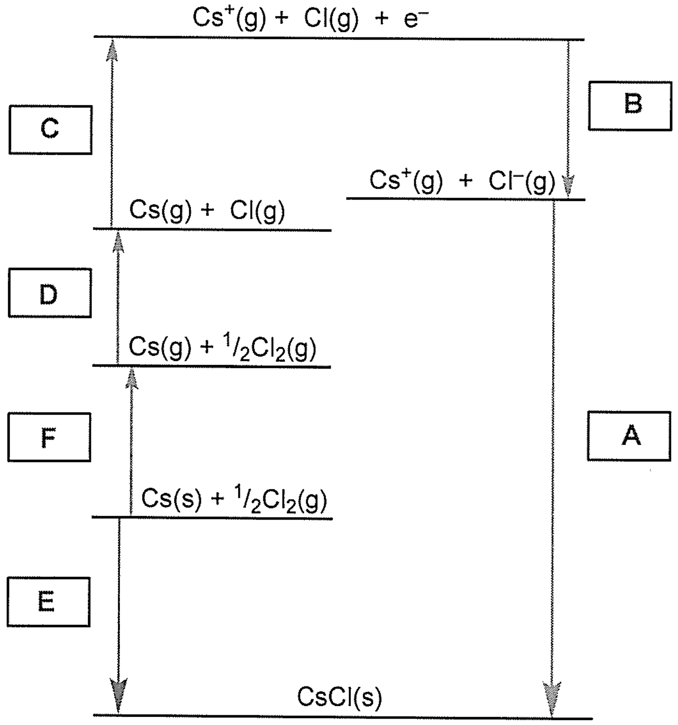
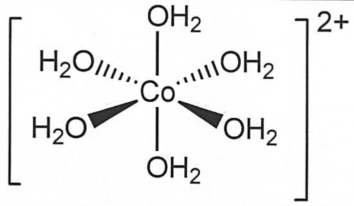
2815/01 Trends and Patterns

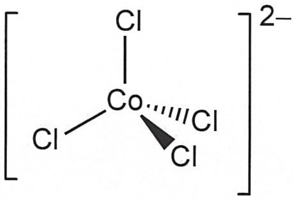
Qu.	Expected answers	Marks	Additional guidance
1 (a)	 6 correct labels: 3 marks 4 correct labels: 2 marks 3 correct labels: 1 mark	3	**Allow** values (except **A**)
(b)	= –443 =+76 + 376 + 122 + –349 + Lattice enthalpy ✓ Lattice enthalpy = –668 (kJ mol^{-1}) ✓	2	**Allow** ECF from **(a)** 668 = 1 mark
(c)	Lattice enthalpy of NaCl would be more exothermic than that of CsCl / lattice enthalpy is greater in magnitude / ORA ✓ Na^+ is smaller than Cs^+ / Na^+ has a larger charge density than Cs^+ / ORA ✓ NaCl has stronger ionic bonding / stronger attraction between the positive and negative ion ✓	3	Not bigger or smaller lattice enthalpy NOT larger charge Correct particles must be used e.g. not Na has a smaller radius All comparative
		8	

Qu.		Expected answers	Marks	Additional guidance
3	(a)	Oxidation: oxidation number of O changes from –1 to 0 ✓ Reduction: oxidation number of O changes from –1 to –2 ✓	2	Allow 1 mark for either 2 correct ON changes (1 ox I red) OR correct ref to ox and red from their ON changes
	(b) (i)	$2MnO_4^- + 6H^+ + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$ Correct reactants and products and balanced (but can include e^- on both sides and H^+ on both sides. ✓ Correct balanced equation with no electrons shown and H^+ only on left hand side ✓	2	**Allow** correct multiples of equation **Ignore** state symbols
	(ii)	Moles of MnO_4^- = $\frac{23.35 \times 0.0150}{1000}$ / 3.5025×10^{-4} / 3.50×10^{-4} / 3.5×10^{-4} ✓ Moles of H_2O_2 = 2.5 × moles of MnO_4^- / 8.75×10^{-4} / 8.76×10^{-4} ✓ Concentration of H_2O_2 = $\frac{8.75 \times 10^{-4} \times 1000}{25.0}$ = 0.035(0) (mol dm^{-3}) ✓ correct answer = 3 marks	3	**Allow** ECF within the question
	(c)	sodium hydroxide / potassium hydroxide / hydroxide ions / potassium thiocyanate / ammonium thiocyanate / thiocyanate ions ✓ observation: orange-red / brown / brown-red / foxy-red ppt with NaOH(aq) or (blood) red with KSCN / NH_4SCN / SCN^- ✓	2	**Allow** formulae Colour AND ppt needed (not red or orange) Not ppt
			9	

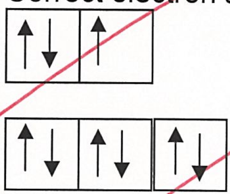
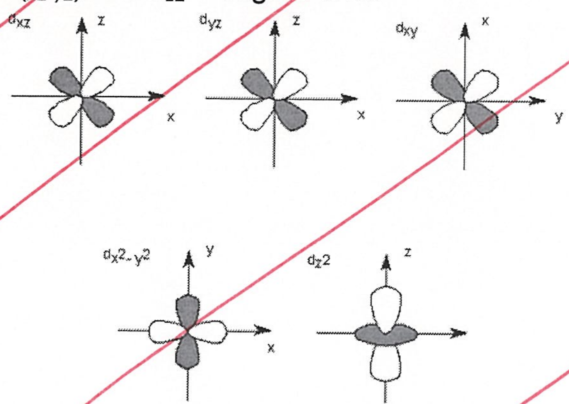
Qu.		Expected answers	Marks	Additional guidance
4	(a)	$1s^22s^2(2)p^63s^2(3)p^6(3)d^9$ ✓ (Cu is a transition element since Cu^{2+} has an) incomplete d sub-shell / AW ✓	2	
	(b)	complex ion: metal/TE atom / ion surrounded by ligands ✓ ligand: a species able to donate a pair of electrons ✓ to form a dative covalent / co-ordinate bond ✓ ligand substitution: 2 examples with colour change and equation , eg $[Cu(H_2O)_6]^{2+}$ and NH_3 ✓ $[Cu(H_2O)_6]^{2+} + 4NH_3 \longrightarrow [Cu(H_2O)_2(NH_3)_4]^{2+} + 4H_2O$✓ blue dark blue ✓ $Cu(H_2O)_6]^{2+}$ and Cl^- ✓ $[Cu(H_2O)_6]^{2+} + 4Cl^- \longrightarrow [CuCl_4]^{2-} + 6H_2O$ ✓ blue yellow/green ✓ octahedral ✓ with shape drawn out, eg $[Cu(H_2O)_6]^{2+}$ ✓ Must have 2 bonds in plane of paper, 2 out of paper and 2 into paper Or 4 in plane of paper, one out of paper and one into paper. tetrahedral ✓ with shape drawn out, eg $[CuCl_4]^{2-}$ ✓ Must have at least 1 bond in plane of paper, 1 out of paper and 1 into paper with last bond one of three types above.	3 5 from 6 4	**Allow** 2 marks for a corectly balanced equation **Allow** other correct examples If incorrect metal mark equations only **Allow** other correct examples Ignore bond angles
		Quality of Written Communication (1) At least 2 complete sentences in which the meaning is clear.✓	1	
			15	

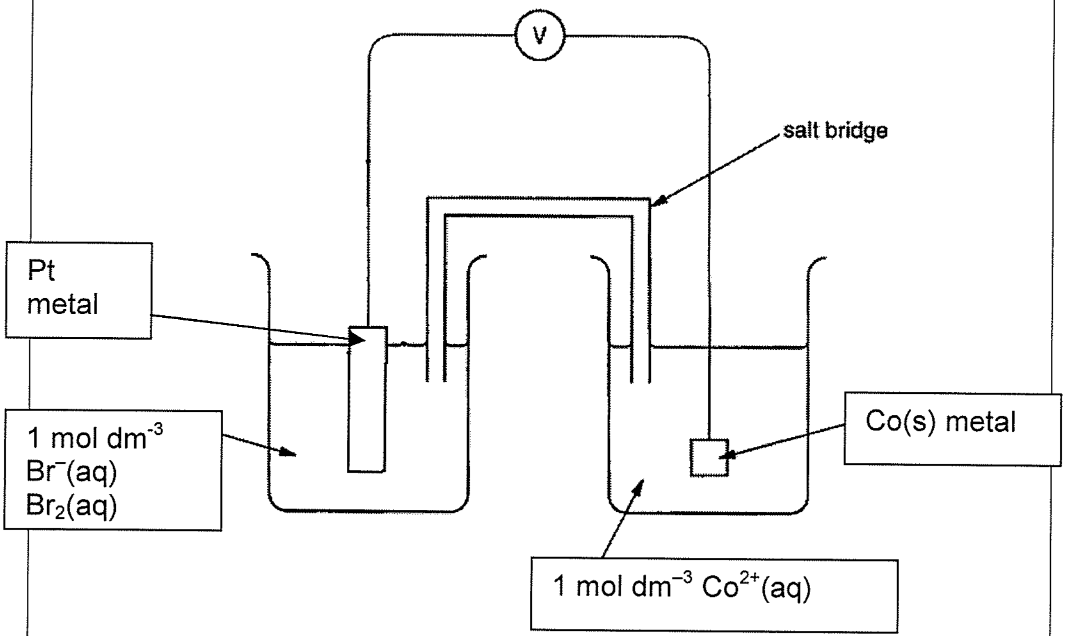
2815/06 Transition Elements

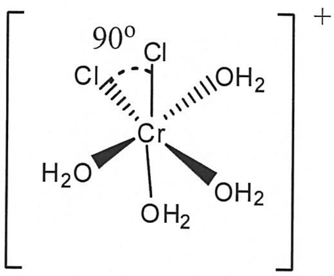
<table>
<tr><th>Qu.</th><th>Expected answers</th><th>Marks</th></tr>
<tr><td>1(a)</td><td>A reaction in which one electron pair donor / ligand ✓ is replaced / displaced/swapped/exchanged ✓ by another (not substituted)</td><td>2</td></tr>
<tr><td>1(b)</td><td>

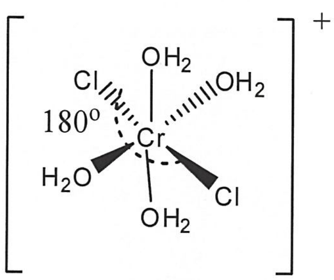
✓


✓
Charge not required
Allow other 3-D representations.</td><td>2</td></tr>
<tr><td>1(c)(i)</td><td>$[Co(NH_3)_6]^{2+}$ ✓
E for forward reaction is less positive / more negative ✓ (not lower)
Reverse reaction / oxidation is more likely to occur ✓</td><td>3</td></tr>
<tr><td>1(c)(ii)</td><td>Ammonia is a <u>stronger ligand</u> than water / ammonia forms <u>stronger bonds</u> / ammonia is a <u>stronger base</u> / ammonia can donate its lone pair more easily ✓</td><td>1</td></tr>
<tr><td>1(d)</td><td><table><tr><th></th><th>$VO_2^{+}(aq)$</th><th>$VO^{2+}(aq)$</th><th>$V^{3+}(aq)$</th><th>$V^{2+}(aq)$</th></tr><tr><td>oxidation state of vanadium</td><td>+5 ✓</td><td>+4 ✓</td><td>+3</td><td>+2</td></tr><tr><td>colour</td><td>yellow</td><td>blue ✓</td><td>green</td><td>lilac/purple/ violet/mauve/ lavender ✓</td></tr></table></td><td>4</td></tr>
<tr><td></td><td></td><td>12</td></tr>
</table>

Qu.	Expected answers	Marks
2(a)(i)	+2 / 2^+ /2 ✓	1
2(a)(ii)	Amount in moles = *cv*/1000 Amount of $S_2O_3^{2-}$ in moles = $\frac{0.500 \times 23.50}{1000}$ = 0.01175 /0.0118 mol ✓ Lose mark if give answer as 0.012 but allow 5 ECF marks in **(iii)**	1
2(a)(iii)	Ratio is 2:1 Amount of I_2 in moles = 0.01175/2 = 0.0058765 mol ✓ Ratio is 2:1 Amount of Cu^{2+} in moles = 0.0058765 × 2 = 0.01175 mol ✓ (Both steps not required can be combined into one step) Mass of copper in 25 cm^3 = 0.01175 × 63.5 / 0.746 g ✓ Mass of copper in 250 cm^3 = 10 × 0.746 g = 7.46 g % Copper = $\frac{7.46}{8.95} \times 100$ = 83.36% ✓ Answer to 3 sig figs = 83.4% ✓ Answer is 83.7% if 0.0118 is used. Allow ECF from **(ii)** (Not all steps required final answer would score 5 marks, whereas 83.36% would score 4 marks)	5
2(b)(i)	Two boxes at higher energy ✓ Correct electron arrangement ✓ 	2
2(b)(ii)	d_{xy} , d_{yz}, d_{xz} – Lower level ✓ $d_{(x2-y2)}$ and d_{z2} – Higher level ✓  NB d_{z2} orbital must be shown on *z* axis	2

Qu.	Expected answers	Marks
3(a)(i)	 Co(s) and $Co^{2+}(aq)$ ✓ $Br_2(aq)$ and $Br^-(aq)$ ✓ State symbols not needed but do not accept $Br_2(g)$ Pt metal ✓ Salt bridge + voltmeter + complete circuit ✓ All solutions at 1 mol dm^{-3} ✓	5
3(a)(ii)	1.37 V ✓ (Ignore sign)	1
3(a)(iii)	$Co(s) + Br_2(aq) \longrightarrow Co^{2+}(aq) + 2Br^-(aq)$ ✓ (State symbols not needed)	1
3(a)(iv)	Reduction occurs at the Br_2 / Br^- electrode ✓ Bromine changes oxidation state from 0 to –1 ✓ or Bromine accepts / gains electrons so is being reduced or E is more positive so reaction more likely to occur from left to right / forwards	2
3(b)	MnO_4^- only ✓/ acidified MnO_4^- / H^+ and MnO_4^- The standard cell potential has to be positive and with MnO_4^- cell potential is +0.16 V whereas with $Cr_2O_7^{2-}$ cell potential is –0.03 V ✓ Allow idea that MnO_4^- is a better oxidizing agent than Cl_2 but $Cr_2O_7^{2-}$ is not	1 1
		11

<table>
<tr><th>Qu.</th><th>Expected answers</th><th>Marks</th></tr>
<tr><td>4</td><td>
<table>
<tr><td></td><td>$CrCl_3$</td><td>H_2O</td></tr>
<tr><td>mass</td><td>2.380</td><td>1.62</td></tr>
<tr><td>Relative formula mass</td><td>158.5</td><td>18</td></tr>
<tr><td>Moles</td><td>0.015</td><td>0.09 ✓</td></tr>
<tr><td>Mole Ratio</td><td>= 0.015 / 0.015</td><td>= 0.09 / 0.015</td></tr>
<tr><td></td><td>1</td><td>6</td></tr>
</table>
The value of *x* in the formula is 6 ✓
</td><td>2</td></tr>
<tr><td></td><td>stereoisomers are molecules of the same structural formula but with a different spatial arrangement of their atoms ✓


cis-isomer ✓


trans-isomer ✓
Isomers must be correctly labelled. ✓ Bond angles not required. Charges must be correct but if no charge or wrong charge allow ECF on second diagram. Ignore any reference to optical isomerism</td><td>4</td></tr>
<tr><td></td><td>When a solution of chromate(VI) is reacted with acid ✓ the dichromate(VI) ion is formed.
$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$ ✓
or $2CrO_4^{2-}(aq) + H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + OH^-(aq)$
or $2CrO_4^{2-}(aq) + H_2O(l) \rightleftharpoons Cr_2O_7^{2-}(aq) + 2OH^-(aq)$
State symbols not needed. Allow correct equations in either direction
A colour change will occur in this reaction as the solution changes from yellow to orange. ✓
If colours are with equation, it must be clear that candidates know which is chromate(VI) and which is dichromate(VI)</td><td>3</td></tr>
<tr><td></td><td>Two complete sentences using correct spelling, punctuation and grammar, discussing the chemistry of chromium where the meaning is clear. ✓</td><td>1</td></tr>
<tr><td></td><td></td><td>10</td></tr>
</table>

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

Qu.	Expected answers	Marks
1(a)(i)	$K_p = \frac{(pSO_3)^2}{(pSO_2)^2 \times (pO_2)}$ ✓	1
(ii)	equilibrium is (well) to right ✓ **a lot** more products than reactants ✓	2
1(b)(i)	*effect on equilibrium position* moves to left because .... forward reaction is exothermic / reverse reaction is endothermic / K_p decreases ✓ *effect on partial pressure of $SO_3(g)$* decreases because ...... equilibrium has moved to left **OR** reverse / K_p decreases ✓	2
(ii)	*effect on equilibrium position* moves to right because fewer gas moles on right ✓ *effect on partial pressure of $SO_3(g)$* increases because .... equilibrium has moved to right / more products **OR** SO_3 ✓	2
1(c)	$3.0 \times 10^2 = \frac{p(SO_3)^2}{25^2 \times 125}$ **OR** $p(SO_3) = \sqrt{(3.0 \times 10^2 \times 25^2 \times 125)}$ ✓ = 4841 kPa ✓ (4841.1229183) *Accept rounding back to 4800 kPa* $\%(SO_3) = 100 \times 4841 / (4841 + 25 + 125) = 97\%$ ✓	3
1(d)(i)	$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$ ✓✓ ZnS, O_2 as reactants **and** SO_2 as a product: 1st mark. ZnO **and** balance: 2nd mark	2
(ii)	ZnS is more available than S. ✓	1
		13

Qu.	Expected answers	Marks
2(a)	H_2O_2 + $2I^-$ + $2H^+$ ⟶ I_2 + $2H_2O$ equation includes H_2O_2, I^-, H^+ as reactants and I_2 as product ✓ equation balanced ✓	2
2(b)(i)	order = 1 with respect to I^- ✓ When $[I^-]$ doubles, rate doubles ✓ order = 0 with respect to H^+ ✓ When $[I^-]$ doubles, rate doubles **OR** when $[I^-]$ quadruples, rate quadruples ✓	4
2(b)(ii)	rate = $k\,[H_2O_2]\,[I^-]$ ✓ *[ECF from **(i)**]*	1
2(b)(iii)	From one of experiments, e.g. Experiment 1: $k = \dfrac{5.75 \times 10^{-6}}{0.05 \times 0.01}$ ✓ = 1.15×10^{-2} ✓ $dm^3\,mol^{-1}\,s^{-1}$ ✓ *[ECF from **(ii)**]. Accept 1.2×10^{-2}*	3
2(c)(i)	$2H_2O_2$ ⟶ $2H_2O$ + O_2 ✓	1
2(c)(ii)	1 dm^3 H_2O_2 ⟶ 40 dm^3 O_2 ✓ amount of $O_2 = \dfrac{40}{24}$ **OR** 1.67 mol ✓ concentration of H_2O_2 = $\dfrac{2 \times 40}{24}$ = 3.3 mol dm^{-3} **OR** 2 × 1.67 = 3.34 ✓ *Accept $3.\dot{3}$*	3
		14

Qu.	Expected answers	Marks
3(a)(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)	moles HI = $\frac{47.2}{128}$ = 0.36875 mol ✓ *accept rounding back to 0.369 mol* [HI] = $\frac{0.36875 \times 1000}{225}$ = 1.64 mol dm^{-3} pH = –log 1.64 = -0.21 ✓	2
3(b)(i)	$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$ ✓ *Equilibrium sign is required*	1
(ii)	$K_a = \frac{[H^+(aq)]\ [CH_3COO^-(aq)]}{[CH_3COOH(aq)]}$ **OR** $[H^+] = \sqrt{([CH_3COOH]\ [K_a])}$ ✓ $[H^+] = \sqrt{\{(1.70 \times 10^{-5}) \times (2.74 \times 10^{-3})\}} = 2.16 \times 10^{-4}$ mol dm^{-3} ✓ *(or 2 marks if no expression given before)* pH = $-\log[H^+(aq)] = -\log 2.16 \times 10^{-4}$ = 3.67 ✓ *ECF: pH Must be from both [CH_3COOH] AND K_a* ***DO NOT ALLOW*** *3.7* *If no square root, ECF answer = 7.33*	3
(iii)	$HI + CH_3COOH \rightleftharpoons I^- + CH_3COOH_2^+$ ✓ acid 1 base 2 base 1 acid 2 ✓ *Mark acid base pairs ECF from equation showing ethanoic acid as proton donor*	2
3(c)(i)	$NaHCO_3$ is an alkali or base / neutralises acid ✓ $HCOOH + NaHCO_3 \longrightarrow HCOONa + CO_2 + H_2O$ ✓ Allow H_2CO_3 instead of $CO_2 + H_2O$	2
(ii)	vinegar is acidic ✓ neutralises alkali in wasp sting ✓	2
(iii)	$[H^+] = \frac{K_a \times [HCOOH(aq)]}{[HCOO^-(aq)]} = \frac{1.60 \times 10^{-4} \times 0.75}{1.92}$ **OR** 6.25×10^{-5} mol dm^{-3} ✓ pH = $-\log[H^+] = -\log(7.5 \times 10^{-5})$ = 4.20 / 4.2 ✓ *ECF: pH Must be from [CH_3COOH], [CH_3COO^-]* ***AND*** *K_a* *If fraction inverted, ECF answer = 3.39*	2
		16

Qu.	Expected answers	Marks
4(a)	moles of NaOH = $\frac{0.152 \times 19.80}{1000}$ / 3.01×10^{-3} mol ✓ moles of acid = 3.01×10^{-3} mol ✓ (3.0096×10^{-3}) moles of acid in flask = 4 × 3.00×10^{-3} = 1.20×10^{-2} mol ✓ (0.0120384) molar mass of compound = $\frac{mass}{n}$ = $\frac{1.368}{1.20 \times 10^{-2}}$ = 114 ✓ Molecular formula = $C_6H_{10}O_2$ ✓ A six carbon carboxylic acid (e.g. hexanoic acid) shown (bod) ✓ Any 2 possible **structural** isomers ✓✓ eg: $CH_3CH_2CH_2{=}CH(CH_3)COOH$ $CH_3CH_2{=}CH(CH_3)CH_2COOH$ *Accept structural formulae or displayed formulae as long as they are unambiguous.*	8
4(b)	**Rate–concentration graphs** Zero order: horizontal line ✓ First order: straight rising line going through origin ✓ Second order: curve rising upwards going through origin OR straight line in a rate vs conc^2 graph ✓ correct labeled axes shown once ✓ *Marks can be obtained by three clear sketch graphs* **pH curves** Sketch graph with a sharp rise for strong acid and strong base with line vertical part of curve centred at about pH 7 Must be some indication of pH numbers fitting the vertical part of curve ✓ Sketch graph with a sharp rise for strong acid and strong base with line vertical part of curve centred at a pH greater than 7 Must be some indication of pH numbers fitting the vertical part of curve ✓ **Vertical** section in strong/strong graph is larger than **vertical** section for weak/strong graph **AND** pH curve for weak starts at higher pH than for strong ✓ correct labeled axes shown once ✓ (For *x* axis, accept 'volume **OR** amount of what is added')	8
QWC	For pH titration pH curve, a statement that the colour change of suitable indicator range matches the vertical section ✓	1
		17