Transition Metal Basics

Mark Scheme

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Transition Metals & Organic Nitrogen Chemistry
Sub Topic	Transition Metal Basics
Booklet	Mark Scheme

Time Allowed: **86 minutes**

Score: **/71**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Question Number	Correct Answer	Reject	Mark
1	**B**		1

Question Number	Correct Answer	Reject	Mark
2	**A**		1

Question Number	Correct Answer	Reject	Mark
3	D		1

Question Number	Correct Answer	Reject	Mark
4	A		1

Question Number	Correct Answer	Reject	Mark
5	D		1

Question Number	Correct Answer	Reject	Mark
6	C		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	C		1

Question Number	Correct Answer	Reject	Mark
9	B		1

Question Number	Correct Answer	Reject	Mark
10	B		1

Question Number	Correct Answer	Reject	Mark
11	B		**1**

Question Number	Correct Answer	Reject	Mark
12	A		**1**

Question Number	Correct Answer	Reject	Mark
13	C		**1**

Question Number	Correct Answer	Reject	Mark
14	D		**1**

Question Number	Correct Answer	Reject	Mark
15	A		**1**

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	If name and formula are given, both must be correct **A** = copper(II) chloride / $CuCl_2$ (1) **B** = tetrachlorocuprate(II) (ion) / $CuCl_4^{2-}$ ALLOW **B** = trichlorocuprate(II) / $CuCl_3^-$ (1) **C** = copper(II) hydroxide / $Cu(OH)_2$ / $Cu(OH)_2(H_2O)_4$ (1) **D** = tetraamminecopper(II) (ion) / $Cu(NH_3)_4^{2+}$ / $Cu(H_2O)_2(NH_3)_4^{2+}$ (1) **E** = copper(I) oxide / Cu_2O (1) **F** = iodine / I_2 / triiodide (ion) / I_3^- / KI_3 (1) IGNORE state symbols even if incorrect. **correct** oxidation numbers with formula. order of the ligands.	**B** = $CuCl_2$	**6**

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	If name and formula are given, both must be correct **X** = (aqueous) ammonia / $NH_3(aq)$ ALLOW NH_3 / ammonium hydroxide (1) **Y** = potassium iodide / KI ALLOW other soluble iodides (1) IGNORE references to concentration	**X** = NaOH iodide / I^- KI **and** acid HI	**2**

Question Number	Acceptable Answers	Reject	Mark
16(a)(iii)	(Product is) ethanoic acid / CH_3COOH / ethanoate(ions) / CH_3COO^- (1) IGNORE carboxylic Ethanal is a reducing agent / reduces Cu^{2+} (1) Stand alone marks IGNORE references to oxidation of ethanol products of reduction (e.g. Cu)		**2**

Question Number	Acceptable Answers	Reject	Mark
16(a)(iv)	(Iodine is formed quantitatively and is determined by) titration against sodium thiosulfate solution (of known concentration)	Colorimetry	**1**

Question Number	Acceptable Answers	Reject	Mark
16(b)(i)	(3)d orbitals / (3)d subshell split (by the attached ligands) (1) Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy d orbital(s) / levels) ALLOW d—d transitions occur (1) Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light (1) Reflected / transmitted / remaining light is coloured / yellow / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen (1) Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell is split	**4**

Question Number	Acceptable Answers	Reject	Mark
16(b)(ii)	Colour depends on the frequency /wavelength /energy of the absorbed light (1) Different **ligands** split the d orbitals to a different extent (1)		**2**

Question Number	Acceptable Answers	Reject	Mark
16(c)(i)	$2Cu^{+}(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$ ALLOW reversible arrows	Electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
16(c)(ii)	The copper(I) is oxidized to copper(II) and (in the same reaction) reduced to copper((0)) OR Copper changes from +1 to 0 and +2 IGNORE Reference to a Cu atom		**1**

Question Number	Acceptable Answers	Reject	Mark
16(c)(iii)	Relevant reduction potentials are $Cu^{2+} + e^{-} \rightleftharpoons Cu^{+}$ $E^{\ominus} = +0.15$ (V) $Cu^{+} + e^{-} \rightleftharpoons Cu$ $E^{\ominus} = +0.52$ (V) ALLOW single arrows (1) $E^{\ominus}_{cell} = 0.52 - 0.15 = (+)0.37$ (V) (1) TE on incorrect $E^{\ominus}$ values providing $E^{\ominus}_{cell}$ is positive (E^{o}_{cell} positive so reaction thermodynamically favourable)		**2**

Total for Question 16 = 21 marks

Question Number	Correct Answer	Reject	Mark
17(a)(i)	$3d^5\ 4s^1$ /$4s^1\ 3d^5$ ALLOW Complete configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ ALLOW Capitals and subscripts		1

Question Number	Correct Answer	Reject	Mark
17 (a)(ii)	It is $4s^1$ rather than $4s^2$ because with two of the reasons below $3d^5$/ half-filled 3d sub shell is particularly stable **(1)** The paired electrons repel **(1)** All six electrons are in separate orbitals (minimizing repulsion) **(1)** ALLOW The energy required to promote/ transfer 4s to 3d is small OR The energy difference between 4s and 3d is small **(1)**		2

Question Number	Correct Answer	Reject	Mark
17(b)(i)	($E^{\ominus}$ $Zn^{2+}(aq)$| $Zn(s)$ = -0.76 V $E^{\ominus}$ $Cr^{3+}(aq)$, $Cr^{2+}(aq)$|Pt = -0.41 V $E^{\ominus}$ [$Cr_2O_7^{2-}(aq)$ + $7H^+(aq)$], [$2Cr^{3+}(aq)$ + $7H_2O(l)$]|Pt = +1.33 V) If no other mark is scored, data scores (1) however shown Calculation of $E^{\ominus}_{cell}$ values: $E^{\ominus}_{cell}$ for first step = 1.33 – -0.76 = (+)2.09 (V) **(1)** $E^{\ominus}_{cell}$ for second step = -0.41 – -0.76 = (+)0.35 (V) **(1)** As (both) values are positive, (both) reactions are spontaneous/feasible **(1)** Third mark is independent		3

Question Number	Correct Answer	Reject	Mark
17(b)(ii)	**Orange** to **green** to **blue** IGNORE qualifying words eg pale blue		1

Question Number	Correct Answer	Reject	Mark
17 (b)(iii)	The small amount of hydrogen produced (does not present a serious risk) ALLOW “Less” for small amount Indication of ventilation		1

Question Number	Correct Answer	Reject	Mark
17(c)(i)	It is bridging/ bidentate ligand	Polydentate	1

Question Number	Correct Answer	Reject	Mark
17(c)(ii)	Dative (covalent) (bonds)/ co-ordinate (bonds)		1

Question Number	Correct Answer	Reject	Mark
17 (c)(iii)	**Any two from:** Chromium atoms/ ions are covalently bonded/bonded to each other OR Two (chromium) ions/ chromium atoms in the complex **(1)** Each ethanoate ligand forms bonds to two different atoms/ ions **(1)** Ethanoate ions are not normally bidentate ligands **(1)** ALLOW Contains both monodentate and bidentate ligands **(1)** Allow six ligands **and** complex not octahedral **(1)**	Just "two different ligands"	2

Question Number	Correct Answer	Reject	Mark
17 (c)(iv)	The energies of the d electron levels are split to different extents (by different ligands) ALLOW d-d (orbitals) splitting is different OR d-d transitions are different **(1)** So different energy/ frequency/ wavelength light absorbed **(1)**	… (just) transmitted	2

Question Number	Correct Answer	Reject	Mark
17(c)(v)	There are two peaks as two different hydrogen environments **(1)** EITHER The areas due to hydrogen in water molecules compared to hydrogen in ethanoate ions is in the ratio 1 to 3/ 4 to 12 OR As there are 4 hydrogen atoms in water and 12 hydrogen atoms in ethanoate ions **(1)**		2

Question Number	Correct Answer	Reject	Mark
17(d)	**First mark** Dilution factor: moles of chromium(II) ethanoate in 25.0 cm^3 = $\frac{2.66 \times 10^{-3}}{10}$ = 2.66×10^{-4} **(1)** **Second mark** Ratio of manganate(VII) to chromium 4 mol manganate(VII) react with 5 mol of chromium (II) OR 8 mol mangante(VII) react with 5 mol of chromium(II) ethanoate **(1)** **Third mark** moles of manganate(VII) ion = $\frac{4 \times 5.32 \times 10^{-4}}{5}$ OR $\frac{8 \times 2.66 \times 10^{-4}}{5}$ = 4.256×10^{-4} **(1)** **Fourth mark** Volume of manganate(VII) solution = $\frac{4.256 \times 10^{-4} \times 1000}{0.00750}$ = 56.75 cm^3 **(1)** Correct answer no working (4) 28.375 cm^3 gets (3) **Fifth mark** This is unsuitable/ inaccurate because it requires refilling the burette hence increasing burette error OR Better to use more concentrated potassium manganate(VII) OR less chromium ethanoate **(1)**		5

(Total for Question 17 = 21 marks)

Question Number	Acceptable Answer	Reject	Mark
18(a)(i)	$[Cu(H_2O)_6]^{2+}$ ALLOW $[Cu(H_2O)_4]^{2+}$ **(1)** $Cu(H_2O)_4(OH)_2$ ALLOW $Cu(OH)_2$ **(1)** $[Cu(NH_3)_4(H_2O)_2]^{2+}$ ALLOW $[Cu(NH_3)_4]^{2+}$ **(1)** ALLOW Ligand in any order Omission of square brackets	$Cu^{2+}(aq)$ $[Cu(NH_3)_6]^{2+}$	3

Question Number	Acceptable Answer	Reject	Mark
18(a)(ii)	(3)d orbitals / (3)d subshell split (by the attached ligands) **(1)** Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy (d orbital(s) / levels) ALLOW d—d transitions occur /electrons are excited **(1)** Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light **(1)** Reflected / transmitted / remaining light is coloured / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen **(1)** Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell / subshells split d—d splitting Emitted 'Reverse' for 'complementary'	4

Question Number	Acceptable Answer	Reject	Mark
18(a)(iii)	The (different) ligands split the (3)d orbitals / subshell to a different extent **(1)** (So) the energy absorbed / reflected / transmitted is different OR Radiation (ALLOW light) is at a different frequency **(1)**	Orbital / shell / subshells unless penalised in 22(a)(ii) Emitted unless penalised in 22(a)(ii)	2

Question Number	Acceptable Answer	Reject	Mark
18(b)	Any 5 of the following: **Step 1**: Minimum amount of solvent to minimise the amount of solid complex left in solution (when it recrystallizes) ALLOW To form a saturated solution (of **C**) OR So the solution is as concentrated as possible **(1)** **Step 2**: (**hot**) So maximum amount / most of complex remains in (hot) solution OR To avoid the premature formation the crystals in the funnel **(1)** (**filter**) To remove **insoluble / undissolved** impurities **(1)** Step 3: To ensure that **maximum** amount of solid crystallizes ALLOW To obtain a better yield (of crystals) **(1)** Step 4: To remove **soluble / dissolved** impurities **(1)** So that the filtered solid is dry ALLOW So that filtration is fast **(1)**	Speed up crystallization Remove insoluble impurities	5

Total for Question 18 = 14 marks