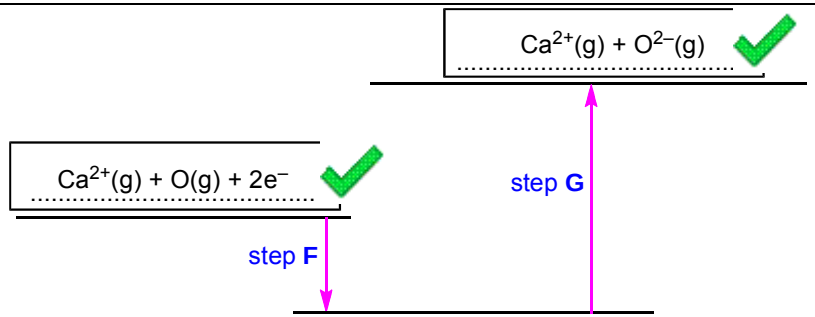
Question			Answer	Marks	Guidance
1	(a)		(The enthalpy change that accompanies) the formation of **one mole** of a(n ionic) compound ✓ from its **gaseous ions** (under standard conditions) ✓	2	**IGNORE** 'energy needed' **OR** 'energy required' **ALLOW** as alternative for compound: lattice, crystal, substance, solid **Note:** **1st mark** requires **1 mole** **2nd mark** requires **gaseous ions** **IF** candidate response has '1 mole of gaseous ions', award 2nd mark but **NOT** 1st mark
	(b)	(i)		2	Correct species **AND** state symbols required for both marks $2e^-$ required for left-hand response **ALLOW** e for e^- Mark each marking point independently
		(ii)	(enthalpy change of) formation (of calcium oxide) ✓ (enthalpy change of) atomisation of oxygen ✓ Second electron affinity (of oxygen) ✓	3	calcium oxide **not** required for this mark **DO NOT ALLOW** 'lattice formation' (*confusion with LE*) atomisation **AND** oxygen/O_2/½O_2/O both required (*atomisation of calcium is also in cycle)* **IGNORE** oxygen or oxygen species, e.g. O^- **DO NOT ALLOW** calcium

Question			Answer	Marks	Guidance
1	(b)	(iii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = –3454 (kJ mol^{-1}) award 2 marks** --- –635 = 178 + 249 + 590 + 1145 + (–141) + 798 + ΔH_{LE}(CaO) **OR** ΔH_{LE}(CaO) = –635 – [178 + 249 + 590 + 1145 + (–141) + 798] **OR** –635 – 2819 ✓ = –3454 ✓ (kJ mol^{-1})	2	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below. **See list below for marking of answers from common errors** --- 1st mark for expression linking ΔH_{LE}(CaO) with ΔH values **ALLOW** LE for ΔH_{LE} **ALLOW** for 1 mark: –3736 use of +141 instead of –141 (+)3454 all signs reversed (+)2184 wrong sign before 2819 –2184 wrong sign for 635 –1858 wrong sign for +798 Any other number:**CHECK** for **ECF** from 1st marking point Award 1 mark for **one** transcription error only and everything else correct: e.g. +187 instead of +178 **IF** any value has been omitted, award zero

Question			Answer	Marks	Guidance
1	(c)		**For first 2 marks,** • **IGNORE** nuclear attraction **OR** proton attraction • Property **AND** effect required • **IGNORE** 'atomic' and 'atoms' and 'molecules' and assume that 'size' and 'charge' refers to ions • **IGNORE** LE increases **OR** LE decreases • **IGNORE** bond strength; strength of ionic bonds		
			First 2 marks Decrease in (ionic) size **AND** **more negative** LE **OR** more **exo**thermic **OR** more attraction ✓ Increase in (ionic) charge **OR** charge density **AND** **more negative** LE **OR** more **exo**thermic **OR** more attraction ✓ --- *Link between LE and attraction* Lattice enthalpy correctly linked to attraction between **IONS** at least once ✓ *e.g. Greater attraction between **ions** gives **more negative** LE*	3	**ANNOTATE WITH TICKS AND CROSSES, etc** **ORA** throughout **ALLOW** pull for attraction **IGNORE** just 'greater force' (*could be repulsion*) **IGNORE** responses in terms of packing **IGNORE** electron density **IGNORE** lower/higher LE --- **For 3rd marking point ONLY, IONS is essential;** **DO NOT ALLOW** attraction between atoms or molecules **DO NOT ALLOW** nuclear attraction
			Total	**12**	

Question			Answer	Marks	Guidance
2	(a)	(i)	Time for concentration (of reactant) to fall to half original value ✓	1	**ALLOW** time for concentration to fall by half **DO NOT ALLOW** concentration of **product** to fall by half **ALLOW** mass **OR** amount as alternative to concentration **ALLOW** time for reactant/substance/atoms to decrease by half
		(ii)	At least two half-lives correctly shown on graph **AND** half-life stated as approx. 54 s ✓ 1st order has a constant half-life ✓	2	**ALLOW** half-life in range 50–56 s **ALLOW** half-life shown on graph **Care**: Initial concentration is ~5.8 and **NOT** 6.0 For constant half-life, **ALLOW** 'half lives are the same', 'two half-lives are 54 s', etc. **ALLOW** 2 tangents drawn, one at half conc of first **AND** evidence that gradient (≡ rate) halves
		(iii)	No change ✓	1	
	(b)	(i)	*Tangent* On graph, tangent drawn to curve at t ~ 40 s ✓ *Calculation of rate from the tangent drawn* e.g. rate = $\frac{5.2}{116}$ = 0.045 **OR** 4.5 x 10^{-2} ✓ *Units* mol dm^{-3} s^{-1} ✓ *Independent mark*	3	Annotate tangent on graph **Note**: This mark can only be awarded from a tangent ***ALLOW ECF*** *for tangent drawn at different time from 40 s* **ALLOW** ±10% of gradient of tangent drawn **ALLOW** 2 SF up to calculator value **ALLOW** trailing zeroes, e.g. 0.04 for 0.040 **IGNORE** '–' sign for rate **Note: IF** candidate calculates rate via ln 2 method (shown in **(ii)**, consult with TL)

Question			Answer	Marks	Guidance
2	(b)	(ii)	$k = \frac{\text{answer to (b)(i)}}{3.45}$ ✓ units: s^{-1} ✓ *Independent mark*	2	From 0.045, $k = \frac{0.045}{3.45} = 0.013$ **ALLOW** concentration range 3.4–3.5 **ALLOW** use of unrounded calculator answer from **(b)(i)** even if different from answer given on **(b)(i)** answer line *Many will keep this value in calculator for **(b)(ii)*** **ALLOW** $k = \ln 2/t_{1/2}$ = 0.693/half life from **(a)(iii)** For 54 s, k = 0.693/54 = 0.013 **ALLOW** 2 SF up to calculator value
	(c)		water is in excess **OR** concentration of H_2O is very large/does not change ✓	1	**IGNORE** water does not affect the rate
			Total	**10**	

Question			Answer	Marks	Guidance
3	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 16.8 with 'no units', award **5 marks** --- At equilibrium, $n(I_2)$ **OR** $[I_2(g)]$ = $4.00 \times 10^{-3} - 1.70 \times 10^{-3} = 2.30 \times 10^{-3}$ (mol / mol dm^{-3}) ✓ $n(HI)$ **OR** $[HI(g)]$ = $2 \times 1.70 \times 10^{-3}$ = 3.40×10^{-3} (mol / mol dm^{-3}) ✓ (K_c =) $\frac{(3.40 \times 10^{-3})^2}{3.00 \times 10^{-4} \times 2.30 \times 10^{-3}}$ ✓ **IGNORE** $K_c = \frac{[HI]^2}{[H_2]\,[I_2]}$ = 16.8 (**3 SF** required) ✓ no units ✓	5	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below --- **ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW ECF** throughout For **all** parts, **ALLOW** numerical answers from 3 significant figures up to the calculator value **ALLOW** omission of trailing zeroes, i.e. 3.40 as 3.4 but final numerical answer for K_c must be to 3 SF **ALLOW ECF** using incorrect values for $[I_2]$ **AND** $[HI]$ **BUT** $[H_2]$ in K_c expression must be 3.00×10^{-4} (given in Q) **ALLOW ECF** from incorrect K_c expression for calculation to 3 SF and units **For 'no units' ALLOW 'none' (ORA) OR '—'** **DO NOT ALLOW** space to be left blank **Common errors:** Use of 1.70×10^{-3} for $n(HI)$ (no factor of x 2) K_c = 4.19 (3SF) and no units: 4 marks Use of K_c expression used is upside down K_c = 0.0597 (3SF) and no units: 4 marks No square for $[HI]^2$ K_c = 4930 and $dm^3\ mol^{-1}$ 4 marks **Note:** different ECF units

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>3</td><td>(b)</td><td>(i)</td><td>
<table>
<tr><th></th><th>$H_2(g)$</th><th>$I_2(g)$</th><th>HI(g)</th></tr>
<tr><td>greater</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>smaller</td><td></td><td>✓</td><td></td></tr>
<tr><td>the same</td><td></td><td></td><td></td></tr>
</table>
Each column should have only one box ticked

Correct ticks for $H_2(g)$ AND $I_2(g)$ AND HI(g) two marks ✓✓
i.e. all three columns correct

Ticks for two of $H_2(g)$, $I_2(g)$ and HI(g) correct one mark ✓
i.e. two columns correct
</td><td>2</td><td>DO NOT ALLOW more than one box ticked in a column (response is a CON)</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>K_c is smaller
AND
(forward) reaction is exothermic OR ΔH is negative ✓</td><td>1</td><td>Link to ΔH/exothermic essential
ALLOW reverse reaction is endothermic
DO NOT ALLOW equilibrium shifts to the right (CON)</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>K_c is the same
AND
K_c is temperature dependent OR K_c is not changed by pressure ✓</td><td>1</td><td>ALLOW K_c is only changed by temperature
IGNORE same number of moles on both side</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>9</td><td></td></tr>
</table>

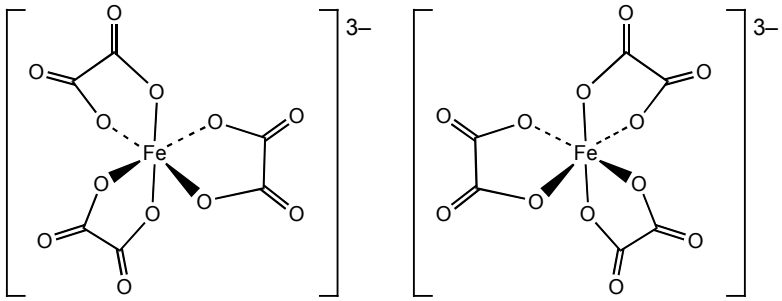
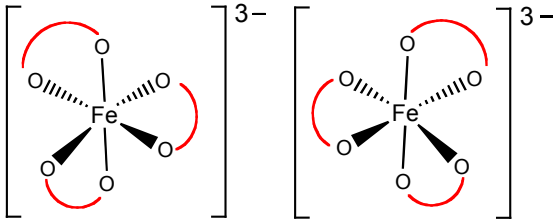
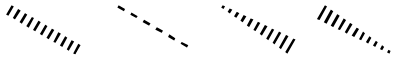
Question			Answer	Marks	Guidance
4	(a)		HC*l* is a strong acid **AND** HC*l*O is a weak acid ✓ **HC*l***: pH = –log 0.14 = 0.85 (**2 DP** required) ✓ **HC*l*O**: **CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 4.14, award all three calculation marks --- $K_a = 10^{-7.43}$ **OR** 3.7×10^{-8} (mol dm^{-3}) ✓ $[H^+] = \sqrt{K_a \times [HClO]}$ **OR** $\sqrt{K_a \times [HA]}$ **OR** $\sqrt{K_a \times 0.14}$ **OR** $\sqrt{3.7 \times 10^{-8} \times 0.14}$ ✓ pH = 4.14 (**2 DP** required) ✓	5	**ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW** HC*l* completely dissociates **AND** HC*l*O partially dissociates **ALLOW** HC*l* $\rightarrow$ H^+ + C*l* **AND** HC*l*O $\rightleftharpoons$ H^+ + C*l*O$^-$ **IGNORE** HC*l* is a stronger acid than HC*l*O **IGNORE** HC*l* produces more H^+ **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below --- **ALLOW** 2 SF to calculator value: $3.715352291 \times 10^{-8}$, correctly rounded **IGNORE** 'HC*l*' if it is clear that it is a 'slip' Always **ALLOW** calculator value irrespective of working as number may have been kept in calculator. ***Note**: pH = 4.14 is obtained from all three values above* *From no square root, pH = 8.28. Worth K_a mark only*

Question			Answer	Marks	Guidance
4	(b)		$2Al + 6CH_3COOH \longrightarrow 2(CH_3COO)_3Al + 3H_2$ ✓ $2Al + 6H^+ \longrightarrow 2Al^{3+} + 3H_2$ ✓	2	**IGNORE** state symbols **ALLOW** correct multiples, e.g.: $Al + 3CH_3COOH \longrightarrow (CH_3COO)_3Al + 1.5H_2$ **ALLOW** any unambiguous formula for $(CH_3COO)_3Al$, *i.e.* $(CH_3CO_2)_3Al$, $Al(CH_3CO_2)_3$, $(CH_3COO^-)_3Al^{3+}$, etc. **Note**: **IF** charges are shown, they **must** be correct with **both** – and 3+ shown **ALLOW** multiples, e.g.: $Al + 3H^+ \longrightarrow Al^{3+} + 1.5H_2$
	(c)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 13.6(0), award **2 marks** --- $[H^+] = \frac{K_w}{[OH^-]}$ **OR** $\frac{1.0 \times 10^{-14}}{[OH^-]}$ **OR** $\frac{1.0 \times 10^{-14}}{0.4(0)}$ **OR** 2.5×10^{-14} (mol dm^{-3}) ✓ Correctly calculates pH = $-\log 2.5 \times 10^{-14} = 13.6(0)$ ✓	2	**ALLOW** alternative approach using pOH: pOH = 0.4(0) ✓ pH = 14 – 0.40 = 13.6(0) ✓ **ALLOW ECF** from $[H^+]$ derived using K_w and $[OH^-]$ BUT **DO NOT ALLOW** an acid pH. **ALLOW** one or more decimal places

Question			Answer	Marks	Guidance
4	(d)	(i)	A buffer solution minimises pH changes ✓ on addition of **small** amounts of acid/H^+ or alkali/OH^-/base ✓ --- HCOOH ⇌ H^+ + $HCOO^-$ ✓ *Equilibrium sign essential*	7	**ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW** resists pH changes **ALLOW** buffer solutions maintains a **nearly**/**virtually** constant pH **DO NOT ALLOW** a response that implies that the pH is actually constant, e.g. does not change pH; maintains pH --- **DO NOT ALLOW** $COOH^-$ **OR** CHOOH **OR** COOH **DO NOT ALLOW** HA ⇌ H^+ + A^-
			For effect of acid and alkali, **ALLOW** wrong carboxylic acid (e.g. CH_3COOH) **OR** HA; **ALLOW** CHOOH for acid (effectively **ECF**) **ALLOW** $COOH^-$ for base **ALLOW** responses based on COOH ⇌ H^+ + COO^- **DO NOT ALLOW** other incorrect formula, e.g. CH_3OOH		**<u>Quality of written communication, QWC</u>** *2 marks are for explaining how the equilibrium system allows the buffer solution to control the pH on addition of H^+ and OH^-*
			Added alkali HCOOH reacts with added alkali/base/OH^- **OR** added alkali/OH^- reacts with H^+ ✓ **QWC**: Equilibrium shifts forming $HCOO^-$ **OR** H^+ **OR** (HCOOH) Equilibrium → right ✓ **Added acid** $HCOO^-$ reacts with added acid/H^+ ✓ **QWC**: Equilibrium shifts forming HCOOH **OR** (HCOOH) Equilibrium → left ✓		**ALLOW** HA **OR** weak acid reacts with added alkali **DO NOT ALLOW** this mark if there is no equilibrium system shown, e.g. HCOOH ⇌ H^+ + $HCOO^-$ is absent **ALLOW** A^- **OR** conjugate base reacts with added acid **IGNORE** salt reacts with added acid **DO NOT ALLOW** this mark if there is no equilibrium system shown, e.g. HCOOH ⇌ H^+ + $HCOO^-$ is absent

Question			Answer	Marks	Guidance
4	(d)	(ii)	**HCOOH** reacts with **NaOH** forming **$HCOO^-$/HCOONa** **OR** $HCOOH + NaOH \rightarrow HCOONa + H_2O$ ✓ *Equilibrium sign allowed* (Some) HCOOH/(weak) acid remains **OR** HCOOH/(weak) acid is in excess ✓	6	**ANNOTATE WITH TICKS AND CROSSES, etc** **DO NOT ALLOW** just 'methanoate/$HCOO^-$ forms' *formulae or names of reactants also required* **ALLOW** $HCOOH + OH^- \rightarrow HCOO^- + H_2O$ ✓ **IGNORE** conjugate base/**salt forms** **IGNORE** HCOOH has been partially neutralised
			Calculation **CHECK THE ANSWER** **IF** answer = 3.99, award all **four** calculation marks		
			n(HCOOH) **OR** [HCOOH] = 0.24(0) (mol / mol dm^{-3}) ✓ $n(HCOO^-)$ **OR** $[HCOO^-]$ **OR** [HCOONa] = 0.4(00) (mol / mol dm^{-3}) ✓ $[H^+] = K_a \times \frac{[HCOOH]}{[HCOO^-]}$ ✓ $pH = -\log [H^+] = -\log(1.70 \times 10^{-4} \times \frac{0.24}{0.4}) = 3.99$ ✓ --- **OR** use of Henderson–Hasselbalch equation: $pH = pK_a + \log \frac{[HCOO^-]}{[HCOOH]}$ **OR** $pH = -\log K_a + \log \frac{[HCOO^-]}{[HCOOH]}$ ✓ = 3.77 + 0.22 = 3.99 ✓		**Note:** There must be a clear statement that 0.24 and 0.4 apply to moles or concentrations of HCOOH and $HCOO^-$. **DO NOT ALLOW** these values if unlabelled **ALLOW** HA/acid and A^-/salt for HCOOH and $HCOO^-$ **DO NOT ALLOW ECF for this mark:** **3.99 is the ONLY correct answer** --- **ALLOW** HA/acid and A^-/salt for HCOOH and $HCOO^-$ **ALLOW** $pH = pK_a - \log \frac{[HCOOH]}{[HCOO^-]}$ **OR** $pH = -\log K_a - \log \frac{[HCOOH]}{[HCOO^-]}$ **ALLOW** = 3.77 – (–0.22) = 3.99 **DO NOT ALLOW ECF for this mark:** **3.99 is the ONLY correct answer**
			Total	**22**	

Question			Answer	Marks	Guidance
5	(a)		$2Fe + 3Cl_2 \longrightarrow 2FeCl_3$ ✓	1	**ALLOW** $2Fe + 3Cl_2 \longrightarrow Fe_2Cl_6$ **ALLOW** multiples, e.g. $Fe + 1½Cl_2 \longrightarrow FeCl_3$ **IGNORE** state symbols **DO NOT ALLOW** $2Fe + 3Cl_2 \longrightarrow 2Fe^{3+} + 6Cl^-$
	(b)		$Fe^{3+} + 3OH^- \longrightarrow Fe(OH)_3$ ✓	1	**IGNORE** state symbols **ALLOW** $[Fe(H_2O)_6]^{3+} + 3OH^- \longrightarrow Fe(H_2O)_3(OH)_3 + 3H_2O$ **ALLOW** $[Fe(H_2O)_6]^{3+} + 3OH^- \longrightarrow Fe(OH)_3 + 6H_2O$
	(c)	(i)	$2[Fe(H_2O)_6]^{3+} + Zn \longrightarrow 2[Fe(H_2O)_6]^{2+} + Zn^{2+}$ All chemical species correct (**IGNORE** e^- for 1st mark) ✓ Balancing with '2' in front of **both** Fe complex ions ✓	2	**IGNORE** state symbols **For 1 mark,** **ALLOW** balancing if (aq) species have been used instead of complex ions: $2Fe^{3+} + Zn \longrightarrow 2Fe^{2+} + Zn^{2+}$
		(ii)	redox ✓	1	**ALLOW** reduction **AND** oxidation **CARE**: possible confusion with **(d)(ii)**
	(d)	(i)	Formula of **E** as $[Fe(CN)_6]^{3-}$ shown as product in equation ✓ Correct balanced equation: $[Fe(H_2O)_6]^{3+} + 6CN^- \longrightarrow [Fe(CN)_6]^{3-} + 6H_2O$ ✓ Notice different charges on complex ions: LHS 3+, RHS 3– state symbols **not** required	2	**ALLOW** equations with KCN, i.e.: $[Fe(H_2O)_6]^{3+} + 6KCN \rightarrow [Fe(CN)_6]^{3-} + 6K^+ + 6H_2O$ $[Fe(H_2O)_6]^{3+} + 6K^+ + 6CN^- \rightarrow [Fe(CN)_6]^{3-} + 6K^+ + 6H_2O$ **ALLOW** ECF for an equation showing formation of $[Fe(CN)_6]^{4-}$ from $[Fe(H_2O)_6]^{2+}$: $[Fe(H_2O)_6]^{2+} + 6CN^- \longrightarrow [Fe(CN)_6]^{4-} + 6H_2O$ Notice different charges on complex ions: LHS 2+, RHS 4–
		(ii)	ligand substitution ✓	1	**ALLOW** ligand exchange **OR** ligand replacement **CARE**: possible confusion with **(c)(ii)**

Question			Answer	Marks	Guidance
5	(e)		**F** and **G**:  1 mark for each isomer ✓✓ *Bonds **must** go to O ligand atoms on **EACH** structure* ***IGNORE** charges on Fe^{3+} and O^{-} at this stage* 3– charge outside brackets of **BOTH** isomers **AND NO** charges shown on Fe or O within brackets **Note**: This mark is only available from structures with three bidentate ligands bonded to Fe via two Os on each ligand ✓	3	**ALLOW** any attempt to show bidentate ligand Bottom line is the diagram below.  **IGNORE** structure between two Os in ligand even if slightly different Must contain 2 out wedges, 2 in wedges and 2 lines in plane of paper. For bond into paper, **ALLOW**: 
	(f)		FeO_4^{2-} ✓	1	Formula **AND** charge needed **ALLOW** other 2– ions containing: Fe **AND** O **AND** Fe has ox no of +6 i.e. **ALLOW** $Fe_2O_7^{2-}$**,** $Fe_3O_{10}^{2-}$, etc.
			Total	**12**	

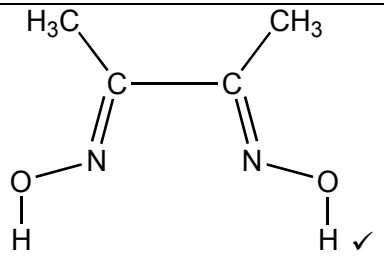
Question			Answer	Marks	Guidance
6	(a)	(i)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 218, award **2 marks** --- $-256 = (6 \times 205) + S(C_6H_{12}O_6) - (6 \times 214 + 6 \times 70)$ **OR** $S(C_6H_{12}O_6) = -256 - (6 \times 205) + (6 \times 214 + 6 \times 70)$ **OR** –256 + 474 ✓ = 218 (J K^{-1} mol^{-1}) ✓	2	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible. Note that **ALL** 4 S values must be used for **ECF** --- **ALLOW** 1 mark for –218 **ALLOW** 1 mark for +730 (*products – reactants*) **Note:** –3190 for simple addition of products + reactants scores zero marks
		(ii)	ΔG = +2879 – 298 × –0.256 ✓ = (+)2955 (kJ mol^{-1}) ✓	2	**ALLOW** 3 SF: 2960 to calculator value of 2955.288 **Award 1 mark for the following:** • ΔG = 2890 to calculator value of 2885.4 *25 °C used rather than 298 K:* • ΔG = 79200 to calculator value of 79167 *ΔS not converted from J K^{-1} mol^{-1} to kJ $K^{-1}mol^{-1}$* • expressions with **one** transcription error: e.g. +2897 instead of +2879; 0.265 instead of 0.256 • ΔG = 2814.036 *use of 218 rather than –256* • Use of 'answer to **(a)(i)**'/1000 (by **ECF**)
		(iii)	ΔH is positive **OR** $\Delta H > 0$ **AND** ΔS is negative **OR** $T\Delta S$ is negative **OR** $\Delta S < 0$ **OR** $T\Delta S < 0$ **AND** ΔG will always be positive **OR** $\Delta G > 0$ ✓	1	**ALLOW** ΔH is endothermic for ΔH is +ve **ALLOW** ΔG will never be less than 0 **DO NOT ALLOW** *S* or *H* i.e. **change** in entropy, ΔS and change in enthalpy ΔH are essential

Question			Answer	Marks	Guidance
6	(b)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 3.12 x 10^{17} g, award **2 marks** --- amount of CO_2 removed = $3.4 \times 10^{18} \times 6 / 2879$ **OR** 7.09×10^{15} (mol) ✓ mass of $CO_2 = 44.0 \times 7.09 \times 10^{15} = 3.12 \times 10^{17}$ g ✓	2	**ALLOW** 2 SF (7.1×10^{15} (mol)) up to calculator value of 7.085793678, correctly rounded **ALLOW** 2 SF (3.1×10^{17} g) up to calculator value, correctly rounded **Correct units required for 2nd mark** e.g. 3.12×10^{14} kg; 3.12×10^{11} tonne **ALLOW** 1 mark for 3.1×10^{17} with no unit **ALLOW** ECF from incorrectly calculated amount of CO_2 provided that both 3.4 x 10^{18} **AND** 2879 have been used e.g. Omission of x 6 gives 1.181 x 10^{15} mol CO_2 and 5.196 x 10^{16} g CO_2
			Total	**7**	

Question			Answer	Marks	Guidance
7	(a)		**Definition** The e.m.f. (of a half-cell) compared with a (standard) hydrogen half-cell/(standard) hydrogen electrode ✓ **Standard conditions** Temperature of 298 K / 25ºC **AND** (solution) concentrations of 1 mol dm^{-3} / 1M **AND** pressure of 101 kPa **OR** 100 kPa ✓	2	**ALLOW** voltage **OR** potential difference **OR** p.d. **OR** electrode potential **OR** reduction potential **OR** redox potential as alternative for e.m.f. **IGNORE** S.H.E. (as abbreviation for standard hydrogen electrode) **ALLOW** 1 atmosphere/1 atm **OR** 10^5 Pa **OR** 1 bar
	(b)		2.71 V ✓	1	**IGNORE** any sign
	(c)	(i)	$Al + 3Fe^{3+} \longrightarrow Al^{3+} + 3Fe^{2+}$ ✓ $2Al + 3I_2 \longrightarrow 2Al^{3+} + 6I^-$ ✓ $2I^- + 2Fe^{3+} \longrightarrow I_2 + 2Fe^{2+}$ ✓	3	Correct species **AND** balancing needed for each mark **IGNORE** state symbols **ALLOW** equilibrium sign (i.e. assume reaction is to right) **ALLOW** correct multiples **IF** there are **more than** three equations • mark a maximum of three equations • mark incorrect equations first
		(ii)	High activation energy **OR** slow rate ✓ Conditions not standard **OR** concentrations not 1 mol dm^{-3} ✓	2	 **DO NOT ALLOW** 'standard conditions' are different

Question			Answer	Marks	Guidance
7	(d)		**ANNOTATE WITH TICKS, CROSSES, etc**	4 max	**ORA** throughout Minimum identification for system **6** is Cl^- Minimum identification for system **7** is ClO^- **Note**: Cl_2 is unsuitable as an identifier as it features in both system **6** and system **7** **IGNORE** reference to gaining and losing electrons; oxidation and reduction
			General (2 marks – assumed to be acid) • (E of) **7** (ClO^-/Cl_2) is more positive/less negative (than **6**) **OR** E_{cell} is (+)0.27 (V) **OR** E_{cell} is positive ✓ • **6** (Cl_2/Cl^-) moves to left **AND 7** (ClO^-/Cl_2) to right ✓		--- **Note**: identification of systems 6 and 7 could be from use of relevant half equations/overall equation **ALLOW** 'greater' or 'higher' for 'more positive' **ALLOW** correct eqn: $Cl^- + ClO^- + 2H^+ \rightarrow Cl_2 + H_2O$ **IGNORE** uncancelled electrons **ALLOW** multiples, e.g. $2Cl^- + 2ClO^- + 4H^+ \rightarrow 2Cl_2 + 2H_2O$ **Note**: **IF** equilibrium shifts are correct, **IGNORE** incorrectly balanced equation but **CON** an equation in wrong direction
			In alkali (3 marking points), • H^+ in **7** (ClO^-/Cl_2) is removed by/reacts with OH^-/alkali ✓ • (E of) **7** (ClO^-/Cl_2) less positive/more negative (than **6**) ✓ • **6** (Cl_2/Cl^-) moves to right **AND 7** (ClO^-/Cl_2) to left ✓		--- **ALLOW** correct eqn: $Cl_2 + H_2O \rightarrow Cl^- + ClO^- + 2H^+$ **IGNORE** uncancelled electrons **ALLOW** multiples, e.g. $2Cl_2 + 2H_2O \rightarrow 2Cl^- + 2ClO^- + 4H^+$ **Note**: **IF** equilibrium shifts are correct, **IGNORE** incorrectly balanced equation but **CON** an equation in wrong direction

Question			Answer	Marks	Guidance
	(e)	(i)	IO_3^- has removed/gained electrons from Sn^{2+} **OR** IO_3^- has been reduced to I_2 / reduced to 0 **OR** IO_3^- has oxidised Sn^{2+} ✓	1	**ALLOW** IO_3^- is the oxidising agent as I has been reduced **DO NOT ALLOW** just IO_3^- has been reduced **DO NOT ALLOW** I is the oxidising agent
		(ii)	$5Sn^{2+} + 2IO_3^- + 12H^+ \longrightarrow I_2 + 5Sn^{4+} + 6H_2O$ All chemical species correct with **no extra** chemical species ✓ Correct balancing with no electrons shown ✓	2	**ALLOW** correct multiples eg $2½\ Sn^{2+} + IO_3^- + 6H^+ \rightarrow ½\ I_2 + 2½\ Sn^{4+} + 3H_2O$ **IGNORE** e^- for 1st marking point
			Total	**15**	

Question			Answer	Marks	Guidance
8	(a)		$(1s^2 2s^2 2p^6)\ 3s^2 3p^6 3d^8 4s^2$ ✓ $(1s^2 2s^2 2p^6)\ 3s^2 3p^6 3d^8$ ✓	2	**ALLOW** 4s before 3d, i.e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$ **IF** candidate has used subscripts **OR** caps, **DO NOT ALLOW** when first seen but credit subsequently, i.e. $1s_2 2s_2 2p_6 3s_2 3p_6 3d_8 4s_2$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3D^8$ For Ni^{2+} **ALLOW** $4s^0$ in electron configuration
	(b)	(i)	Acts as a base **OR** alkali **AND** removes/accepts a proton (from DMGH) ✓	1	
		(ii)	4 ✓	1	
		(iii)	(Each) DMG has 1– charge which **cancel** 2+ charge on Ni^{2+} ✓	1	**ALLOW** 2 x –1 + 2 = 0 For Ni^{2+}, **ALLOW** Ni has an oxidation number of (+)2 **ALLOW** Ni^{2+} cancelled out by 2 DMG^- **ALLOW** 'balanced' for cancelled
		(iv)	 ✓	1	**ALLOW** OH for O—H **ALLOW** CH_3— **DO NOT ALLOW** —H—O

Question			Answer	Marks	Guidance
8	(c)		**Marks are for correctly calculated values** *amount of Ni* ---------- amount $Ni(DMG)_2$ **OR** amount hydrated salt **OR** amount Ni^{2+} $= \frac{2.57}{288.7}$ = **$8.9(0) \times 10^{-3}$** mol ✓ *M values* ---------- *M*(hydrated salt) = $\frac{2.50}{8.90 \times 10^{-3}}$ = **280.9** (g mol^{-1}) ✓ *M*(anhydrous salt) = $\frac{1.38}{8.90 \times 10^{-3}}$ = **155.0** (g mol^{-1}) ✓ *H_2O* ---------- mass H_2O = 2.50 – 1.38 = **1.12 g** ✓ *n*(H_2O) from mass or *M* values $= \frac{1.12}{18.0}$ = **$6.2(2) \times 10^{-2}$ OR** 280.9 – 155.0 **~125.9** ✓ waters of crystallisation $= \frac{6.22 \times 10^{-2}}{8.90 \times 10^{-3}}$ = **7** **OR** $\frac{125.9}{18.0}$ = **7** ✓ *Anion* ---------- Molar mass of anion = 280.9 – (58.7 + 7 x 18) = **96.1** (g mol^{-1}) **OR** Molar mass of anion = 155.0 – 58.7 = **96.3** (g mol^{-1}) ✓ *Formula* ---------- Formula of salt is **$NiSO_4 \bullet 7H_2O$** ✓	**7 max**	**ANNOTATE WITH TICKS AND CROSSES, etc** **Note:** The answers incorporate three different approaches to solving this problem. **IF candidate attempts calculation via another method, consult your TL** **ECF** answer above **ALLOW** numerical answers 280.8 – 280.9 (**ALLOW** 281) **IGNORE** further figures **ALLOW** numerical answers 155.0 – 155.1 (**ALLOW** 155) **IGNORE** further figures **ASSUME** that 'unlabelled 1.12 g' applies to H_2O unless contradicted **ALLOW** numerical answers 125.7 – 125.9 (**ALLOW** 126) **ECF** answer above **7** as whole number is required **Note:** Mark for 7 can be credited within formula **BUT** there must be some relevant working to derive ~7, e.g. 6.99 **ALLOW** numerical answers 96.0 – 96.4 (**ALLOW** 96)
			Total	**13**	