3 (a)	Add (aqueous) sodium hydroxide which will give a brown/rusty ppt (1)	1	Allow solid for precipitate or (s) in equation Allow Use aqueous thiocyanate ions which gives a (blood) red colouration
(b) (i)	$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$ Correct reactants and products (1); Correct balancing (electrons cancelled out) (1)	2	
(ii)	Moles of dichromate(VI) = 3.53 x 10-4 (1); Moles of iron(II) = 2.12 x 10-3 (1); Moles of impure iron(II) sulphate = 2.36 x 10-3 (1); Percentage purity = 89.8 / 89.8 – 90.0 (1)	4	Allow alternative working out via mass instead of moles e.g. mass of iron in hydrated FeSO4 from percentage composition compared to mass of iron from moles of iron(II). Allow ecf throughout unless percentage is above 100%
		Total = 7	
4 (a) (i)	(Blue to) yellow (solution) / (blue to) green (solution) (1)	1	
(ii)	Lone pair on chloride ion (1); Donated to copper(II) ion (1)	2	Allow dative bond / coordinate bond (1) Allow marks via a diagram that must show lone pairs and the dative bond
(b)	(Light) blue precipitate / blue solid (1); With excess (dark) blue solution (1)	2	Not just goes blue
(c)	Any three from Ammonia molecule 1 lone pair (and 3 bond pairs) (1); Ammonia ligand 4 bond pairs / lone pair is now a bond pair / ligand does not have a lone pair (1); Lone pairs repel more than bond pairs (1); In complex equal repulsion between electron pairs (1)	3	Not bonds repel / atoms repel
		Total = 8	

Question	Expected Answers	Marks
1 (a) (i)	6	1
(ii)	Species with (lone) pair of electrons	1
	Capable of being donated / forms a dative covalent bond / co-ordinate bond to a metal ion. (allow suitable diagram)	1
(b) (i)	$[Co(H_2O)_6]^{2+}$ is octahedral $[CoCl_4]^{2-}$ is tetrahedral (both needed for 1 mark)	1
(ii)	pink to blue	1
(iii)	<u>Ligand</u> substitution / exchange/displacement	1
(c) (i)	1 mark for correct 3-D diagram of cis isomer	1
	1 mark for correct 3-D diagram of trans isomer	1
	(see additional sheet for diagrams. Allow planar diagrams if two appropriate 90° angles are shown)	
(ii)	Geometric / cis - trans	1
(d)	1 mark for using cis isomer	1
	1 mark for correct 3-D diagrams which are mirror images of each other.	1
	(see additional sheet for diagrams. If all diagrams are drawn as non-3d do not penalise in (d))	
		Total: 11

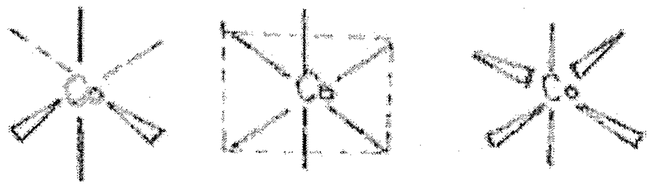
Question	Expected Answers	Marks
3. (a)	Stainless steel + corrosion resistant / Alloys / making tools + very hard Chrome plating + prevents rusting / corrosion	1
(b) (i)	All oxidation number worked out to show that none have changed (Cr = +6, H = +1, O = -2)	1
(ii)	Yellow to orange	1
(iii)	NaOH or another suitable alkali /OH^- (not H_2O)	1
(c) (i)	Brown solution/brown precipitate/black solid Add starch to get blue / black colour	1
(ii)	Titration / volumetric analysis using sodium thiosulphate(with starch indicator) (allow from equation)	1 1
	$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$	1
	1 mol $Cr_2O_7^{2-}$ = 6 mols $S_2O_3^{2-}$	1
		Total: 9

Question	Expected Answers	Marks
4. (a)	A = Platinum(electrode) B = $H^+(aq)$ / HCl(aq) / other suitable acid C = Voltmeter / galvanometer D = $Cl_2(g)$ State symbols needed for B and D All correct = 2, 3 correct =1	 2
(b) (i)	Arrow marked on or close to wire via voltmeter pointing from hydrogen half cell to chlorine half cell Electrons flow to half cell with more +ve standard electrode potential	1 1
(ii)	Pressure = 1 Atm / 100 kPa Temp = 298 K / 25^0C Concentration = 1 mol dm^{-3} All 3 correct = 2 marks 2 correct = 1 mark	 2
(c)	The standard electrode potential for ClO_3^- / ½Cl_2 is more positive than that of ½ Cl_2 / Cl^- ClO_3^- has a greater tendency to gain electrons than Cl_2 / ClO_3^- is a better oxidising agent than Cl_2 Alternative: Because $E^{\ominus}$ is positive, the reaction will go from left to right therefore ClO_3^- is reduced so it must be a better oxidising agent than chlorine.	1 1
		Total: 8

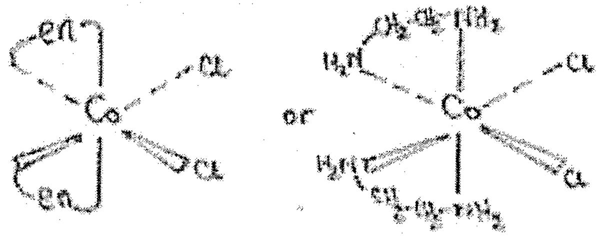
2815/6 Transition Elements January 2006

Additional sheet

1. (c) (i) Allow any suitable 3-D diagrams. Possibilities to include:

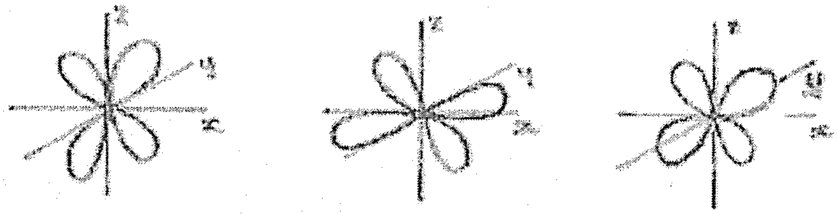


(d) Allow any suitable 3-D diagrams such as:

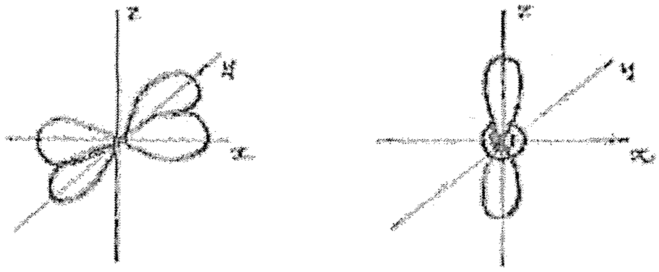


2. (a)

Correct lower energy d-orbitals include:



Correct higher energy d-orbitals include:



Question			Expected Answers	Marks
1	(a)		partial dissociation: HCOOH $\rightleftharpoons$ H^+ + $HCOO^-$ ✓	[1]
	(b)	(i)	pH = –log (1.55×10^{-3}) = 2.81/2.8 ✓ [H^+] deals with negative indices over a very wide range/ pH makes numbers manageable /removes very small numbers ✓	[2]
		(ii)	$K_a = \frac{[H^+(aq)]\,[HCOO^-(aq)]}{[HCOOH(aq)]}$ ✓ (state symbols not needed)	[1]
		(iii)	$K_a = \frac{[H^+(aq)]^2}{[HCOOH(aq)} = \frac{(1.55 \times 10^{-3})^2}{0.015}$ ✓ = 1.60×10^{-4} (mol dm^{-3})✓ pK_a = –log K_a = –log (1.60×10^{-4}) = 3.80 ✓	[3]
		(iv)	Percentage dissociating = $\frac{(1.55 \times 10^{-3}) \times 100}{0.015}$ = 10.3 % / 10% ✓ *(working not required)*	[1]
	(c)	(i)	HCOOH + NaOH ⟶ HCOONa + H_2O ✓ *state symbols not needed*	[1]
		(ii)	n(HCOOH) = 0.0150 x 25.00/1000 = 3.75×10^{-4} ✓ volume of NaOH(aq) that reacts is 30 cm^3✓ so [NaOH] = 3.75×10^{-4} x 1000/30 = 0.0125 mol dm^{-3} ✓	[2]
		(iii)	K_w = [H^+(aq)][OH^-(aq)] ✓ pH = –log(1×10^{-14}/0.0125) = 12.10/12.1 ✓ (calc 12.09691001)	[3]
		(iv)	metacresol purple ✓ pH range coincides with pH change **during sharp rise** OR pH 6-10 /coincides with equivalence point/end point ✓	[2]
				Total: 16

Question			Expected Answers	Marks
2	(a)		$K_c = \frac{[HI]^2}{[H_2]\,[I_2]}$ ✓	[1]
	(b)	(i)	H_2 0.30 0.14 ✓; I_2 0.20 0.04; HI 0 0.32 ✓	[2]
		(ii)	$K_c = \frac{0.32^2}{0.14 \times 0.04}$ = 18.28571429 ✓ = 18 (to 2 sig figs) ✓ no units ✓ (or ecf based on answers to (i) and/or (a))	[3]
	(c)		K_c is constant ✓ Composition of mixture is the same ✓	[2]
	(d)		(Forward) reaction is exothermic (ora) ✓ because equilibrium moves to the left / K_c is less ✓	[2]
	(e)	(i)	$I_2(aq) + H_2S(g) \longrightarrow 2HI(aq) + S(s)$ species and balance ✓ state symbols: accept (s) for I_2; (aq) for H_2S ✓	[2]
		(ii)	amount I_2 reacted = 1.89 mol / HI formed = 3.44 mol ✓ theoretical amount HI produced = 3.78 mol/484 g ✓ % yield = $\frac{3.44 \times 100}{3.78}$ or $\frac{440 \times 100}{484}$ = 91.0 % ✓	[3]
		(iii)	$[HI] = \frac{3.44 \times 1000}{750}$ = 4.58/4.59 mol dm^{-3} ✓ pH = –log 4.59 = –0.66 ✓	[2]
				Total: 17

Question	Expected Answers	Marks
3	From graph, constant half-life ✓ Therefore 1st order w.r.t. $[CH_3COCH_3]$ ✓	[2]
	From table, rate doubles when $[H^+]$ doubles ✓ Therefore 1st order w.r.t. $[H^+]$ ✓	[2]
	From table, rate stays same when $[I_2]$ doubles ✓ Therefore zero order w.r.t. $[I_2]$ ✓ Order with no justification does **not** score.	[2]
	rate = $k[H^+][CH_3COCH_3]$ ✓ (from all three pieces of evidence) $k = \frac{rate}{[H^+][CH_3COCH_3]} / \frac{2.1 \times 10^{-9}}{0.02 \times 1.5 \times 10^{-3}}$ ✓ = 7.0×10^{-5} ✓ $dm^3\ mol^{-1}\ s^{-1}$ ✓ accept 7×10^{-5}	[4]
	rate determining step involves species in rate equation ✓ two steps that add up to give the overall equation ✓ The left hand side of a step that contains the species in rate-determining step ✓ i.e., for marking points 2 and 3: $CH_3COCH_3 + H^+ \longrightarrow [CH_3COHCH_3]^+$ $[CH_3COHCH_3^+] + I_2 \longrightarrow CH_3COCH_2I + HI + H^+$	[3]
	organises relevant information clearly and coherently, using specialist vocabulary where appropriate Use of the following four words/phrases: constant, half-life, order, doubles/x2 ✓	[1]
		Total: 14