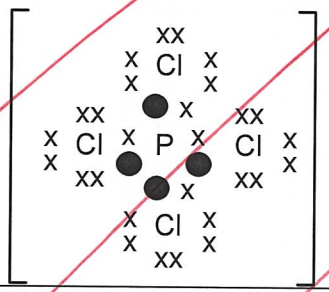
Mark Scheme Page 3 of 5	Unit Code 2815/01	Session June	Year 2008	Version Final Mark Scheme	
Question	**Expected Answers**			**Marks**	**Additional Guidance**
2 (a)	$MoO_3 + 2Al \rightarrow Al_2O_3 + Mo$ (1)			1	**Ignore** state symbols **Allow** correct multiples
(b)	[Kr] $4d^3$ **and** (Mo^{3+}) has an incomplete filled d-subshell (1)			1	**Allow** has incomplete 4d sub-shell / incomplete d orbital **Ignore** errors in [Kr]
(c)	Correct molar ratio of Mo and Cr species $3MoO_2 + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 3MoO_4^{2-}$ (1); **But** $3MoO_2 + Cr_2O_7^{2-} + 2H^+ \rightarrow 2Cr^{3+} + H_2O + 3MoO_4^{2-}$ (2)			2	Ignore H^+, H_2O and e^- in equation For the second mark the H^+ and H_2O must be cancelled down to 2 and 1
(d) (i)	K_2FeO_4 (1)			1	
(ii)	Moles of Fe_2O_3 = 0.00627 (1); Moles of OH^- = 0.0400 (1); Fe_2O_3 in excess since there needs to be 0.0627 moles of OH^- / evidence of working out the reagent in excess (1)			3	**Allow** reverse argument e.g. 0.0400 moles of OH^- can only react with 0.004 moles of Fe_2O_3 **Allow** ecf from wrong moles
				Total = 8	

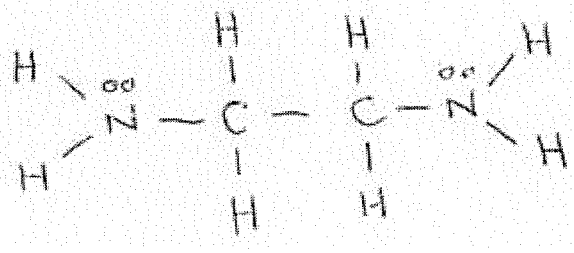
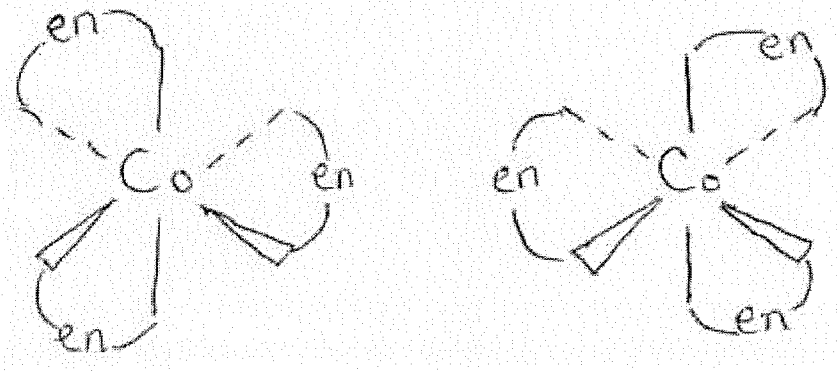
Mark Scheme Page 4 of 5	Unit Code 2815/01	Session June	Year 2008	Version Final Mark Scheme	
Question	**Expected Answers**			**Marks**	**Additional Guidance**
3 (a)	$Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$ (1); atomisation (of oxygen) / ΔH_{at} (1); Second electron affinity (of oxygen) / ΔH_{ea2} (1); $Ca(s) \rightarrow Ca(g)$ (1)			4	State symbols needed
(b)	Al_2O_3 – intermediate bonding / electrostatic attraction between ions (1); $AlCl_3/Al_2Cl_6$ – van der Waals / temporary dipole – temporary dipole / induced dipole – induced dipole interactions / intermolecular forces (1); Correct comparison of strength of forces e.g. intermediate bonds stronger than van der Waals (1)			3	**Allow** giant ionic / giant intermediate **Allow** simple molecular Comparison of forces **dependent** on forces being correct
(c)	Al_2O_3 does not dissolve / does not react (1); $AlCl_3$ reacts / $AlCl_3$ is hydrolysed / polarisation of water molecules by aluminium ion (1) $AlCl_3$ – gives a colourless solution / misty fumes / steamy fumes / pH 1 to 6 (1)			3	**Allow** mark from an appropriate equation **Allow** acidic solution / gets hot / exothermic
(d) (i)	Correct dot and cross diagram (1)  			1	**Ignore** lack of charge **Ignore** inner shells
(ii)	Tetrahedral / correct drawing of tetrahedral (1); Has four bond pairs / repulsion between four bond pairs / four bonds repelling (1)			2	**Allow** ecf from wrong dot and cross diagram for a PCl_4^+ species
				Total 13	

Mark Scheme Page 5 of 5	Unit Code 2815/01	Session June	Year 2008	Version Final Mark Scheme	
Question	**Expected Answers**			**Marks**	**Additional Guidance**
4	Bonding in complex ion Ligand donates an electron pair / copper accepts electron pair (1); Dative (covalent) / coordinate (1)			2	**Allow** even if not a copper complex **Allow** marks from a diagram
	Shape of complex ion Correct name or formula of copper complex ion (1); Correct shape of a copper complex either by name or clear drawing with indication of three dimensions (1); Correct bond angle (1) • *e.g.* $[Cu(H_2O)_6]^{2+}$ is octahedral and 90° • *e.g.* $[CuCl_4]^{2-}$ is (flattened) tetrahedral and bond angle between 90° and 110°			3	**Allow** last two marking points if not a copper complex
	Ligand substitution Correct example of ligand substitution reaction involving a copper complex (1); Correct equation (1); Idea of one ligand being swapped with another one (1)			3	**Allow** all marks from an equation **Allow** last two marking points if not a copper complex
	Colour Correct colour of two copper complex ions one mark for each correct colour			2	If one colour given is wrong max 1 If two colours wrong score 0
	Quality of Written Communication. Answer must address the question set and include at least three of the following terms in the correct context • Electron / lone pair • Covalent • Dative • Coordinate • Octahedral • Tetrahedral • Square planar • Molecule			1	
				Total = 11	

2815/06 Transition Elements

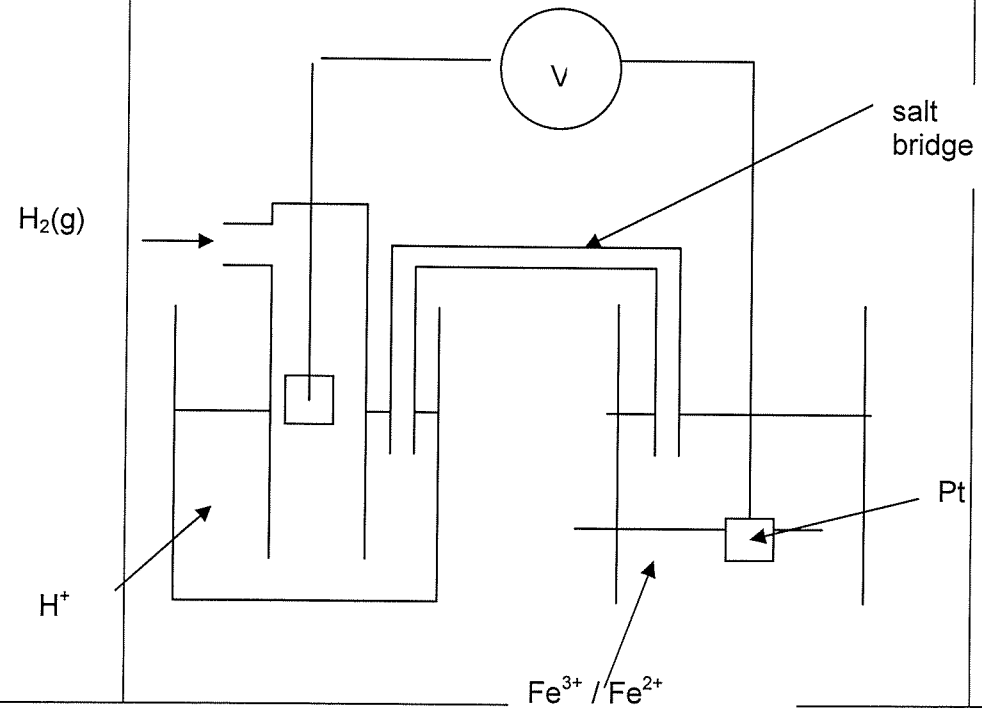
Mark Scheme Page 1 of	Unit Code	Session	Year	Version

Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument

Question	Expected Answers	Marks
1 (a) (i)	Pink to blue	1
(ii)	Tetrahedral	1
(iii)	Ligand substitution Accept ligand exchange	1
(b)	 Lone pairs shown on both nitrogens Accept H_2N – with lone pair shown on nitrogen atom Accept a complex if ligand is shown as a displayed formula	1
(c) (i)	Optical	1
(ii)	 Accept three loops Accept other correct ways of showing 3-d structure Ignore charges or lack of charge	2 Total: 7

Mark Scheme Page 2 of	Unit Code	Session	Year	Version
Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument			

Question	Expected Answers	Marks
2 (a)	The emf / voltage / potential difference of a cell made from a Fe^{3+} / Fe^{2+} half cell	1
	Combined with a (standard) hydrogen half cell	1
	Solutions all 1 mol dm^{-3} (accept equimolar solutions)	
	and	
	Temp 298 K / 25 ^{0}C	
	and	
	Pressure of gas 1 atm / 100 / 101 kPa	1
	(all three needed)	
(b)	Complete circuit including voltmeter and salt bridge	1
	Platinum electrode for Fe^{3+} / Fe^{2+} half cell labelled	1
	Fe^{3+} / Fe^{2+}	1



(c) (i)	Emf = (+) 0.23 V	1
(ii)	$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ Electrons must be cancelled Accept multiples	1 Total: 8

Mark Scheme Page 4 of	Unit Code	Session	Year	Version
Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument			

Question	Expected Answers	Marks
4 (a)	Standard cell potential is + 0.37 V Standard cell potential is positive therefore the reaction is feasible Alternative: Second equilibrium is less positive and will move from right to left supplying electrons First equilibrium will accept electrons and move from left to right so that equation as written is likely to occur.	1 1
(b)	Oxidation ***and*** reduction Of the same species / Cu^+	1 1
(c)	As solid / in non aqueous solvents / when ***not*** in aqueous solution	1 Total: 5

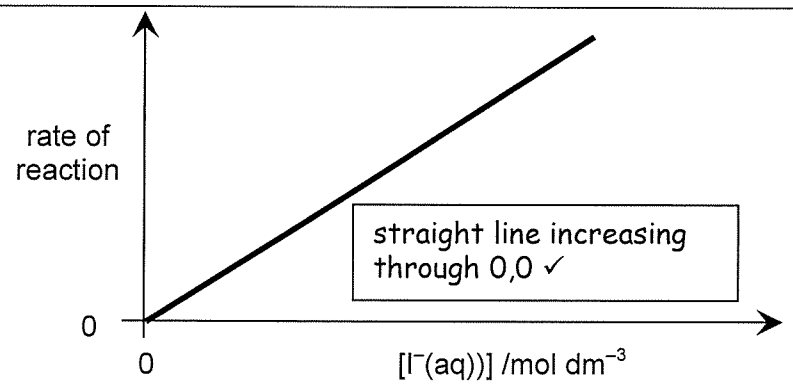
Mark Scheme Page 5 of	Unit Code	Session	Year	Version
Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument			

Question	Expected Answers	Marks
5 (a)	Zinc (Accept Zn)	1
(b)	On titration, solution changes from (dark) brown	1
	to straw coloured /becomes lighter / straw coloured / accept colour starts to disappear	1
	Starch indicator added close to end point / when straw coloured	1
	End point is when blue/black colour disappears to leave 'off white' precipitate / solid	1
	$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$ (1 mark for correct species 1 mark for balanced)	2
	$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ (1 mark for correct species 1 mark for balanced)	2
	Quality of Written Communication: One mark awarded for correct spelling, punctuation and grammar in at least two complete and relevant sentences	1

(c)	Moles $S_2O_3^{2-}$ used = 0.00378 moles	1
	25 cm^3 Cu^{2+} = 0.00378 moles	1
	500 cm^3 Cu^{2+} = 0 0756 moles Cu^{2+}	1
	Mass of Cu = 0.0756 x 63.5 = 4.80 g	1
	% Cu = (4.80/6.00) x 100 = 80.0%	1
	Allow ecf on the calculation.	
		Total: 15

2816/01 Unifying Concepts in Chemistry/ Experimental Skills 2 Written Paper

Question	Expected Answers	Marks
1 (a)	$K_c = \frac{[CH_3COOH]\,[C_2H_5OH]}{[CH_3COOC_2H_5]\,[H_2O]}$ ✓ Square brackets required. Do **not** award if *p* used anywhere	[1]
(b)(i)	component $CH_3COOC_2H_5$ H_2O CH_3COOH C_2H_5OH initial amount /mol 8.0 5.0 0.0 0.0 ⇌ amount /mol *6.0* *3.0* 2.0 *2.0* ✓ ✓	[2]
(ii)	Allow 6, 3, 2 and 2 (ie without '.0') $\frac{\text{moles of component}}{\text{total number of moles}}$ ✓ For 'component', **allow** a specific example or 'substance' moles of a component relative to *OR* compared with total number of moles **credit** 'amount' in place of 'moles'	[2]
	2/total moles in (i) = 2/13 *OR* 0.15(4) ✓ ie answer depends on total moles in (i) allow 0.153846153 and any correct rounding back to 2 sig figs If 2/13 is shown, then ignore anything that follows.	
	$K_c = \frac{2.0 \times 2.0}{6.0 \times 3.0}$ = 4.0/18.0 = 0.22222.... ✓ = 0.22 (ie to 2 sig figs) ✓ no units *OR* '–' *OR* 'none' ✓ **Credit** units if shown cancelled in working For ECF, the values used should be the candidate values from (b)(i). If K_c expression is incorrect, then the **only** acceptable *ECF* response is from an 'upside-down' expression.	[3]
(c)	**equilibrium/reaction** has **shifted** to the right/in favour of products ✓ forward reaction is endothermic ✓ **allow** 'it is endothermic' *OR* 'the reaction is endothermic' K_c has increased ✓	[3]
		11

2	(a)(i)	Expt 2: initial rate = 4.6×10^{-6} mol dm^{-3} s^{-1} ✓ Expt 3: initial rate = 2.3×10^{-6} mol dm^{-3} s^{-1} ✓ Expt 4: initial rate = 5.75×10^{-6} mol dm^{-3} s^{-1} ✓ If powers of ten are not shown, then do **not** credit on the first occasion. Then treat as *ECF*.	[3]
	(ii)	$k = \frac{\text{rate}}{[H_2O_2]\,[I^-]}$ *OR* $\frac{2.30 \times 10^{-6}}{0.020 \times 0.010}$ ✓ $= 1.15 \times 10^{-2}$ / 0.0115 / 0.012 ✓ units: $dm^3\ mol^{-1}\ s^{-1}$ ✓ **allow**: $mol^{-1}\ dm^3\ s^{-1}$ Correct numerical value automatically gets the 1st mark also, even if values from a **different** experiment have been used. If an incorrect rate value is used from (a)(i), then mark 2nd mark and units mark are available (ie *ECF*)	[3]
	(iii)	Overall reaction: 1 mol H_2O_2 reacts with 2 mol I^- and 2 mol H^+ / shows stoichiometry/shows mole ratio ✓ 2nd order (overall) OR 1st order wrt H_2O_2 *and* 1st order wrt I^- / rate determining step involves H_2O_2 and I^- ✓ rate is not affected by H^+ / the reaction is zero order wrt H^+ / the rate determining step does not involve H^+ ✓ Note that '$[H^+]$ is a catalyst' will *CON* this marking point. reaction must proceed via more than one step ✓	**4 marking points giving 3 max**
	(b)	 Allow 2 mm tolerance on 0,0	[1]

(c)	H : O : N : C = 6.38/1 : 51.06/16 : 29.79/14 : 12.77/12 *OR* = 6.38 : 3.19 : 2.13 : 1.06 ✓ empirical/molecular formula = $H_6O_3N_2C$✓ Correct empirical formula automatically gets 1st mark M_r = 6 + 48 + 28 + 12 = 94 ✓ 150 cm^3 of solution needs 2.30 x 150/1000 = 0.345 mol ✓ mass required = 94 x 0.345 = 32.43 g ✓ --- Upside down expression can gain final 4 marks ECF from 1st marking point gives $C_6N_3O_2H$ ✓ M_r = 147 ✓ 150 cm^3 of solution needs 2.30 x 150/1000 = 0.345 mol ✓ mass required = 147 x 0.345 = 50.715 g ✓ (or *ECF* from 2 steps above) --- Use of atomic numbers can gain final 4 marks ECF from 1st marking point gives $H_3O_3N_2C$ ✓ M_r = 91 ✓ 150 cm^3 of solution needs 2.30 x 150/1000 = 0.345 mol ✓ mass required = 91 x 0.345 = 31.395 g ✓ (or *ECF* from 2 steps above) --- **For all possible routes, allow rounding back to 2 sig figs in final answer**	**[5]**
		15

3	(a)	partly dissociates/ionises ✓ proton/H^+ donor ✓	[2]
	(b)	(K_w =) $[H^+(aq)]\,[OH^-(aq)]$ ✓ *state symbols not needed* $[H^+(aq)] = 10^{-pH} = 10^{-12.72} = 1.91/1.9 \times 10^{-13}$ mol dm^{-3} ✓ $[KOH] / [OH^-(aq)] = \frac{K_w}{[H^+(aq)]} = \frac{1.0 \times 10^{-14}}{1.91 \times 10^{-13}}$ = 0.0524 mol dm^{-3} ✓ (calculator: 0.052480746) Accept any value between 0.052 and 0.053 (answer depends on degree of rounding for H^+ but 2 sig fig minimum.) Alternatively via pOH pOH = 14 – 12.72 = 1.28 ✓ $[KOH] / [OH^-(aq)] = 10^{-pOH}$ = 0.0524 mol dm^{-3} ✓ (calculator: 0.052480746)	[1] [2]
	(c)	n(vitamin C) = 0.500/176 = 2.84×10^{-3} ✓ [vitamin C] = 1000/125 x 2.84×10^{-3} = 0.0227(2) mol dm^{-3} ✓ $K_a = \frac{[H^+]\,[C_6H_7O_6^-]}{[C_6H_8O_6]}$ ✓ $= \frac{[H^+]^2}{[C_6H_8O_6]}$ $[H^+] = \sqrt{(K_a \times [C_6H_8O_6])}$ *OR* $\sqrt{(6.76 \times 10^{-5} \times 0.0227)}$ ✓ = 1.24×10^{-3} mol dm^{-3} ✓ (must involve a square root of two numbers multiplied together) pH = $-\log(1.24 \times 10^{-3})$ = 2.91 ✓ Accept a calculated value between 2.90 to 2.91 Common incorrect responses: 4.41 would score 5 marks (uses cm^3 instead of dm^3) 5.91 would score 5 marks (conversion multiplies by 1000 instead of dividing by 1000) 5.81 would score 5 marks (no square root) 2.1 would score 1 mark in isolation ($[H^+] = \sqrt{K_a}$)	[6]
			13

4	**Buffer** A buffer solution minimises/resists/opposes pH changes ✓ Do not **allow** 'keeps pH constant'. **How a buffer works** *Mark this part for any of the possible buffer systems above.* equilibrium: HA ⇌ $H^+ + A^-$ ✓ HA reacts with added alkali / $HA + OH^- \rightarrow$ / added alkali reacts with H^+ / $H^+ + OH^- \rightarrow$ ✓ $\rightarrow A^-$ / Equil $\rightarrow$ right ✓ A^- reacts with added acid / $[H^+]$ increases ✓ $\rightarrow$ HA / Equil $\rightarrow$ left ✓ **Components** methanoic acid / HCOOH ✓ sodium methanoate / HCOONa ✓ *ECF*: salt of weak acid chosen above. Do **not** allow a carboxylate ion **Quality of Written Communication** A correct equation and a correct chemistry sentence related to buffers ✓ *Write Q by equation and tick through QWC prompt*	**[1]** **[5]** **[2]** **[1]**
		9