CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



MARK SCHEME

11 GROUP 17

SCORE	PERCENTAGE
/	%

STEMUP

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Paper 1 Multiple Choice Answers: Group 17

Question	Paper	Q. No.	Answer
610	9701_s21_qp_13	15	C
611	9701_s20_qp_12	7	B
612	9701_s20_qp_12	14	B
613	9701_s20_qp_13	13	D
614	9701_m19_qp_12	18	A
615	9701_w19_qp_11	16	C
616	9701_s18_qp_12	14	A
617	9701_w18_qp_11	16	A
618	9701_s17_qp_11	19	A
619	9701_w17_qp_11	19	B
620	9701_s16_qp_12	19	C
621	9701_w15_qp_11	17	B
622	9701_w15_qp_12	17	D
623	9701_m22_qp_12	6	B
624	9701_s20_qp_12	18	D
625	9701_w19_qp_12	16	D
626	9701_s17_qp_13	17	D
627	9701_m16_qp_12	16	B
628	9701_s16_qp_13	17	C
629	9701_s16_qp_13	18	D
630	9701_w16_qp_11	19	B
631	9701_m22_qp_12	11	C
632	9701_m22_qp_12	22	D
633	9701_m21_qp_12	17	A
634	9701_s21_qp_11	16	C
635	9701_s21_qp_12	16	D
636	9701_s21_qp_13	16	D
637	9701_w21_qp_11	16	D
638	9701_w21_qp_12	15	A
639	9701_w21_qp_12	16	C
640	9701_w21_qp_12	17	D
641	9701_w21_qp_13	18	A
642	9701_m20_qp_12	18	A
643	9701_s20_qp_11	12	D
644	9701_s20_qp_11	18	D
645	9701_s20_qp_13	17	A
646	9701_w20_qp_11	16	C
647	9701_m19_qp_12	17	D
648	9701_s19_qp_11	16	C
649	9701_s19_qp_13	16	C
650	9701_s19_qp_13	17	C
651	9701_w19_qp_11	17	A
652	9701_w19_qp_12	17	A
653	9701_s18_qp_11	16	D
654	9701_s18_qp_12	17	D
655	9701_s18_qp_13	16	B

Paper 1 Multiple Choice Answers: Group 17 (continued)

Question	Paper	Q. No.	Answer
656	9701_w18_qp_12	16	C
657	9701_s17_qp_11	17	A
658	9701_s17_qp_12	17	D
659	9701_w17_qp_11	18	C
660	9701_w17_qp_12	17	A
661	9701_s16_qp_11	15	C
662	9701_w16_qp_11	14	D
663	9701_w16_qp_12	16	A
664	9701_s15_qp_11	17	D
665	9701_s15_qp_13	19	B
666	9701_w15_qp_11	18	A
667	9701_w15_qp_12	18	D
668	9701_m22_qp_12	23	B
669	9701_m21_qp_12	16	A
670	9701_s21_qp_12	17	D
671	9701_w21_qp_11	17	D
672	9701_m20_qp_12	14	C
673	9701_w20_qp_12	17	C
674	9701_s19_qp_11	17	D
675	9701_s19_qp_12	17	B
676	9701_m18_qp_12	24	C
677	9701_s18_qp_11	14	D
678	9701_w18_qp_11	17	D
679	9701_w18_qp_12	17	C
680	9701_m17_qp_12	16	C
681	9701_m17_qp_12	17	A
682	9701_s17_qp_11	18	C
683	9701_s17_qp_12	16	C
684	9701_s17_qp_13	16	A
685	9701_w17_qp_11	17	D
686	9701_w17_qp_12	16	A
687	9701_m16_qp_12	14	D
688	9701_s16_qp_12	18	A
689	9701_w16_qp_12	15	C
690	9701_s15_qp_11	16	A

62. 9701_m17_ms_22 Q: 2

<table>
<tr><td>(a)(i)</td><td>bond in which the centres of positive and negative charges do not coincide
OR electron distribution is asymmetric / unequal
OR two (bonded) atoms are partially charged</td><td>1</td></tr>
<tr><td rowspan="2">(a)(ii)</td><td>HF has the strongest (permanent) dipole–dipole / van der Waals' (forces) / HF has hydrogen bonding</td><td>1</td></tr>
<tr><td>requires more energy to overcome (than weaker (permanent) dipole–dipole/ van der Waals' forces between other hydrogen halides)</td><td>1</td></tr>
<tr><td rowspan="3">(a)(iii)</td><td>thermal stability of the hydrogen halides decreases down group (17)</td><td>1</td></tr>
<tr><td>larger (halogen) atoms / atomic radius (down group) / increased shielding</td><td>1</td></tr>
<tr><td>bond energies decrease / less energy required to break H–X</td><td>1</td></tr>
<tr><td rowspan="2">(b)(i)</td><td>M1
base is Cl^- AND conjugate acid is HCl
OR
base is HSO_4^- AND conjugate acid is H_2SO_4</td><td>1</td></tr>
<tr><td>M2
Cl^- / HSO_4^- / base is a proton acceptor
OR
HCl / H_2SO_4 / (conjugate) acid has one more H^+</td><td>1</td></tr>
<tr><td rowspan="2">(b)(ii)</td><td>H_2SO_4 is (too strong) an oxidising agent</td><td>1</td></tr>
<tr><td>I_2 would be formed instead</td><td>1</td></tr>
<tr><td rowspan="2">(c)(i)</td><td>$\Delta_r H$ = $\Delta_r H${products} – $\Delta_r H${reactants} = 2 × (–242) – 4 × (–92)</td><td>1</td></tr>
<tr><td>= –116 (sign AND answer)</td><td>1</td></tr>
<tr><td rowspan="2">(c)(ii)</td><td>heterogeneous (catalyst)</td><td>1</td></tr>
<tr><td>provides an alternative reaction pathway of lower activation energy</td><td>1</td></tr>
<tr><td rowspan="2">(c)(iii)</td><td>reaction is exothermic</td><td>1</td></tr>
<tr><td>(increased temperature) shifts equilibrium to the left AND decreases yield of products (Cl_2 and / or H_2O) / less product formed</td><td>1</td></tr>
<tr><td>(c)(iv)</td><td>
<table>
<tr><th></th><th>HCl</th><th>O_2</th><th>Cl_2</th><th>H_2O</th></tr>
<tr><td>initial number of moles</td><td>1.60</td><td>0.500</td><td>0</td><td>0</td></tr>
<tr><td>M1 eqm number of moles</td><td>1.60 – 2 × 0.600 = 0.400</td><td>0.500 – ½ × 0.600 = 0.200</td><td>0.600</td><td>0.600</td></tr>
<tr><td>M2 mole fraction</td><td></td><td></td><td>$\frac{0.600}{1.80}$</td><td></td></tr>
<tr><td>M3 partial pressure</td><td></td><td></td><td>$\frac{0.600}{1.80} \times p_{tot} = 5.00 \times 10^4$</td><td></td></tr>
</table>
</td><td>3</td></tr>
<tr><td rowspan="2">(c)(v)</td><td>$K_p = \frac{(3.6\times10^4)^2 \times (3.6\times10^4)^2}{(4.8\times10^4)^4 \times 3.0\times10^4} = 1.05 \times 10^{-5}$</td><td>1</td></tr>
<tr><td>units = Pa^{-1}</td><td>1</td></tr>
<tr><td>(c)(vi)</td><td>K_p would not change</td><td>1</td></tr>
</table>

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63. 9701_w17_ms_22 Q: 3

(a)	(IE) decreases / lower because increasing **distance** of outer electron(s) from nucleus **OR** increasing distance of outer / valence shell from nucleus **OR** increased **shielding** / screening (from inner shells)	1
	reduces nuclear **attraction** (for electrons)	1
(b)(i)	(Melting point) increases / higher because (molecules have an) increasing (number of) electrons	1
	increasing strength / number / amount of IMFs / Van der Waals' / id–id / London / dispersion (forces)	1
(b)(ii)	increased metallic / (cat)ionic radius / size OR decreasing (cat)ion charge-density	1
	decreased attraction (of ions) for delocalised / outer electrons	1
(c)(i)	reaction 1: HNO_3 or nitric((V)) acid	1
	reaction 2: water / H_2O	1
(c)(ii)	barium oxide	1
	$2Ba + O_2 \rightarrow 2BaO$	1
(c)(iii)	NO_2 / nitrogen dioxide / nitrogen(IV) oxide **AND** O_2 / oxygen	1
	(red / yellow-)brown gas **OR** gas given off that relights glowing splint	1
(c)(iv)	white ppt / solid / suspension	1
	of $BaSO_4$ / barium sulfate **OR** $Mg(OH)_2$ / magnesium hydroxide	1
	$BaSO_4$ is insoluble **OR** $Mg(OH)_2$ is insoluble / partially / slightly / sparingly soluble	1

64. 9701_s19_ms_22 Q: 2

(a)	*trend in volatility down the group* decrease (in volatility)	1
	identification of specific IMF increasing increasing (strength of) induced dipole (id) (interactions between molecules)	1
	explanation in terms of electrons increasing number of electrons	1
(b)(i)	*Conditions for reaction with Cl_2 at room temperature* ultra-violet / uv	1
(b)(ii)	$I_2(g/s) + H_2(g) \rightleftharpoons 2HI(g)$ **M1** correctly balanced equation	1
	M2 correct state symbols AND use of equilibrium sign	1
(c)(i)	proton / H^+ donor	1
(c)(ii)	acid HCl AND conjugate base Cl^-	1
(c)(iii)	co-ordinate / dative (covalent)	1
(c)(iv)	(triangular / trigonal) pyramid(al)	1
	$107^{(0)}$	1

65. 9701_s16_ms_22 Q: 2

(a) (i)	enthalpy / energy / heat change when one mole of gaseous atoms is produced	[1]
	from the element in its standard state	[1]
	under standard conditions	[1]
(ii)	fluorine and chlorine are gases / bromine liquid and iodine solid OR as ΔH_{at} for bromine / iodine also includes changes of state	[1]
(iii)	($\frac{1}{2}Cl_2 + \frac{1}{2}I_2 \rightarrow ICl$) $\Delta H_f = (\frac{1}{2}E(Cl_2) + \frac{1}{2}E(I_2)) - E(ICl)$ OR $E(ICl) = (151/2) + (242/2) + 24$	[1]
	E(IC*l*) = (+) 220.5 / 221	[1]
(b) (i)	stronger / more / greater id–id / London / dispersion forces	[1]
	due to increasing numbers of electrons	[1]
(ii)	(intermolecular forces in HF are) hydrogen bonds (which are) stronger (than vd*W*) / more energy needed to separate molecules OR HF much more polar / F much more electronegative Intermolecular forces in HF stronger (than in HC*l*, HBr, HI)	[1] [1] [1] [1]
(c) (i)	**P** = iodine / I_2 / I; **Q** = chlorine / Cl_2 / C*l*	[1]
(ii)	weaker H–**P** than H–**Q** bond ORA / easier / less energy to break H–**P** than H–**Q** ORA	[1]
	due to greater distance / shielding of nucleus from bond pair ORA	[1]
(iii)	2H**P** (or 2HI) → (or ⇌) H_2 + $\mathbf{P}_2$ (or I_2)	[1]
(iv)	$Ag^+(aq)$ + $\mathbf{Q}^-$(aq) (or Cl^-) →Ag**Q**(s) (or AgC*l*(s))	[1]
	Ag**Q**(s) / AgC*l*(s) + $2NH_3(aq) \rightarrow Ag(NH_3)_2^+(aq)$ + $\mathbf{Q}^-$(aq) / Cl^-(aq)	[1]
(d) (i)	no of C*l* increases by one each time / matches group number	[1]
	due to increasing number of valence/outer(most/shell) electrons / oxidation number / valency (of Mg, A*l*, Si)	[1]
(ii)	$MgCl_2(+aq) \rightarrow Mg^{2+} + 2Cl^-$	[1]
	$AlCl_3 + 6H_2O \rightarrow Al(H_2O)_6^{3+} + 3Cl^-$ / $Al(H_2O)_5(OH)^{2+} + H^+ + 3Cl^-$	[1]
	$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4H^+ + 4Cl^-$	[1]

66. 9701_s21_ms_21 Q: 3

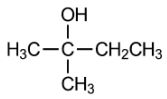
Question	Answer	Marks
(a)(i)	NaC*l* + H_2SO_4 → $NaHSO_4$ + HC*l* OR 2NaC*l* + H_2SO_4 → Na_2SO_4 + 2HC*l*	**1**
(a)(ii)	displacement / acid-base (reaction)	**1**
(b)(i)	hydrogen iodide / HI	**1**
(b)(ii)	dark grey solid I_2 / iodine	**1**
	other product S / sulfur OR H_2S / hydrogen sulfide OR H_2O / water / steam	**1**
(c)	**M1** iodide ions are strong(er) reducing agents (than chloride ions) ORA	**1**
	M2 HI / iodide is oxidised OR HC*l* / chloride is not oxidised	**1**
(d)	$2Br^- + 2H^+ + H_2SO_4 \rightarrow Br_2 + 2H_2O + SO_2$	**1**

67. 9701_s21_ms_22 Q: 1

Question	Answer	Mark
(a)	**M1** cream	1
	M2 AgBr	1
(b)	(1)MBr_2 + $2AgNO_3$ → 2AgBr + **M**$(NO_3)_2$	1
(c)	**M1** *calculate Mr of* ***M****Br_2 using 8.415 × 10^{-4} mol* ***M****Br_2 in 0.250 g* M_r = ……. = 297(.1)……	1
	M2 *calculate the atomic mass of* ***M*** *using* M_r *calculated in M1* 297.1 – (2 × 79.9) = 137(.4)	1
	M3 *identify group 2 element from* A_r *in M2* Ba / barium	1
(d)(i)	(solution / mixture / liquid) turns (colourless to) orange or brown	1
(d)(ii)	displacement	1
(e)	**M1** *reagent:* concentrated sulfuric acid	1
	M2 *observation:* brown vapour / gas (forms)	1
(f)(i)	*explain* ***how the action of heat*** *is used to identify the 3 samples* **M1** nitrate AND carbonate lose mass / less than 1 g	1
	M2 nitrate produces brown (NO_2) fumes	1
	M3 MgO no reaction / MgO no change	1
(f)(ii)	*electronic configuration of* Mg^{2+} ($1s^2$) $2s^22p^6$	1

Question	Answer	Mark
(g)	*One similarity* **M1** solid(s) disappear(s)	1
	One difference **M2** $MgCO_3$ fizzes (due to CO_2) OR no fizzing with $Mg(OH)_2$	1

68. 9701_m20_ms_22 Q: 2

(a)	darker / stronger / deeper down the group	**1**
(b)(i)	weaker oxidising agents / (relative reactivity as oxidising agents) decreases **down the group**	**1**
(b)(ii)	**M1** (structure =) simple / molecular, because it has a low melting / boiling point **M2** (bonding =) covalent, because it is hydrolysed	**2**
(c)(i)	**M1** cream ppt / solid **M2** (ppt / solid) partially dissolves in (aqueous) ammonia	**2**
(c)(ii)	**M1** *Acid behaviour of H_2SO_4* H_2SO_4 acts as an acid with Cl^- OR acid / base reaction with Cl^- **M2** *Oxidising behaviour of H_2SO_4* H_2SO_4 acts as an oxidising agent with I^- OR H_2SO_4 does not oxidise Cl^- **M3** *Products formed* (for iodide reaction) I_2 / S / SO_2 / H_2S is formed OR (for chloride reaction) (only) HCl is formed OR *Comparison of oxidising strength* H_2SO_4 not strong enough to / cannot oxidise Cl^- (to Cl_2) OR I^- more powerful reducing agent than Cl^-	**3**
(d)(i)	**M1** increases (down the group) because of increasing VdW **M2** because of increasing number of electrons	**2**
(d)(ii)	**M1** less stable (down the group) / decreases **M2** lower H–Hal bond enthalpy / energy	**2**
(e)(i)	in the same phase / state	**1**
(e)(ii)	$C_2H_5CH(OH)C_2H_5 + HCl \rightarrow C_2H_5CH(Cl)C_2H_5 + H_2O$	**1**
(e)(iii)		**1**
(e)(iv)	substitution	**1**

69. 9701_s17_ms_23 Q: 2

<table>
<tr><td>(a)(i)</td><td><table>
<tr><td>halogen</td><td>colour</td><td>state</td></tr>
<tr><td>chlorine</td><td>yellow / green</td><td>gas</td></tr>
<tr><td>bromine</td><td>red / brown / orange</td><td>liquid</td></tr>
<tr><td>iodine</td><td>grey / black</td><td>solid</td></tr>
</table></td><td>2</td></tr>
<tr><td>(a)(ii)</td><td>increasing number of electrons</td><td>1</td></tr>
<tr><td></td><td>(gives) increasing strength of van der Waals' / id-id forces / London / dispersion forces</td><td>1</td></tr>
<tr><td>(b)</td><td>oxidising power decreases down the group. ora</td><td>1</td></tr>
<tr><td></td><td>ability to accept electrons decreases (down the group) ora</td><td>1</td></tr>
<tr><td></td><td>because (outer shell experiences) more shielding
OR
increased distance from nucleus (to outer shell) (outweighs the increasing nuclear charge down the group) ora</td><td>1</td></tr>
<tr><td>(c)(i)</td><td>solid sodium chloride: steamy / misty / white fumes</td><td>1</td></tr>
<tr><td></td><td>solid sodium iodide: purple fumes</td><td>1</td></tr>
<tr><td>(c)(ii)</td><td>(conc sulfuric) not powerful enough oxidising agent (to oxidise chloride)
OR
chloride not powerful enough reducing agent (to reduce sulfuric acid)</td><td>1</td></tr>
<tr><td></td><td>iodide reduces sulfuric acid
OR
iodide / I^- is oxidised
OR
sulfuric acid oxidises iodide</td><td>1</td></tr>
<tr><td>(c)(iii)</td><td>$2NaBr + 2H_2SO_4 \rightarrow Br_2 + SO_2 + Na_2SO_4 + 2H_2O$
OR
$NaBr + H_2SO_4 \rightarrow NaHSO_4 + HBr$ AND $2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$
OR
$2NaBr + H_2SO_4 \rightarrow Na_2SO_4 + 2HBr$ AND $2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$</td><td>2</td></tr>
<tr><td>(d)(i)</td><td>AgI (and AgCl solid) / silver ions reacting with iodide ions</td><td>1</td></tr>
<tr><td>(d)(ii)</td><td>AgCl (precipitate) dissolves (in ammonia) owtte</td><td>1</td></tr>
<tr><td></td><td>Total:</td><td>15</td></tr>
</table>

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70. 9701_s21_ms_23 Q: 1

Question	Answer	Marks
(a)(i)	increases	1
(a)(ii)	chlorine gas bromine liquid iodine solid	1
(b)	**M1** observation with $Cl_2(aq)$ (colourless / pale green to) orange / brown	1
	M2 observation with $I_2(aq)$ no visible change	1
	M3 explanation chlorine is a stronger oxidising agent (than bromine) AND iodine is a weaker oxidising agent	1
(c)	$Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$	1
(d)(i)	proton / H^+ acceptor	1
(d)(ii)	$ClO^- + H_2O \rightarrow HClO + OH^-$	1
(e)	**M1** *Use volume O_2 to express / find no mol O_2 produced* 24 / 24 000 mol O_2 produced = 1×10^{-3} (mol)	1
	M2 *Use 1:1 ratio to deduce no mol NaClO in 1000 cm^3 sample* M1 × 1000 / 5 = 0.2 (mol dm^{-3})	1
	M3 *Use amount of NaClO and its molecular mass (74.5) to find the mass of NaClO added* –24 / 24 000 × 1000 / 5 × 74.5 = 14.9 (g dm^{-3})	1
(f)	**M1** products contain Cl^- AND Cl_2	1
	M2 correct balanced equation $ClO^- + 2HCl \rightarrow Cl^- + H_2O + Cl_2$	1

71. 9701_s18_ms_23 Q: 3

<table>
<tr><td>(a)(i)</td><td>(volatility) decreases</td><td>1</td></tr>
<tr><td>(a)(ii)</td><td>increasing numbers / more of electrons (in molecules)</td><td>1</td></tr>
<tr><td></td><td>increased strength of id-id / VdW / IMFs</td><td>1</td></tr>
<tr><td>(b)</td><td>$Cl_2 + 2NaI \rightarrow 2NaCl + I_2$</td><td>1</td></tr>
<tr><td>(c)(i)</td><td><table><tr><td></td><td>NaI(aq) + $AgNO_3$(aq)</td><td>NaCl(aq) + $AgNO_3$(aq)</td></tr><tr><td>colour of ppt</td><td>yellow</td><td>white</td></tr><tr><td>name of ppt</td><td>silver iodide</td><td>silver chloride</td></tr><tr><td>effect of addition of aqueous ammonia to the precipitate</td><td>No (visible) change</td><td>dissolves / soluble</td></tr></table></td><td>3</td></tr>
<tr><td>(c)(ii)</td><td>$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$</td><td>1</td></tr>
<tr><td>(d)</td><td>M1 sulfuric acid acts as an acid with NaCl (and NaBr)
OR
$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
OR
$2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$</td><td>1</td></tr>
<tr><td></td><td>sulfuric acid acts as an oxidising agent with NaI / I
OR
NaI is a reducing agent</td><td>1</td></tr>
<tr><td></td><td>I^- more powerful reducing agent than Cl^-
OR
sulfuric acid can oxidise I^- but not Cl^-
OR
sulfuric acid is a stronger oxidising agent than iodide ions
OR
sulfuric acid is not as strong an oxidising agent than chloride ions</td><td>1</td></tr>
<tr><td>(e)(i)</td><td>(Species that) gains <u>electrons</u> / <u>electron</u> acceptor</td><td>1</td></tr>
<tr><td>(e)(ii)</td><td>$Cl_2 + H_2O \rightarrow HCl + HClO$</td><td>1</td></tr>
<tr><td>(e)(iii)</td><td>$3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$</td><td>1</td></tr>
<tr><td></td><td>0 to –1 (+)5 AND chlorine has been oxidised and reduced.</td><td>1</td></tr>
</table>

72. 9701_s19_ms_22 Q: 3

(a)(i)	$SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(aq/g)$ (state symbols required)	**1**
(a)(ii)	hydrolysis	**1**
(a)(iii)	$NaCl$ – ionic	**1**
	$SiCl_4$ – covalent	**1**
(a)(iv)	**M1** statement correctly comparing the **difference** in electronegativity between Si and Cl AND Na and Cl OR Na is less electronegative that Si *ORA*	**1**
	M2 $NaCl$ transfer of electrons	**1**
	M3 $SiCl_4$ shared (pair of) electrons	**1**
(b)(i)	<table><tr><td>Chlorine containing species</td><td>Cl_2</td><td>HCl</td><td>$HOCl$</td></tr><tr><td>Oxidation number of chlorine</td><td>0</td><td>–1</td><td>(+)1</td></tr></table> Award 2 marks for 3 correct oxidation numbers Award 1 Mark for 2 correct oxidation numbers	**2**
(b)(ii)	disproportionation	**1**
(b)(iii)	kills micro-organisms	**1**
(c)	$2NaOH + HCl + HClO \rightarrow NaCl + NaClO + 2H_2O$ **M1** Identifies the product $NaClO$ **M2** Correctly balances the equation OR The overall equation may be seen as: $NaOH + HCl \rightarrow NaCl + H_2O$ **AND** $NaOH + HClO \rightarrow NaClO + H_2O$	**2**

73. 9701_s20_ms_21 Q: 3

(a)	**M1** (enthalpy / energy change) when one mole of a compound/substance is formed **M2** from its elements in their standard states	**2**
(b)	**M1** *use of correct stoichiometry in calculation* $3x\Delta H_f NO_2$ $1x\text{-}\Delta H_f H_2O$ $2x\Delta H_f HNO_3$ $1x\Delta H_f NO$ **M2** *correct signs associated with the appropriate* ΔH_f values/terms *used for the calculation of* $\Delta H_{reaction}$ **M3** $\Delta H_{reaction} = -(102 - 286) + (-346 + 91.1) = -70.9\ kJ\ mol^{-1}$	**3**
(c)	**M1** nitrogen has a triple bond **M2 EITHER** high energy is needed to break the bond **OR** at normal temperatures there is not enough energy to break the bond / to overcome the activation energy	**2**
(d)	lightning	**1**
(e)(i)	**M1** *define homogeneous* (homogeneous catalyst is) in the same phase / state as the reactants **M2 and M3** *Define catalyst* *All 3 points scores 2 marks. Any 2 points scores 1 mark* increase the rate **AND** lowers the activation energy **AND** without being chemically altered at the end of the reaction / are regenerated at the end of the reaction	
(e)(ii)	**M1** $NO_2 + SO_2 \rightarrow NO + SO_3$ **M2** $NO + ½\ O_2 \rightarrow NO_2$	**2**