OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced GCE

Unit **F325:** Equilibria, Energetics and Elements

Mark Scheme for January 2011

Oxford Cambridge and RSA Examinations

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of pupils of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, OCR Nationals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support which keep pace with the changing needs of today's society.

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by Examiners. It does not indicate the details of the discussions which took place at an Examiners' meeting before marking commenced.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

© OCR 2011

Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

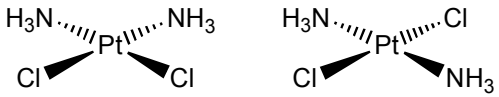
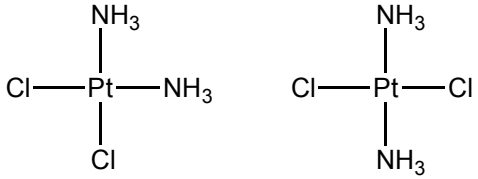
Question			Answer	Mark	Guidance
1	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 8.3×10^4 **OR** 83333 award **2 marks** **THEN IF** units are **dm^6 mol^{-2} s^{-1}**, award 1 further mark		
			$k = \frac{rate}{[H_2(g)]\,[NO(g)]^2}$ **OR** $\frac{3.6 \times 10^{-2}}{(1.2 \times 10^{-2}) \times (6.0 \times 10^{-3})^2}$ ✓		
			= 8.3×10^4 **OR** 83000 **OR** 83333 ✓	2	**ALLOW** 2 SF up to calculator value of 8.33333333×10^4 correctly rounded **ALLOW ECF** for calculated answer from incorrectly rearranged *k* expression but **not** for units (Marked independently see below)
			units: $dm^6\ mol^{-2}\ s^{-1}$ ✓	1	**ALLOW** dm^6, mol^{-2} and s^{-1} in any order, ***eg*** $mol^{-2}\ dm^6\ s^{-1}$ **DO NOT ALLOW** other units (Rate equation supplied on paper – **not** derived from data)
	(b)	(i)	*effect on rate* × 2 ✓	1	**ALLOW** 'doubles' **OR** *rate* = 7.2 x 10^{-2} (mol dm^{-3} s^{-1})
		(ii)	*effect on rate* × ¼ **OR** x 0.25 ✓	1	**ALLOW** 'a quarter' **OR** decrease by ¼ **OR** decrease by 0.25 **OR** rate decreases by 4 **OR** decrease by 75% **OR** *rate* = 0.9 × 10^{-2} (mol dm^{-3} s^{-1}) **DO NOT ALLOW** just 0.5^2 of rate **OR** rate decreases by 2^2
		(iii)	*effect on rate* × 64 ✓	1	**ALLOW** *rate* = 2.3(04) (mol dm^{-3} s^{-1}) **DO NOT ALLOW** just 'increases by 4 and then by 16 / 4^2 **OR** increases by 4^3

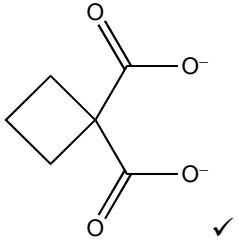
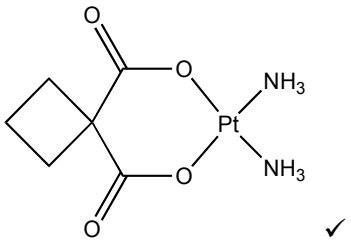
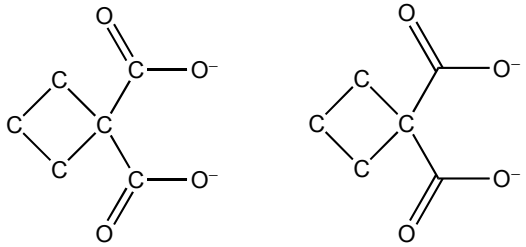
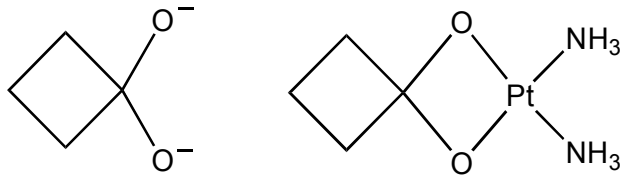
Question			Answer	Mark	Guidance
1	(c)	(i)	(initial) rate increases **AND** more frequent collisions **OR** more collisions **per second/time** ✓	1	**BOTH** points required for mark **ALLOW** rate increases **AND** concentration increases For concentration increases, **ALLOW** particles closer together **OR** less space between particles **DO NOT ALLOW** just more collisions **OR** collisions more likely
		(ii)	rate constant does not change ✓	1	
	(d)		step 1: $H_2(g) + 2\,NO(g) \longrightarrow N_2O(g) + H_2O(g)$ LHS of step one ✓ step 2: $H_2(g) + N_2O(g) \longrightarrow N_2(g) + H_2O(g)$ rest of equations for step 1 **AND** step 2 ✓	2	State symbols **NOT** required For 'rest of equations', This mark can **only** be awarded if 1st mark can be awarded **ALLOW** other combinations of **two** steps that together give the overall equation (shown above part in scoris window), *eg* step 1: $\longrightarrow N_2(g) + ½\,O_2(g) + H_2O(g)$ step 2: $H_2(g) + ½\,O_2(g) \longrightarrow H_2O(g)$ step 1: $\longrightarrow H_2O_2(g) + N_2(g)$ step 2: $H_2(g) + H_2O_2(g) \longrightarrow 2H_2O(l)$ There may be others with species, such as $H_2N_2O_2$ and HNO. Provided the two steps add up to give the overall equation **AND** charges balance, the 2nd mark can be awarded
			Total	**10**	

Question			Answer	Mark	Guidance
2	(a)		Fe: $(1s^2 2s^2 2p^6)3s^2 3p^6 3d^6 4s^2$ ✓ Fe^{2+}: $(1s^2 2s^2 2p^6)3s^2 3p^6 3d^6$ ✓	2	**ALLOW** 4s before 3d, i.e. $(1s^2 2s^2 2p^6)3s^2 3p^6 4s^2 3d^6$ **ALLOW** $4s^0$ **ALLOW** subscripts **IGNORE** $1s^2 2s^2 2p^6$ is written out a second time
	(b)		coloured (compound/complex/precipitate/ions) **OR** catalyst ✓	1	**IGNORE** 'variable oxidation states' **….** but **ALLOW** the idea that Fe^{2+} can react to form an **ion** with a different charge/oxidation state. '**ion**' is essential: 'atom' or 'metal' is **not** sufficient **IGNORE** partially filled d sub-shell/d orbital (question refers to property of Fe^{2+})
	(c)		Fe oxidised from +2 to +3 ✓ Cr reduced from +6 to +3 ✓	2	**CHECK** and credit oxidation numbers on equation **ALLOW** Fe^{2+} oxidised to Fe^{3+} **ALLOW** Cr^{6+} reduced to Cr^{3+} **ALLOW** + sign after number in oxidation number, *ie* 2+, etc **ALLOW** 1 mark only if oxidation numbers given with no identification of which species has been oxidised or reduced, *ie* Fe goes from +2 to +3 **AND** Cr goes from +6 to +3 Fe reduced from +2 to +3 **AND** Cr oxidised from +6 to +3 (*oxidation and reduction the wrong way around*) **DO NOT ALLOW** just 'Fe is oxidised **and** Cr reduced' **IGNORE** other oxidations numbers (even if wrong) **IGNORE** any references to electrons

Question			Answer	Mark	Guidance
2	(d)		(K_{stab} =) $\dfrac{\left[[Fe(NH_3)_6]^{2+}\right]}{\left[[Fe(H_2O)_6]^{2+}\right]\left[NH_3\right]^6}$ On **top**, **ONLY** $[Fe(NH_3)_6]^{2+}$ shown **AND** on bottom, $[Fe(H_2O)_6]^{2+}$ **AND** $[NH_3]^6$ shown ✓ correct use of square brackets and double square brackets in expression ✓	2	**IGNORE** state symbols **ALLOW** 1 mark if complete expression with correct use of double brackets is shown but upside down **DO NOT ALLOW** round brackets for concentrations and complex ions **ALLOW for 1 mark** (K_{stab} =) $\dfrac{\left[[Fe(NH_3)_6]^{2+}\right]\left[H_2O\right]^6}{\left[[Fe(H_2O)_6]^{2+}\right]\left[NH_3\right]^6}$
	(e)	(i)	O_2/oxygen bonds to Fe^{2+}/Fe(II)/Fe ✓ When required, O_2 substituted **OR** O_2 released ✓	2	**ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW** O_2 binds to Fe^{2+} **OR** O_2 donates electron pair to Fe^{2+} **ALLOW** O_2 bonds to metal ion/metal **DO NOT ALLOW** just O_2 bonds to haemoglobin **OR** O_2 bonds to complex **ALLOW** bond breaks between O_2 and Fe^{2+} when O_2 required **OR** O_2 replaces H_2O **OR** vice versa **ALLOW** O_2 replaces CO_2 **OR** vice versa **ALLOW** O_2 replaces a ligand **OR** vice versa **IGNORE** just 'by ligand substitution' (in the question)

Question			Answer	Mark	Guidance
2	(e)	(ii)	(For complex) with CO, stability constant is greater (than with complex in O_2) **OR** with CO, stability constant is high ✓ (Coordinate) bond with CO is stronger (than O_2) **OR** bond with CO is strong ✓	2	**ANNOTATE WITH TICKS AND CROSSES, etc** **Comparison** of CO and O_2 is **NOT** required **ALLOW** stability constant with/of CO is greater **IGNORE** (complex with) CO is more stable **ALLOW** bond with CO is less likely to break **OR** bond with CO more likely to form **OR** 'CO cannot be removed' **OR** idea that attachment of CO is irreversible **OR** CO is a stronger ligand (than O_2) **OR** CO has greater affinity for ion/metal/haemoglobin (than O_2) **IGNORE** CO bonds more easily
	(f)	(i)	Pt^{2+}/Pt is +2/2+, 2 x Cl^- –2 ✓	1	**DO NOT ALLOW** response in terms of Cl_2 rather than Cl^- **DO NOT ALLOW** 'charges cancel' without the charges involved being stated

Question			Answer	Mark	Guidance
2	(f)	(ii)	 **OR**  ✓✓ For each structure Ligand donates an electron pair to metal (ion)/Pt^{2+}/Pt **OR** forms a coordinate bond to the metal (ion)/Pt^{2+}/Pt ✓	3	**IGNORE** any charge, ie Pt^{2+} **OR** Cl^-, even if wrong **IGNORE** any angle, even if wrong **ACCEPT** bonds to H_3N (does not need to go to 'N') Assume that a solid line is in plane of paper Each structure **must** contain 2 'out wedges' **AND** 2 'in wedges' or **dotted** lines **OR** 4 **solid** lines at right angles (all in plane of paper) **DO NOT ALLOW any** structure that cannot be in one plane **DO NOT ALLOW any** structure with Cl_2 as a ligand **DO NOT** apply **ECF** from one structure to the other **ALLOW** coordinate bonds shown on diagrams provide that they start from a lone pair **ALLOW** 'dative covalent bond' or 'dative bond' as alternative for 'coordinate bond **IGNORE** *cis* and *trans* labels (even if incorrect) **IGNORE** incorrect connectivity to NH_3, ie **ALLOW** NH_3—
		(iii)	platin binds to DNA (of cancer cells) **OR** platin stops (cancer) cells dividing/replicating ✓	1	

Question	Answer	Mark	Guidance
2 (g)	**1,1-cyclobutanedicarboxylate ion**  ✓ **Correct charge required** **(could also be 2– outside square brackets)** **carboplatin** (*cis* isomer shown below)  ✓	2	Must show cyclobutane ring with both COO^- groups bonded to same carbon **ALLOW** COO^- **OR** CO_2^- for each carboxylate ion **ALLOW** structures showing CH_2 or C atoms provided it is clear that C skeleton is shown, **Note**: H atoms are not required if C atoms shown, *ie*  **DO NOT ALLOW** circle inside cyclobutane ring Two bonds from Pt to O atoms Any bonds from ligand **MUST** come from O **OR** from atom with lone pair **IGNORE** any charge shown **Note**: H atoms are not required if C atoms shown, (see ion in 1st structure) **ALLOW ECF** from 1st structure provided that the attached atoms are capable of forming coordinate bonds (*ie* they contain a lone pair of electrons) ***Example*** if 1st structure is as below, then **ALLOW** 1 mark **ECF**  **X** **ECF ✓**
	Total	**18**	

Question			Answer	Mark	Guidance
3	(a)	(i)	$HOCH_2COOH + NaOH \rightarrow HOCH_2COONa + H_2O$ ✓	1	**ALLOW:** $HOCH_2COOH + OH^- \rightarrow HOCH_2COO^- + H_2O$ **ALLOW:** $H^+ + OH^- \rightarrow H_2O$ **DO NOT ALLOW** molecular formulae (cannot see which OH has reacted)
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = **0.142** (mol dm^{-3}), award **2 marks** --- amount of $HOCH_2COOH = 0.125 \times \frac{25.0}{1000}$ = 0.003125 (mol) ✓ concentration NaOH = $0.003125 \times \frac{1000}{22.00}$ = 0.142 (mol dm^{-3}) ✓ ---	2	**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** 3.125×10^{-3} mol **ALLOW ECF**: answer above × $\frac{1000}{22.00}$ **ALLOW** 2 SF: 0.14 to calculator value: 0.142045454 --- If candidate has written in **(a)(i)**: $HOCH_2COOH$ + **2**NaOH, mark by **ECF**: concentration NaOH = **2** × $0.003125 \times \frac{1000}{22.00}$ = 0.284 (mol dm^{-3})
		(iii)	Vertical section matches the (pH) range (of the indicator) **OR** colour change (of the indicator) **OR** end point (of the indicator) ✓	1	**ALLOW** stated pH range for vertical section at about 7–10, 6–10, etc ie **ALLOW** 'pH range must be about 7–10' **ALLOW** 'pH changes rapidly' for vertical section **ALLOW** 'equivalence point' for vertical section, *ie* **ALLOW** equivalence point matches the (pH) range, *etc* **DO NOT ALLOW** just 'end point matches (pH) range' **DO NOT ALLOW** just 'indicator matches vertical section' Response **must** link either the pH range or colour change or end point with the vertical section / pH range ~ 7–10

Question			Answer	Mark	Guidance
3	(b)	(i)	$(K_a =)\ \dfrac{[H^+][HOCH_2COO^-]}{[HOCH_2COOH]}$ ✓	1	**IGNORE** state symbols **IGNORE** $\dfrac{[H^+]^2}{[HOCH_2COOH]}$ in **(i)** but **ALLOW** in **(ii)**
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = **1.46 x 10^{-4}**, award **2 marks** **THEN IF** units are **mol dm^{-3}**, award 1 **further mark** --- $[H^+] = 10^{-2.37} = 0.00427$ (mol dm^{-3}) ✓ $K_a = \dfrac{0.00427^2}{0.125} = 1.46 \times 10^{-4}$ ✓ units: mol dm^{-3} ✓	2 1	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below **UNITS** can be credited with no numerical answer --- **ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW** 4.27 x 10^{-3} (mol) **ALLOW** 2 SF: 0.0043 up to 0.004265795188 (calc value) **IF** candidate has rounded to 0.00427 (mol dm^{-3}) in 1st response, credit **EITHER** 2 SF: 1.5 x 10^{-4} up to 1.458632 × 10^{-4} (from 0.00427) **OR** 2 SF: 1.5 x 10^{-4} up to 1.455760687 × 10^{-4} (from unrounded calculator value of 0.004265795188) **ALLOW** calculation based on equilibrium conc of glycolic acid as 0.125 – $[H^+]$: Using $[H^+] = 0.00427$, $K_a = \dfrac{0.00427^2}{0.125 - 0.00427} = 1.51 \times 10^{-4}$ For **UNITS** this is the **ONLY** correct answer
		(iii)	% dissociation = $\dfrac{0.00427}{0.125} \times 100 = 3.4$ (%) ✓ Assume working from **EITHER** from a rounded $[H^+]$ **OR** unrounded calculator value of **b(ii)** $[H^+]$	1	**ALLOW** ECF using calculated $[H^+]$ from **b(ii),** **ALLOW** 2 SF: 3.4 % up to calculator value ***Note:*** $[H^+]$ from **b(ii)** displayed *at top of answer window* ***DO NOT MARK THIS TWICE!***

Question			Answer	Mark	Guidance
3	(c)		**ONE mark for equilibrium expression** equilibrium: $HOCH_2COOH \rightleftharpoons H^+ + HOCH_2COO^-$ ✓ --- **Four marks for action of buffer** $HOCH_2COOH$ reacts with added alkali **OR** $HOCH_2COOH + OH^- \rightarrow$ **OR** added alkali reacts with H^+ **OR** $H^+ + OH^- \rightarrow$ ✓ $\rightarrow HOCH_2COO^-$ **OR** Equilibrium $\rightarrow$ right ✓ $HOCH_2COO^-$ reacts with added acid ✓ $\rightarrow HOCH_2COOH$ **OR** Equilibrium $\rightarrow$ left ✓ --- **Two marks for preparation of buffer** Ammonia reacted with an **excess** of glycolic acid **OR** some glycolic acid remains ✓ $HOCH_2COOH + NH_3 \rightarrow HOCH_2COONH_4$ ✓	1 4 2	**ANNOTATE WITH TICKS AND CROSSES, etc** **DO NOT ALLOW** H^+, A^- and HA **ALLOW** < – > as alternative for equilibrium sign --- **ALLOW** response in terms of H^+, A^- and HA Equilibrium responses **must** refer back to a written equilibrium: **IF** more than one equilibrium shown, assume correct one **ALLOW** weak acid reacts with added alkali **DO NOT ALLOW** acid reacts with added alkali **ALLOW** conjugate base reacts with added acid **DO NOT ALLOW** salt/base reacts with added acid --- **ALLOW** as products $HOCH_2COO^- + NH_4^+$ **ALLOW** $\rightleftharpoons$ sign instead of $\rightarrow$
	(d)		Base 1 + Acid 2 $\rightleftharpoons$ Acid 1 + Base 2 1st mark for identifying acids and bases. ✓ 2nd mark for correct pairing (ie numbers) ✓	2	**ALLOW**: Base 2 + Acid 1 $\rightleftharpoons$ Acid 2 + Base 1

Question			Answer	Mark	Guidance
3	(e)		$2HSCH_2COO^- + R–S–S–R \longrightarrow {}^-OOCCH_2S–SCH_2COO^- + 2R–SH$ ✓ $2R–SH + H_2O_2 \longrightarrow R–S–S–R + 2H_2O$ ✓	2	**ALLOW** $(SCH_2COO^-)_2$ **ALLOW** equation with ammonium salt, ie: $2HSCH_2COONH_4$ + …… $\longrightarrow H_4NOOCCH_2S–SCH_2COONH_4$ + ……
			Total	**20**	

Question			Answer	Mark	Guidance
4	(a)	(i)	Complete circuit with electrodes to voltmeter **AND** salt bridge between solutions ✓ Sn^{4+}/Sn^{2+} half cell with Pt electrode **AND** both solutions labelled as 1 mol dm^{-3} / 1M H^+/H_2 half cell with Pt electrode **AND** H^+ solution labelled as 1 mol dm^{-3} / 1M ✓	3	**ANNOTATE WITH TICKS AND CROSSES, etc** circuit shown **must** be complete, *ie* must be capable of working salt bridge **must** be labelled and must dip into both solutions **ALLOW** concentration label of 'equimolar' or similar wording for Sn^{4+}/Sn^{2+} half cell **ALLOW** any strong acid **IF** both half cells are correct with no concentrations, **ALLOW** 1 out of the 2 marks available for the 2 half cells **IGNORE** any stated temperature or pressure, even if wrong
		(ii)	$2Cr + 3Sn^{4+} \rightarrow 2Cr^{3+} + 3Sn^{2+}$ ✓ $Cr + 3Cu^{+} \rightarrow Cr^{3+} + 3Cu$ ✓ $Sn^{2+} + 2Cu^{+} \rightarrow Sn^{4+} + 2Cu$ ✓ Conditions not standard **OR** concentrations not 1 mol dm^{-3} ✓ High activation energy **OR** slow rate ✓	5	**ANNOTATE WITH TICKS AND CROSSES, etc** Correct species **AND** balancing needed for each mark **ALLOW** equations as shown with equilibrium sign **ALLOW multiples** but **electrons** must not be shown **IF** three equations have correct species but no balancing, **AWARD** 1 mark **ALLOW** not favoured kinetically
	(b)	(i)	$CH_3OH + 1½O_2 \rightarrow CO_2 + 2H_2O$ ✓	1	Correct species **AND** balancing needed **ALLOW** multiple, *ie* $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$ **ALLOW** CH_4O for formula of methanol
		(ii)	$CH_3OH + H_2O \rightarrow 6H^+ + 6e^- + CO_2$ ✓	1	
		(iii)	less CO_2 **OR** less greenhouse gases ✓ greater efficiency ✓	2	**ALLOW** no CO_2 **OR** no greenhouse gases **ALLOW (**very) efficient **IGNORE** less pollution **OR** 'renewable fuels'
		(iv)	methanol is a **liquid** **AND** methanol is easier to store/transport ✓	1	**Both points required for mark** Response **MUST** state that methanol is a **liquid** **IGNORE** methanol has a higher boiling point Assume that '**it**' refers to methanol **IGNORE** safety issues, *eg* H_2 leakage, flammability, explosive
			Total	**13**	

Question			Answer	Mark	Guidance
5	(a)		**A**: **forms** fewer **moles**/**molecules** of gas ✓ **B**: **forms** gas from a liquid ✓ **C**: **forms** liquid from gases ✓ **D**: **forms** more **moles**/**molecules** of gas ✓	4	**Note**: Responses must imply the key difference between the sides of the equation **IGNORE** comments about C(s)
	(b)		$\Delta S = \Sigma S$(products) – ΣS(reactants) = 40 + 214 – 89 = 165 (J K^{-1} mol^{-1}) **=** 0.165 (kJ K^{-1} mol^{-1}) ✓ At 25 ˚C, ΔG = +178 – 298 × 0.165 ✓ = (+)129 ✓ units: kJ mol^{-1} ✓ **OR** (+)129,000 ✓ units: J mol^{-1} ✓ As ΔG > 0, reaction is **not** feasible **OR** as ΔG > 0, $CaCO_3$ is stable ✓ ---------- Minimum temperature for feasibility when 0 = $\Delta H - T\Delta S$ **OR** $\Delta H = T\Delta S$ **OR** $T = \frac{\Delta H}{\Delta S}$ ✓ = $\frac{178}{0.165}$ = 1079 K **OR** 806 °C ✓ The units **must** be with the stated temperature	1 4 2	**ANNOTATE WITH TICKS AND CROSSES, etc** *Mark is for the working line:* 40 + 214 – 89 = 165 **UNITS** have a separate mark **ALLOW** 129 to calculator value of 128.83 **DO NOT ALLOW** 128 (incorrect rounding) **IF** 25 ºC used rather than 298 K, credit by **ECF**, calculated ΔG = 174 to calculator value of 173.875 ***ENTROPY APPROACH***---------- **ALLOW** At 25 ˚C, $\Delta S_{total} = 0.165 - \frac{178}{298}$ ✓ = –0.432 ✓ kJ K^{-1} mol^{-1} ✓ **OR** –432 ✓ J K^{-1} mol^{-1} ✓ As ΔS < 0, reaction is **not** feasible ✓ ***ENTROPY APPROACH***---------- Minimum temperature for feasibility when 0 = $\Delta S_{system} + \Delta S_{surroundings}$ **OR** $\Delta S_{system} = \frac{\Delta H}{T}$ **ALLOW** 1080 K up to calculator value of 1078.787879, correctly rounded, eg 1078.79 is correct value to 6SF **DO NOT ALLOW** 1078 (incorrect rounding) **IF** 1079 K is given and additional temperature in ºC is incorrect, **IGNORE** ºC temperature (and vice versa)
			Total	**11**	

Question			Answer	Mark	Guidance
6	(a)	(i)	(K_w =) $[H^+(aq)]$ $[OH^-(aq)]$ ✓	1	**IGNORE** state symbols **ALLOW** $[H_3O^+(aq)]$ $[OH^-(aq)]$
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = **2.3×10^{-10}** (mol dm^{-3}), award **2 marks** **IF** answer = **2.34×10^{-10}** (mol dm^{-3}) , award **1 mark** --- $[H^+] = 10^{-pH} = 4.27 \times 10^{-5}$ (mol dm^{-3}) ✓ $[OH^-] = \frac{1.0 \times 10^{-14}}{4.27 \times 10^{-5}}$ $= 2.34 \times 10^{-10}$ $= 2.3 \times 10^{-10}$ (mol dm^{-3}) ✓	2	**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** 4.3×10^{-5} up to calculator: $4.265795188 \times 10^{-5}$ **ALLOW** 0.0000427 Answer **MUST** be to 2 SF (in question) **ALLOW** = 2.3×10^{-x} (mol dm^{-3}) for 1 mark (must be a negative power) **ALLOW** alternative approach based on pOH: pOH = 14 – 4.27 = 9.63 ✓ (**DO NOT ALLOW** 9.6) $[OH^-] = 10^{-pOH} = 10^{-9.63} = 2.3 \times 10^{-10}$ (mol dm^{-3}) ✓
	(b)	(i)	Endothermic **because** K_w increases with temperature ✓	1	Endothermic **AND** reason required for the mark **ALLOW** Endothermic **because** increasing temperature shifts equilibrium/reaction to the right
		(ii)	K_w value from graph from 2.2 to 2.6×10^{-14} (mol^2 dm^{-6})✓ Using 2.4×10^{-14}, $[H^+] = \sqrt{2.4 \times 10^{-14}}$ **OR** 1.55×10^{-7} ✓ pH = –log (1.55×10^{-7}) = 6.81 (using $K_w = 2.4 \times 10^{-14}$) ✓	3	**ANNOTATE WITH TICKS AND CROSSES, etc** Actual $K_w = 2.38 \times 10^{-14}$ mol^2 dm^{-6} For this mark, candidate **must** use a value between 2.0 and 3.0×10^{-14} (mol^2 dm^{-6}), *ie* from the approximately correct region of the graph, **ALLOW** 6.8 up to calculator value **Note**: You will need to calculate the pH value from the candidate's estimate of K_w at 37 ºC before awarding the 3rd marking point **ONLY** award an **ECF** pH mark if candidate has generated a value of $[H^+]$ by attempting to take a square root of a value between 2.0 and 3.0×10^{-14}

Question			Answer	Mark	Guidance
6	(b)	(iii)	(Work is) inaccurate **OR** invalid **because** K_w varies with temperature ✓	1	Response requires **reason** for inaccuracy/invalidity in terms of K_w **ALLOW** incorrect with reason **IGNORE** unreliable **ALLOW** inaccurate because wrong K_w was used For K_w varies with temperature, **ALLOW** equilibrium shifts with temperature
	(c)				**ANNOTATE WITH TICKS AND CROSSES, etc**
			Acid and alkali mixed ✓		**ALLOW** 'base' for 'alkali throughout **ALLOW** if mentioned anywhere which could be within a definition for enthalpy change of neutralisation
			Amounts of acid **AND** alkali stated ✓		Amounts could be expressed as amounts, moles, volumes **OR** concentrations
			Temperature taken at start **AND** finish ✓		**ALLOW** temperature change
			energy, $Q = mc\Delta T$ **OR** in words **AND** meaning of m, c **AND** ΔT given ✓		m = mass/volume of solution/reactants/mixture, etc (but **NOT** surroundings) c = (specific) heat capacity (of solution/water) **OR** 4.18/4.2 ΔT = temperature change
			Energy scaled up to form 1 mol of water ✓		**ALLOW** divide energy by moles
			ΔH_{neut} = –energy change ✓	6	**ALLOW** '–' sign shown in earlier part, ie $\Delta H_{neut} = -\frac{Q}{n}$ **ALLOW** a statement linking ΔH with temperature change, *ie*: **IF** temperature increases, ΔH_{neut} is **–ve** **OR IF** temperature decreases, ΔH_{neut} is +ve

Question			Answer	Mark	Guidance
6	(d)		**Ionic radius** Potassium ion **OR** K^+ **OR** K ion is smaller **OR** K^+ has greater charge density ✓ **Lattice enthalpy** Lattice enthalpy of KF is more negative than RbF ✓ **OR** K^+ has greater attraction for F^- **Hydration enthalpy** ΔH(hydration) of K^+ is more negative than Rb^+ ✓ **OR** K^+ has greater attraction for H_2O **Enthalpy change of solution** Idea that ΔH(solution) is affected more by lattice enthalpy than by hydration enthalpy ✓	4	**ANNOTATE WITH TICKS AND CROSSES, etc** **Throughout question, ORA** in terms of Rb^+ **Throughout question, ALLOW** energy for enthalpy **DO NOT ALLOW** potassium **OR** K **OR** reference to atoms (*ie* reference to ions is required throughout a response) **ALLOW** lattice enthalpy of KF > lattice enthalpy of RbF **ALLOW** more energy needed to separate K^+ **AND** F^- **IGNORE** KF has stronger bonds **ALLOW** ΔH(hydration) of K^+ > ΔH(hydration) of Rb^+ **ALLOW** more energy needed to separate K^+ **AND** H_2O **IGNORE** K^+ has a stronger bond to H_2O **ALLOW** a correct attempt to link the contribution of lattice enthalpy and hydration enthalpy to ΔH(solution), *ie* lattice enthalpy is a more important factor than hydration enthalpy
	(e)		(During dissolving,) entropy/disorder increases **OR** disorder increases ✓ $T\Delta S > \Delta H$ **OR** $T\Delta S$ is more positive than ΔH **OR** $\Delta H - T\Delta S$ is negative ✓	2	**ALLOW** entropy change is positive **OR** ΔS is positive **OR** $T\Delta S$ is positive **ALLOW** ΔS(system) > $\Delta H/T$ **ALLOW** ΔS(system) is more positive than $\Delta H/T$ ✓ **ALLOW** ΔS(system) + ΔS(surroundings) is positive **ALLOW** Energy contribution from increase in entropy is greater than decrease in energy from enthalpy change **OR** entropy change outweighs enthalpy change **IGNORE** ΔG is negative
			Total	**20**	

Question			Answer	Mark	Guidance
7	(a)	(i)	**amount $S_2O_3^{2-}$ used** = 0.00100 × $\frac{24.6}{1000}$ = 2.46 × 10^{-5} mol ✓ **amount O_2 in 25 cm^3 sample** = $\frac{2.46 \times 10^{-5}}{4}$ = 6.15 × 10^{-6} mol ✓ **Concentration of O_2 in sample** = 6.15 × 10^{-6} × $\frac{1000}{25}$ = 2.46 × 10^{-4} (mol dm^{-3}) ✓ **mass concentration of O_2 in mg dm^{-3}** = 2.46 × 10^{-4} × 32 g = 7.872 × 10^{-3} (g dm^{-3}) = 7.872 (mg dm^{-3}) ✓	4	**ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW** 0.0000246 (mol) **ECF** = $\frac{\text{answer above}}{4}$ **ALLOW** 0.00000615 g **ECF** answer above × $\frac{1000}{25}$ **ALLOW** 0.000246 g **ECF** = answer above × 32 x 1000 **ALLOW** 7.9 **OR** 7.87 **ALLOW** 2 SF up to calculator value **Must be in mg for mark** **Note:** Candidate may work out steps 3 and 4 in the opposite order, *ie* **mass of O_2 in sample** = 6.15 x 10^{-6} × 32 × 1000 = 1.968 × 10^{-1} mg **mass concentration of O_2 in mg dm^{-3}** = 1.968 x 10^{-1} × $\frac{1000}{25}$ = 7.872 (mg dm^{-3})
		(ii)	**Comment** 7.872 > 5 so fish can survive ✓	1	**ECF** If final answer > 5 fish **can** survive If final answer < 5 fish **cannot** survive
	(b)	(i)	NO ✓	1	**ALLOW** N_2H_2

Question			Answer	Mark	Guidance
7	(b)	(ii)	$2H_2O + 2I^- + 2NO_2^- \longrightarrow 2NO + I_2 + 4OH^-$ **OR** $2H^+ + 2I^- + 2NO_2^- \longrightarrow 2NO + I_2 + 2OH^-$ **species** ✓ **balance** ✓	2	**IGNORE** state symbols **ALLOW** multiples **For species ONLY, IGNORE** any extra H_2O or e^- on either side of the equation **ALLOW** on LHS: $2HI + 2NO_2^-$ **OR** $2I^- + 2HNO_2$ **ALLOW** species and equation involving N_2H_2: $6H_2O + 8I^- + 2NO_2^- \longrightarrow N_2H_2 + 4I_2 + 10OH^-$ **OR** $6H^+ + 8I^- + 2NO_2^- \longrightarrow N_2H_2 + 4I_2 + 4OH^-$ **species** ✓ **balance** ✓
			Total	**8**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

14 – 19 Qualifications (General)
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553

© OCR 2011