
1.1	1.8 (mg)	allow an answer in range 1.7–1.9	1	AO3 5.4.3.4
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1.2	$\frac{3.02 + 3.01 + x}{3} = 3.06$ 3.15 (mg)	an answer of 3.15 (mg) scores 2 marks allow any other suitable method if no other mark awarded allow 9.18 for 1 mark	1 1	AO2 5.4.3.4
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1.3	$\frac{50}{1000} \text{ or } \frac{1}{20} \text{ or } 0.05$ $(0.05) \times 300$ 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
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2.1	AlBr_3 $2 \text{ Al} + 3 \text{ Br}_2 \rightarrow 2 \text{ AlBr}_3$	ignore state symbols ignore charges ignore brackets as eg $\text{Al}(\text{Br})_3$ allow 1 mark for balancing their equation with an incorrect product	1 1	AO2 5.1.1.1 5.1.2.6
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3.1		an answer of 137 scores the 2 calculation marks		AO2 5.3.1.2 5.3.1.3 5.1.1.5
	$[12 + (3 \times 16)]$ or 60		1	
	(197 – 60 =) 137		1	
	barium or Ba	barium or Ba without working scores this mark	1	

4.1	(Mg) $\frac{0.12}{24}$ or 0.005 (moles) (Fe) $\frac{2}{3} \times 0.005 = 0.00333$(moles) (mass Fe) = 0.00333×56 = 0.1866 (g) = 187 (mg) OR (Mg) = $\frac{0.12}{(3 \times 24 =) 72}$ (1) = 0.00166 or $\frac{1}{600}$ (moles) (1) (mass of Fe) = 0.00166 or $\frac{1}{600} \times 112$ (2 $\times$ 56) (1) = 0.1866 (g) (1) 187 (mg) (1)	an answer of 185–190 (mg) scores 5 marks an answer of 0.185–0.19 scores 4 marks mark is for $\div$ by 24 mark is for $\times \frac{2}{3}$ mark is for $\times 56$ an answer of 280 (mg) scores 4 marks an answer of 0.280 scores 3 marks (no ratio from equation) 184 scores 0 [(3$\times$24) + (2$\times$56)]	1 1 1 1 1	AO2 5.3.2.2
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4.1 cont.	OR 72 g Mg → 112g Fe (1) 1 g Mg → $\frac{112}{72}$ or 1.56 g Fe (1) 0.12 g Mg → $\frac{112}{72} \times 0.12$ (1) = 0.1866 (g) (1) = 187 (mg) (1)			
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5.1	$\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$	allow multiples	1	AO2 5.1.1.1 5.7.1.3
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6.1		an answer of 1.8×10^2 (mol) gains 4 marks		AO2 5.8.1.2 5.3.2.1
	mass = 14 520 g		1	
	$(=) \frac{14\,520}{80 \text{ (mol)}}$	allow correct substitution of incorrectly converted mass must use M_r given (80) to gain marks in steps 2 and 3	1	
	$(=) 181.5 \text{ (mol)}$		1	
	$(=) 1.8 \times 10^2 \text{ (mol)}$	allow answer correctly given in standard form to correct sig figs from an incorrect calculation	1	

7.1	$\text{Ca}(\text{NO}_3)_2$	allow $\text{Ca}^{2+}(\text{NO}_3^-)_2$	1	AO2 4.4.2.2
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8.1	26	must be this order	1	AO2 4.1.1.4 4.1.1.5
	30		1	
	26		1	

9.1	$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$	allow fractions / multiples allow 1 mark for O_2	2	AO1 AO2 4.1.1.1 4.5.2.2
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10.1	between 69.5 and 70.0		1	AO2 4.1.1.6
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11.1	(M_r of TiCl_4 =) 190 (moles Na) = $\frac{20\,000}{23}$ =) 870 (mol) (moles TiCl_4 = $\frac{40\,000}{190}$ =) 211 (mol) either (sodium is in excess because) 870 mol Na is more than the 844 mol needed or (because) 211 mol TiCl_4 is less than the 217.5 mol needed	an incorrect answer for one step does not prevent allocation of marks for subsequent steps allow 1 mark for 0.870 mol Na and 0.211 mol TiCl_4 allow use of incorrectly calculated M_r from step 1 the mark is for correct application of the factor of 4 other correct reasoning showing, with values of moles or mass, an excess of sodium or insufficient TiCl_4 is acceptable allow use of incorrect number of moles from steps 2 and / or 3 alternative approaches: approach 1: (M_r of TiCl_4 =) 190(1) (40 kg TiCl_4 needs) $\frac{40}{190} \times 4 \times 23$ (kg Na) (1) (=) 19.4 (kg) (1) so 20 kg is an excess (1) approach 2: (M_r of TiCl_4 =) 190(1) (20 kg Na needs) $\frac{20}{4 \times 23} \times 190$ (kg TiCl_4) (1) (=) 41.3 (kg) (1) so 40 kg is not enough (1)	1 1 1 1	AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4
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12.1	2 NO ₂ → N ₂ + 2 O ₂	allow multiples if incorrect, allow N ₂ for 1 mark	2	AO2 4.1.1.1 4.3.1.1
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13.1	2.0×10^3 moles		1	AO2 4.3.2.1
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14.1	$\frac{50}{1000} \text{ (dm}^3\text{)}$ $= 0.05 \text{ (dm}^3\text{)}$ $\left(\frac{3.2}{0.05}\right) = 64 \text{ (g per dm}^3\text{)}$ alternative approach: $\frac{3.2}{50} \text{ (1)}$ $= 0.064 \text{ (1)}$ $(\times 1000) = 64 \text{ (g per dm}^3\text{) (1)}$ alternative approach: $\frac{1000}{50} \text{ (1)}$ $= 20 \text{ (1)}$ $(\times 3.2) = 64 \text{ (g per dm}^3\text{) (1)}$	an answer of 64 (g per dm³) scores 3 marks an incorrect answer for one step does not prevent allocation of marks for subsequent steps an 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
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15.1	HNO_3		1	AO1 5.1.1.1 5.4.2.2
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16.1	$\frac{1}{40} \times 6.02 \times 10^{23}$ or $0.025 \times 6.02 \times 10^{23}$	an answer of 1.51×10^{22} scores 2 marks	1	AO2 5.3.2.1
	1.51×10^{22}	allow 1.505×10^{22}	1	

17.1	$2 \text{ Na} + \text{Cl}_2 \rightarrow 2 \text{ NaCl}$		1	AO2 5.1.1.1 5.1.2.5
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18.1	$M_r \text{ CuSO}_4 = 159.5$ $\frac{0.319}{159.5}$ $= 0.002 \text{ (mol)}$	an answer of 0.002 or 2×10^{-3} (mol) scores 3 marks allow correct use of incorrectly calculated value for M_r allow 2×10^{-3} (mol)	1 1 1	AO2 5.3.2.1 5.3.2.5
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19.1	(M_r CaO =) 56 (M_r CaSO₃ =) 120 $\frac{7}{56} \times 120$ = 15(.0 g)	an answer of 15(.0 g) scores 4 marks in all approaches allow a correct calculation using an incorrectly calculated M_r alternative approach A (M_r CaO =) 56 (1) $\frac{7}{56} = 0.125$ (moles) (1) (mass CaSO₃ =) 0.125×120 (1) = 15(.0 g) (1)	1 1 1 1	AO2 5.3.1.2 5.3.2.1 5.3.2.2
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20.1	$2 \text{C}_4\text{H}_{10} + 9 \text{O}_2 \rightarrow 8 \text{CO} + 10 \text{H}_2\text{O}$	allow correct multiples / halves	1	AO2 5.7.1.3 5.9.3.1 5.1.1.1
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21.1	(the isotopes contain) different numbers of neutrons		1	AO2 4.1.1.5
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22.1	$(M_r \text{ of Al}_2\text{O}_3 =) 102$	an answer of 941 (kg) scores 4 marks	1	AO2 4.3.2.2
	$\left(\frac{2\,000\,000}{102} =\right) 19\,608 \text{ (mol Al}_2\text{O}_3)$	allow correct calculation using incorrectly calculated value of M_r of Al_2O_3	1	
	$\left(19\,608 \times \frac{3}{2} =\right) 29\,412 \text{ (mol O}_2)$	allow correct calculation using incorrectly calculated value of moles of Al_2O_3	1	
	$\left(\frac{29\,412 \times 32}{1000} =\right) 941 \text{ (kg)}$	allow 941.1764706 (kg) correctly rounded to at least 2 significant figures	1	
	alternative approach: $(2 M_r \text{ of Al}_2\text{O}_3 =) 204 \text{ (1)}$ 204 (kg of Al_2O_3) gives 96 (kg of O_2) (1) (2000 kg of Al_2O_3 gives) $\frac{2000}{204} \times 96 \text{ (kg of O}_2)$ or $\frac{2000000}{204} \times 96 \text{ (g of O}_2) \text{ (1)}$ = 941 (kg) (1)	allow correct answer using incorrectly calculated value of moles of O_2		

23.1	moles Cu = 0.04 or $\frac{2.54}{63.5} = 0.04$ moles H₂O = 0.04 or $\frac{0.72}{18} = 0.04$ ratio = 1:1 so equation 2 is correct alternative approach A (calculating mass of water from copper) moles Cu = 0.04 or $\frac{2.54}{63.5} = 0.04(1)$ 0.02 x 18 = 0.36 (g of water for equation 1) (1) 0.04 x 18 = 0.72 (g of water) so equation 2 is correct (1) alternative approach B (calculating mass of copper from water) moles H₂O = 0.04 or $\frac{0.72}{18} = 0.04(1)$ 0.08 x 63.5 = 5.08 (g of copper for equation 1) (1) 0.04 x 63.5 = 2.54 (g of copper) so equation 2 is correct (1)	alternative approach C (mass ratio) (copper : water for equation 1) 127 : 18 = 7.06 : 1 (1) (copper : water for equation 2) 63.5 : 18 = 3.53 : 1 (1) 2.54 : 0.72 = 3.53 : 1 = 63.5 : 18 so equation 2 is correct (1)	1 1 1	AO2 4.3.2.1 4.3.2.3
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24.1	$2\text{CH}_4(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}(\text{g}) + 4\text{H}_2\text{O}(\text{g})$	allow correct multiples / fractions	1	AO2 4.9.3.1
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25.1	13 14	this order only	1 1	AO2 5.1.1.4 5.1.1.5
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26.1	$2 \text{ NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2 \text{ H}_2\text{O}$	allow 1 mark for Na_2SO_4 and H_2O	2	AO2 5.1.1.1 5.4.2.2
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27.1	$(\text{moles Au} = \frac{0.175}{197} =) 0.000888$		1	AO2 5.3.1.1 5.3.2.2
	$(\text{moles Cl}_2 = 0.000888 \times \frac{3}{2} =) 0.00133$	allow a correct calculation using an incorrectly calculated value of moles of gold	1	
	$(\text{mass Cl}_2 =) 0.00133 \times 71$	allow a correct calculation using an incorrectly calculated value of moles of chlorine	1	
	$= 0.0946 \text{ (g)}$		1	
	$= 94.6 \text{ (mg)}$	allow a correct conversion using an incorrectly calculated mass of chlorine	1	

28.1	$\text{C}_3\text{H}_8 + 5 \text{O}_2 \rightarrow 3 \text{CO}_2 + 4 \text{H}_2\text{O}$	allow multiples	1	AO2 5.1.1.1 5.7.1.3
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29.1	$\frac{0.22 + 0.23 + 0.20 + \mathbf{X}}{4} = 0.21$ $(\mathbf{X} =) 0.19 \text{ (g)}$		1 1	AO2 5.10.1.2
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29.2	C	allow ecf from question 04.3	1	AO2 5.10.1.2
	biggest difference between the maximum and minimum values	allow calculated range if all ranges are shown A 0.04; B 0.06; C 0.15 and D 0.12	1	

30.1	$\frac{(203 \times 30) + (205 \times 70)}{100}$ or $\frac{6090 + 14\,350}{100}$		1	AO2 4.1.1.6
	= 204.4	ignore units	1	

31.1	(total) mass before = 156.76 (g) and (total) mass after = 156.76 (g) or increase in mass of beaker A and contents = 29.96 (g) and decrease in mass of beaker B and contents = 29.96 (g)	allow $78.26 + 78.50 = 156.76$ and $108.22 + 48.54 = 156.76$ allow $108.22 - 78.26 = 29.96$ and $48.54 - 78.50 = -29.96$	1	AO2
	(so) the mass of products equals the mass of the reactants or (so) there is no change in mass during the reaction	allow (so) no atoms were lost or made during the reaction	1	AO1 4.3.1.1

32.1	(M_r of Fe_2O_3 =) 160		1	AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4
	(moles $\text{Fe}_2\text{O}_3 = \frac{3000}{160} =$) 18.75 (mol)	allow correct use of incorrectly calculated M_r	1	
	(moles Al = $\frac{1000}{27} =$) 37.0 (mol)	allow 37.037037 (mol) correctly rounded to at least 2 significant figures if both MP2 and MP3 are not awarded allow 1 mark for 0.01875 mol Fe_2O_3 and 0.037 mol Al	1	
	(aluminium is limiting because) 37.0 mol is less than the (2 x 18.75 =) 37.5 mol (aluminium needed) or iron oxide is in excess because 18.75 mol is more than the ($\frac{37.0}{2} =$) 18.5 mol (iron oxide needed)	allow correct use of incorrect number of moles from steps 2 and/or 3	1	

32.1 ctd	alternative approaches: approach 1: (finding required mass of aluminium by moles method) (M_r of Fe_2O_3 =) 160 (1) (moles $\text{Fe}_2\text{O}_3 = \frac{3000}{160}$ =) 18.75 (mol) (1) (moles Al needed = 18.75×2 =) 37.5 (mol) and (mass Al needed = 37.5×27 =) 1012.5 (g) or 1.0125 kg (1) (so) 1.00 kg of aluminium is not enough (1) approach 2: (finding required mass of aluminium by proportion method) (M_r of Fe_2O_3 =) 160 (1) (3.00 kg Fe_2O_3 needs) $\frac{3.00}{160} \times 2 \times 27$ (kg Al) (1) (=) 1.0125 (kg) (1) (so) 1.00 kg of aluminium is not enough (1)	allow correct use of incorrectly calculated M_r allow correct use of incorrectly calculated moles of iron oxide allow correct use of incorrectly calculated moles of aluminium needed dependent on calculated mass of aluminium needed being greater than 1.00 (kg) allow correct use of incorrectly calculated M_r dependent on calculated mass of aluminium needed being greater than 1.00 (kg)		AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4
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32.1 ctd	alternative approaches: approach 3: (finding required mass of iron oxide by moles method) M_r of Fe_2O_3 =) 160 (1) (moles Al = $\frac{1000}{27}$ =) 37.0 (mol) (1) (moles Fe_2O_3 needed) = $\frac{37.0}{2}$ = 18.5 (mol) and (mass Fe_2O_3 needed = 18.5×160 =) 2960 (g) or 2.96 (kg) (1) (so) 3.00 kg of iron oxide is an excess (1) approach 4: (finding required mass of iron oxide by proportion method) (M_r of Fe_2O_3 =) 160 (1) (1.00 kg Al needs) $\frac{1.00}{2 \times 27} \times 160$ (kg Fe_2O_3) (1) (=) 2.96 (kg) (1) (so) 3.00 kg of iron oxide is an excess (1)	allow 37.037037 (mol) correctly rounded to at least 2 significant figures allow correct use of incorrectly calculated moles of aluminium allow correct use of incorrectly calculated moles of iron oxide needed allow correct use of incorrectly calculated M_r dependent on calculated mass of iron oxide needed being less than 3.00 (kg) allow correct use of incorrectly calculated M_r dependent on calculated mass of iron oxide needed being less than 3.00 (kg)		AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4
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33.1	4.48 (g iron) and 8.52 (g chlorine)		1	AO2
	(moles Fe = $\frac{4.48}{56}$ =) 0.08	allow correct calculation using incorrectly calculated mass of iron	1	4.1.1.1 4.1.2.6 4.3.2.3
	(moles Cl = $\frac{8.52}{35.5}$ =) 0.24	allow correct calculation using incorrectly calculated mass of chlorine allow (moles Cl ₂ = $\frac{8.52}{71}$ =) 0.12	1	
	(Fe : Cl = 0.08 : 0.24 =) 1 : 3	allow correct calculation using incorrectly calculated moles of iron and / or chlorine	1	
	2 Fe + 3 Cl ₂ → 2 FeCl ₃	allow multiples / fractions allow a correctly balanced equation including Fe and Cl ₂ from an incorrect ratio of Fe : Cl allow 1 mark for Fe and Cl ₂ (reactants) and FeCl ₃ (product) or allow 1 mark for Fe and Cl ₂ (reactants) and a formula for iron chloride correctly derived from an incorrect ratio of Fe : Cl (product)	2	

34.1	didn't stir (the solution enough)	allow measured the temperature before the temperature stopped falling allow measured the temperature too soon	1	AO3 4.5.1.1 RPA 4
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[illegible]

36.1	mass (of flask and contents) decreases		1	AO1
	(because) carbon dioxide is produced	}	1	AO2
	(and) carbon dioxide escapes (from the flask)		1	AO2
				4.3.1.3 4.7.2.4

37.1	(atoms with the) same number of protons	allow atoms with the same atomic number allow atoms of the same element ignore the same number of electrons	1	AO1 5.1.1.5
	(but with) different numbers of neutrons	ignore (but with) different mass numbers do not accept (but with) different relative atomic mass	1	

37.2	$\frac{(39 \times 93.1) + (41 \times 6.9)}{100}$ $= 39.138$ $= 39.1$	allow correctly rounded answer to 1 decimal place from an incorrect calculation using all the values given in the question	1 1 1	AO2 5.1.1.6
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38.1	$\text{Zn}(\text{NO}_3)_2$		1	AO2 5.1.1.1 5.4.2.2
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39.1	(mass of oxygen = 0.20 – 0.12) = 0.08 (g) (moles of oxygen) = $\frac{0.08}{32}$ = 0.0025	} allow 1 mark for 0.005 } if derived from $\frac{0.08}{16}$	1 1 1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1 5.4.1.1
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39.2	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	

40.1	(X=) $(33 \times 7) - [(37 \times 3) + 35 + 34 + 29]$ = 22 (micrograms per m ³)	allow $33 \times 7 = (37 \times 3) + 35 + 34 + 29 + \mathbf{X}$	1 1	AO2 5.9.3.1
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40.2	$2\text{NO}_2 \rightarrow \text{N}_2 + 2\text{O}_2$	allow multiples or halves allow 1 mark for N_2 and O_2	2	AO2 5.3.1.1 5.10.1.1
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41.1	(atoms with the) same number of protons	allow atoms with the same atomic number allow atoms of the same element ignore the same number of electrons	1	AO1 4.1.1.4 4.1.1.5
	(but with) different numbers of neutrons	ignore (but with) different mass numbers do not accept (but with) different relative atomic mass	1	

41.2	$(A_r =) \frac{(69 \times 60) + (71 \times 40)}{100}$		1	AO2 4.1.1.6
	= 69.8		1	

41.3	(number of electrons) = 31		1	AO2
	(number of neutrons) = 38		1	4.1.1.4 4.1.1.5

42.1	$(3 \times M_r \text{H}_2\text{O} = 3 \times (2 + 16) =) 54$ $(A_r \text{R} = 150 - 54 =) 96$ alternative approach: $(M_r \text{RO}_3 = 150 - 6 =) 144 \text{ (1)}$ $(A_r \text{R} = 144 - (3 \times 16) =) 96 \text{ (1)}$	 ignore units ignore units	1 1	AO2 4.3.1.1 4.3.1.2
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43.1	$2\text{K} + 2\text{H}_2\text{O} \rightarrow 2\text{KOH} + \text{H}_2$	allow multiples allow 1 mark for KOH and H ₂	2	AO1 AO2 4.1.1.1 4.1.2.5
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44.1	(number of moles = $\frac{0.24}{63.5} =$) 3.78×10^{-3} or 0.00378		1	AO2 4.3.2.1
	(number of atoms =) $0.00378 \times 6.02 \times 10^{23}$	allow correct use of an incorrectly calculated number of moles	1	
	= 2.28×10^{21}	allow a correct evaluation to 3 significant figures of an incorrect expression which involves only a mass from the graph, the A_r of copper and the Avogadro constant	1	

45.1	C_9H_{20}		1	AO2 4.7.1.1
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46.1	K_2SO_4		1	AO2 5.1.1.1 5.4.3.4 RPA9
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46.2	$9 \pm 3 \text{ cm}^3$		1	AO2 5.3.1.4
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47.1	$4 \text{ Na} + \text{TiCl}_4 \rightarrow 4 \text{ NaCl} + \text{Ti}$	allow multiples allow 1 mark for NaCl and Ti with incorrect / no balancing	2	AO2 5.1.1.1 5.3.1.1
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47.2	method 1: (moles of Al = $\frac{108}{27}$ =) 4 (moles CuCl₂ = $\frac{1210}{134.5}$ =) 8.996 (identifying limiting reactant) <table border="1"> <tr> <td>4 moles Al gives 6 moles Cu</td> </tr> <tr> <td>8.996 moles CuCl₂ gives 8.996 moles Cu</td> </tr> </table> therefore aluminium is the limiting reactant (mass of Cu = 2 × 3 × 63.5) = 6 × 63.5 = 381 (g)	4 moles Al gives 6 moles Cu	8.996 moles CuCl ₂ gives 8.996 moles Cu	allow 9 allow correct use of an incorrectly calculated value(s) for moles of Al and / or CuCl₂ <u>must</u> follow on from MP3	1 1 1 1 1	AO2 5.3.2.2 5.3.2.4
4 moles Al gives 6 moles Cu						
8.996 moles CuCl ₂ gives 8.996 moles Cu						

47.2 cont.	method 2: $2\text{Al} + 3\text{CuCl}_2 \rightarrow 3\text{Cu} + 2\text{AlCl}_3$ (2×27) (3×134.5) (3×63.5) 54 (g) 403.5 (g) 190.5 (g) (1) (1) (1) (so) 108 g Al (reacts with 807 g CuCl₂) to produce 381 g Cu (1) (so) there is excess CuCl₂ or 807 g CuCl₂ is less than 1210 g CuCl₂ (1) therefore aluminium is limiting reactant (1) method 3: 134.5 g CuCl₂ produces 63.5 g Cu (1) (mass conversion 1.21 kg CuCl₂ ⇒ 1210 (g) (1) 1210 g CuCl₂ produces $(\frac{63.5}{134.5} \times 1210)$ ⇒ 571 g Cu (1) 54 g Al produces 190.5 g Cu (1) 108 g Al produces $(\frac{190.5}{54} \times 108)$ ⇒ 381 (g) (1) (therefore) aluminium is the limiting reactant (1)	allow correct use of an incorrect calculation of mass for Al / CuCl₂ / Cu <u>must</u> follow on from MP4 / MP5 allow correct use of an incorrect / no conversion of mass of CuCl₂ <u>must</u> follow on from MP3 and MP5		
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48.1	(conversion) $\left(\frac{150}{1000} =\right) 0.15 \text{ (dm}^3\text{)}$ (concentration =) $\frac{2.40}{0.15}$ = 16 (g/dm³) OR (conversion) $\frac{1000}{150} \text{ (1)}$ = 6.67 (1) (6.67 × 2.4) = 16 (g/dm³) (1) OR (concentration =) $\frac{2.4}{150} \text{ (1)}$ = 0.016 (1) (conversion) (0.016 × 1000) = 16 (g/dm³) (1)	allow correct use of incorrect / no conversion	1 1 1	AO2 5.3.2.5
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49.1	$\left(\text{moles of C}_{70} \text{ molecules} = \frac{1}{70} = \right) 0.0142857$ (molecules =) $0.0142857 \times 6.02 \times 10^{23}$ $= 8.6 \times 10^{21}$	allow correct use of an incorrect attempt at the calculation of the number of moles of C ₇₀ molecules	1 1 1	AO2 4.3.2.1
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50.1	$2 \text{ Rb} + 2 \text{ H}_2\text{O} \rightarrow 2 \text{ RbOH} + \text{H}_2$	ignore state symbols allow multiples allow 1 mark for H_2 allow 1 mark for RbOH	3	AO2 4.1.1.1 4.1.2.5 4.3.1.1
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50.2	(relative atomic mass =) $\frac{(90.48 \times 20) + (0.27 \times 21) + (9.25 \times 22)}{100}$ = 20.1877 = 20.2	allow (relative atomic mass =) $\frac{1809.6 + 5.67 + 203.5}{100}$ allow (relative atomic mass =) $18.096 + 0.0567 + 2.035$ allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all of the values in Table 1 ignore units	1 1 1	AO2 4.1.1.6
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51.1	$(M_r \text{ of SiO}_2 = 28 + (2 \times 16)) = 60$ (conversion 1.2 kg =) 1200 (g) (number of moles of SiO₂ = $\frac{1200}{60}$) = 20 (number of moles of Mg = 20×2) = 40 (mass of Mg = 40×24) = 960 (g) alternative approach: $(M_r \text{ of SiO}_2 = 28 + (2 \times 16)) = 60$ (1) 48 g Mg reacts with 60 g SiO₂ (1) (conversion 1.2 kg =) 1200 (g) (1) $48 \times \frac{1200}{60}$ (g Mg reacts with 1200 g SiO₂) (1) = 960 (g) (1)	allow correct use of an incorrectly converted or unconverted mass of SiO₂ allow correct use of an incorrectly calculated M_r of SiO₂ allow correct use of an incorrectly calculated number of moles of SiO₂ allow correct use of an incorrectly calculated number of moles of Mg allow correct use of an incorrectly calculated M_r of SiO₂ allow correct use of an incorrectly calculated mass of Mg and / or incorrectly converted or unconverted mass of SiO₂	1 1 1 1 1	AO2 4.3.1.2 4.3.2.1 4.3.2.2
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52.1	$\text{C}_9\text{H}_{20} + 14 \text{O}_2 \rightarrow 9 \text{CO}_2 + 10 \text{H}_2\text{O}$	allow multiples allow 1 mark for $\text{C}_9\text{H}_{20} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ with incorrect / no multipliers	2	AO2 4.1.1.1 4.3.1.1 4.7.1.3
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53.1	$(M_r =)$ $(1 \times 2) + 32 + (4 \times 16)$ $= 98$		1 1	AO2 5.3.1.2
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53.2	(unit conversion) $(25 \text{ cm}^3 \div 1000) = 0.025 \text{ dm}^3$ $(\text{conc}) = \frac{0.30}{0.025} \text{ (g/dm}^3\text{)}$ $= 12 \text{ (g/dm}^3\text{)}$ alternative approach: $\frac{0.30}{25} \text{ (g/cm}^3\text{) (1)}$ $= 0.012 \text{ (g/cm}^3\text{) (1)}$ (unit conversion) (0.012×1000) $= 12 \text{ (g/dm}^3\text{) (1)}$	allow correct use of incorrect / no unit conversion allow correct conversion of an incorrect concentration calculation	1 1 1	AO2 5.3.2.5
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54.1	$4 \text{ Na} + \text{O}_2 \rightarrow 2 \text{ Na}_2\text{O}$	allow multiples	1	AO2 5.1.1.1 5.1.2.5 5.3.1.1 5.4.1.1
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55.1	46		1	AO2 5.1.1.5
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55.2	$(A_r =) \frac{(35 \times 75.77) + (37 \times 24.23)}{100}$ $= 35.4846$ $= 35.48$	allow an answer correctly calculated to 2 decimal places from an incorrect calculation which uses the values in the question	1 1 1	AO2 5.1.1.6
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56.1	$(\text{moles Mg}) = \frac{0.72}{24}$		1	AO2 5.3.1.1 5.3.2.2 5.4.2.1 5.4.2.3 RPA8
	= 0.03		1	
	$(\text{moles Mg} = \text{moles MgCl}_2)$ $(\text{so mass MgCl}_2 =) 0.03 \times 95$	allow a correct calculation using an incorrectly calculated value of moles of magnesium	1	
	= 2.85 (g)	allow a correct calculation using an incorrectly calculated value of moles of magnesium chloride	1	
	$(100.0 \text{ cm}^3 = 0.100 \text{ dm}^3)$ $\text{concentration} = \frac{\text{mass}}{\text{volume}})$			
	= $\frac{2.85}{0.100}$	allow correct use of incorrectly calculated mass of magnesium chloride	1	
	= 28.5 (g/dm ³)		1	

57.1	$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$		1	AO2 5.7.1.3
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58.1	(mass X =) [0.29 × 3] – [0.30 + 0.26] = 0.31 (g)	allow 0.87 – 0.56 allow $\frac{0.3 + \mathbf{X} + 0.26}{3} = 0.29$	1 1	AO2 5.10.1.2 RPA13
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60.1	(0.3 °C) is the uncertainty (because 0.3 °C) is the range about the mean value	allow values are (a maximum of) 0.3 (°C) either side of the mean allow (because) $16.8 = 16.5 + 0.3$ and $16.2 = 16.5 - 0.3$	1 1	AO2 4.3.1.4 4.5.1.1 RPA4
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61.1	the mass of acid dissolved is doubled and the volume of the solution is halved		1	AO2 4.3.2.5
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62.1	$\text{Ba} + 2 \text{HCl} \rightarrow \text{BaCl}_2 + \text{H}_2$	allow multiples allow 1 mark for BaCl_2 allow 1 mark for H_2 ignore state symbols	3	AO2 4.1.1.1 4.4.1.2 4.4.2.1
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63.1	$\frac{3}{2} \times 12\text{g}$		1	AO2 4.3.1.1 4.3.2.1 4.3.2.2
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64.1	(mean rate =) $\frac{0.78 + 0.81 + 0.81}{3}$ 0.80 (cm³/s) 0.80 = $\frac{20}{\text{mean time taken}}$ (mean time taken =) $\frac{20}{0.80}$ = 25 (s) alternative approach: 0.78 = $\frac{20}{\text{time}}$ or 0.81 = $\frac{20}{\text{time}}$ (1) (trial 1 time = $\frac{20}{0.78}$ =) 25.6 (1) (trial 2 and 4 time = $\frac{20}{0.81}$ =) 24.7 (1)	allow $\frac{0.78 + 0.81 + 0.68 + 0.81}{4}$ = 0.77 (cm³/s) for 1 mark allow correct use of incorrectly determined mean rate	1 1 1 1	AO3 AO2 AO2 AO2 4.6.1.1 RPA5
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65.1	$\text{CuFeS}_2 + 4\text{O}_2 \rightarrow \text{CuSO}_4 + \text{FeSO}_4$	allow multiples allow O_2 for 1 mark	2	AO2 4.1.1.1 4.3.1.1 4.10.1.4
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66.1	$(M_r \text{ of } \text{NH}_2 \text{ and } \text{COOH}) = (2 \times 1) + 14 + 12 + (2 \times 16) + 1 = 61$ $(M_r \text{ of section} = 75 - 61) = 14$	allow correct use of incorrectly determined M_r of NH_2 and COOH	1 1	AO2 4.3.1.2 4.7.3.3
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