected was 12.0 cm^3.

Calculate the number of molecules of 1-bromobutane produced in this experiment.

Give your answer to an appropriate number of significant figures.

(2)

(Total for question = 15 marks)

Q28.

Aqueous sodium carbonate and aqueous sodium sulfate are both colourless solutions.

Give the reagent and the observation to show the presence of carbonate ions.

(2)

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(Total for question = 2 marks)

Q29.

Tests are carried out on aqueous solutions of two salts, **X** and **Y**.

Y contains one cation and one anion.

The observations for each test are recorded in the table.

(i) Complete the table by writing the names or formulae of the species.

(2)

Test	Observation	Inference
Test 3 Add dilute aqueous ammonia to an aqueous solution of **Y** until it is present in excess	A pale blue precipitate forms The precipitate dissolves in excess ammonia to form a deep blue solution	The cation in **Y** is .....
Test 4 To an aqueous solution of **Y**, add dilute nitric acid followed by aqueous silver nitrate	A white precipitate forms	The anion in **Y** is .....

(ii) Give the formula of the complex ion present in the deep blue solution at the end of **Test 3**.

(1)

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(iii) Give a reagent that could be added to the mixture at the end of **Test 4** to confirm the identity of the anion in **Y**.
Include the observation when this reagent is added.

(2)

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(Total for question = 5 marks)

Q30.

Aqueous sodium carbonate and aqueous sodium sulfate are both colourless solutions.

Give the reagent and the observation to show the presence of sulfate ions.

(2)

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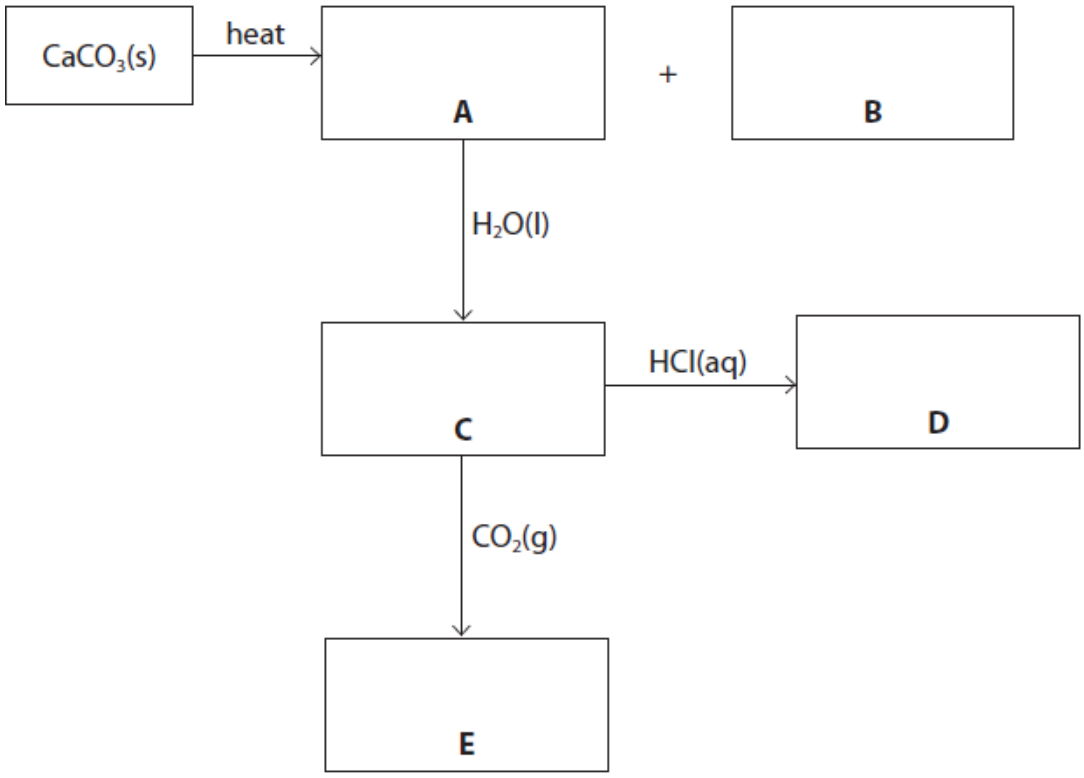
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(Total for question = 2 marks)

Q31.

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

The flow chart shows some reactions involving calcium compounds.



Identify the substances **A** to **E** by writing their formulae and state symbols in the boxes.

(5)

Q32.

Chlorine and bromine are elements in Group 7 of the Periodic Table.

Both elements exist in a number of different oxidation numbers and therefore are involved in many redox reactions.

(a) Write an equation for the reaction between chlorine and cold, dilute aqueous sodium hydroxide. State symbols are not required.

(1)

(b) Chlorine dioxide reacts with cold, dilute aqueous sodium hydroxide.

The ionic equation for the reaction is:

$$2ClO_2(aq) + 2OH^-(aq) \rightarrow ClO_2^-(aq) + ClO_3^-(aq) + H_2O(l)$$

Using oxidation numbers, explain why the chlorine in ClO_2 has undergone disproportionation.

(3)

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(c) Chloride ions (Cl^-) can be oxidised to chlorine molecules (Cl_2) by manganate(VII) ions.

A dilute solution containing manganate(VII) ions (MnO_4^-) and an excess of dilute sulfuric acid is added to the solution containing chloride ions.

As the manganate(VII) ion solution is added, it changes from purple to colourless.

(i) The formula of the manganese species that is formed during this reaction is

(1)

☒ **A** $Mn^{2+}(aq)$

☒ **B** $Mn^{3+}(aq)$

☒ **C** $Mn^{4+}(aq)$

☒ **D** $MnO_4^{2-}(aq)$

(ii) Using oxidation numbers, deduce the molar ratio of MnO_4^- to Cl^- that would appear in the balanced chemical equation for the reaction.

(2)

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(d) Potassium bromide reacts with concentrated sulfuric acid. Three of the products of the reaction are hydrogen bromide, bromine and sulfur dioxide.

(i) Explain why the hydrogen bromide, which is a colourless gas, appears as misty fumes when it makes contact with moist air.

(2)

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(ii) State the type of reaction that occurs in the formation of sulfur dioxide.

(1)

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Q33.

Many vehicles are fitted with airbags which provide a gas-filled safety cushion to protect the occupant of the vehicle if there is a crash.

(a) The first reaction in airbags is the thermal decomposition of sodium azide, NaN_3, to form sodium and nitrogen gas.

(i) Write the equation for this decomposition of sodium azide.

State symbols are not required.

(1)

(ii) In the reaction in (i), a typical airbag is inflated by about 67 dm^3 of gas.

Calculate the **minimum mass** of sodium azide, in grams, needed to produce this volume of gas. Use the Ideal Gas Equation and give your answer to an appropriate number of significant figures.

For the purpose of this calculation, assume that the temperature is 300 °C and the pressure is 140 000 Pa.

(4)

(b) The second reaction in the airbag is between the sodium produced in the reaction (a)(i) and potassium nitrate.

$$\text{.....}Na + \text{.....}KNO_3 \rightarrow \text{.....}K_2O + \text{.....}Na_2O + \text{.....}N_2$$

Balance the above equation, justifying your answer in terms of the changes in oxidation numbers.

(3)

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(c) The third reaction in the airbag is between the metal oxides and silicon dioxide.

State the type of reaction taking place and justify why this reaction is necessary.

(3)

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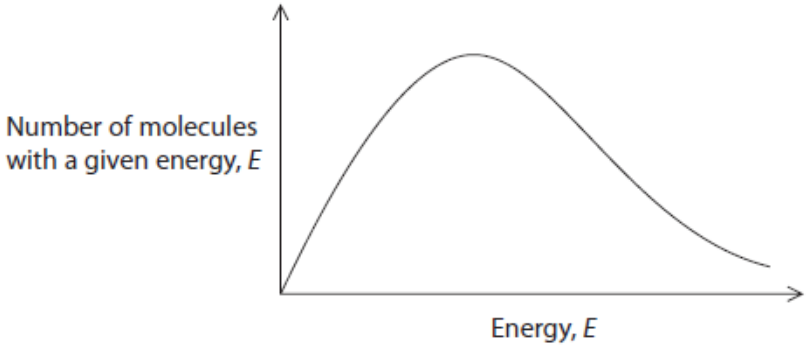
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(d) The Maxwell-Boltzmann distribution diagram shows the molecular energies for the gaseous system immediately after the airbag has been deployed.



What is the change in shape of the curve when the airbag **cools**?

(1)

☒ **A** the peak would shift to the left and be higher

☒ **B** the peak would shift to the left and be lower

☒ **C** the peak would shift to the right and be higher

☒ **D** the peak would shift to the right and be lower

(Total for question = 12 marks)

Q34.

This question is about some redox reactions of chlorine, bromine and iodine.

An **excess** of aqueous potassium bromide was added to chlorine water and the solution turned orange.

(i) Write an equation for this reaction. State symbols are not required.

(1)

(ii) Silver nitrate solution was added to the mixture in (i) and excess dilute ammonia solution was then added to the precipitate formed.

Only some of the precipitate dissolved.

Deduce why only **some** of the precipitate dissolved.

(3)

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(iii) Aqueous potassium bromide was added to aqueous iodine, instead of chlorine water. There was no reaction.

Give a reason why no reaction occurred.

(1)

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(Total for question = 5 marks)

Q35.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about dissolving different compounds.

Which of these compounds is the most soluble in water?

(1)

☐ **A** barium sulfate

☐ **B** calcium sulfate

☐ **C** magnesium sulfate

☐ **D** strontium sulfate

(Total for question = 1 mark)

Q36.

This question is about the solubility of metal hydroxides.

Which of these metal hydroxides is the most soluble in water?

(1)

☒ **A** barium hydroxide

☒ **B** calcium hydroxide

☒ **C** magnesium hydroxide

☒ **D** potassium hydroxide

(Total for question = 1 mark)

Q37.

Magnesium and strontium are elements in Group 2 of the Periodic Table. The first three ionisation energies of magnesium and strontium are shown in the table.

Element	Ionisation energy / kJ mol^{-1}		
	First	Second	Third
magnesium	738	1451	7733
strontium	550	1064	4210

(a) (i) Explain why the first ionisation energy of magnesium is larger than that of strontium.

(2)

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(ii) Explain why the second ionisation energy of magnesium is larger than its first ionisation energy.

(2)

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(iii) Explain why the third ionisation energy of magnesium is **significantly** larger than its second ionisation energy.

(2)

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Q38.

Aqueous silver nitrate is used as a test for halide ions. A student decides to carry out this test on a solution of magnesium chloride. The bottle of solid magnesium chloride shows the formula $MgCl_2.6H_2O$.

(a) The student dissolves a small amount of $MgCl_2.6H_2O$ in water and adds aqueous silver nitrate, $AgNO_3(aq)$, to the solution.

(i) Calculate the molar mass of $MgCl_2.6H_2O$

(1)

Molar mass = ... g mol^{-1}

(ii) State what the student would see after adding the aqueous silver nitrate.

(1)

.....

(iii) Write an ionic equation for this reaction. Include state symbols.

(1)

(b) Using aqueous silver nitrate, it is sometimes difficult to distinguish between chloride, bromide and iodide ions.

Describe how aqueous ammonia can be used to distinguish between these three ions.

(3)

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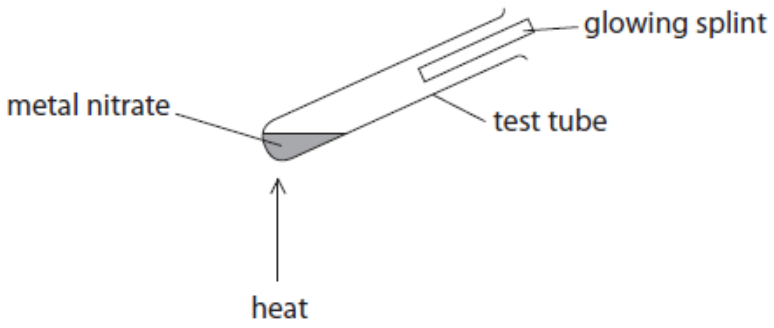
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(Total for question = 6 marks)

Q39.

Thermal decomposition is the breaking down of a substance by heat.

An experiment was carried out to investigate the thermal decomposition of a metal nitrate using the apparatus shown.



(i) The glowing splint is used as a test for one of the gases given off in this experiment.

Identify this gas and the positive result of the test.

(1)

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(ii) Give the name and appearance of the other gas given off in this experiment when a Group 2 nitrate is heated.

(1)

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(iii) Write the equation for the decomposition if the Group 1 compound, sodium nitrate, was used in this experiment.

State symbols are not required.

(1)

(iv) Describe the apparatus that would be used to compare the decomposition of metal carbonates. Include how the rate of decomposition would be compared

(2)

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(Total for question = 5 marks)

Q40.

Thermal decomposition is the breaking down of a substance by heat.

Explain why magnesium carbonate decomposes much more readily on heating than barium carbonate.

(3)

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(Total for question = 3 marks)

Q41.

This question is about some Group 2 compounds.

Explain the trend in the thermal stability of carbonates in Group 2.

(3)

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Q42.

Colour is often used in chemistry to identify substances.

Compare and contrast the origin of the colour of a copper(II) complex with the origin of the colour of the copper(II) ion in a flame test.

You do not need to state any specific colours.

(6)

(Total for question = 6 marks)

Q43.

This is a question about halogenoalkanes and related compounds.

In aqueous sodium hydroxide, 1-bromoethane reacts to produce ethanol.

(i) Write the mechanism for this reaction, including all relevant curly arrows, lone pairs and dipoles. Include the transition state.

(4)

(ii) Give the reagents that are used to test that bromide ions are formed in this reaction mixture. Include the result of the test.

(2)

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(Total for question = 6 marks)