## 3.2 The mole concept

01. 0620_m21_qp_62 Q: 4

Old concrete contains calcium carbonate. Calcium carbonate reacts with dilute hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Plan an investigation to find which of two lumps of concrete contains the larger percentage of calcium carbonate. Your plan should include how you will use your results to determine which one of the two lumps has the larger percentage of calcium carbonate.

You have access to all common laboratory materials and a supply of dilute hydrochloric acid.

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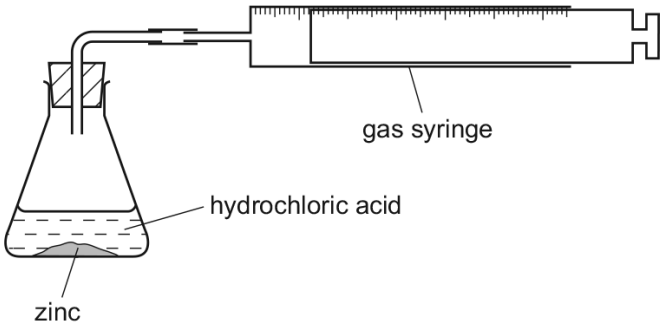
..... [6]

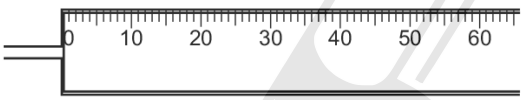
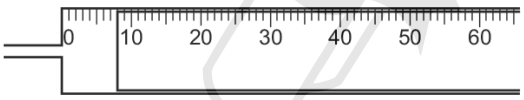
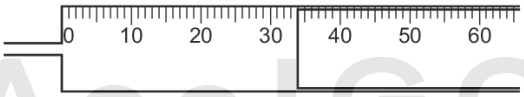
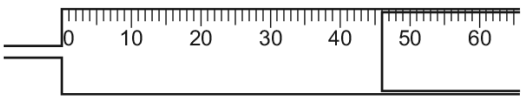
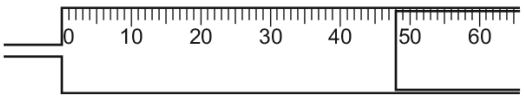
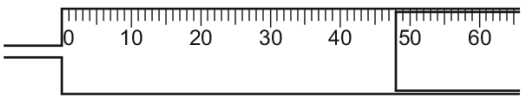
02. 0620_s14_qp_61 Q: 3

A student investigated the reaction of zinc powder with dilute hydrochloric acid using the apparatus below.




The same mass of zinc was added to different volumes of hydrochloric acid at room temperature, 20 °C. The total volume of hydrogen gas given off in each experiment was measured.

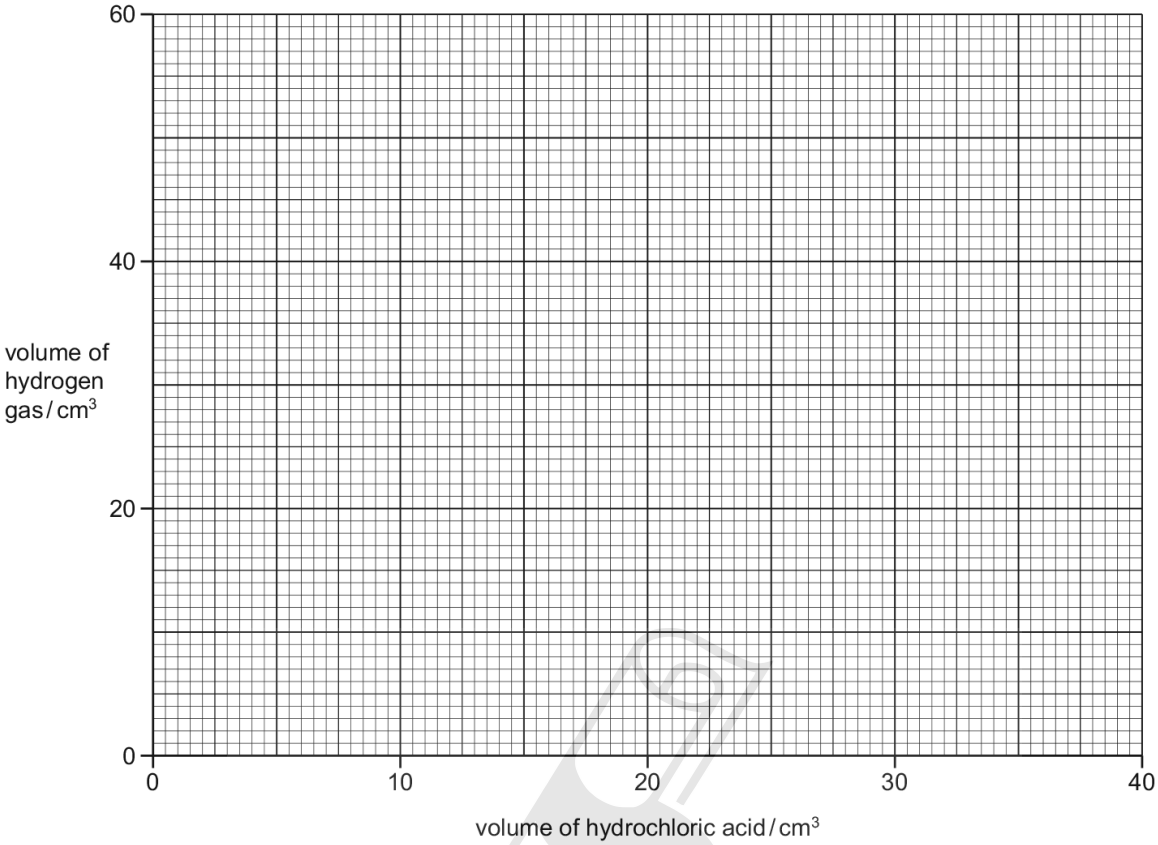
**(a)** Use the gas syringe diagrams to record the volumes of hydrogen gas in the table.

| volume of hydrochloric acid / $cm^3$ | gas syringe diagram | volume of hydrogen gas / $cm^3$ |
|---|---|---|
| 0 |  | |
| 5 |  | |
| 10 |  | |
| 15 |  | |
| 20 |  | |
| 30 |  | |
| 40 |  | |



[3]

**(b)** On the grid, plot the points and draw a smooth line graph.




[4]

**(c)** **(i)** Which point is inaccurate?

..... [1]

**(ii)** Suggest a possible reason for this inaccurate measurement.

..... [1]

**(iii)** **Use your graph** to work out the volume that would be expected to be formed.
Show clearly **on the grid** how you got your answer.

..... [2]

**(d)** Explain why the volume of hydrogen gas does not increase after 30 $cm^3$ of hydrochloric acid.

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..... [2]

**(e)** Sketch on the grid the graph you would expect if the experiments were repeated using the same mass of zinc granules. [2]

[Total: 15]

03. 0620_s17_qp_61 Q: 2

A student investigated the reaction between aqueous sodium thiosulfate and two different aqueous solutions of potassium iodate labelled solution **C** and solution **D**.

Two experiments were carried out.

*Experiment 1*

- A burette was filled with aqueous sodium thiosulfate. The initial burette reading was recorded.
- Using a measuring cylinder, 20 $cm^3$ of solution **C** were poured into a conical flask. 10 $cm^3$ of dilute sulfuric acid and 1 g of potassium iodide were added to the flask to form a solution of iodine. The flask was swirled to mix the contents.

- Aqueous sodium thiosulfate was slowly added from the burette to the flask and swirled to mix thoroughly.
- When the contents of the flask turned pale yellow, starch solution was added and the solution turned blue-black.
- More aqueous sodium thiosulfate was then added slowly to the flask until the solution just turned colourless. The final burette reading was recorded.

**(a)** Use the burette diagrams to record the readings in the table and complete the table.


initial reading final reading

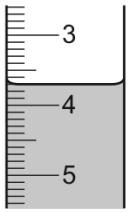
| | |
|---|---|
| final burette reading / $cm^3$ | |
| initial burette reading / $cm^3$ | |
| difference / $cm^3$ | |

[2]

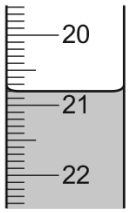
*Experiment 2*

- The conical flask was emptied and rinsed with distilled water.
- Experiment 1 was repeated using solution **D** instead of solution **C**.

**(b)** Use the burette diagrams to record the readings in the table and complete the table.




initial reading




final reading

| | |
|---|---|
| final burette reading / $cm^3$ | |
| initial burette reading / $cm^3$ | |
| difference / $cm^3$ | |

[2]

**(c) (i)** Which solution of potassium iodate, solution **C** or solution **D**, is the more concentrated? Explain your answer.

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..... [2]

**(ii)** How many times more concentrated is this solution of potassium iodate?

..... [1]

**(d)** Predict the volume of aqueous sodium thiosulfate which would be needed to react completely with 30 $cm^3$ of solution **D**.

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..... [2]

**(e) (i)** State **two** sources of error in the experiments.

1. .....

2. .....
[2]

**(ii)** Suggest **two** improvements to reduce the sources of error in **(e)(i)**.

1. .....

2. .....
[2]

[Total: 13]

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04. 0620_s17_qp_62 Q: 4

Calcium carbonate and kaolinite are both white solids found in sedimentary rocks.

Calcium carbonate reacts with dilute hydrochloric acid to form aqueous calcium chloride. Kaolinite does **not** react with dilute acids.

You are provided with a mixture of calcium carbonate and kaolinite and access to dilute hydrochloric acid.

Plan an experiment to determine the percentage by mass of calcium carbonate in the mixture.

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[Total: 6]

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05. 0620_s21_qp_62 Q: 4

The mineral epsomite contains hydrated magnesium sulfate. When epsomite is heated strongly, it loses water and eventually becomes anhydrous magnesium sulfate.

Plan an investigation to find the percentage by mass of water in a sample of epsomite. Your plan should include how you would calculate the percentage by mass of water in epsomite.
You have access to common laboratory apparatus.

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06. 0620_w20_qp_63 Q: 4

A toothpaste contains:

- sodium fluoride
- calcium carbonate
- silica
- mint flavouring.

Sodium fluoride and the mint flavouring are soluble in water.
Calcium carbonate and silica are insoluble in water.
Calcium carbonate reacts with dilute hydrochloric acid to form the soluble salt calcium chloride.

Plan an investigation to find the percentage by mass of silica in the toothpaste.

In your answer you should include how you will calculate the percentage by mass of silica in the toothpaste.

You have access to normal laboratory apparatus.

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..... [6]

01. 0620_m21_ms_62 Q: 4

| Question | Answer | Marks |
|---|---|---|
| | any 6 from:<br>1 equal / known / stated mass of concrete<br>2 crush concrete / lumps<br>3 add **excess** hydrochloric acid<br><br>**THEN** (mass left unreacted)<br>4 filter<br>5 wash and dry residue<br>6 find mass of residue<br>7 lower mass of residue has most calcium carbonate<br><br>**OR** (volume of gas made by end / in a set time)<br>4 collect gas produced<br>5 suitable apparatus to collect gas and measure volume named/drawn<br>6 and measure volume / amount of gas formed<br>7 larger volume of gas means more calcium carbonate<br><br>**OR** (mass lost)<br>4 place container on balance / weigh before<br>5 cotton wool in opening of container<br>6 measure mass loss / weigh after<br>7 bigger mass loss is more calcium carbonate<br><br>**OR** (mass calcium chloride made)<br>4 filter<br>5 evaporate (filtrate) to dryness<br>6 measure mass solid calcium chloride<br>7 bigger mass is more calcium carbonate<br><br>**max 6** | **6** |

02. 0620_s14_ms_61 Q: 3

**(a)** volumes of hydrogen completed correctly (3)
0, 8, 34, 42, 46, 48, 48 [3]
**guidance:** 7 correct (3); 6 correct (2); 5 correct (1); 4 or fewer correct (0)

**(b)** points plotted correctly including origin (3)
**guidance:** 7 correct (3); 6 correct (2); 5 correct (1); 4 or fewer correct (0)

smooth curve missing anomalous point (1) [4]

**(c) (i)** point at 5 $cm^3$ / 8 $cm^3$ $H_2$ / second point (1) [1]

**(ii)** leak / loss / escape of gas or wrong amount / too little HC *l* or zinc (1) [1]
**allow:** syringe sticking

**(iii)** reading from graph (1) ± half small square

indication on graph (1) [2]

**(d)** excess acid (1)

all zinc reacted (1) [2]
**allow:** used up

**(e)** sketch curve identical (2)

different curve levelling out at 48 $cm^3$ (1) [2]
**note:** must be some indication of a second curve

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03. 0620_s17_ms_61 Q: 2

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|---|---|---|
| (a) | initial and final readings completed correctly: 4.1, 38.3 | 1 |
| | difference completed correctly: 34.2 | 1 |
| (b) | initial and final readings completed correctly: 3.7, 20.8 | 1 |
| | difference completed correctly: 17.1 | 1 |
| (c)(i) | solution **C** is more concentrated | 1 |
| | a greater volume of thiosulfate was needed | 1 |
| (c)(ii) | 2 □ as concentrated | 1 |

| | | |
|---|---|---|
| (d) | 1.5 □ value from table in **(b)** for Experiment 2 | **1** |
| | unit: $cm^3$ | **1** |
| (e)(i) | 2 sources of error, e.g.:<br>□ using a measuring cylinder to measure solution **C** / solution **D**<br>□ only carrying out the experiments once<br>□ going past the end-point | **2** |
| (e)(ii) | 2 meaningful improvements **related to (e)(i)**:<br>□ use a pipette / burette<br>□ repeat the experiment<br>□ improvement linked to going past the end-point | **2** |

04. 0620_s17_ms_62 Q: 4

| | | |
|---|---|---|
| | | **6** |
| | **the filtration method**<br>any 6 from:<br>□ weigh mixture (of calcium carbonate and kaolinite)<br>□ add (dilute) hydrochloric acid<br>□ in excess / continue adding until there is no more fizzing / add until no more gas is evolved<br>□ filter<br>□ wash residue / kaolinite<br>□ dry<br>□ weigh residue / kaolinite<br>□ (change in mass / initial mass) □ 100 (%) | |
| | **the gas collection / loss of mass method**<br>any 6 from:<br>□ weigh mixture (of calcium carbonate and kaolinite)<br>□ add (dilute) hydrochloric acid<br>□ in excess / continue adding until there is no more fizzing / add until no more gas is evolved<br>□ collect gas in a syringe / measure final total mass<br>□ measure volume of gas / mass loss<br>□ calculate moles of $CaCO_3$ / $CO_2$<br>□ calculate mass of $CaCO_3$<br>□ (mass of $CaCO_3$ / initial mass) □ 100 (%) | |
| | **the calcium chloride method**<br>any 4 from:<br>□ weigh mixture (of calcium carbonate and kaolinite)<br>□ add (dilute) hydrochloric acid<br>□ in excess / continue adding until there is no more fizzing / add until no more gas is evolved<br>□ filter | **1** |

05. 0620_s21_ms_62 Q: 4

| Question | Answer | Marks |
|---|---|---|
| | any 6 from:<br>• weighed sample / stated mass (e.g. 5 g) / known mass of epsomite<br>• in a crucible<br>• heated (strongly using a Bunsen burner / spirit burner)<br>• reweigh<br>• heat again, reweigh, continue until mass stops changing<br>• calculate mass of water lost by original mass – final mass<br>• calculate percentage water by 100 × mass water / original mass | **6** |

06. 0620_w20_ms_63 Q: 4

| Question | Answer | Marks |
|---|---|---|
| | any 6 from:<br>• weigh toothpaste<br>• add (dilute) hydrochloric acid<br>• to excess / until no more fizzing<br>• filter<br>• wash residue / silica (with water) and dry<br>• weigh residue / silica<br>• (mass silica / initial mass) × 100(%)<br><br>**max 6** | **6** |