

Conservation of mass and balanced equations

Q1. (2018)

04.4	AlBr ₃	ignore state symbols ignore charges ignore brackets as eg Al(Br) ₃	1	AO2 5.1.1.1 5.1.2.6
	2 Al + 3 Br ₂ (→ 2 AlBr ₃)		1	
		allow 1 mark for balancing their equation with an incorrect product		

Q2. (2020)

03	Level 3: The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO3
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	5.3.1.3 5.4.2.2
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content: <ul style="list-style-type: none"> weigh test tube add metal carbonate weigh test tube and metal carbonate heat allow to cool weigh test tube and metal oxide repeat (heat, cool and weigh) until no change in mass determine mass of metal carbonate used determine mass of carbon dioxide produced repeat with different metal carbonate(s) <p>an alternative method can be based on any mass of metal carbonates and at end divide by this mass to find mass carbon dioxide per gram metal carbonate</p> <p>level 3 change in mass is determined for at least one other carbonate</p>		

Q3. (2020)

04.7	2 NaOH + H ₂ SO ₄ → Na ₂ SO ₄ + 2 H ₂ O	allow 1 mark for Na ₂ SO ₄ and H ₂ O	2	AO2 5.1.1.1 5.4.2.2
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Q4. (2021)

06.2	(without a lid the) mass of magnesium oxide was less		1	AO3 5.4.1.1
	(because) products escaped	allow magnesium oxide escaped	1	

Q5. (2021)

06.4	3:2 ratio Fe : O ₂ (molecules) or 3:4 ratio Fe : O (atoms)		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1
	(formula) Fe ₃ O ₄	allow 1 mark for Fe ₃ O ₂ from 3:2 ratio Fe : O (atoms) (MP2 but not MP1)	1	5.3.2.2 5.3.2.3 5.4.1.1
	3Fe + 2O ₂ → Fe ₃ O ₄	allow multiples allow correct use of incorrectly determined formula allow 1 mark for Fe, O ₂ and Fe ₃ O ₄ or allow 1 mark for Fe, O ₂ and incorrectly determined formula	2	

Q6. (2023)

03.1	4Na + O ₂ → 2Na ₂ O	allow multiples	1	AO2 5.1.1.1 5.1.2.5 5.3.1.1 5.4.1.1
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Q7. (2024)

04.5	1 : 2		1	AO2 5.3.2.3
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Relative formula mass (Mr)

Q1. (2018)

06.2		an answer of 137 scores the 2 calculation marks		AO2 5.3.1.2 5.3.1.3 5.1.1.5
	[12 + (3 × 16)] or 60		1	
	(197 – 60 =) 137		1	
	barium or Ba	barium or Ba without working scores this mark	1	

Q2. (2018)

06.4		an answer of 140–150 scores 4 marks		AO3 5.3.1.2 5.3.1.3
		an answer of 0.14–0.15 scores 3 marks		
	(from graph) volume to 240 cm ³ mass = 1.45 g	allow answer based on any reading from the graph (eg 250 cm ³ = 1.5 g)	1	
	ratio is $\frac{1}{100}$ (ie $\frac{24\,000}{240}$)	allow ratio from their volume eg $\frac{24\,000}{250}$	1	
	100 × 1.45	$\left(\frac{24\,000}{250}\right) \times 1.5$	1	
	145	allow range 140–150	1	
	or			
	allow method using answer from question 06.3			
	$x = \frac{y}{m}$ (1)	(rearrangement of $y = mx$ where m = answer from question 06.3)		
	24 (dm ³) to 24 000 (cm ³) (1)			
	$\frac{24\,000}{\text{answer from question 06.3}}$ (1)			
	144 (1)	allow range 140–150		

Q3. (2019)

02.5		an answer of 60 (%) scores 3 marks		AO2 5.3.1.2
	3 × 16 or 48		1	
	$\frac{48}{80} (\times 100)$		1	
	60 (%)		1	
		an answer of 20 (%) scores 2 marks for:		
		$\frac{16}{80} (\times 100)$ (1)		
		= 20 (%) (1)		

Q4. (2019)

04.6		an answer of 1.51×10^{22} scores 2 marks		AO2 5.3.2.1
	$\frac{1}{40} \times 6.02 \times 10^{23}$ or $0.025 \times 6.02 \times 10^{23}$		1	
	1.51×10^{22}	allow 1.505×10^{22}	1	

Q5. (2023)

02.2	$(M_r =)$ $(1 \times 2) + 32 + (4 \times 16)$		1	AO2 5.3.1.2
	$= 98$		1	

Q6. (2023)

02.3	$(A_r \text{ O} \times 4 =)$ 4×16 or 64		1	AO2 5.3.1.2
	(percentage of oxygen =) $\frac{64}{110} \times 100$	allow correct use of incorrectly determined mass of oxygen	1	
	$= 58.18$		1	
	$= 58 (\%)$	allow a correctly calculated answer to 2 significant figures from an incorrect calculation which uses the values in the question	1	

Q7. (2024)

01.3	(% copper = $100 - 13.5 =$ 86.5 (%))		1	AO2 5.2.2.7
	(mass of copper =) $\frac{86.5}{100} \times 5.25$	allow correct use of an incorrectly determined percentage of copper	1	
	= 4.54125 (g)		1	
	= 4.54 (g)	allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses the values in the question	1	
OR				
	(mass of zinc =) $\frac{13.5}{100} \times 5.25$ (1)			
	= 0.70875 (g) (1)			
	(mass of copper = $5.25 - 0.70875$) = 4.54125 (g) (1)	allow correct use of an incorrectly determined mass of zinc		
	= 4.54 (g) (1)	allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses the values in the question		

Using moles to calculate masses

Q1. (2018)

08.3

an answer of 185–190 (mg)
scores **5** marksAO2
5.3.2.2an answer of 0.185–0.19 scores
4 marks

$$(\text{Mg}) \frac{0.12}{24} \text{ or } 0.005 \text{ (moles)}$$

mark is for + by 24

1

$$(\text{Fe}) \frac{2}{3} \times 0.005 = 0.00333 \text{ (moles)}$$

mark is for $\times \frac{2}{3}$

1

$$(\text{mass Fe}) = 0.00333 \times 56$$

mark is for $\times 56$

1

$$= 0.1866 \text{ (g)}$$

1

$$= 187 \text{ (mg)}$$

1

an answer of 280 (mg) scores **4**
marksan answer of 0.280 scores **3**
marks (no ratio from equation)184 scores **0** $[(3 \times 24) + (2 \times 56)]$ **OR**

$$(\text{Mg}) = \frac{0.12}{(3 \times 24 =) 72} \text{ (1)}$$

$$= 0.00166 \text{ or } \frac{1}{600} \text{ (moles) (1)}$$

$$(\text{mass of Fe}) = 0.00166$$

$$\text{or } \frac{1}{600} \times 112 (2 \times 56) \text{ (1)}$$

$$= 0.1866 \text{ (g) (1)}$$

$$187 \text{ (mg) (1)}$$

08.3
cont.**OR**

$$72 \text{ g Mg} \rightarrow 112 \text{ g Fe (1)}$$

$$1 \text{ g Mg} \rightarrow \frac{112}{72} \text{ or } 1.56 \text{ g Fe (1)}$$

$$0.12 \text{ g Mg} \rightarrow \frac{112}{72} \times 0.12 \text{ (1)}$$

$$= 0.1866 \text{ (g) (1)}$$

$$= 187 \text{ (mg) (1)}$$

Q2. (2020)

06.3	(moles Au = $\frac{0.175}{197}$ =) 0.000888		1	AO2 5.3.1.1 5.3.2.2
	(moles Cl ₂ = 0.000888 × $\frac{3}{2}$ =) 0.00133	allow a correct calculation using an incorrectly calculated value of moles of gold	1	
	(mass Cl ₂ =) 0.00133 × 71	allow a correct calculation using an incorrectly calculated value of moles of chlorine	1	
	= 0.0946 (g)		1	
	= 94.6 (mg)	allow a correct conversion using an incorrectly calculated mass of chlorine	1	

Q3. (2021)

04.4	(percentage and mass of other elements) 28.08 (%) = 16.29 (g)		1	AO2 5.2.2.7
	(mass of fork) = $\frac{16.29}{28.08} \times 100$ (g)		1	
	= 58.01 (g)		1	
	(mass of iron = $\frac{71.92}{100} \times 58.01$) = 41.72 (g)	allow (mass of fork – mass of other elements) = 41.72 (g) allow 41.7 (g) allow correct use of incorrect calculation of mass and / or percentages	1	

Q4. (2021)

06.1	(mass of oxygen = 0.20 – 0.12) = 0.08 (g)		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1 5.4.1.1
	(moles of oxygen) = $\frac{0.08}{32}$	} allow 1 mark for 0.005 if derived from $\frac{0.08}{16}$	1	
	= 0.0025		1	

Q5. (2021)

06.3	(mass of copper oxide =)			AO2
	$\frac{79.5}{63.5} \times 0.5$		1	5.1.1.1 5.3.1.1 5.3.1.3
	= 0.62598 (g)		1	5.3.2.1 5.3.2.2
	= 0.626 (g)	allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all the values in the question	1	5.3.2.3 5.4.1.1

Q6. (2022)

07.4	method 1:			AO2
	(moles of Al = $\frac{108}{27}$ =) 4		1	5.3.2.2 5.3.2.4
	(moles CuCl ₂ = $\frac{1210}{134.5}$ =) 8.996	allow 9	1	
	(identifying limiting reactant) 4 moles Al gives 6 moles Cu 8.996 moles CuCl ₂ gives 8.996 moles Cu	allow correct use of an incorrectly calculated value(s) for moles of Al and / or CuCl ₂	1	
	therefore aluminium is the limiting reactant	<u>must</u> follow on from MP3	1	
	(mass of Cu = 2 × 3 × 63.5) = 6 × 63.5		1	
	= 381 (g)		1	

07.4 cont.	method 2:		
	$2\text{Al} + 3\text{CuCl}_2 \rightarrow 3\text{Cu} + 2\text{AlCl}_3$		
	$(2 \times 27) (3 \times 134.5) (3 \times 63.5)$		
	54 (g) 403.5 (g) 190.5 (g)		
	(1) (1) (1)		
	(so)		
	108 g Al (reacts with 807 g CuCl_2) to produce 381 g Cu (1)	allow correct use of an incorrect calculation of mass for Al / CuCl_2 / Cu	
	(so) there is excess CuCl_2		
	or		
	807 g CuCl_2 is less than 1210 g CuCl_2 (1)		
	therefore aluminium is limiting reactant (1)	<u>must</u> follow on from MP4 / MP5	
	method 3:		
	134.5 g CuCl_2 produces 63.5 g Cu (1)		
	(mass conversion 1.21 kg CuCl_2 $\Rightarrow$ 1210 (g) (1)		
	1210 g CuCl_2 produces $(\frac{63.5}{134.5} \times 1210 \Rightarrow 571 \text{ g Cu})$ (1)	allow correct use of an incorrect / no conversion of mass of CuCl_2	
	54 g Al produces 190.5 g Cu (1)		
	108 g Al produces $(\frac{190.5}{54} \times 108 \Rightarrow 381 \text{ (g)})$ (1)		
	(therefore) aluminium is the limiting reactant (1)	<u>must</u> follow on from MP3 and MP5	

Q7. (2024)

05.3	(bonds broken $\Rightarrow$ $945 + 3\text{X}$)		1	AO2 5.5.1.1 5.5.1.3
	(bonds made $= 6 \times 391 \Rightarrow$ 2346)		1	
	(energy released = bonds made – bonds broken $\Rightarrow$ $93 = 2346 - [945 + 3\text{X}]$)	allow correct use of incorrectly determined value(s) of bonds broken and/or bonds formed	1	
	$(3\text{X} \Rightarrow 1308 \text{ (kJ/mol)})$		1	
	$(\text{X} \Rightarrow 436 \text{ (kJ/mol)})$	allow correct use of an incorrectly determined value for 3X	1	

Q8. (2024)

08.3

$$(\text{number of moles}) = \frac{2380}{6.02 \times 10^{23}}$$

$$= 3.95 \times 10^{-21} \text{ (mols)}$$

allow 3.953488×10^{-21} (mols)
correctly rounded to at least 2
significant figures

1

AO2
5.2.3.3
5.3.2.1

1

Concentrations of solutions

Q1. (2018)

01.5

$$\frac{50}{1000} \text{ or } \frac{1}{20} \text{ or } 0.05$$

$$(0.05) \times 300$$

15 (g)

or

$$\frac{300}{1000} \text{ or } \frac{3}{10} \text{ or } 0.03 \text{ (1)}$$

$$(0.3) \times 50 \text{ (1)}$$

15 (g) (1)

an answer of 15 (g) scores 3 marks

the second mark is dependent on the first mark being scored

the second mark is dependent on the first mark being scored

if no other mark awarded allow 150 or 15 000 for 1 mark

1

1

1

AO2
5.3.2.5

Q2. (2019)

01.5

$$\frac{50}{1000} \text{ (dm}^3\text{)}$$

$$= 0.05 \text{ (dm}^3\text{)}$$

$$\left(\frac{3.2}{0.05} \right) = 64 \text{ (g per dm}^3\text{)}$$

alternative approach:

$$\frac{3.2}{50} \text{ (1)}$$

$$= 0.064 \text{ (1)}$$

$$(\times 1000) = 64 \text{ (g per dm}^3\text{)} \text{ (1)}$$

alternative approach:

$$\frac{1000}{50} \text{ (1)}$$

$$= 20 \text{ (1)}$$

$$(\times 3.2) = 64 \text{ (g per dm}^3\text{)} \text{ (1)}$$

an answer of 64 (g per dm³) scores 3 marksan incorrect answer for one step does **not** prevent allocation of marks for subsequent stepsan answer of 0.16 / 0.064 / 0.64 / 6.4 / 6.4×10^{-5} (g per dm³) gains 2 marks

1

1

1

AO2
5.3.2.5

Q3. (2019)

A)

05.6	4.75 (g)	allow values in range 4.7–4.8 (g)	1	AO2 5.4.3.4
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B)

05.7		an answer in the range 0.18–0.25 scores 2 marks (3 marks with correct unit)		AO2 5.4.3.4
	(working) Y increase and X increase measured from graph	allow ecf from question 05.6		
	and substitution into $\frac{Y \text{ increase}}{X \text{ increase}}$	eg = $\frac{2.0}{10}$	1	
	correct evaluation	eg = 0.2	1	
	(units) g/hour	allow g/h or g/hr or g per hour	1	

Q4. (2020)

05.7	(unit conversion) $30.0 \text{ cm}^3 = 0.030 \text{ dm}^3$ or $0.500 \text{ dm}^3 = 500 \text{ cm}^3$		1	AO2 5.3.2.1 5.4.1.2 5.5.1.1
	(moles = $\frac{30}{500} \times 0.1 =$) 0.006 or (moles = $\frac{0.030}{0.50} \times 0.1 =$) 0.006	allow correct use of incorrect / no unit conversion	1	
	mass = 0.006×159.5	allow correct use of incorrect value for number of moles	1	
	= 0.957 (g)	allow 0.96 (g)	1	

Q5. (2022)

01.5	83 (g at 80 °C)	allow a value in range 82–84 (g at 80 °C)	1	AO2
	32 (g at 20 °C)	allow a value in range 32–33 (g at 20 °C)	1	AO2
	(83–32 =) 51 (g)	allow a correct calculation using incorrectly read values for mass at 80 °C and/or 20 °C	1	AO3 5.4.2.3

Q6. (2022)

02.5	(conversion) $\frac{25}{1000} =) 0.025 \text{ (dm}^3\text{)}$		1	AO2 5.3.2.5 5.4.3.4
	(concentration =) $\frac{0.86}{0.025}$	allow correct use of incorrect / no conversion	1	
	= 34.4 (g per dm ³)	allow 34 (g per dm ³)	1	
	OR			
	(conversion) $\frac{1000}{25} \text{ (1)}$			
	= 40 (1)			
	(40 × 0.86) = 34.4 (g per dm ³) (1)	allow correct use of incorrect / no conversion allow 34 (g per dm ³)		
	OR			
	(concentration =) $\frac{0.86}{25} \text{ (1)}$			
	= 0.0344 (1)			
(conversion) (0.0344 × 1000) = 34.4 (g per dm ³) (1)	allow 34 (g per dm ³)			

Q7. (2023)

02.4	(unit conversion) (25 cm ³ ÷ 1000) = 0.025 dm ³		1	AO2 5.3.2.5
	(conc =) $\frac{0.30}{0.025}$ (g/dm ³)	allow correct use of incorrect / no unit conversion	1	
	= 12 (g/dm ³)		1	
	alternative approach:			
	$\frac{0.30}{25}$ (g/cm ³) (1)			
	= 0.012 (g/cm ³) (1)			
	(unit conversion) (0.012 × 1000) = 12 (g/dm ³) (1)	allow correct conversion of an incorrect concentration calculation		

Q8. (2023)

06.3	(moles Mg =) $\frac{0.72}{24}$		1	AO2 5.3.1.1 5.3.2.2 5.4.2.1 5.4.2.3 RPA8
	= 0.03		1	
	(moles Mg = moles MgCl ₂) (so mass MgCl ₂ =) 0.03 × 95	allow a correct calculation using an incorrectly calculated value of moles of magnesium	1	
		allow a correct calculation using an incorrectly calculated value of moles of magnesium chloride		
	= 2.85 (g)		1	
	(100.0 cm ³ = 0.100 dm ³ concentration = $\frac{\text{mass}}{\text{volume}}$)			
	= $\frac{2.85}{0.100}$	allow correct use of incorrectly calculated mass of magnesium chloride	1	
	= 28.5 (g/dm ³)		1	