Mark Scheme (Results)

Summer 2018

Pearson Edexcel International
Advanced Level In Chemistry (WCH05)
Paper 01
General Principles of Chemistry II - Transition Metals and Organic Nitrogen Chemistry

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Summer 2018
Publications Code

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	**The only correct answer is A** ***B*** *is not correct because this is the other common oxidation number associated with iron* ***C*** *is not correct because this is the numerical value of the charge on the complex* ***D*** *is not correct because this is the number of cyano ligands in the complex*	**(1)**

Question Number	Correct Answer	Mark
2	**The only correct answer is B** ***A*** *is not correct because this is calculated on the basis of a 1:2 reaction and that 2 mol hydrogen atoms forms 1 mol hydrogen gas* ***C*** *is not correct because this is calculated on the basis of a 1:2 reaction and does not take into account that 2 mol hydrogen atoms forms 1 mol hydrogen gas* ***D*** *is not correct because this is calculated on the basis of a 1:3 reaction but does not take into account that 2 mol hydrogen atoms forms 1 mol hydrogen gas*	**(1)**

Question Number	Correct Answer	Mark
3(a)	**The only correct answer is D** ***A*** *is not correct because both oxidation states in the system must be present* ***B*** *is not correct because both oxidation states in the system must be present* ***C*** *is not correct because the electrode must be inert*	**(1)**

Question Number	Correct Answer	Mark
3(b)	**The only correct answer is B** ***A*** *is not correct because the value for the Fe(III)/Fe(II) electrode reaction has been incorrectly doubled* ***C*** *is not correct because the subtraction has been incorrectly reversed* ***D*** *is not correct because the value for the Fe(III)/Fe(II) electrode reaction has been incorrectly doubled and the subtraction has been incorrectly reversed*	**(1)**

Question Number	Correct Answer	Mark
4	**The only correct answer is C** ***A*** *is not correct because* if E_{cell} is positive ΔS_{total} must be positive but ΔS_{system} could be negative ***B*** *is not correct because* if E_{cell} is positive ΔS_{total} must be positive but $\Delta S_{surroundings}$ could be negative ***D*** *is not correct because* if E_{cell} is positive ΔS_{total} must be positive but ΔS_{system} or $\Delta Ss_{urroundings}$ could be negative	**(1)**

Question Number	Correct Answer	Mark
5	**The only correct answer is D** ***A*** *is not correct because hydrogen is the fuel so must be oxidised, hence oxygen is reduced* ***B*** *is not correct because hydrogen is the fuel so must be oxidised, hence oxygen is reduced* ***C*** *is not correct because reduction occurs at the positive electrode (the cathode)*	**(1)**

Question Number	Correct Answer	Mark
6	**The only correct answer is A** ***B*** *is not correct because a large number of valence electrons is a factor in heterogeneous catalysis but not in homogeneous catalysis* ***C*** *is not correct because active sites are involved in heterogeneous catalysis but not in homogeneous catalysi* ***D*** *is not correct because* Fe^{3+} *cannot oxidise peroxodisulfate ions*	**(1)**

Question Number	Correct Answer	Mark
7	**The only correct answer is B** ***A*** *is not correct because* an atom of vanadium has three unpaired electrons ***C*** *is not correct because* an atom of manganese has five unpaired electrons ***D*** *is not correct because* an atom of iron has four unpaired electrons	**(1)**

Question Number	Correct Answer	Mark
8	**The only correct answer is B** ***A*** *is not correct because this formula would give a peak in the graph when equimolar quantities of M & L were present (at 5 cm^3)* ***C*** *is not correct because this answer is based on the ratio of 3.33:10 (rather than 3.33:(10−3.33)* ***D*** *is not correct because this is a common complex formula but incorrect in this case*	**(1)**

Question Number	Correct Answer	Mark
9	**The only correct answer is B** ***A*** *is not correct because the addition of water has no effect apart from hydrating the ions. The addition of sulfuric acid changes the vanadium species but not the oxidation state. Addition of zinc reduces V(V) to V(II). So there are two oxidation states* ***C*** *is not correct because the addition of water has no effect apart from hydrating the ions. The addition of sulfuric acid changes the vanadium species but not the oxidation state. Addition of zinc reduces V(V) to V(II). So there are two oxidation states* ***D*** *is not correct because the addition of water has no effect apart from hydrating the ions. The addition of sulfuric acid changes the vanadium species but not the oxidation state. Addition of zinc reduces V(V) to V(II). So there are two oxidation states*	**(1)**

Question Number	Correct Answer	Mark
10	**The only correct answer is C** ***A*** *is not correct because this value is obtained by addition of the enthalpy changes given in the stem* ***B*** *is not correct because this value is obtained by subtraction of the enthalpy changes given in the stem* ***D*** *is not correct because this value is half the correct value*	**(1)**

Question Number	Correct Answer	Mark
11	**The only correct answer is C** ***A*** *is not correct because* a true statement but irrelevant ***B*** *is not correct because* a true statement but irrelevant ***D*** *is not correct because* a true statement but irrelevant	**(1)**

Question Number	Correct Answer	Mark
12	**The only correct answer is D** ***A*** *is not correct because arenes will not undergo electrophilic addition reactions* ***B*** *is not correct because electrophilic substitution is a characteristic reaction of arenes but will not occur with dilute sulfuric acid* ***C*** *is not correct because phenylamine is not hydrolysed*	**(1)**

Question Number	Correct Answer	Mark
13	**The only correct answer is D** ***A*** *is not correct because dipole-dipole forces are possible but the high melting temperature of alanine is due to the ionic forces between the zwitterions* ***B*** *is not correct because London forces are present but the high melting temperature of alanine is due to the ionic forces between the zwitterions* ***C*** *is not correct because hydrogen bonds are possible but the high melting temperature of alanine is due to the ionic forces between the zwitterions*	**(1)**

Question Number	Correct Answer	Mark
14(a)	**The only correct answer is C** ***A*** *is not correct because a nitrogen with two H atoms attached is an amine* ***B*** *is not correct because the group lower far right is an ester but candidates might overlook the methyl group* ***D*** *is not correct because Benzene ring is a phenyl group. Candidates might mistake phenyl for phenol*	**(1)**

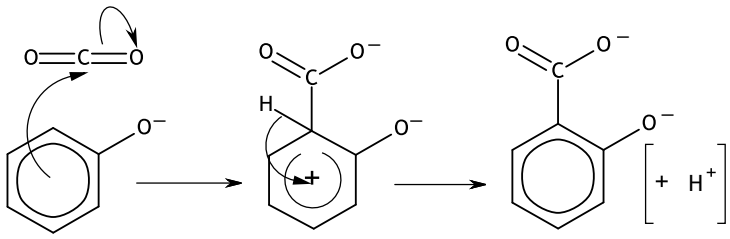
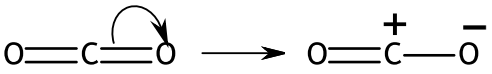
Question Number	Correct Answer	Mark
14(b)	**The only correct answer is A** ***B*** *is not correct because candidates might identify one or both of the* CH_2 *groups as asymmetric* ***C*** *is not correct because candidates might identify one or both of the* CH_2 *groups as asymmetric* ***D*** *is not correct because candidates might identify all of the C atoms in the aliphatic chain as asymmetric*	**(1)**

Question Number	Correct Answer	Mark
15	**The only correct answer is A** ***B*** *is not correct because the amide group has been reversed implying a single monomer with an acid (chloride) and an amine* ***C*** *is not correct because Kevlar has benzene rings* ***D*** *is not correct because the amide group has been reversed implying a single monomer with an acid (chloride) and an amine group, and because Kevlar has benzene rings*	**(1)**

Question Number	Correct Answer	Mark
16	**The only correct answer is A** ***B*** *is not correct because the molecular ion peak will be at 73 but m/e = 30 requires* CH_2NH_2 *fragment* ***C*** *is not correct because the molecular ion peak will be at 73 but m/e = 30 requires* CH_2NH_2 *fragment* ***D*** *is not correct because because The molecular ion peak will be at 73 but m/e = 30 requires* CH_2NH_2 *fragment*	**(1)**

Question Number	Correct Answer	Mark
17	**The only correct answer is D** ***A*** *is not correct because equilibrium position is not affected by use of a support* ***B*** *is not correct because polymeric supports are often expensive and this is a disadvantage of their use* ***C*** *is not correct because side reactions can occur but this is a disadvantage (unlike combinatorial chemistry)*	**(1)**

Question Number	Correct Answer	Mark
18	**The only correct answer is D** ***A*** *is not correct because not used at all in solvent extraction* ***B*** *is not correct because not used at all in solvent extraction* ***C*** *is not correct because not used at all in solvent extraction*	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	 **M1** Structure of CO_2 and curly arrow from C=O bond to the oxygen atom or just beyond it. ALLOW dipolar electrophile  **(1)** **M2** Curly arrow from on or within the circle to the carbon of the electrophile (molecule or dipolar ion) ALLOW Curly arrow from anywhere within the hexagon Arrow to **any** part of the electrophile including to the δ+ charge (if given). TE on any electrophile **(1)** **M3** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe **and** negative charges COO^- and O^- (OR COO^- and OH) ALLOW dotted horseshoe Do NOT penalise incorrect position of the O^- / phenol group at this marking point **(1)** **M4** Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure with O^- / phenol group in the 2 position and carboxylate ion **(1)** Correct Kekulé structures score full marks ALLOW phenol group as OH throughout	electrophile with a net charge Curly arrow starting on or outside the hexagon Partial bonds to H and CO_2^- unless clearly part of a 3D structure carboxylic acid group	**(4)**

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	Any **strong** acid by name or formula e.g. sulfuric acid / H_2SO_4 hydrochloric acid / HCl(aq) ALLOW nitric acid / HNO_3 / HCl If name and formula are given, both must be correct IGNORE conc / dilute / H^+ just 'acid' / 'strong acid'		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(b)	Higher temperature / pressure **(1)** IGNORE References to catalysts / use of milder / harsher (conditions) Phenol reacts with electrophiles much faster / under milder conditions than benzene ALLOW Phenol reacts with electrophiles more easily / readily OR Phenol more reactive than benzene / phenol reacts faster than benzene / phenol more susceptible to attack **(1)** Because the electron density of the benzene ring in phenol is higher **(1)** Due to interaction between the (oxygen) lone pair and the π electrons of the benzene ring ALLOW (Oxygen / OH) lone pair donated to the benzene ring Two electrons from oxygen donated to the benzene ring **(1)** Or Reverse argument for benzene	charge density (of ring)	**(4)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	Esterification ALLOW Ester formation Ethanoylation Acetylation Acylation IGNORE Addition-elimination / Condensation	Friedel-Crafts	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Any **three** of the following **Feasibility** Ethanoic acid does not react with phenol OH groups to form esters **(1)** **Reference to equilibrium or completion** Reaction with ethanoic acid would be an equilibrium / reversible / does not go to completion (so low yield) OR Reaction with ethanoyl chloride goes to completion (so high yield) **(1)** **Reference to rate of reaction** Reaction with ethanoic acid is slow or needs a catalyst or requires heat OR Reaction with ethanoyl chloride is fast or does not require a catalyst or occurs at room temperature **(1)** **Reference to products** Toxic / poisonous HCl is a by-product ALLOW Corrosive **(1)** IGNORE Reference to thermicity Reference to reactivity Reference to 'vigorous' reactions Explanations of reactivity, even if incorrect Safety / ease of handling ethanoic acid Reference to cost ALLOW Reverse arguments	Just 'HCl is formed' Just 'harmful'	**(3)**

(Total for Question 19 = 13 marks)

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	Left-hand label: H^+((aq)) /H_3O^+((aq)) / hydrogen ions OR HCl((aq)) / H_2SO_4((aq)) / HNO_3((aq)) **and** 1 mol dm^{-3} / activity = 1 **(1)** Right- hand label: H_2 ((g)) / hydrogen **and** 1 atm / 101 / 100 kPa (kN m^{-2}) /101 000 / 100 000 Pa (N m^{-2}) / 1.01 /1.0 /1 (Bar) **(1)** IGNORE Temperature Both substances correct but any number of conditions omitted scores **(1)**	H_2SO_4((aq)) with concentration of 0.5 mol dm^{-3}	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	Platinum is used because it is (chemically) inert (and conducts electricity) ALLOW unreactive OR Platinum catalyses $2H^+ + 2e \rightleftharpoons H_2$ OR Platinum catalyses $H_2 \rightleftharpoons 2H^+ + 2e$ ALLOW Platinum catalyses the electrode reaction Platinum is a catalyst **(1)** Using platinum black increases the surface area (making the catalysis more efficient) ALLOW Increase the number of active sites **(1)** IGNORE Reference to cost or rate of reaction		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	0.0(V) /zero ALLOW 0 (V) IGNORE Charges		**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iv)	It is not possible to measure the potential difference (of a half cell) between the metal electrode and the ion solution ALLOW A potential difference requires a complete circuit/two electrodes OR Current will not flow unless the circuit is complete OR The potential of a single electrode can only be measured by reference to / comparison with / against another electrode.		**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(v)	**M1** Conditions of the reaction are not standard OR Concentration is not 1 mol dm^{-3} OR Temperature not 298 K **(1)** IGNORE Temperature too low **M2** Reaction is (very) slow OR Activation energy is high OR Reaction is kinetically unfavourable OR Reaction mixture is kinetically stable **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	$Cr_2O_7^{2-} + 8H^+ + 3C_2H_5OH \rightleftharpoons 2Cr^{3+} + 3CH_3CHO + 7H_2O$ OR Multiples Correct species throughout and no electrons **(1)** Fully balanced and surplus H^+ eliminated **(1)** IGNORE State symbols even if incorrect Use of → instead of ⇌ Fully correct reverse equation scores 1 mark		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	oxidation of ethanol to ethanal E_{cell} = 1.33 − (−0.61) = (+)1.94 (V) **(1)** oxidation of ethanal to ethanoic acid E_{cell} = 1.33 − (−0.94) = (+)2.27 (V) **(1)** Correct values with no working scores both marks If no other mark is scored E_{cell} (to ethanal) = 0.72 (V) **and** E_{cell} (to ethanoic acid) = 0.39 (V) scores 1 mark		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	**Route 1** (Depends on E_{cell} (to ethanoic acid) more positive than E_{cell} (to ethanal)) The oxidation of ethanal (to ethanoic acid) is more favourable / feasible / spontaneous than the oxidation of ethanol to ethanal (because the E_{cell} value is more positive) ALLOW Ethanal is oxidised more easily than ethanol **Route 2** (Depends on **both** E_{cell} values being positive) Both oxidations are thermodynamically favourable / feasible IGNORE To prevent further oxidation		**(1)**

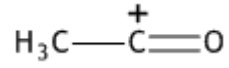
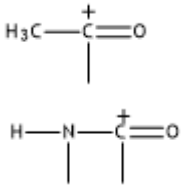
Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	**M1** Relevant reaction is $MnO_4^- + 8H^+ + 5e^{(-)} \rightleftharpoons Mn^{2+} + 4H_2O$ OR Multiples **and** $E^\ominus$ = +1.51 (V) **(1)** IGNORE State symbols even if incorrect **M2** More positive $E^\ominus$ value shows that MnO_4^- is a stronger oxidising agent than $Cr_2O_7^{2-}$ so oxidation might proceed further / to CO_2 and H_2O ALLOW More positive $E^\ominus$ value shows that MnO_4^- is a stronger oxidising agent than $Cr_2O_7^{2-}$ so only ethanoic acid formed / ethanal not formed **(1)** Allow higher for more positive in both No TE on incorrect manganate(VII) equation		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	**M1 and M2** $3MnO_4^{2-} + 2H_2O \rightleftharpoons 2MnO_4^- + MnO_2 + 4OH^-$ ALLOW $5MnO_4^{2-} + 8H^+ \rightleftharpoons 4MnO_4^- + Mn^{2+} + 4H_2O$ Species and no electrons **(1)** Balanced ALLOW Multiples **(1)** IGNORE State symbols even if incorrect **M3** E_{cell} = (0.59 – 0.56) = (+)0.03 (V) OR (for ALLOW equation) E_{cell} = (1.51 – 0.56) = (+)0.95 (V) **and in both cases** (Positive so disproportionation is) feasible **(1)** Correctly balanced equation except for missing charge(s) can score M2 and M3 M3 dependent on use of correct manganese species for appropriate equations in M1 Fully correct use of reverse disproportionation to give −0.03 (V) / −0.95 (V) scores 2/3		**(3)**

(Total for Question 20 = 18 marks)

Question Number	Acceptable Answers	Reject	Mark
21(a)	**Step 1** Concentrated HNO_3 / nitric acid **and** concentrated H_2SO_4 / sulfuric acid ALLOW Concentrated HNO_3 / nitric acid and H_2SO_4 / sulfuric acid **(1)** (reflux) at 55°C (standalone mark) ALLOW 50 – 60 °C **(1)** **Step 2** Condition mark dependent on reagents correct or minor error Tin / Sn and hydrochloric acid / HCl(aq) ALLOW HCl Fe/Zn for Sn **(1)** Concentrated (HCl(aq)) OR (heat under) reflux OR **followed by** NaOH / OH^- **(1)** **Step 3** Ethanoyl chloride / CH_3COCl OR Ethanoic anhydride / $(CH_3CO)_2O$ **(1)** Ignore any heating for Step 3	dilute (HCl) $AlCl_3$	**(5)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	Penalise the omission of the positive charge in (b)(i) and (b)(ii) once only Penalise use of structures once only ALLOW Atoms in any order (*m/e* = 135) $C_8H_9NO^+$ **(1)** (*m/e* = 77) $C_6H_5^+$ **(1)**	Just structure	**(2)**

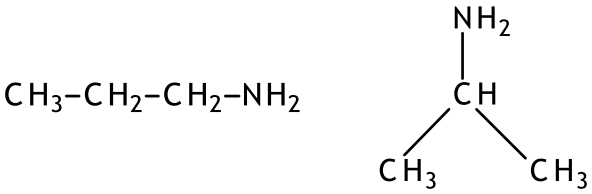
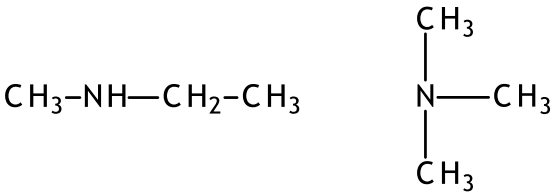
Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	(*m/e* = 43)  ALLOW CH_3CO^+ OR  OR Bracketed structures with charges outside brackets ALLOW Correct charge on any part of the ion COMMENT Allow open bonds on C or N eg 		**(1)**

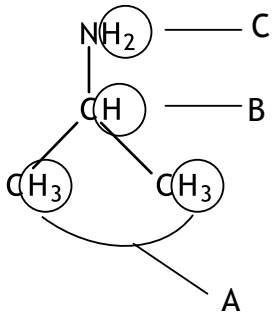
Question Number	Acceptable Answers	Reject	Mark
21(c)	Both bond and range required (Alkane) C—H stretch at 2962 - 2853 (cm^{-1}) **(1)** IGNORE Methyl group / CH_3 (Amide) C=O stretch 1700 – 1630 (cm^{-1}) **(1)** IGNORE Amide N—H stretch at 3500 - 3140 (cm^{-1})	 1485-1365 1700 - 1680 Additional ranges e.g. from benzene ring	**(2)**

(Total for Question 21 = 10 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)	<table><tr><td></td><td>C</td><td>H</td><td>N</td></tr><tr><td>% mass</td><td>61.0</td><td>15.3</td><td>23.7</td></tr><tr><td>Mol</td><td>61.0/12</td><td>15.3/1</td><td>23.7/14</td></tr><tr><td>Mol =</td><td>5.083</td><td>15.3</td><td>1.693</td></tr><tr><td>Ratio</td><td>3.00</td><td>9.04</td><td>1.00</td></tr></table> **(1)** **(1)** Empirical formula = C_3H_9N **(1)** Correct formula without working scores M3 only Do not penalise the use of structural formulae or $C_3H_7NH_2$ here or in part (b)		**(3)**

Question Number	Acceptable Answers	Reject	Mark
22(b)	42.7/24000 (= 1.779×10^{-3}) mol weighs 0.105 (g) 1 mol weighs 0.105 x 24000/42.7 = 59.016 / 59 g **(1)** Correct answer with some working scores the mark Formula mass of C_3H_9N = 59 So molecular formula (is the same as the empirical formula) is C_3H_9N **(1)** M2 depends on M1		**(2)**

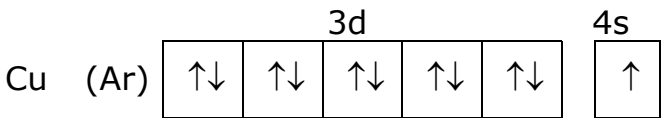
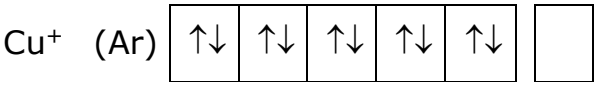
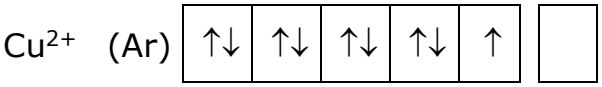
Question Number	Acceptable Answers	Reject	Mark
22(c)	1 mark each for any two structures  ALLOW  (secondary and tertiary amines even though not on spec) OR Fully displayed OR Skeletal		**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(d)	 Correct structure identified from (c) or re-drawn **(1)** Three proton environments (with 6 (A), 2 (C) and 1 (B) protons) identified with methyl group protons linked in some way **(1)** No TE on incorrect structure	Indication of splitting pattern	**(2)**

(Total for Question 22 = 9 marks)

TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Acceptable Answers	Reject	Marks
23(a)(i)	 **(1)**  **and**  **(1)** ALLOW Single-headed arrows Unpaired electrons pointing either up or down Single electron in any 3d box for Cu^{2+} Penalise parallel arrows once only No TE on incorrect Cu configuration		**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	(When the electronic structure is derived according to the aufbau rules), the final/last electron added is placed in a (3)d orbital / the (3)d orbitals / the (3)d subshell IGNORE Cu has valence electrons in the d subshell	The outermost/ highest energy electron is in a (3)d orbital Shell for subshell	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(a)(iii)	(Cu^{2+}) has a partially filled d orbital OR (Cu^{2+}) d orbitals are/ subshell is partially filled OR (Cu^{2+}) has a half-filled d orbital ALLOW (Cu^{2+}) d orbitals are/ subshell is incomplete (Cu^{2+}) d orbitals are/ subshell is not filled General definition of transition metal COMMENT Do not penalise shell for subshell	empty d orbital(s) / subshell	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	**M1** The Cu^{2+} ions are coordinated / surrounded by / complexed/bonded to (water) ligands OR In water Cu^{2+} exists as $Cu(H_2O)_6^{2+}$ **(1)** **M2** (3)d orbitals / (3)d subshell split (by the attached ligands into two different energy levels) **(1)** **M3** Electrons absorb energy /photons of a certain frequency (in the visible region) ALLOW Energy / photons / light is absorbed **(1)** **M4** 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 Electrons excited d—d transitions occur **(1)** **M5** 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 COMMENT Do not penalise shell for subshell	Just 'mention of ligand' orbital emitted	**(5)**

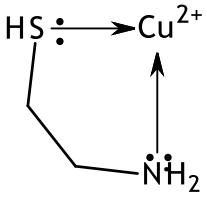
Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	There are no ligands coordinated around / bonded to / surrounding the Cu^{2+} ions (so the d subshell is not split)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	Buffer (solution) OR The components of a suitable buffer e.g. a weak acid and its conjugate base ALLOW Addition of (measured amounts of) any carbonate / hydrogencarbonate / hydroxide by name or formula Ammonia / NH_3((aq)) IGNORE Descriptions of the buffer Addition of alkali/OH^-	Just 'Acid' copper / nickel compounds	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(ii)	Amount of edta = 0.205 x 27.50/1000 * **(1)** (= 5.6375 x 10^{-3} / 0.0056375) Mass of copper in sample = ans* x 10 x 63.5 **(1)** = 3.5798 g** Proportion of copper = 100 x ans** /3.63 = 98.6174 / 98.6 /99 % **(1)** Correct answer with no working scores 3 marks ALLOW use of A_r(Cu) = 64 (⇒99.39 / 99.4%) Penalise arithmetical errors once only at **M3** TE at each stage but do not award M3 if % Cu is ≥100 IGNORE SF except 1 SF Do not penalise correct intermediate rounding		**(3)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(iii)	Nickel ions also form a complex with edta ALLOW Nickel also forms a complex with edta Nickel (ions) react(s) with edta		**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	Penalise failure to mention the central ion once only A bidentate ligand occupies two coordination positions of the central cation OR forms two dative covalent bonds with the central cation (1) The sulfur (atom) lone pair and the nitrogen (atom) lone pair of cysteamine bond to the central cation / Cu^{2+} ion ALLOW This mark from the diagram in (d)(ii) (1)		**(2)**

Question Number	Acceptable Answers	Reject	Mark
23d(ii)	 ALLOW Two or three cysteamine ligands IGNORE Charge on Cu Omission of lone pairs length of the carbon chain	Dative bond(s) from the H atoms covalent bonds (instead of dative bonds)	**(1)**

Question Number	Acceptable Answers	Reject	Mark
***23d(iii)**	Copper(I) complexes are (usually) linear **(1)** The carbon chain in cysteamine is too short to give a bond angle of 180° / to give linear geometry OR The resulting 5-membered ring would have bond angles of (about) 108° (rather than 180°) ALLOW **Two** separate cysteamine molecules would have to bond with copper(I) **(1)** IGNORE Just 'cysteamine acts as a monodentate ligand'		**(2)**

(Total for Question 23 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS

TOTAL FOR PAPER = 90 MARKS