

Reactions of Acids

Mark Scheme



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1. Acids react predictably with different substances to form a salt.

Circle the letter of the correct answer for each of the following questions.

- a. A white precipitate of barium sulfate can be formed by mixing two solutions.

Which pair of solutions would produce a precipitate of barium sulfate?

B – is the only correct answer.	1 mark
	Total: 1 mark

- b. A student adds magnesium ribbon to a test tube containing dilute hydrochloric acid.

A gas is produced which burns with a squeaky pop. What is the correct word equation for this reaction?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c. All neutralisation reactions between an acid and an alkali involve the same fundamental process.

Which ionic equation correctly represents this process?

A – is the only correct answer.	1 mark
	Total: 1 mark

- d. What is the correct sequence of steps for the preparation of a pure sample of copper(II) sulfate crystals from copper(II) oxide and sulfuric acid?

D – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 4 marks)

2. There are three methods of preparing salts.

Method A – use a burette and an indicator.

Method B – mix two solutions and obtain the salt by precipitation.

Method C – add an excess of an insoluble base or carbonate to a dilute acid and remove the excess by filtration.

For each of the following salt preparations, choose one of the **methods A, B or C**, name any additional reagent needed and then write the equation.

- a. The soluble salt, copper(II) chloride, from the insoluble substance, copper(II) carbonate.

Method: C.	1 mark
Reagent: hydrochloric acid. Accept: HCl.	1 mark
Word equation: copper(II) carbonate + hydrochloric acid → copper(II) chloride + water + carbon dioxide	1 mark
	Total: 3 marks

- b. The soluble salt, sodium sulfate, from the soluble base, sodium hydroxide.

Method: A	1 mark
Reagent: sulfuric acid. Accept: H ₂ SO ₄	1 mark
Balanced symbol equation: 2NaOH + H ₂ SO ₄ → Na ₂ SO ₄ + 2H ₂ O	1 mark
	Total: 3 marks

- c. The insoluble salt, silver chloride, from the soluble salt, silver nitrate.

Method: B	1 mark
Reagent: sodium chloride or hydrochloric acid. Accept: NaOH or HCl.	1 mark
Balanced symbol equation: AgNO ₃ + NaCl → AgCl + NaNO ₃	2 marks
Marking note: 1 mark for the correct balanced reactants and 1 for the correct balanced products.	
	Total: 4 marks

- d. In Method C, it is important to add the insoluble base in excess.

Explain why.

An explanation to include the following:	1 mark
To make sure that all of the acid is reacted / neutralised.	1 mark
Allow: to make sure that the acid is the limiting reactant. Do not accept to make the reaction faster.	
So that the excess / unreacted solid / base / carbonate can be removed by filtration	1 mark
	Total: 2 marks

(Total for Question 2 is 12 marks)

3. Pure dry crystals of copper(II) sulfate can be made by reacting excess copper(II) carbonate powder with warm, dilute sulfuric acid.

- a. During the reaction, bubbles of a colourless gas are given off. State the name of this gas.

Carbon dioxide.	1 mark
	Total: 1 mark

- b. Why is excess copper(II) carbonate used?

To ensure all the acid is reacted or neutralised.	1 mark
	Total: 1 mark

- c. How is the excess copper(II) carbonate removed from the reaction mixture?

An answer to include:	
Filtration or the use of a filter.	1 mark
	Total: 1 mark

- d. Describe how you can obtain pure dry crystals of copper(II) sulfate from a solution of copper(II) sulfate.

A description to include the following:	
Heat or evaporate the solution (to remove water) or until crystals start to form.	1 mark
Leave solution to cool and for crystals to form / leave to crystallise.	1 mark
	Total: 2 marks

- e. Describe one other reaction that makes copper(II) sulfate.

React sulfuric acid with copper(II) oxide or copper(II) hydroxide.	1 mark
	Total: 1 mark

- f. Write a word equation for the reaction you suggested in part (e).

Option 1: copper(II) oxide used: copper(II) oxide + sulfuric acid → copper(II) sulfate + water	1 mark
Option 2: copper(II) hydroxide used: copper(II) hydroxide + sulfuric acid → copper(II) sulfate + water	1 mark
	Total: 1 mark

- g. Copper(II) sulfate is used as a fungicide on plants.

Explain why the chemicals used in fungicides need to be as pure as possible.

An explanation to include:	
So that it does not harm the plant / other organisms / the environment.	1 mark
	Total: 1 mark

- h. A student repeats the experiment using excess sulfuric acid.

How much copper(II) sulfate can the student obtain from 3.1 g of copper(II) carbonate?

4.0 (g)	1 mark
	Total: 1 mark

- i. A sample of 25.0 g of impure copper(II) sulfate contains 24.5 g of pure copper(II) sulfate.

Calculate the percentage purity of the copper(II) sulfate.

Percentage = $(24.5 \div 25) \times 100$	
Percentage = 98 %	1 mark
	Total: 1 mark

- j. A different student performs the experiment.

They react 6.2 g of copper(II) carbonate with excess sulfuric acid and produce 7.2 g of pure, dry copper(II) sulfate crystals. The balanced equation for the reaction is:



Calculate the percentage yield of copper(II) sulfate.

Relative atomic masses: C = 12, O = 16, S = 32, Cu = 63.5)

Mr(CuCO ₃) = 123.5 Mr(CuSO ₄) = 159.5	1 mark
Maximum mass of CuSO ₄ = $(6.2 \div 123.5) \times 159.5 = 8.0 \text{ (g)}$	1 mark
Percentage yield = $(7.2 \div 8.0) \times 100 = 90 \text{ (%)}$	1 mark
Accept: 89.9%	
	Total: 3 marks

(Total for Question 3 is 13 marks)

4. A student is asked to make a pure, dry sample of zinc chloride crystals. Zinc chloride is a soluble salt. Describe a method the student could use to prepare these crystals starting from a solid metal oxide and a dilute acid.

In your method, you should:

- Name all the apparatus required.
- Describe the steps you would take.
- Explain the key reasons for the steps in your procedure.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A simple, limited description of at least one relevant step. The order may be incorrect and reasons are likely to be missing. Minimal apparatus is named.
Level 2	3 - 4	A method is described with some logical sequence. There may be omissions in the steps or the reasons given for them. Some apparatus is named.
Level 3	5 - 6	A detailed and coherent method is described which correctly links the key steps to their reasons. Most apparatus is named. The response is logically structured.

Indicative content:	
Reactants and Apparatus: • Reactants: Zinc oxide and hydrochloric acid. Apparatus: • Beaker / conical flask. • Measuring cylinder. • Spatula. • Stirring rod. • Bunsen burner, tripod, and gauze (or water bath). • Filter funnel and filter paper. • Evaporating basin. • Crystallising dish / watch glass. Reaction Stage: Step 1: Measure a set volume of hydrochloric acid into a beaker. Step 2: Gently warm the acid. Reason: To speed up the rate of reaction. Step 3: Add zinc oxide powder using a spatula, stirring continuously, until no more dissolves. Reason: This is to add the zinc oxide in excess to ensure all the acid is neutralised / reacted. This prevents the final product from being contaminated with acid. Separation Stage 1 (Filtration): Step 4: Filter the mixture using a filter funnel and filter paper. Reason: To remove the excess/unreacted (insoluble) zinc oxide. The filtrate is the zinc chloride solution. Separation Stage 2 (Crystallisation): Step 5: Pour the filtrate into an evaporating basin and heat it gently.	

Reason: To evaporate some of the water to form a more concentrated / saturated solution. Step 6: Stop heating when crystals start to form (the point of crystallisation). Reason: To allow large crystals to form upon cooling and to prevent the formation of anhydrous powder. Step 7: Leave the solution to cool slowly. Reason: As the solution cools, the solubility of zinc chloride decreases, and crystals will form. Drying Stage: Step 8: Remove the crystals from the solution (by decanting or filtering). Step 9: Pat the crystals dry with filter paper or leave them in a warm, dry place. Reason: To obtain a pure, dry sample of crystals as requested.	
	Total: 6 marks

(Total for Question 4 is 6 marks)

5. A student plans to make a sample of the soluble salt nickel(II) sulfate by reacting nickel(II) carbonate with dilute sulfuric acid. Nickel(II) carbonate is an insoluble green powder.

- a. Name the gas produced during this reaction.

Carbon dioxide.	1 mark
	Total: 1 mark

- b. Describe the chemical test and the positive result for this gas.

A description to include the following:	
Test: bubble the gas through limewater. Accept calcium hydroxide solution.	1 mark
Result: (limewater) turns cloudy / milky / forms a white precipitate.	1 mark
	Total: 2 marks

- c. The student adds the nickel(II) carbonate until it is in excess.
Explain why it is necessary to add an excess and how this excess solid is then removed from the mixture.

An explanation to include the following:	
Explanation of excess: to ensure all the acid is reacted / neutralised.	1 mark
Removal of excess: by filtration	1 mark
	Total: 2 marks

The balanced chemical equation for the reaction is shown below.

- d. Complete the equation by adding the chemical formulae of the **two** other products.

1 mark for each correct product.	
H ₂ O and CO ₂ - are the two missing products.	2 marks
	Total: 2 marks

- e. Describe the method the student should use to obtain a pure, dry sample of nickel(II) sulfate crystals from this solution.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A simple, limited description of at least one relevant step. The order may be incorrect and reasons are likely to be missing or incorrect.
Level 2	3 - 4	A method is described with some logical sequence. There may be omissions in the steps or the scientific reasons for them. The outcome would be a sample of crystals, but purity or dryness may not be fully addressed.
Level 3	5 - 6	A detailed and coherent method is described. The key steps are explained with clear scientific reasoning and are in a logical order to produce a pure, dry sample.

Indicative content:	
Step 1: Pour the (nickel(II) sulfate) solution into an evaporating basin. Heat the solution gently using a Bunsen burner or water bath. Reason: To evaporate the water and make the solution more concentrated / saturated. Step 2: Stop heating when small crystals start to form on a glass rod (the point of crystallisation). Reason: This prevents the salt from becoming anhydrous / forming a powder. It allows larger crystals to form. Step 3: Leave the concentrated solution in a cool place to cool down slowly. Reason: The solubility of the salt decreases as the temperature falls, causing crystals to form. Step 4: Remove the crystals from the remaining solution by filtration (or by decanting the liquid). Wash the crystals with a small amount of cold, distilled water. Reason: To remove any remaining soluble impurities. Step 5: Dry the crystals by patting them between filter papers or by placing them in a desiccator / warm oven. Reason: To obtain a dry sample of crystals as required in the question.	
	Total: 6 marks

- f. The student started with 3.0 g of nickel(II) carbonate and produced 3.5 g of nickel(II) sulfate. Calculate the percentage yield for this experiment.

$\text{Mr}(\text{NiCO}_3) = 119$	$\text{Mr}(\text{NiSO}_4) = 155$	1 mark
Maximum mass of $\text{NiSO}_4 = (3.0 \div 119) \times 155 = 3.907 \text{ (g)}$		1 mark
Percentage yield $= (3.5 \div 3.907) \times 100 = 89.6 \%$		1 mark
		Total: 3 marks

- g. Lead(II) sulfate is an insoluble salt.

Name **two** soluble compounds that could be mixed to produce a precipitate of lead(II) sulfate.

Compound 1: lead(II) nitrate.	1 mark
Compound 2: sodium sulfate.	1 mark
	Total: 2 marks

(Total for Question 5 is 18 marks)

6. A student investigates the reaction between zinc metal and dilute hydrochloric acid to produce the soluble salt zinc chloride.

- a. State the **word** equation for the reaction between zinc and hydrochloric acid.

zinc + hydrochloric acid → zinc chloride + hydrogen	2 marks
1 mark for the correct reactants and 1 for the correct products.	
	Total: 2 marks

- b. The student observes bubbles of gas being produced.

- i. Name the gas produced.

Hydrogen	1 mark
	Total: 1 mark

- ii. Describe the chemical test for this gas.

A description to include:	
Test: place a <u>lit splint</u> into the gas	
Positive result: and it gives a squeaky pop.	
Marking note: both points must be stated correctly for the mark.	
	Total: 1 mark

- c. The balanced equation for the reaction is:

Calculate the atom economy for the production of zinc chloride (ZnCl_2) by this method.

Relative atomic masses (A_r): H = 1, Cl = 35.5, Zn = 65

$\text{Mr}(\text{ZnCl}_2) = 136$ and Sum of $\text{Mr}(\text{reactants}) = 138$	1 mark
Atom economy: $(136 \div 138) \times 100 = 98.6\%$	1 mark
	Total: 2 marks

- d. A student reacts 3.25 g of zinc powder with 50.0 cm^3 of 1.50 mol/dm^3 hydrochloric acid.

Determine which reactant is limiting and calculate the maximum mass of zinc chloride (ZnCl_2) that can be formed.

Moles Zn = $3.25 \div 65 = 0.05$ (mol)	1 mark
Moles HCl = $(50.0 \div 1000) \times 1.50 = 0.075$ (mol)	1 mark
HCl is the limiting reactant because 0.05 mol Zn requires 0.1 mol HCl, which is more than is available.	1 mark
Max mass $\text{ZnCl}_2 = (0.075 \div 2) \times 136 = 5.1$ (g)	1 mark
	Total: 4 marks

- e. Suggest **one** practical reason why the actual yield of pure, dry zinc chloride crystals obtained by the student would be less than the maximum theoretical mass calculated in part (d).

Accept any one of the following:	
- Reaction is reversible / does not go to completion. - Some product lost during handling / transfer (e.g. filtration). - Unwanted side reactions occurred. - Some reactant may not have reacted.	
	Total: 1 mark

(Total for Question 6 is 11 marks)