5070 Chemistry Paper 4 - Stoichiometry

Topical questions | 5 questions

1. Question part 1/2 | 5070 May-June 2024 P4 V1 Q4

4 Barium carbonate decomposes when heated. The word equation for the reaction is shown.

barium carbonate $\rightarrow$ barium oxide + carbon dioxide

Plan an experiment to determine the percentage loss in mass when barium carbonate is heated.

Your plan must include the use of common laboratory apparatus and a sample of barium carbonate. No other chemicals should be used.

Your plan must include:

- the apparatus needed
- the method to use and the measurements to take
- procedures to ensure that the percentage determined is as accurate as possible
- how the measurements are used to determine the percentage loss in mass.

You may draw a diagram to help answer the question.

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5070 Chemistry Paper 4 - Stoichiometry

Topical questions | 5 questions

1. Question part 2/2 | 5070 May-June 2024 P4 V1 Q4

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[6]

2. Question part 1/4 | 5070 Oct-Nov 2024 P4 V1 Q2

2 A student titrates four samples of 0.800 mol / dm^3 aqueous sodium hydroxide, NaOH(aq), with aqueous ethanedioic acid.

In titration 1 the student:

- rinses and fills a burette with aqueous ethanedioic acid
- uses a volumetric pipette to add 25.0 cm^3 of NaOH(aq) to a conical flask
- adds thymolphthalein indicator to the conical flask
- places the conical flask on a white tile
- adds aqueous ethanedioic acid from the burette while swirling the flask, adding drop by drop near the end-point, until the solution just changes colour.

The student repeats the titration three more times.

(a) Fig. 2.1 shows the burette readings for two of the titrations.

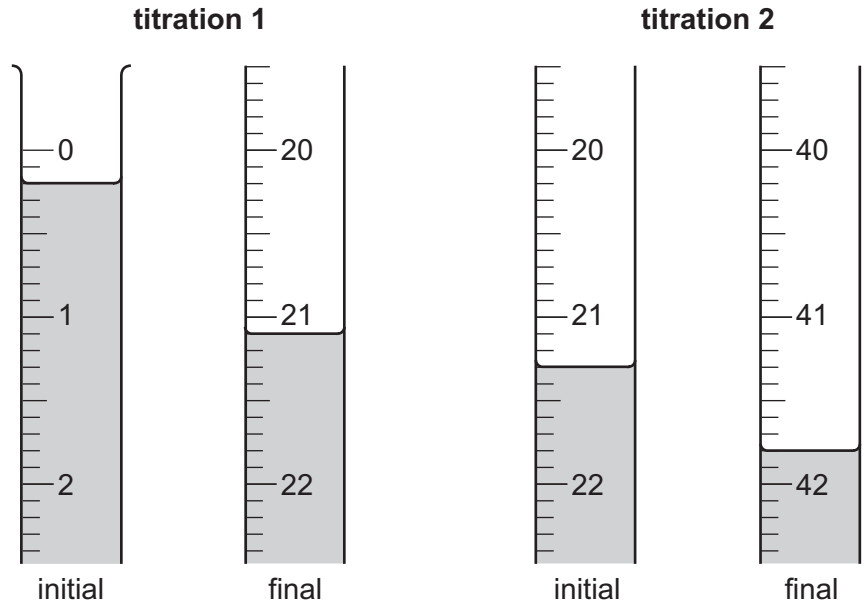

Fig. 2.1

Record the burette readings in Table 2.1.

Complete Table 2.1.

Table 2.1

	titration number			
	1	2	3	4
final burette reading / cm^3			20.1	40.4
initial burette reading / cm^3				20.5
volume of ethanedioic acid added / cm^3			20.1	
best titration results (✓)				

[3]

(b) Tick (✓) the two best titration results in Table 2.1. [1]

(c) Use the ticked (✓) titration results in Table 2.1 to calculate the average volume of aqueous ethanedioic acid needed to neutralise 25.0 cm^3 of the aqueous sodium hydroxide.

volume ..... cm^3 [1]

(d) Calculate the number of moles of NaOH in 25.0 cm^3 of 0.800 mol/dm^3 NaOH(aq).

number of moles ..... [1]

(e) One mole of ethanedioic acid is neutralised by two moles of sodium hydroxide.

Use your answers to **(c)** and **(d)** to calculate the concentration, in mol/dm^3, of ethanedioic acid.

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

concentration ..... mol/dm^3 [3]

2. Question part 3/4 | 5070 Oct-Nov 2024 P4 V1 Q2

(f) The formula of ethanedioic acid is $C_2H_2O_4 \cdot nH_2O$.

(i) $100\,cm^3$ of the aqueous ethanedioic acid contains 6.3 g of $C_2H_2O_4 \cdot nH_2O$.

Use your answer from **(e)** to calculate the relative formula mass, M_r, of $C_2H_2O_4 \cdot nH_2O$.

M_r ..... [2]

(ii) Use your answer from **(f)(i)** to deduce the value of n in $C_2H_2O_4 \cdot nH_2O$.

Give your answer to the nearest whole number.

[A_r: H, 1; C, 12; O, 16]

n ..... [1]

(g) State why the conical flask is placed on a white tile before aqueous ethanedioic acid is added from the burette.

..... [1]

(h) State why a measuring cylinder is **not** used to measure $25.0\,cm^3$ of NaOH(aq) in this experiment.

..... [1]

[Total: 14]

2. Question part 4/4 | 5070 Oct-Nov 2024 P4 V1 Q2

Question 3 starts on page 8.

2 A student titrates four samples of aqueous sodium carbonate with 0.500 mol / dm^3 dilute hydrochloric acid, HCl(aq).

In titration 1 the student:

- rinses and fills a burette with 0.500 mol / dm^3 HCl(aq)
- adds 25.0 cm^3 of aqueous sodium carbonate to a conical flask
- adds methyl orange indicator to the conical flask
- adds HCl(aq) from the burette while swirling the flask, adding drop by drop near the end-point, until the solution just changes colour.

The student repeats the titration three more times.

(a) Fig. 2.1 shows the burette readings for two of the titrations.

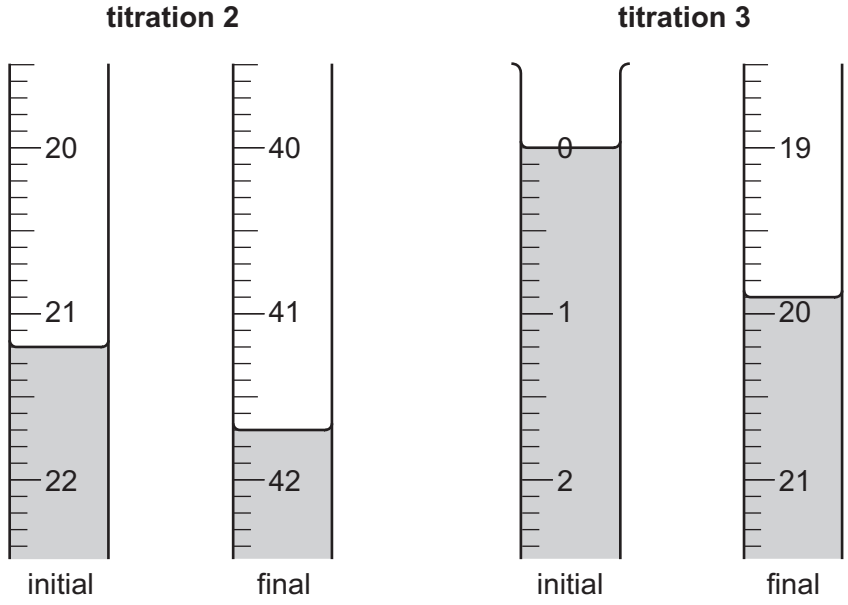

Fig. 2.1

Record the burette readings in Table 2.1.

Complete Table 2.1.

Table 2.1

	titration number			
	1	2	3	4
final burette reading / cm^3	21.1			40.4
initial burette reading / cm^3	0.2			20.3
volume of HCl(aq) used / cm^3	20.9			
best titration results (✓)				

[3]

(b) Tick (✓) the two best titration results in Table 2.1. [1]

(c) Use the ticked (✓) titration results in Table 2.1 to calculate the average volume of HCl(aq) needed to neutralise 25.0 cm^3 of the aqueous sodium carbonate.

volume ..... cm^3 [1]

(d) Use your answer from **(c)** to calculate the number of moles of HCl in the average volume of HCl(aq) needed to neutralise 25.0 cm^3 of the aqueous sodium carbonate.

number of moles ..... [1]

(e) The equation for the reaction between hydrochloric acid and sodium carbonate is:

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

Use your answer from **(d)** to calculate the concentration of the aqueous sodium carbonate.

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

concentration ..... mol/dm^3 [3]

(f) The student is provided with 150 cm^3 of the aqueous sodium carbonate.

Use your answer to **(e)** to calculate the mass of Na_2CO_3 in 150 cm^3 of this solution.

[A_r: C, 12; O, 16; Na, 23]

mass ..... g [3]

(g) State why the conical flask is swirled while HCl(aq) is added from the burette.

..... [1]

(h) State why the HCl(aq) is added drop by drop near the end-point.

..... [1]

[Total: 14]

4. Question part 1/3 | 5070 May-June 2025 P4 V1 Q2

2 Solid **A** is impure calcium carbonate.

A student determines the number of moles of calcium carbonate in a sample of **A**.

(a) The student:

- places the sample of **A** into a beaker
- uses a measuring cylinder to add 100 cm^3 of 0.250 mol/dm^3 hydrochloric acid, HC*l*, to the beaker
- stirs the mixture until no further effervescence is observed
- labels the mixture **B**.

Calculate the number of moles of HC*l* added to the beaker.

number of moles ..... [1]

(b) The student:

- rinses a burette with water and then with 0.100 mol/dm^3 sodium hydroxide, NaOH
- fills the burette with 0.100 mol/dm^3 NaOH
- adds 25.0 cm^3 of **B** and five drops of methyl orange indicator to a conical flask
- adds NaOH from the burette to the conical flask until the methyl orange indicator just changes colour
- repeats this titration two more times.

Fig. 2.1 shows the initial and final burette readings for titration 1.

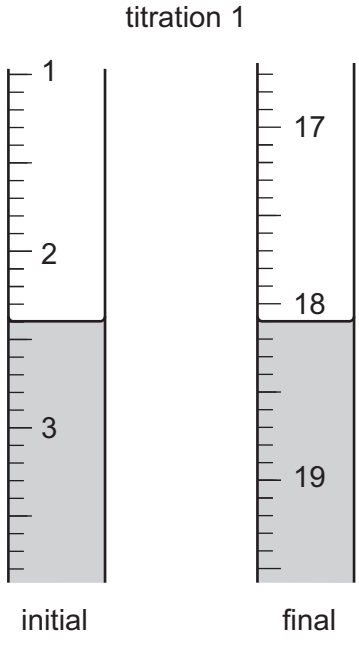

Fig. 2.1

Table 2.1 shows some of the student's results.

(i) Complete Table 2.1 by:

- writing the initial and final readings for titration 1
- calculating the volume of NaOH used in each titration
- ticking (✓) the best titration results.

Table 2.1

	titration 1	titration 2	titration 3
final burette reading / cm^3		15.4	30.8
initial burette reading / cm^3		0.2	15.4
volume used / cm^3			
best titration results (✓)			

[3]

(ii) Use the best titration results (✓) to calculate the average volume of NaOH used.

average volume ..... cm^3 [1]

(c) The acid used in **(a)** to prepare mixture **B** is in excess.

Use your answer to **(b)(ii)** to calculate the number of moles of 0.100 mol / dm^3 NaOH that react with 25.0 cm^3 of **B**.

number of moles ..... [1]

(d) Calculate the number of moles of NaOH that react with 100 cm^3 of **B**.

number of moles ..... [1]

(e) The answer to **(d)** is equal to the number of moles of HC*l* that remain in the beaker after the acid reacts with the calcium carbonate in the sample of **A**.

Use your answers to **(a)** and **(d)** to calculate the number of moles of HC*l* that react with the calcium carbonate in the sample of **A**.

number of moles ..... [1]

(f) The equation for the reaction between hydrochloric acid and calcium carbonate is shown.

$$2HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$$

Calculate the number of moles of calcium carbonate in the sample of **A**.

number of moles ..... [1]

(g) In **(a)** the mixture of **A** and acid is stirred until effervescence stops.

(i) Give a reason for mixing the reactants by stirring.

..... [1]

(ii) Give a reason for waiting for the effervescence to stop.

..... [1]

(h) In **(a)** a measuring cylinder is used to add 100 cm^3 of 0.250 mol/dm^3 HCl to the beaker.

Explain why using the measuring cylinder makes the volume of HCl used inaccurate. Suggest an improvement.

explanation .....

.....

improvement .....

[2]

(i) In **(b)** the burette is rinsed with water and then with 0.100 mol/dm^3 NaOH.

Explain why the burette is rinsed with sodium hydroxide after rinsing with water.

.....

..... [1]

[Total: 14]

5. Question part 1/3 | 5070 May-June 2025 P4 V2 Q2

2 Solid **W** is an impure organic acid, H_3A.

A student determines the mass of H_3A in a sample of **W** by titration with 0.100 mol / dm^3 sodium hydroxide, NaOH.

The student:

step 1 places the sample of **W** in a beaker
step 2 uses a measuring cylinder to add 100 cm^3 of distilled water to the beaker
step 3 stirs the mixture until the solid is fully dissolved
step 4 labels this mixture **X**
step 5 pipettes 25.0 cm^3 of NaOH into a conical flask and adds five drops of thymolphthalein indicator
step 6 fills the burette with **X**
step 7 adds **X** to the conical flask until the solution just changes colour
step 8 repeats this titration two more times.

(a) Explain why it is important to use distilled water and **not** tap water for the experiment.

.....

..... [1]

(b) Fig. 2.1 shows the initial and final burette readings for titration 1.

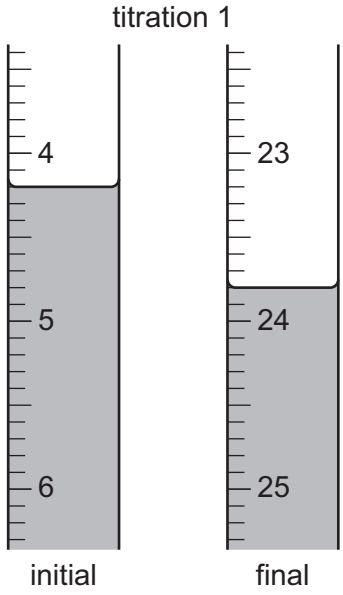

Fig. 2.1

(i) Table 2.1 shows some of the student's results.

Complete Table 2.1 by:

- writing the initial and final readings for titration 1
- calculating the volume of **X** used in each titration
- ticking (✓) the best titration results.

Table 2.1

	titration 1	titration 2	titration 3
final burette reading / cm^3		19.2	38.6
initial burette reading / cm^3		0.1	19.3
volume used / cm^3			
best titration results (✓)			

[3]

(ii) Use the best titration results (✓) to calculate the average volume of **X** used.

average volume ..... cm^3 [1]

(c) Calculate the number of moles of NaOH in 25 cm^3 of 0.100 mol / dm^3 NaOH.

number of moles ..... [1]

(d) The equation for the reaction between H_3A and NaOH is shown.

$$H_3A + 3NaOH \rightarrow Na_3A + 3H_2O$$

Calculate the number of moles of H_3A that react with 25.0 cm^3 of 0.100 mol / dm^3 NaOH.

number of moles ..... [1]

(e) Calculate the number of moles of H_3A in the sample of **W**.

number of moles ..... [1]

5. Question part 3/3 | 5070 May-June 2025 P4 V2 Q2

(f) The relative molecular mass of H_3A is 210.

Calculate the mass of H_3A in the sample of **W**.

mass ..... g [1]

(g) In step 2 a measuring cylinder is used to add 100 cm^3 of distilled water to the beaker.

Explain why using the measuring cylinder makes the volume of distilled water used inaccurate. Suggest an improvement.

explanation .....

.....

improvement .....

[2]

(h) Before the student does step 6 the burette is rinsed with distilled water and then with **X**.

(i) Explain why the burette is rinsed with distilled water.

..... [1]

(ii) Suggest and explain the effect on the titration results if the burette is **not** rinsed with **X** after rinsing with distilled water.

effect .....

explanation .....

.....

[2]

[Total: 14]