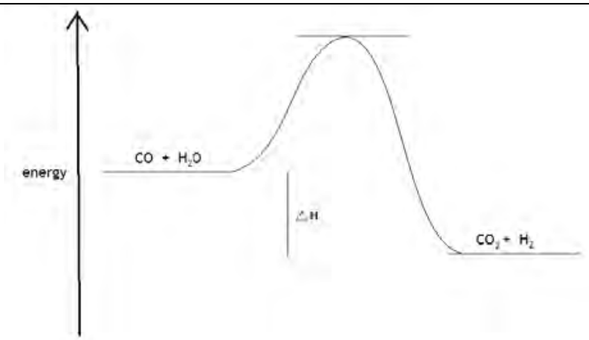
Question number	Answer	Notes	Marks
1 a i	M1 $n(Na_2S_2O_3) = \frac{0.300 \times 20}{1000}$ OR 0.006(0) mol (= $n(SO_2)$) M2 *M*r of SO_2 = 32 + (2 x16) OR 64 M3 mass of SO_2 = (0.006 × 64) = 0.38 (g)	 Mark CQ throughout Accept any number of sig fig Correct final answer with or without marking scores 3 marks	3
ii	M1 mass of SO_2 in 1 dm^3 = $\frac{0.38(4) \times 1000}{50}$ = 7.6(8) (g) M2 this is less than 100 so no SO_2 will escape **OR** M1 volume of solvent is 50cm^3 which would dissolve (100/20) = 5(g) M2 0.384(g) is less than 5(g) so no SO_2 would escape	M1 CQ on M3 in ai Accept any number of sig fig If candidate value for M1 is greater than 100, award M2 for opposite argument If no answer to M1 then M2 cannot be awarded If answers based on volume of solvent = 20cm^3 eg 20cm^3 which would dissolve (100/50) = 2(g) 0.384(g) is less than 2(g) so no SO_2 would escape worth 1 mark	

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

Question number	Answer	Notes	Marks
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	
	M2 (therefore there are) more successful collisions (per second)	if state activation energy is lowered scores 0/2 references to concentration scores 0/2	2

e	Any three from M1 concentration of the (hydrochloric/nitric) acid M2 volume of the (hydrochloric/nitric) acid M3 volume of sodium thiosulfate M4 temperature	Allow amount for volume If neither M2 or M3 scored allow 1 mark for total volume of the mixture OR depth of liquid in the flask 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	3

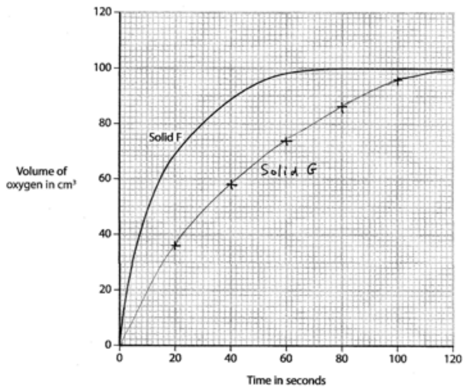
Question number	Answer	Notes	Marks
2 a	CH_4 + H_2O → CO + $3H_2$	Accept fractions and multiples	1
b i	M1 (increased pressure) has no effect (on yield) M2 because equal numbers of (gas) moles/molecules on each side	Ignore no effect on other factors eg equilibrium (position) Do not award M2 if M1 is incorrect	2
ii	M1 (at higher temperature equilibrium position shifts to left so yield of hydrogen) decreases 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	2

c i		M1 for $CO_2 + H_2$ / products below $CO + H_2O$ M2 for approximately vertical line/arrow with ΔH 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

Question number	Answer	Notes	Marks
2 d	M1 identifying reaction 3 or reaction 4 M2 a correct explanation for either eg in reaction 3, there is gain of hydrogen in reaction 4, there is gain of oxygen	Ignore reactions 5 and 6 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 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 Ignore other explanations Allow: Identifying both Reaction 3 and 4 <u>only</u> for 2 marks Ignore any explanations	2

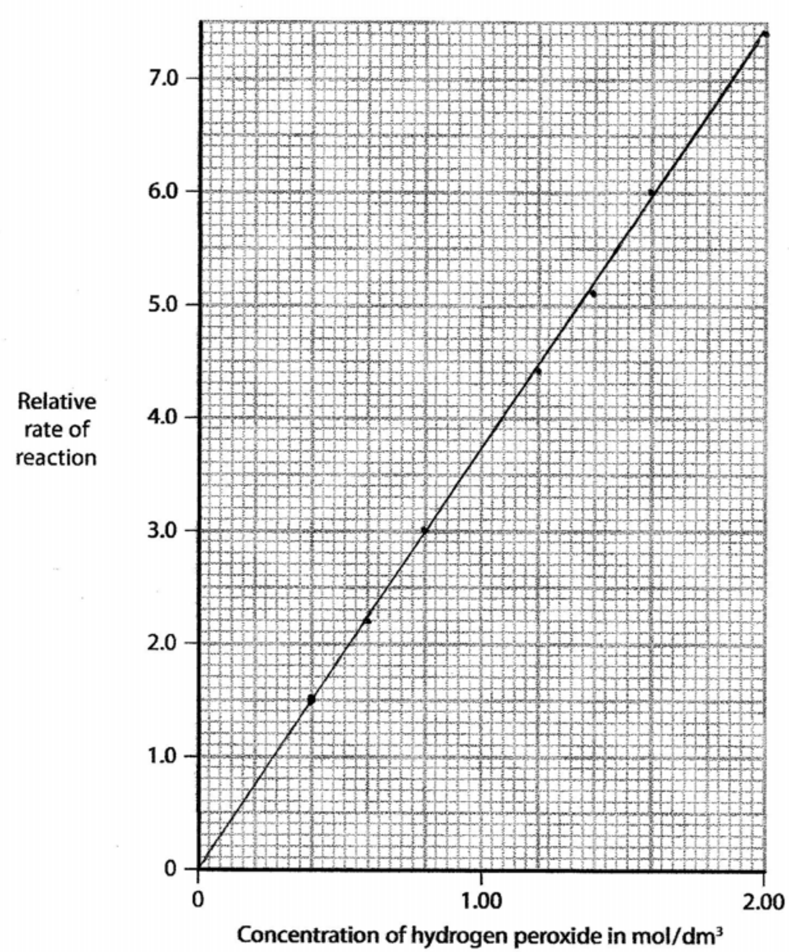
e	M1 $n(NH_3) = \frac{34 \times 1000}{17} = 2000$ (mol) M2 M_r $(NH_4NO_3) = 80$ M3 mass $(NH_4NO_3) = 80 \times 2000 = 160\ 000$ g / 160 kg **OR** M1 M_r $(NH_4NO_3) = 80$ M2 (so) 17 (kg NH_3) gives 80 (kg NH_4NO_3) M3 (so) 34 (kg NH_3) gives $\frac{80}{17} \times 34 = 160$ kg / 160 000 g	Correct final answer with or without working scores 3 marks Do not award M3 if unit missing or incorrect Mark CQ throughout	3

Question number	Answer	Notes	Marks
3 a	M1 volume M2 concentration	Ignore amount of solution for both, but accept amount in cm^3 for M1 Reject volume of gases Allow mass of solution Ignore strength Ignore temperature / pressure Accept in either order	2
b i ii	B D		1 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		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 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	3
ii	M1 some indication on graph M2 volume CQ on candidate curve	eg vertical line up from 70s OR horizontal line to where line from 70s would meet curve OR cross on graph Must be an integer (cm^3) No marks if original curve used	2
iii	curve steeper /gradient steeper/greater OR curve levels off earlier / curve reaches $100cm^3$ in shorter time / OWTTE	Accept line for curve Accept graph is steeper 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	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_2/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)		1
			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

Question number			Answer	Notes	Marks
4				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	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)