Acids

1. Magnesium nitrate is used in fertilisers as a source of nitrogen.

* A student plans to prepare 250.0 cm^3 of a 0.4000 mol dm^{-3} solution of magnesium nitrate, starting from magnesium nitrate crystals, $Mg(NO_3)_2 \cdot 6H_2O$.

Describe how the student would prepare the solution, giving full details of quantities, apparatus and method.

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[6]

2(a). A student carries out a titration to determine the concentration of some hydrochloric acid.

The student titrates the hydrochloric acid against a standard solution of sodium carbonate, Na_2CO_3. The equation is shown below.

$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

- The student prepares 0.150 mol dm^{-3} Na_2CO_3 in a 250.0 cm^3 volumetric flask.
- The hydrochloric acid is added to a 50.0 cm^3 burette.
- The student pipettes the $Na_2CO_3(aq)$ using a 25.0 cm^3 pipette.

The student's burette readings are shown in the table.
The rough titre has been omitted.

i. Complete the table by adding the titres to the table.

Final reading / cm^3	24.60	48.45	34.30
Initial reading / cm^3	0.40	24.60	10.00
Titre / cm^3	.....	.....	.....

[1]

ii. Calculate the mean titre of HCl , to the nearest 0.05 cm^3, that the student should use for analysing the results.

mean titre = ... cm^3 **[1]**

(b). Calculate the concentration, in mol dm^{-3}, of the hydrochloric acid.

Give your answer to **3** significant figures.

concentration of HCl = ... mol dm^{-3} **[3]**

(c). In the titrations, the student measured volumes with a pipette and a burette.

- The pipette had an uncertainty of ± 0.04 cm^3 in the volume measured.
- The burette had an uncertainty of ± 0.05 cm^3 in the volume measured.

Determine whether the volume measured by the pipette or the volume measured by the burette has the greater percentage uncertainty.

[2]

3(a). Sodium hydroxide is an alkali.

What is meant by the term alkali?

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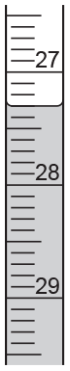
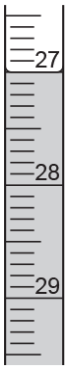
[1]

(b). 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 cm^3 of distilled water and make the solution up to 250 cm^3 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 cm^3.

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 cm^3, 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 ± 0.05 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?

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[1]

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

- The student prepares a 250.0 cm^3 solution from 1.513 g of **A**.
- The solution of **A** is added to the burette and titrated with 25.0 cm^3 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 cm^3.

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]

(d). What is meant by the term standard solution?

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[1]

4(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 sample of carbonate is dissolved in approximately 100 cm^3 of distilled water in a beaker and the solution transferred to a volumetric flask. The volume of the solution is made up to 250.0 cm^3 with distilled water.

Another student suggests two possible sources of error:

- A small amount of solid remained in the weighing bottle.
- A small amount of solution remained in the beaker.

State whether the other student's statements are correct.

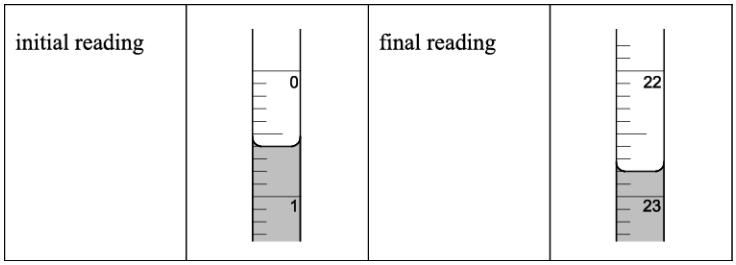
How could the procedure be improved?

---**[2]**

(b). 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]**

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

$$M_2CO_3(aq) + 2HCl(aq) \rightarrow 2MCl(aq) + CO_2(g) + H_2O(l)$$

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

$n(M_2CO_3)$ = ……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]

5. Ethanoic acid, CH_3COOH, is the main dissolved acid in vinegar.

Ethanoic acid is a weak acid.
What is meant by *acid* and *weak acid*?

---**[1]**

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

$$SrCO_3 + 2HNO_3 \rightarrow Sr(NO_3)_2 + CO_2 + H_2O$$

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.

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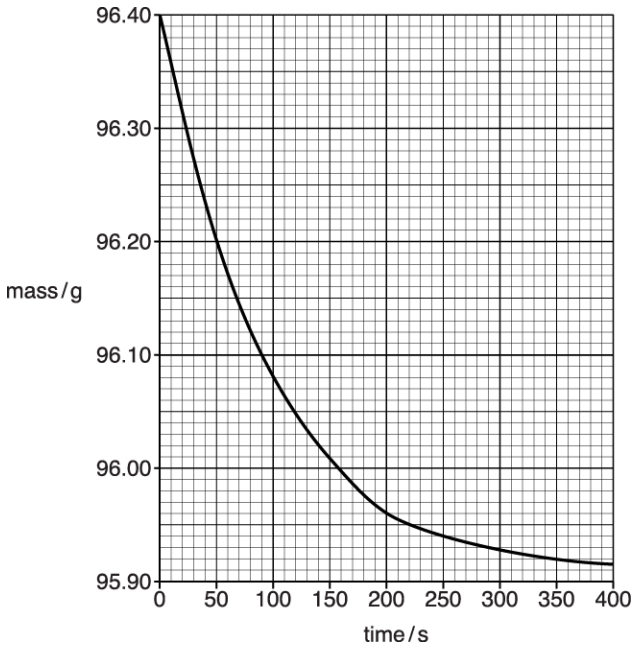
[1]

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.

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[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.

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[3]

7(a). A student was given 200 cm^3 of solution **X** in which sodium hydroxide, NaOH, and sodium hydrogencarbonate, $NaHCO_3$, had **both** been dissolved.

The student carried out **two different** titrations on samples of solution **X** using 0.100 mol dm^{-3} sulfuric acid, H_2SO_4.

- In the first titration, **both** NaOH **and** $NaHCO_3$ were neutralised.
- In the second titration, **only** NaOH was neutralised.

The student's results for the titrations of 25.0 cm^3 samples of solution **X** are shown.

volume of H_2SO_4 needed to neutralise **both** NaOH **and** $NaHCO_3$	29.50 cm^3
volume of H_2SO_4 needed to neutralise **only** NaOH	18.00 cm^3

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$
$$2NaHCO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$$

i. Calculate the amount, in mol, of H_2SO_4 used to neutralise **only** the NaOH in 25.0 cm^3 of solution **X**.

Amount = …… mol **[1]**

ii. Calculate the concentration, in mol dm^{-3}, of NaOH in solution **X**.

Concentration = …… mol dm^{-3} **[1]**

(b). i. Calculate the amount, in mol, of $NaHCO_3$ in the 200 cm^3 of solution **X**.

Amount = …… mol **[2]**

ii. Calculate the mass of $NaHCO_3$ in the 200 cm^3 of solution **X**.

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

Mass = …… g **[1]**

8(a) Calcium hydroxide is both a base and an alkali. Refer to any relevant ions in your answer.

Explain what is meant by the terms *base* and *alkali*.

Base

……
……

Alkali

……
……

[2]

(b) A student prepares a solution of calcium nitrate from calcium carbonate.

What reagent would the student need to use?

Write the equation for the reaction.

Reagent

……

……

Equation

……

……

[2]

9. Cerium behaves as a typical metal when it reacts with dilute sulfuric acid to form the salt cerium(III) sulfate and a second product.

i. Identify the second product.

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[1]

ii. Write the formula of cerium(III) sulfate and, explain what has happened to the cerium in this reaction in terms of the number of electrons transferred.

Formula ……

Explanation

……

……

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[2]

iii. How has a salt been formed in this reaction?

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[1]

10. Calcium phosphate(V), $Ca_3(PO_4)_2$, is a salt used in fertilisers.

Calcium phosphate(V) can be prepared by reacting together an acid and a base.

i. Suggest the **formula** of the acid used to prepare $Ca_3(PO_4)_2$.

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[1]

ii. **Name** a base which could be used to prepare $Ca_3(PO_4)_2$.

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[1]

11(a). 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 cm^3.
- The student titrates a 25.0 cm^3 portion of this solution with 0.120 mol dm^{-3} NaOH.
- 25.25 cm^3 of 0.120 mol dm^{-3} NaOH are required to reach the end point.

Name the apparatus that the student should use to

- make up the acid solution to 250.0 cm^3
- measure the 25.0 cm^3 portion of acid solution.

make up the acid solution to 250 cm^3: ---

measure the 25.0 cm^3 portion: ---

[1]

(b). 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]**

(c). The student is not confident that their titre is accurate.
Suggest what the student should do next to reduce the effect of any random error in the titration.

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[2]

END OF QUESTION PAPER