Answers

All exam-style questions and sample answers in this title were written by the authors.
In examinations, the way marks are awarded may be different.

Chapter 1

Practice question 1

balance	grams (g)
measuring cylinder	cubic centimetres (cm^3)
thermometer	degrees Celsius (°C)
ruler	centimetres (cm)
gas syringe	cubic centimetres (cm^3)

Practice question 2

a g **b** °C **c** s **d** cm **e** m^2 **f** cm^3

Practice question 3

a g/s **b** kg/m^3 **c** cm^3/s

Practice question 4

a 692 381 **b** 1 949 789 **c** 0.17
d 0.09 **e** 0.000 008 5

Practice question 5

a 115 362 **b** 0.123 451 **c** 0.000 002
d 232.013 4 **e** 104 895.82

Practice question 6

a $3 \times 10 \times 10 \times 10 = 3000$
b $45 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 45\,000\,000$
c $4 \times 10 = 40$
d 1 230 000 000 000

Practice question 7

a 0.02 **b** 0.000 034 **c** 0.000 000 009
d 0.000 43

Practice question 8

a **i** 0.003 g **ii** 0.000 004 g **iii** 3000 g
b **i** 0.004 m **ii** 0.02 m **iii** 0.000 000 007 m
c **i** 0.04 m **ii** 0.2 m

Practice question 9

a **i** 0.042 g **ii** 0.000 402 g **iii** 345 000 g
b **i** 0.000 000 074 m
ii 0.000 000 007 4 m
iii 0.000 000 704 m

Practice question 10

a 1.34×10^5 **b** 1.03×10^5 **c** 1.2×10^8 **d** 1.4×10^2

Practice question 11

a 3.4×10^{13} **b** 1.42×10^5 g **c** $1.45 \times 10^2\ m^3$

Practice question 12

a 3.4×10^{-3} **b** 5.4×10^{-6}
c 5.07×10^{-4} **d** 9.754×10^{-9}

Practice question 13

a 1.5×10^{-10} m **b** 3×10^{-3} g
c 2.3×10^{-8} g **d** $9 \times 10^{-4}\ m^3$

Practice question 14

a **i** 400 000 atoms **ii** 424 000 atoms
b **i** 0.3 g **ii** 0.32 g
c **i** 1 200 000 atoms **ii** 1 060 000 atoms
d **i** 0.4 g **ii** 0.41 g

Further questions

1 **a** The diameter of a gold coin is 3 cm.
b The thickness of a gold ring is 3 mm.
c The mass of a gold bar is 12.4 kg.
d The thickness of gold leaf (sheet) is 0.1 µm.
2 **a** 1.204×10^{24}
b 6.02×10^{22}
3 **a** $a = 2 \times 10^{-2}$ m = 0.02 m, $b = 2 \times 10^{-2}$ m = 0.02 m, $c = 5 \times 10^{-2}$ m = 0.05 m
b **i** $0.02 \times 0.02 \times 0.05 = 0.000\,02\ m^3$
ii 2×10^{-5} m
c **i** density $= \dfrac{0.054}{0.000\,02} = 2700\ kg/m^3$
ii $3000\ kg/m^3$

Chapter 2

Practice question 1

a 42 °C **b** 96 °C **c** 13 °C

Practice question 2

a $24\ cm^3$ **b** $1.8\ cm^3$ **c** $7.2\ cm^3$

Practice question 3

a $21.3\ cm^3$ **b** $15.8\ cm^3$

Practice question 4

a 8.5 °C **b** 36.0 °C **c** 98.5 °C

Practice question 5

a 11.70 cm^3 **b** 27.75 cm^3 **c** 31.45 cm^3

Practice question 6

	Independent variable	Dependent variable
a	volume of acid	pH
b	time	mass
c	temperature	time
d	type of substance	pH

Practice question 7

a atomic number
b temperature

Practice question 8

Volume is continuous.
Time is continuous.
Temperature is continuous.
Type of substance is categorical.
Atomic number is discrete.

Practice question 9

a

Volume of acid cm^3	pH
0	
1	
2	
3	
4	
5	
6	

b

Time s	Mass g
0	
30	
60	
90	
120	
150	
180	

c

Temperature °C	Time s
10	
20	
30	
40	

d

Substance	pH
A	
B	
C	
D	
E	

Practice question 10

a

Temperature of acid °C	Time s			Mean s
	Test 1	Test 2	Test 3	
20				
30				
40				

b

Metal	Mass g	Volume cm^3	Density g/cm^3
copper			
iron			
aluminium			
tin			

Practice question 11

a 20.03 cm^3 (4 sf)

b $\frac{20}{16} = 1.3\ cm^3/s$ (2 sf)

c $\frac{1.24}{10} = 0.12\ g/s$ (2 sf)

Further questions

1 **a** and **b**

Type of metal	Mass g	New volume cm^3	Volume of metal cm^3	Density g/cm^3
iron	31.4	9.0	4.0	7.9
aluminium	11.9	9.4	4.4	2.7
copper	33.9	8.8	3.8	8.9

The measurement with the least number of significant figures is the volume (2 sf) so density should be recorded to 2 sf.

2 **a** and **b**

Test	Maximum temperature of solution °C	Temperature change °C
1	34.0	11.0
2	32.0	9.0
3	33.5	10.5

c $\frac{11.0 + 9.0 + 10.5}{3} = 10.2\,°C$ (3 sf)

d $\frac{-2.5 + (-3.0) + (-4.0)}{3} = -3.2\,°C$ (2 sf)

Chapter 3

Practice question 1

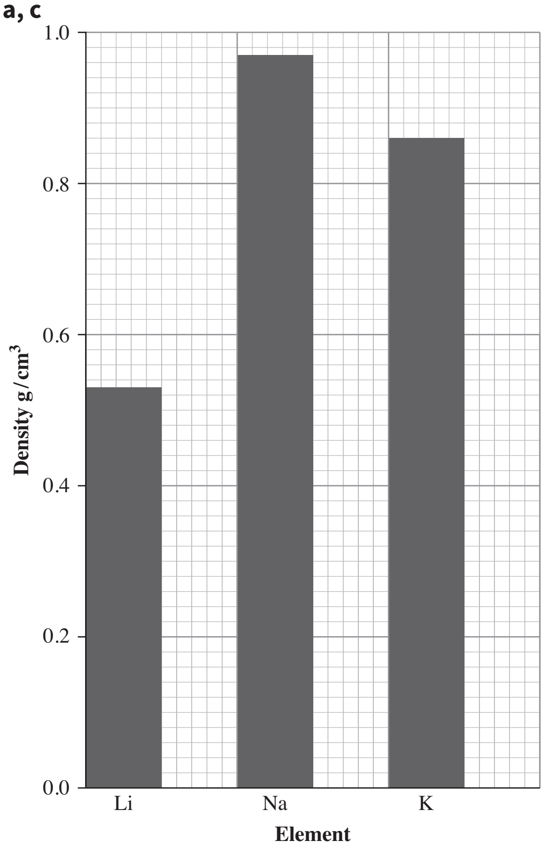
b 1 large square ≡ 40, meaning that a maximum value of 120 °C can be plotted.

Practice question 2

1 large square ≡ 200 °C, meaning that a maximum value of 1600 °C can be plotted.

Practice question 3

a, c

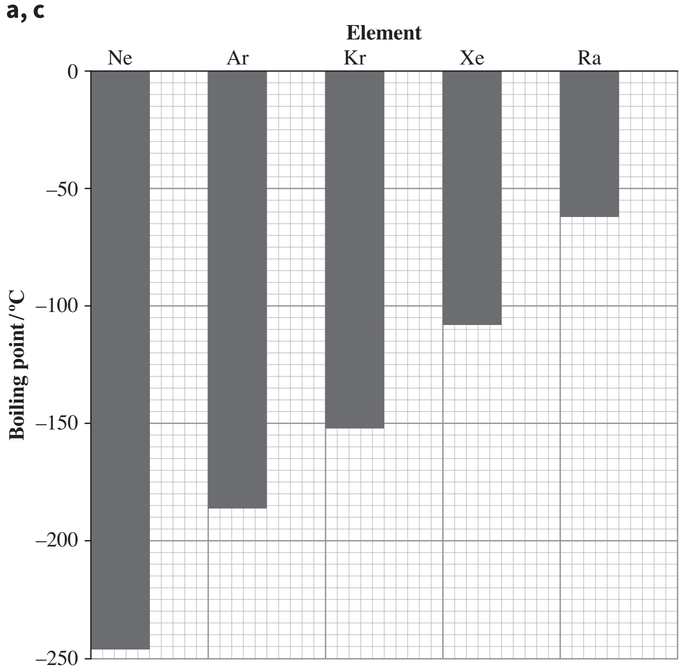


Densities of three Group 1 alkali metals

b 1 small square ≡ 0.02 g/cm^3

Practice question 4

a, c



Boiling points of five noble gases

b 1 small division ≡ 5 °C

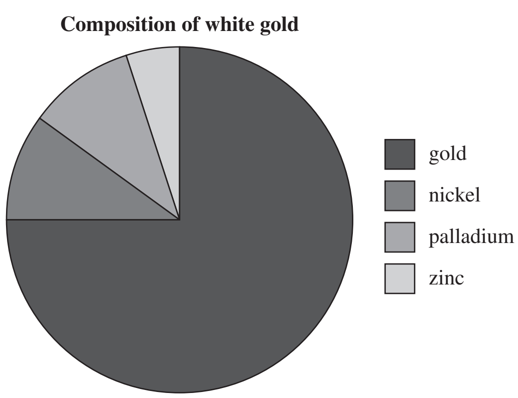
Practice question 5

copper 324°, tin 36°

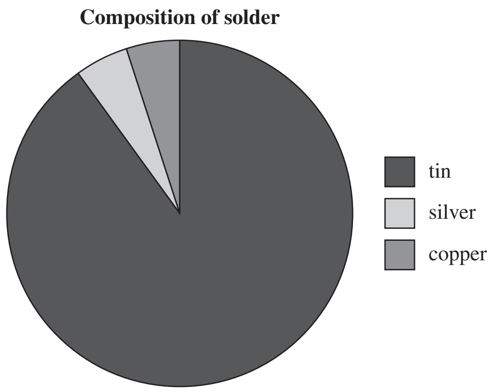
Practice question 6

Metal	Angle °	Angle rounded to nearest whole number
iron	266.4	266°
chromium	64.8	65°
nickel	28.8	29°
Total angle		**360°**

Practice question 7



Practice question 8



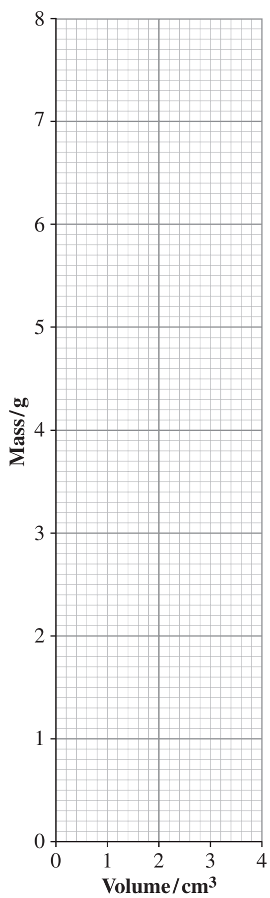
Practice question 9

The independent variable, time, should be on the horizontal axis.
The dependent variable, volume of hydrogen, should be on the vertical axis.

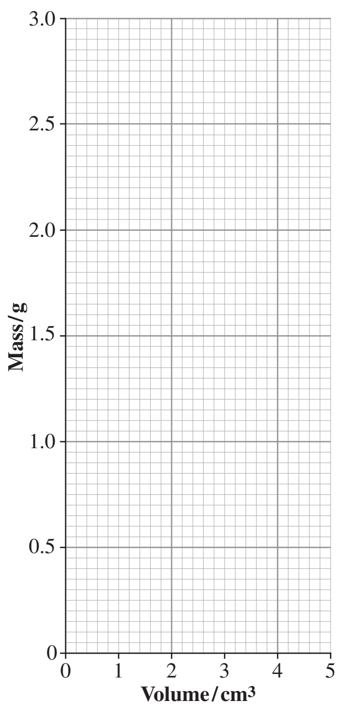
Practice question 10

The independent variable, concentration of hydrochloric acid, should be on the horizontal axis.
The dependent variable, time, should be on the vertical axis.

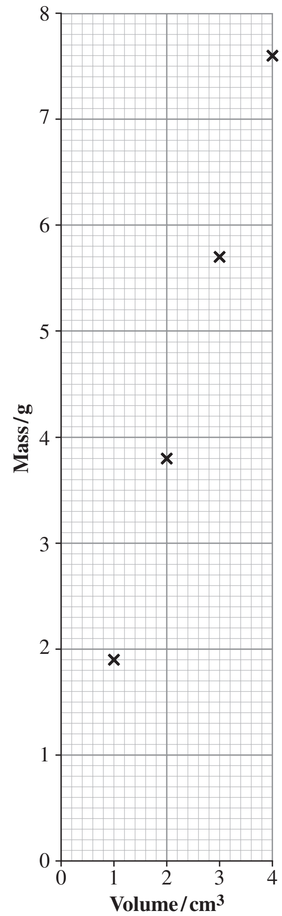
Practice question 11



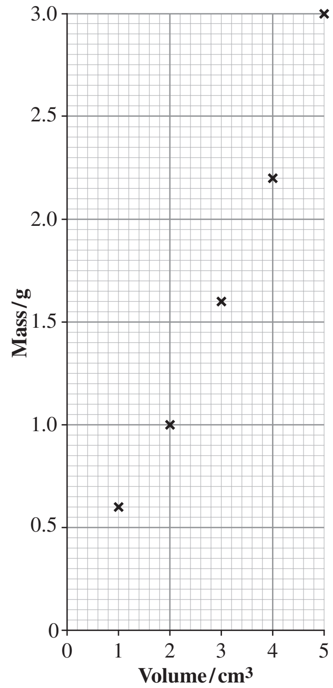
Practice question 12



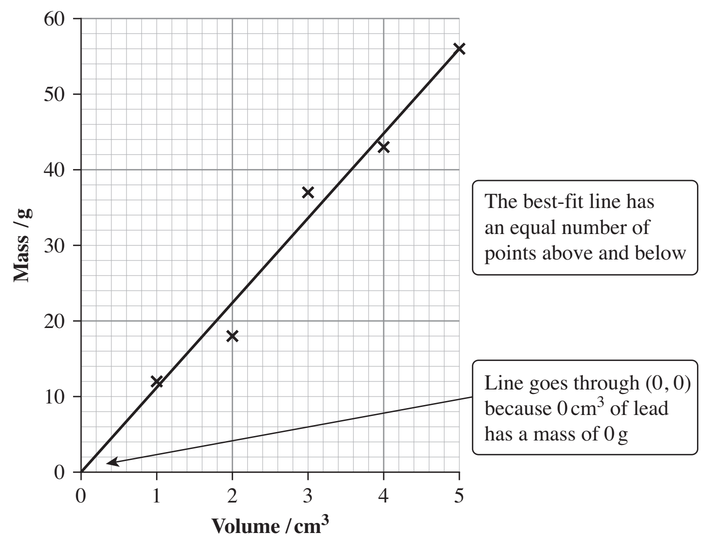
Practice question 13



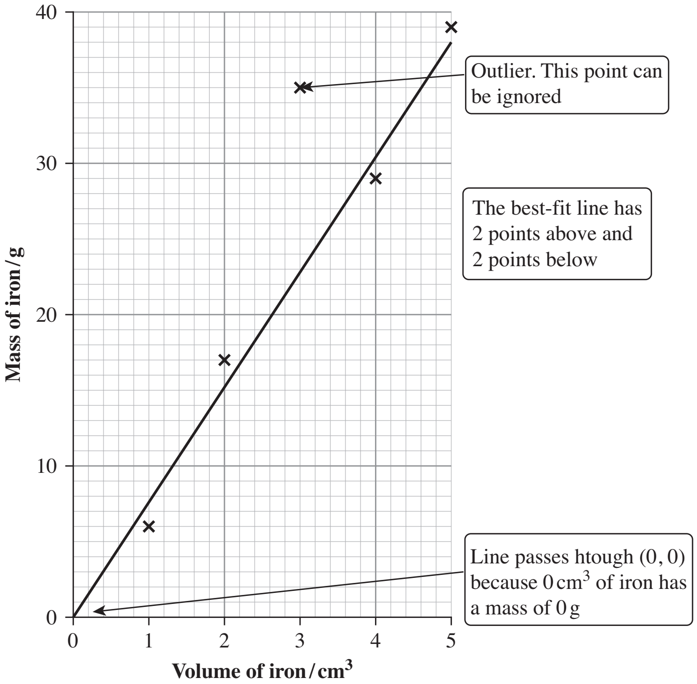
Practice question 14



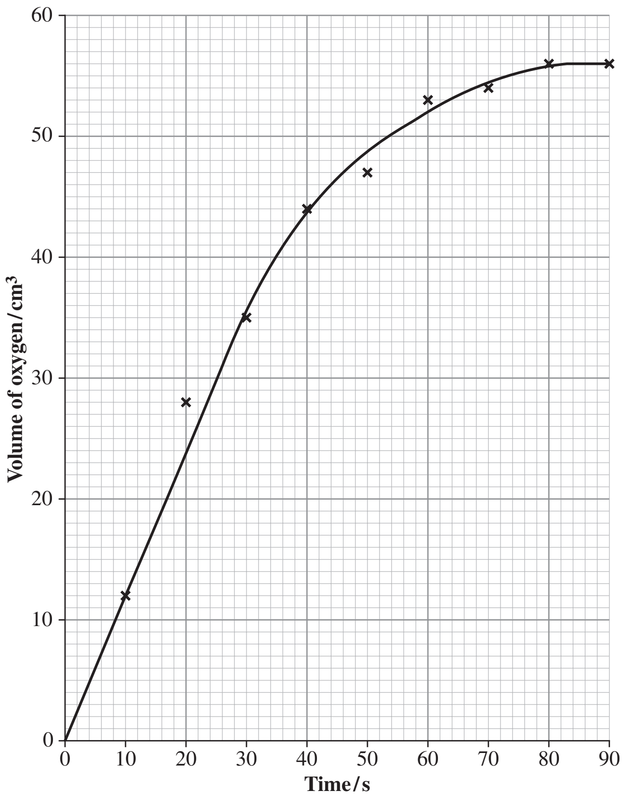
Practice question 15



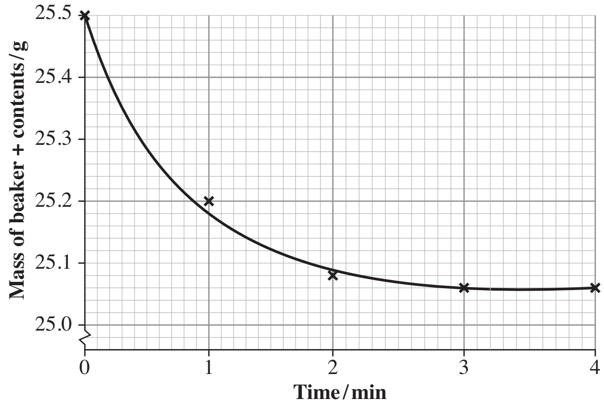
Practice question 16



Practice question 17

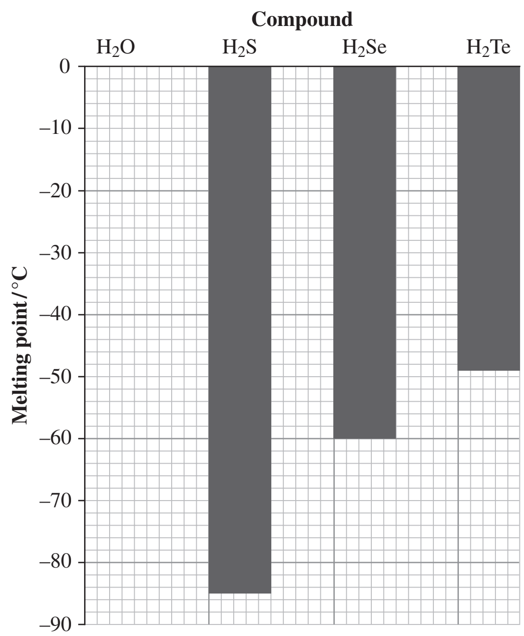


Practice question 18

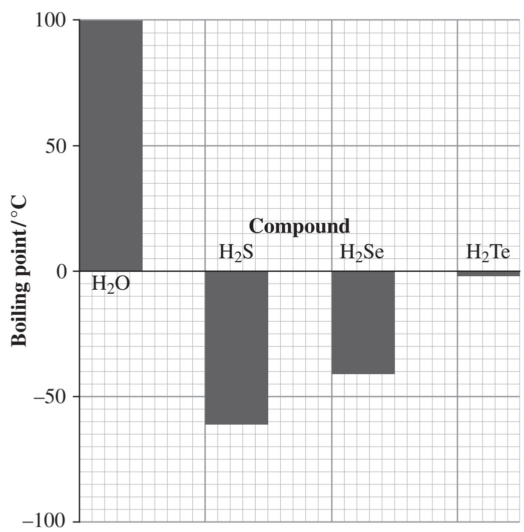


Further questions

1 a i



ii



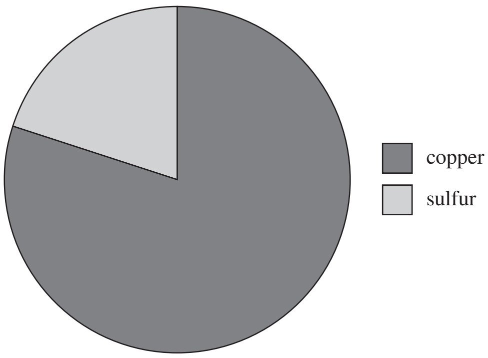
b **i** H_2O does not fit the pattern.

ii If H_2O did fit the pattern, then on Earth's surface it would be above its boiling point and in the gas state, meaning there would be no liquid water for life on Earth.

2 **a**

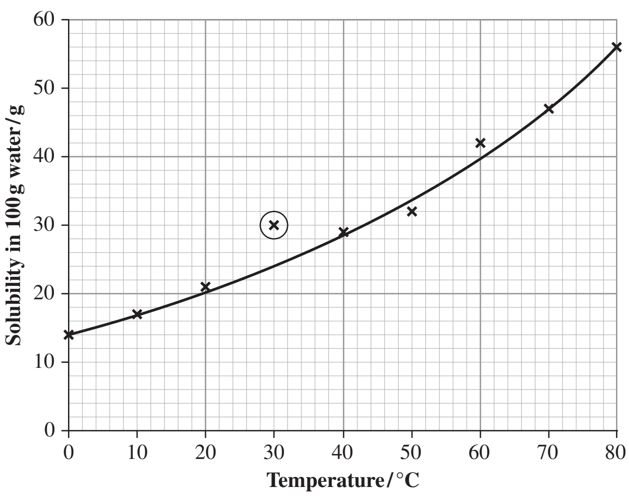
Ore	Percentage copper (rounded to nearest whole number)	Percentage sulfur
Covellite, CuS	67	33
Chalcocite, Cu_2S	80	20
Dignite, Cu_9S_5	78	22

b



c A bar chart is best to compare the percentage of copper in different ores because the percentages do not form part of a whole and so this cannot be shown on one pie chart. In order to compare the percentages several pie charts would need to be drawn, whereas a bar chart makes it easier to compare the percentages all in one chart.

3



Chapter 4

Practice question 1

a The total number of hybrid and electric cars produced increased year by year by increasing amounts.

b On the scale each large square represents 10 000 cars. The highest number of cars produced was 52 000 and the lowest number was 23 000.

c The increase in number of cars produced is 52 000 – 23 000 = 29 000 cars

Practice question 2

a The greatest percentage of fresh water is held in the ice caps and glaciers.

b The percentage is slightly less than 75%, so a reasonable estimate is about 70%.

c The smallest percentage of freshwater is held as surface water.

Practice question 3

a $9\,cm^3$ **b** $22\,cm^3$ **c** 2.5 minutes **d** 3.5 minutes

Practice question 4

a 46 g **b** 55 g **c** $5.4\,cm^3$

Practice question 5

a B and D **b** A and E
c A and C **d** B and F

Practice question 6

The graph has the steepest gradient at the start. The gradient gradually decreases until at about 3 minutes when it becomes zero (horizontal).
This means that the reaction has the fastest rate at the start. The rate of reaction gradually decreases until, at about 3 minutes, the reaction stops.

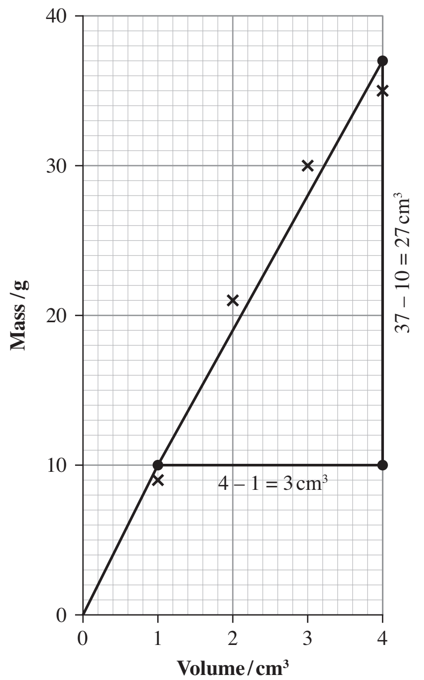
Practice question 7

$$\text{gradient} = \frac{\text{vertical change}}{\text{horizontal change}} = \frac{\text{change in mass}}{\text{change in volume}}$$

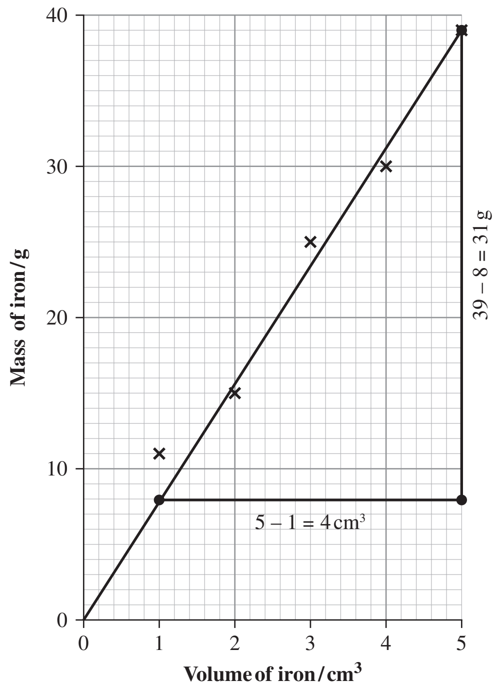
$$= \frac{37 - 10}{4 - 1} = \frac{27}{3}$$

$$= 9\,g/cm^3$$

(The reference density for copper is $8.92\,g/cm^3$.)



Practice question 8



$$\text{gradient} = \frac{\text{vertical change}}{\text{horizontal change}} = \frac{\text{change in mass}}{\text{change in volume}}$$

$$= \frac{39 - 8}{5 - 1} = \frac{31}{4}$$

$= 7.75$

$= 7.8\ g/cm^3$ (2 sf)

(Reference value for iron is $7.86\ g/cm^3$.)

Further questions

1 **a** **i** 180 °C

ii The melting point of potassium is 65 °C so the difference is 180 – 65 = 115 °C.

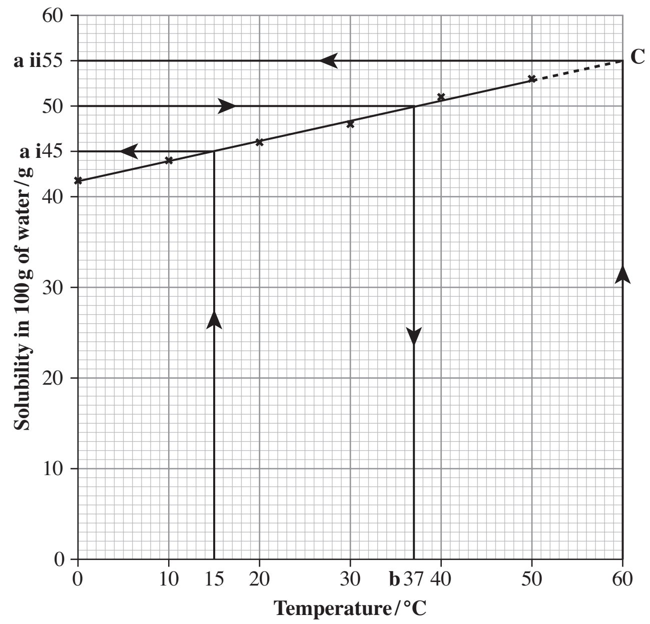
b **i** The melting point gets gradually less (going down Group 1).

ii A sensible estimate for the melting point of rubidium is from 30 °C to 40 °C.

c **i** Lithium oxide contains just under 50% lithium (by mass).

ii Sodium oxide contains about 75% sodium (by mass).

2



a **i** 45 g

ii 55 g

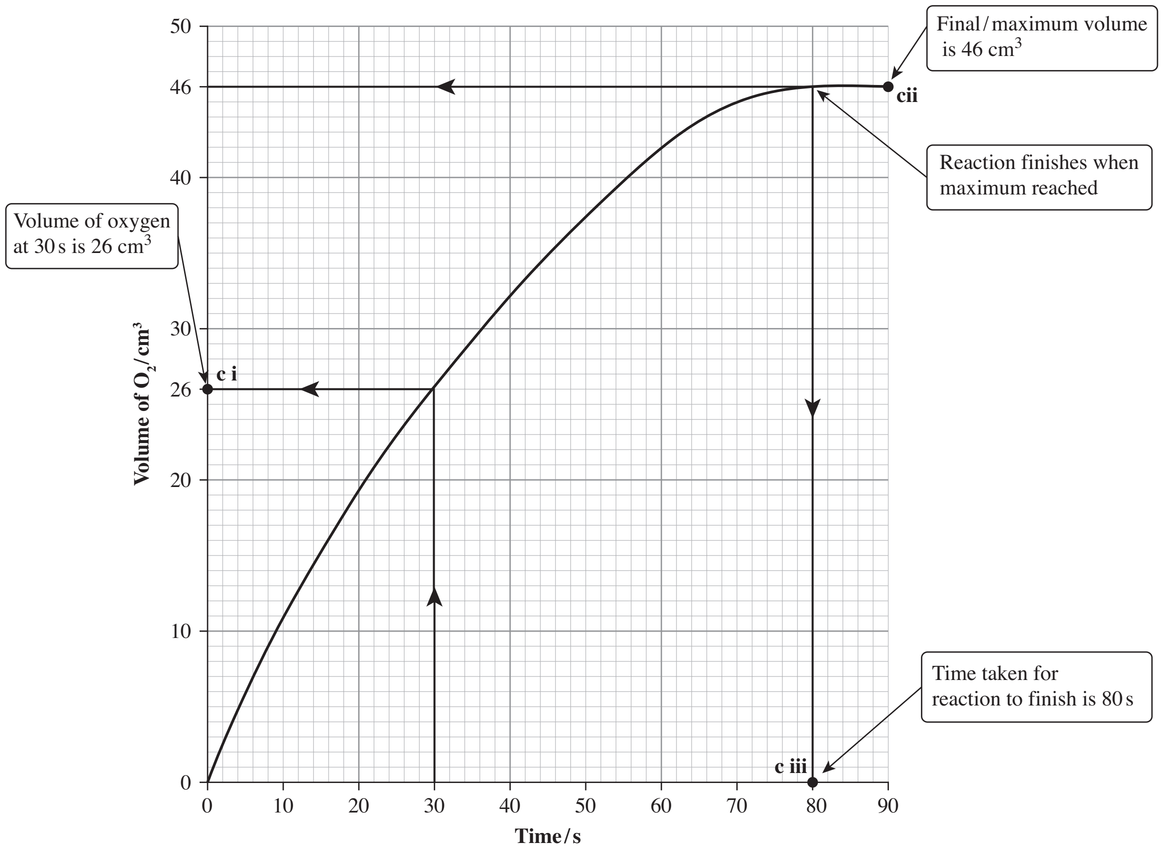
b 37 °C

3 **a** The graph shows that as time increases the volume of oxygen produced also increases, until it reaches a maximum value.

b **i** The gradient is calculated by dividing volume by time so the units are cm^3/s.

ii The rate of reaction is fastest at the start of the reaction. The rate of reaction decreases until it is $0\ cm^3/s$.

c **i** $26\,cm^3$ **ii** $46\,cm^3$ **iii** 78 s



Chapter 5

Practice question 1

a $40 + (16 + 1) \times 2$
b $40 + 12 + 16 \times 3$
c $1 + 14 + 16 \times 3$
d $24 + 32 + 16 \times 4$
e $39 + 55 + 16 \times 4$
f $24 + (14 + 16 \times 3) \times 2$
g $(14 + 1 \times 4) \times 2 + 32 + 16 \times 4$

Practice question 2

a $40 + (16 + 1) \times 2 = 74$
b $40 + 12 + 16 \times 3 = 100$
c $1 + 14 + 16 \times 3 = 63$
d $24 + 32 + 16 \times 4 = 120$
e $39 + 55 + 16 \times 4 = 158$
f $24 + (14 + 16 \times 3) \times 2 = 148$
g $(14 + 1 \times 4) \times 2 + 32 + 16 \times 4 = 132$

Practice question 3

a $\frac{40}{40 + 12 + 16 \times 3} \times 100 = 40\%$

b $\frac{12}{40 + 12 + 16 \times 3} \times 100 = 12\%$

c $\frac{16 \times 3}{40 + 12 + 16 \times 3} \times 100 = 48\%$

Practice question 4

Answers given to two significant figures.

a $\frac{14}{1 + 14 + 48} \times 100 = 22\%$

b $\frac{24}{24 + 32 + 4 \times 16} \times 100 = 20\%$

c $\frac{24}{24 + (14 + 48) \times 2} \times 100 = 16\%$

d There are two N atoms in the chemical formula so

$$\text{percentage mass} = \frac{14 \times 2}{2 \times (14 + 4) + 32 + (16 \times 4)} \times 100$$
$$= 21\%$$

Practice question 5

a number of moles $= \frac{\text{mass}}{M_r} = \frac{10}{24 + 16} = 0.25\,\text{mol}$

b $\frac{285}{24 + 35.5 \times 2} = 3\,\text{mol}$

c $\frac{10}{40 + 12 + 16 \times 3} = 0.1\,\text{mol}$

d $\frac{34}{14 + 3 \times 1} = 2\,\text{mol}$

e $1.8\,\text{kg} = 1800\,\text{g}, \frac{1800}{2 \times 1 + 16} = 100\,\text{mol}$

Practice question 6

a number of moles $= \frac{\text{volume}}{\text{molar volume}} = \frac{36}{24} = 1.5\,\text{mol}$

b $\frac{3}{24} = 0.125\,\text{mol}$

c $\frac{12}{24} = 0.5\,\text{mol}$

d $6000\,\text{cm}^3 = 6\,\text{dm}^3\ (1\,\text{dm}^3 = 1000\,\text{cm}^3), \frac{6}{24} = 0.25\,\text{mol}$

e $300\,\text{cm}^3 = 0.3\,\text{dm}^3, \frac{0.3}{24} = 0.0125\,\text{mol}$

Practice question 7

a concentration $= \frac{\text{number of moles}}{\text{volume}} = \frac{0.5}{1} = 0.5$
$= 0.5\,\text{mol/dm}^3$

b $\frac{0.5}{0.5} = 1\,\text{mol/dm}^3$

c $\frac{1}{2} = 0.5\,\text{mol/dm}^3$

d $500\,\text{cm}^3 = 0.5\,\text{dm}^3, \frac{0.5}{0.5} = 1\,\text{mol/dm}^3$

e $250\,\text{cm}^3 = 0.25\,\text{dm}^3, \frac{0.5}{0.25} = 2\,\text{mol/dm}^3$

Practice question 8

a volume = number of moles × molar volume = 2 × 24
$= 48\,\text{dm}^3$

b mass = number of moles × M_r
$= 0.5 \times (40 + 12 + 16 \times 3) = 50\,\text{g}$

c number of moles = concentration × volume
$= 0.1 \times 0.25 = 0.025$ moles

d volume $= \frac{\text{number of moles}}{\text{concentration}} = \frac{0.04}{0.5} = 0.08\,\text{dm}^3$

Practice question 9

a $M_r = \frac{\text{mass}}{\text{number of moles}} = \frac{36}{2} = 18$

b molar gas volume $= \frac{\text{volume}}{\text{number of moles}} = \frac{48}{2} = 24\,\text{dm}^3$

Practice question 10

Step 1 Mass of NaOH (unknown)
M_r of NaOH = 40
Volume of NaOH solution = $0.02\,\text{dm}^3$
Concentration of NaOH = $0.2\,\text{mol/dm}^3$

number of moles of NaOH $= \frac{\text{mass of NaOH}}{M_r \text{ of NaOH}}$

Rearranging gives:
mass of NaOH = number of moles of NaOH × M_r of NaOH

Step 2 mass of NaOH = number of moles of NaOH × 40
So number of moles of NaOH is still unknown.

Step 3 concentration of NaOH $= \frac{\text{number of moles of NaOH}}{\text{volume of NaOH}}$

Rearranging gives:
number of moles of NaOH = concentration of NaOH × volume of NaOH
$= 0.2 \times 0.02$
$= 0.004\,\text{mol/dm}^3$

Step 4 mass of NaOH = number of moles of NaOH × 40
$= 0.004 \times 40$
$= 0.16\,\text{g}$

Practice question 11

Step 1 Mass of CO_2 = 0.6 g
M_r of $CO_2 = 12 + 16 \times 3 = 60$
Volume of CO_2 unknown

number of moles of $CO_2 = \frac{\text{volume of } CO_2}{\text{molar gas volume}}$

Rearranging gives:
volume of CO_2 = number of moles CO_2 × molar gas volume

Step 2 volume of CO_2 = number of moles CO_2 × 24

Step 3 number of moles of $CO_2 = \frac{\text{mass of } CO_2}{M_r \text{ of } CO_2}$

Step 4 number of moles of $CO_2 = \frac{0.6}{60} = 0.01$ moles

Step 5 volume of CO_2 = number of moles of CO_2 × 24
$= 0.01 \times 24 = 0.24\,\text{dm}^3$

Practice question 12

a M_r of $CuCO_3$ = 124, M_r of CuO = 80, M_r of CO_2 = 44

b 124 g of CuCO produces 80 g of CuO.

So $\frac{124}{124}$ = 1 g of $CuCO_3$ produces $\frac{80}{124}$ g of CuO.

So 31 g of $CuCO_3$ produces $\frac{80}{124} \times 31$ g of CuO = 20 g

c mass of $CO_2 = \frac{44}{124} \times 31 = 11$ g

Practice question 13

a 24 g of magnesium produce 40 g of MgO (a ratio of 2 : 2 is same as 1 : 1).

So $\frac{24}{24}$ = 1 g of Mg produces $\frac{40}{24}$ g of MgO.

So 0.96 g of Mg produces $0.96 \times \frac{40}{24} = 1.6$ g of MgO.

b 24 g of Mg produces 40 g of MgO.

So $\frac{24}{40}$ g of Mg produces $\frac{40}{40}$ = 1 g of MgO.

So $\frac{24}{40} \times 0.2$ g of Mg produces 0.2 g of MgO.

0.12 g of Mg is needed to produce 0.2 g of MgO.

Practice question 14

a 28 g of N_2 produces $2 \times (14 + 3 \times 1) = 34$ g of NH_3.

So $\frac{28}{28}$ = 1 g of N_2 produces $\frac{34}{28}$ g of NH_3.

So 0.7 g of N_2 produces $\frac{34}{28} \times 0.7 = 0.85$ g of NH_3.

b $3 \times (2 \times 1) = 6$ g of H_2 produces $2 \times (14 + 3 \times 1) = 34$ g of NH_3.

So $\frac{6}{34}$ g of H_2 produces $\frac{34}{34}$ = 1 g of NH_3.

So $\frac{6}{34} \times 0.17 = 0.03$ g of H_2 produces 0.17 g of NH_3.

Practice question 15

a M_r of $CuCO_3$ = 124, M_r of CuO = 80, M_r of CO_2 = 44

b 1 mole of $CuCO_3$ produces 1 mole of CuO.

number of moles of $CuCO_3 = \frac{\text{mass of } CuCO_3}{M_r \text{ of } CuCO_3}$

$= \frac{372}{124} = 3$ moles

This means that 3 moles of CuO are produced.
Rearranging gives:
mass of CuO = number of moles of CuO × M_r of CuO
$= 3 \times 80 = 240$ g

c 1 mole of $CuCO_3$ produces 1 mole of CO_2.
As worked out above, 372 g $CuCO_3$ contains 3 moles, so 3 moles of carbon dioxide are produced.
Mass CO_2 = number of moles CO_2 × M_r of CO_2
$= 3 \times 44 = 132$ g

Practice question 16

a M_r of SO_2 = 64 g
1 mole of S produces 1 mole of SO_2.

number of moles S $= \frac{\text{mass of S}}{M_r \text{ of S}} = \frac{3.2}{32} = 0.1$ moles

mass SO_2 = number of moles of SO_2 × M_r of SO_2
$= 0.1 \times 64 = 6.4$ g

b number of moles of $SO_2 = \frac{\text{mass of } SO_2}{M_r \text{ of } SO_2} = \frac{3.2}{64}$
$= 0.05$ moles

mass S = number of moles of S × M_r of S $= 0.05 \times 32$
$= 1.6$ g

Practice question 17

a M_r of $NH_3 = 14 + 3 \times 1 = 17$
M_r of $N_2 = 2 \times 14 = 28$
According to the chemical equation, 1 mole of N_2 produces 2 moles of NH_3.

number of moles $N_2 = \frac{\text{mass of } N_2}{M_r \text{ of } N_2} = \frac{21}{28} = 0.75$ moles

This means that $2 \times 0.75 = 1.5$ moles of NH_3 are produced.
mass of NH_3 = number of moles NH_3 × M_r
$= 1.5 \times 17 = 25.5$ g

b 3 moles of H_2 produce 2 moles of NH_3.
So 1.5 moles H_2 produce 1 mole of NH_3.

number of moles $NH_3 = \frac{\text{mass of } NH_3}{M_r \text{ of } NH_3} = \frac{0.34}{17}$
$= 0.02$ moles

This means that 0.02 moles × 1.5 = 0.03 moles of H_2 are required.
mass of H_2 = number of moles H_2 × M_r
$= 0.03 \times 2 = 0.06$ g of H_2

Further questions

1 **a** **i** $64 + 32 + 4 \times 16 = 160$
ii $160 + 5 \times (2 \times 1 + 16) = 250$
b $\frac{5 \times 18}{250} \times 100 = 36\%$

2 **a** **i** M_r of $NH_4NO_3 = 14 + 4 \times 1 + 14 + 3 \times 16 = 80$
percentage by mass of N $= \frac{28}{80} \times 100 = 35\%$
Note there are two lots of N in the formula (14 + 14 = 28).
ii M_r of $(NH_4)_2SO_4 = (14 + 4 \times 1) \times 2 + 32 + 16 \times 4 = 132$
percentage by mass of N $= \frac{28}{132} \times 100 = 21\%$ (to 2 sf)
iii M_r of $CO(NH_2)_2 = 12 + 16 + (14 + 2 \times 1) \times 2 = 60$
percentage by mass of N $= \frac{28}{60} \times 100 = 47\%$ (2 sf)

b 1 mole NH_3 produces 1 mole NH_4NO_3.

$$\text{number of moles } NH_4NO_3 = \frac{\text{mass of } NH_4NO_3}{M_r \text{ of } NH_4NO_3} = \frac{50\,000}{80} = 625 \text{ moles}$$

Note the mass in kilograms (kg) should be converted to grams g.
625 moles of NH_3 are required.
mass NH_3 required = number of moles of NH_3 × M_r of NH_3 = 625 × 17
= 10 625 g
(or 10.6 kg (3 sf)
This mass may also be calculated without moles using the reacting masses method.

3 a M_r of Fe_2O_3 = 56 × 2 + 16 × 3 = 160

$$\text{number of moles of } Fe_2O_3 = \frac{\text{mass of } Fe_2O_3}{M_r \text{ of } Fe_2O_3} = \frac{16\,000}{160} = 100 \text{ moles}$$

b i The ratio Fe_2O_3 : Fe is 1 : 2 so 200 moles of Fe are produced.

ii Mass of Fe = A_r of Fe × moles of Fe
= 56 × 200 = 11 200 g

c i The ratio Fe_2O_3 : CO_2 is 1 : 3 so 300 moles of CO_2 are produced.

ii $$\text{number of moles of } CO_2 = \frac{\text{volume of } CO_2}{\text{molar volume}}$$

So volume of CO_2 = number of moles of CO_2 × molar volume
= 300 × 24
= 7200 dm^3

4 a concentration of

$$NaOH = \frac{\text{number of moles of NaOH}}{\text{volume of NaOH in } dm^3}$$

So number of moles of NaOH = concentration of NaOH × volume of NaOH

$$= 0.1 \times \frac{25}{1000}$$

= 0.0025 moles

b The ratio HCl : NaOH is 1 : 1 so 0.0025 moles of HCl react.

c $$\text{concentration of HCl} = \frac{\text{number of moles of HCl}}{\text{volume of HCl in } dm^3} = \frac{2.5 \times 10^{-3}}{15.6/1000} = \frac{0.0025}{15.6/1000} = 0.16 \text{ mol/dm}^3$$

Chapter 6

Practice question 1

surface area of cube = 6 × area of one square face
= 6 × 3 × 3
= 54 mm^2

Practice question 2

surface area of octahedron = 8 × area of one triangular face
= 8 × 4
= 32 mm^2

Practice question 3

surface area of cylinder = 2 × area of one circular face + area of curved surface
The diameter = 0.5 cm so the radius = 0.25 cm
Area of circular face = $\pi \times 0.25^2$
Area of curved surface = $\pi \times 0.5 \times 10$
So surface area of cylinder = $2 \times \pi \times 0.25^2 + \pi \times 0.5 \times 10$
= 16.1 cm^2 (3sf) using the value of π from the calculator
= 16 cm^2 (2sf)

Practice question 4

a Surface area of cube = 6 × 1 × 1
= 6 cm^2

b Surface area of cube when cut = 8 × 6 × 0.5 × 0.5
= 12 cm^2

Practice question 5

Surface area of 3 cm × 3 cm × 3 cm cube = 6 × 9 = 54 cm^2

Volume of 3 cm × 3 cm × 3 cm cube = 3^3 = 27 cm^3

Surface area : volume ratio is 54 : 27 or 2/cm.

Surface area of separate 1 cm × 1 cm × 1 cm cubes = 27 × 6 × 1 = 162 cm^2

Volume of separate cubes = 27 × 1 = 27 cm^3

Surface area : volume ratio is 162 : 27 or 6/cm.

The surface area : volume ratio increases when the cube is broken down into smaller cubes.

Practice question 6

a i Surface area = 6 × 4 × 4 = 96 cm^2
Volume = 4^3 = 64 cm^3
Surface area : volume ratio is 96 : 64 or 1.5/cm

ii Surface area = 8 × 6 × 2 × 2
= 192 cm^2
Volume = 8 × 2^3
= 64 cm^3
Surface area : volume ratio is 192 : 64 or 3/cm.

iii Surface area = 64 × 6 × 1 = 384 cm^2
Volume = 64 × 1 = 64 cm^3
Surface area : volume ratio is 384 : 64 or 6/cm.

b The more the cube is broken up, the greater the amount of surface that is exposed. The volume remains the same so the surface area : volume ratio increases.

Further questions

1 The radius of the cylinder is $\frac{0.5}{2} = 0.25\,\text{cm}$.

Surface area of single stick of chalk $= 2 \times \pi \times 0.25^2 + 2 \times \pi \times 0.25 \times 8$
$= 12.96\,\text{cm}^2$

The length of the broken pieces of chalk is $\frac{8}{4} = 2\,\text{cm}$.

Surface area of broken chalk $= 4 \times (2 \times \pi \times 0.25^2 + 2 \times \pi \times 0.25 \times 2)$
$= 14.14\,\text{cm}^2$

The surface area of the broken chalk is slightly greater, meaning that more of the chalk is exposed to the acid and the reaction happens more quickly.

2 **a** Surface area of hexagonal tube $= 6 \times 0.5 \times 25 = 75\,\text{cm}^2$

b Total surface area of 100 hexagonal tubes $= 100 \times 75 = 7500\,\text{cm}^2$

c Volume of block $= 10 \times 10 \times 25 = 2500\,\text{cm}^3$

d Surface area : volume ratio is 7500 : 2500 or 3/cm.

e Surface area of empty block $= 4 \times 10 \times 25 = 1000\,\text{cm}^2$
So surface area : volume ratio is 1000 : 2500 or 0.4/cm.

Additional questions involving several maths skills

1 **a** **i** $M_r\,(CaCO_3) = 40 + 12 + (3 \times 16)$
$= 100$

ii $M_r\,(CO_2) = 12 + (2 \times 16)$
$= 44$

b **i** 100 g of calcium carbonate produce 40 g carbon dioxide.

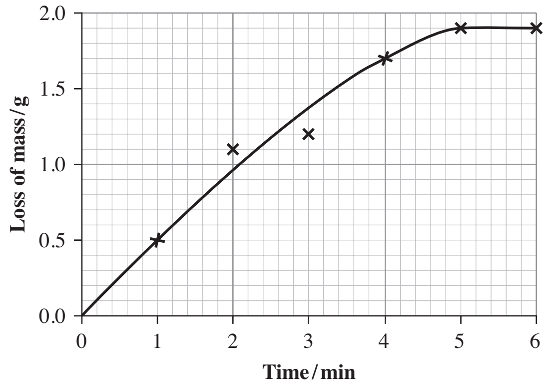
ii 10 g produces 4 g.

iii 5 g produces 2 g.

c

Time	Total mass g	Loss of mass g
0	79.4	**0**
1	78.9	**0.5**
2	78.3	**1.1**
3	78.2	**1.2**
4	77.7	**1.7**
5	77.5	**1.9**
6	77.5	**1.9**

d See graph below.
The line should be a line of best fit. The best fit line should pass somewhere between the points at 2 and 3 minutes.

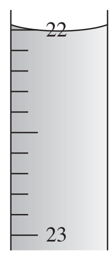
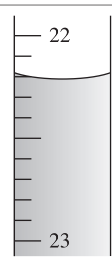
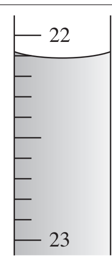


e **i** The rate of reaction is shown by the gradient of the graph.

ii The rate of reaction is greatest at the start. It then gets gradually less until it is zero.

iii The reaction has stopped when the rate of reaction (gradient) is zero, which occurs at about 5 minutes. This answer will depend upon the line of best fit drawn.

2 **a**

Experiment	Burette diagram	Volume of sodium hydroxide added cm³
1		**22.0**
2		**22.2**
3		**22.1**

b $\frac{22.0 + 22.2 + 22.1}{3} = 22.1\,\text{cm}^3$

c **i** moles = concentration × volume

ii number of moles of sodium hydroxide = concentration of sodium hydroxide × volume of sodium hydroxide added (in dm^3)

$= 1 \times \frac{22.1}{1000}$

$= 0.0221$ moles

d **i** 1 mole

ii 0.0221 moles of ethanoic acid

e concentration of ethanoic acid

$= \frac{\text{number of moles of ethanoic acid}}{\text{volume of ethanoic acid in flask (in dm}^3\text{)}}$

$= \frac{0.0221}{0.025}$

$= 0.884\,\text{mol/dm}^3$