

Question number	Answer	Notes	Marks
1 a i	<p>M1 <math>n(\text{Na}_2\text{S}_2\text{O}_3) = \frac{0.300 \times 20}{1000}</math> OR 0.006(0) mol (= <math>n(\text{SO}_2)</math>)</p> <p>M2 <math>M_r</math> of <math>\text{SO}_2 = 32 + (2 \times 16)</math> OR 64</p> <p>M3 mass of <math>\text{SO}_2 = (0.006 \times 64) = 0.38</math> (g)</p>	<p>Mark CQ throughout Accept any number of sig fig Correct final answer with or without marking scores 3 marks</p>	3
ii	<p>M1 mass of <math>\text{SO}_2</math> in 1 dm<sup>3</sup> = <math>\frac{0.38(4) \times 1000}{50}</math>  = 7.6(8) (g)</p> <p>M2 this is less than 100 so no <math>\text{SO}_2</math> will escape</p> <p><b>OR</b></p> <p>M1 volume of solvent is 50cm<sup>3</sup> which would dissolve (100/20) = 5(g)</p> <p>M2 0.384(g) is less than 5(g) so no <math>\text{SO}_2</math> would escape</p>	<p>M1 CQ on M3 in ai</p> <p>Accept any number of sig fig</p> <p>If candidate value for M1 is greater than 100, award M2 for opposite argument If no answer to M1 then M2 cannot be awarded</p> <p>If answers based on volume of solvent = 20cm<sup>3</sup> eg 20cm<sup>3</sup> which would dissolve (100/50) = 2(g) 0.384(g) is less than 2(g) so no <math>\text{SO}_2</math> would escape worth 1 mark</p>	

b	as the (hydrochloric) acid/HCl is added	Allow (immediately) after (all) the acid/HCl added  Ignore when the solutions are mixed	1
c	i timer started too late / stopped too early  OR thermometer (scale) read incorrectly / timer read incorrectly	Allow misread/incorrectly recorded the temperature/time	1
ii	19.5 (s)	Accept range 19-20	1

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1 d i	M1 times are (very) short	Accept reaction happens too/very/so quickly (so hard to time accurately/precisely) Ignore reaction is quicker Ignore hard(er) to measure rate Allow human reaction time becomes significant Allow references to shorter times producing greater percentage (measurement) uncertainties/errors	2
	M2 heat loss greater	Accept heat loss occurs more quickly Accept difficult to maintain a higher temperature/keep temperature constant Ignore references to evaporation occurring	
	ii M1 more collisions/particles have energy equal to/greater than the activation energy	Ignore particles have more (kinetic) energy Ignore harder/more vigorous collisions Ignore references to speed of particles	2
	M2 (therefore there are) more successful collisions (per second)	if state activation energy is lowered scores 0/2 references to concentration scores 0/2	

e	<p>Any three from</p> <p>M1 concentration of the (hydrochloric/nitric) acid</p> <p>M2 volume of the (hydrochloric/nitric) acid</p> <p>M3 volume of sodium thiosulfate</p> <p>M4 temperature</p> <p>Allow amount for volume</p> <p>If neither M2 or M3 scored allow 1 mark for total volume of the mixture OR depth of liquid in the flask</p> <p>Ignore reference to volume of water Ignore references to size of flask/same apparatus Ignore references to distance of eye from flask/the X/references to timing</p>	3
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2 a	$\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2$	Accept fractions and multiples	1
b i	M1 (increased pressure) has no effect (on yield)	Ignore no effect on other factors eg equilibrium (position)	2
	M2 because equal numbers of (gas) moles/molecules on each side	Do not award M2 if M1 is incorrect	
ii	M1 (at higher temperature equilibrium position shifts to left so yield of hydrogen) decreases		2
	M2 because (forward) reaction is exothermic	Accept because backward reaction is endothermic Accept because reaction moves in the endothermic direction	
		Ignore references to Le Chatelier's principle eg increase in temperature favours the endothermic reaction  Do not award M2 if M1 is incorrect	



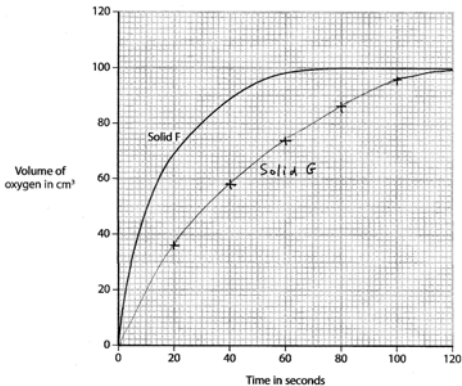
c	i		M1 for $\text{CO}_2 + \text{H}_2$ / products below $\text{CO} + \text{H}_2\text{O}$  M2 for approximately vertical line/arrow with $\Delta H$ symbol/enthalpy change/-41kJ/mol between reactants and products  M2 CQ on M1 unless if products above the activation energy	2
	ii	no effect / OWTTE		1
	iii	M1 provides alternative pathway / route / OWTTE  M2 with lower activation energy	Accept words such as another / different in place of alternative, but not just route  Accept lowers the activation energy Accept less energy needed to start the reaction  Reject (catalyst) provides energy for M1 and M2 Ignore references to providing surface for reaction	2

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2 d	<p>M1 identifying reaction 3 or reaction 4</p> <p>M2 a correct explanation for either eg</p> <p>in reaction 3, there is gain of hydrogen</p> <p>in reaction 4, there is gain of oxygen</p>	<p>Ignore reactions 5 and 6</p> <p>Accept increase in oxidation number of H / changes from 0 to (+)1 Accept decrease in oxidation number of N / changes from 0 to -3 Ignore references to gain/loss of electrons</p> <p>Accept decrease in oxidation number of O / changes from 0 to -2 Accept increase in oxidation number of N / changes from -3 to (+)2 Ignore references to gain/loss of electrons</p> <p>Ignore other explanations</p> <p>Allow:</p> <p>Identifying both Reaction 3 and 4 <u>only</u> for 2 marks Ignore any explanations</p>	2

e	<p>M1 <math>n(\text{NH}_3) = \frac{34 \times 1000}{17} = 2000 \text{ (mol)}</math></p> <p>M2 <math>M_r (\text{NH}_4\text{NO}_3) = 80</math></p> <p>M3 mass <math>(\text{NH}_4\text{NO}_3) = 80 \times 2000 = 160\,000 \text{ g} / 160 \text{ kg}</math></p> <p><b>OR</b></p> <p>M1 <math>M_r (\text{NH}_4\text{NO}_3) = 80</math></p> <p>M2 (so) 17 (kg <math>\text{NH}_3</math>) gives 80 (kg <math>\text{NH}_4\text{NO}_3</math>)</p> <p>M3 (so) 34 (kg <math>\text{NH}_3</math>) gives <math>\frac{80}{17} \times 34 = 160 \text{ kg}</math> / 160 000 g</p>	<p>Correct final answer with or without working scores 3 marks</p> <p>Do not award M3 if unit missing or incorrect</p> <p>Mark CQ throughout</p> <p>3</p>
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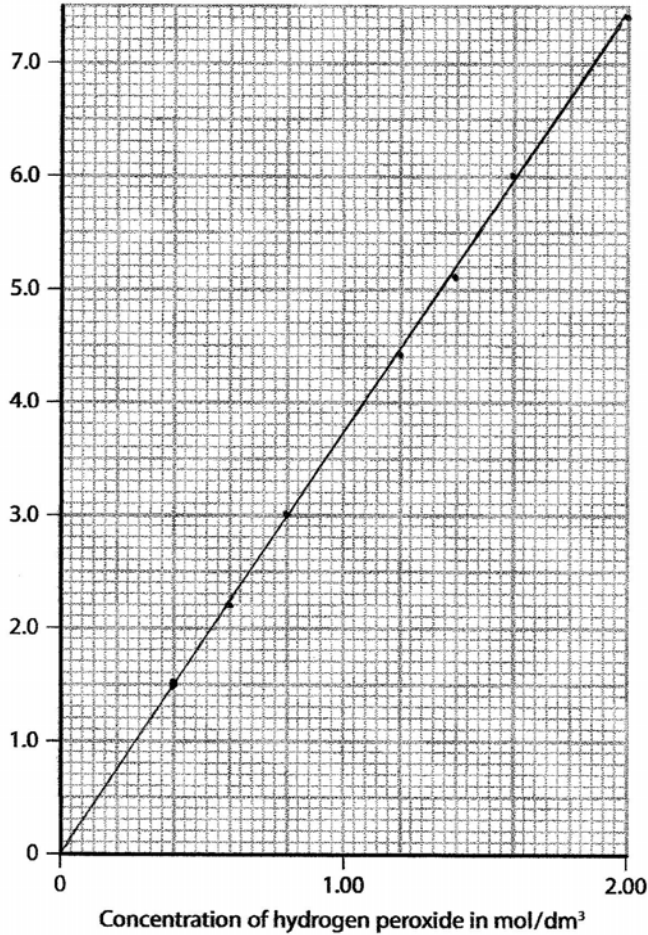


Question number	Answer	Notes	Marks
3 a	M1 volume  M2 concentration	Ignore amount of solution for both, but accept amount in $\text{cm}^3$ for M1 Reject volume of gases Allow mass of solution  Ignore strength  Ignore temperature / pressure  Accept in either order	2
b i	B		1
ii	D		1
c	M1 filter (and dry) and weigh solid/A/it  M2 mass is (still) 1g / mass is unchanged	Mark M1 and M2 independently  Accept separate/remove solid/A/it from reaction mixture and weigh it  Accept reverse argument, eg if it was a reactant, the mass would decrease	2

Question number	Answer	Notes	Marks
3 d i		<p>M1 + M2 all five points plotted to nearest gridline          Points at zero and 120 are not essential but must be correct if plotted          Deduct 1 mark for each error up to max 2</p> <p>M3 curve of best fit          Curve does not need to be labelled          If curve correct but points not visible under curve, award M1 and M2          Curve CQ on points plotted          Penalise repeated straight line(s) joining points / more than one curve visible</p>	3
ii	<p>M1 some indication on graph</p> <p>M2 volume CQ on candidate curve</p>	<p>eg vertical line up from 70s          OR          horizontal line to where line from 70s would meet curve          OR          cross on graph</p> <p>Must be an integer (cm<sup>3</sup>)</p> <p>No marks if original curve used</p>	2
iii	<p>curve steeper / gradient steeper / greater          OR          curve levels off earlier / curve reaches 100cm<sup>3</sup> in shorter time / OWTTE</p>	<p>Accept line for curve          Accept graph is steeper</p> <p>Accept answers that do not depend on graph but can be obtained from the table of results, eg bigger volume in a shorter time, reaction stopped earlier</p>	1
Total 12 marks			

Question number			Answer	Notes	Marks
4	a		weigh (solid) before and after mass unchanged	M1 and M2 are independent	1 1
	b	i	(total) volume / temperature mass / amount OR state of subdivision / particle size / surface area	Ignore amount	1  1
		ii	ref to hydrogen peroxide / solution / liquid / water / reactant / spray AND ref to stopping escaping / spitting (out) / leaving / OWTTE	Reject idea of evaporation	1
	c	i	oxygen/O <sub>2</sub> /gas escapes/given off	Ignore O Reject reference to wrong gas	1
		ii	rate OR reaction slowing (down)	Accept loss of mass per unit time	1
		iii	8 (minutes)		1

Question number			Answer	Notes	Marks
4	d	i	T		1
		ii	0.8(0) loss in mass is double/twice that for 0.4(0)/S OR S loses 0.4g and T loses 0.8 g	Accept $150 - 149.6 = 0.4$ and $150 - 149.2 = 0.8$ but not just $150 - 149.2 = 0.8$ M2 DEP on M1	1 1

Question number	Answer	Notes	Marks
4	<div style="display: flex; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg); margin-right: 10px;">Relative rate of reaction</div>  </div>	<p>             M1 + M2 for all 7 points plotted to nearest gridline              Deduct 1 mark for each error              M3 for straight line of best fit              Must be drawn with ruler              Need not be drawn to origin but must reach origin if extrapolated           </p>	3

Question number			Answer	Notes	Marks
4	f		more particles/molecules (in a given volume) collide more frequently / more collisions per unit time/per second/per minute	Ignore greater chance of collision Max 1 if reference to greater energy / moving faster	1 1

(Total for Question 4 = 16 marks)