Mark Scheme (Results)

Summer 2017

Pearson Edexcel IAL
In Chemistry (WCH05) Paper 01
General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry

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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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

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	Answer	Mark
(1)	**The only correct answer is C** ***A*** *is not correct because these are in the d-block but are not transition metals* ***B*** *is not correct because tin is in Group 4* ***D*** *is not correct because these are in the d-block but are not transition metals*	**(1)**

Question Number	Incorrect answers	Mark
(2)	**The only correct answer is A** ***B*** *is not correct because there should be a decrease of 2 oxidation numbers as the ratio of* Tl^{3+} *:* I^{-} *= 1 : 2* ***C*** *is not correct because there should be a decrease in oxidation number as iodide ions are oxidised so thallium ions are reduced* ***D*** *is not correct because there should be a decrease in oxidation number as iodide ions are oxidised so thallium ions are reduced*	**(1)**

Question Number	Incorrect answers	Mark
(3)	**The only correct answer is C** ***A*** *is not correct because light is not emitted when an electron drops back to the ground state* ***B*** *is not correct because this happens in a flame test* ***D*** *is not correct because light is not emitted when an electron is promoted*	**(1)**

Question Number	Incorrect answers	Mark
(4)	**The only correct answer is C** ***A*** *is not correct because do not give a pale blue precipitate with aqueous copper(II) sulfate* ***B*** *is not correct because do not give a pale blue precipitate with aqueous copper(II) sulfate* ***D*** *is not correct because do not give a pale blue precipitate with aqueous copper(II) sulfate*	**(1)**

Question Number	Incorrect answers	Mark
(5)	**The only correct answer is A** ***B*** *is not correct because uses* MnO_4^- *concentration as 0.0100 mol* dm^{-3} ***C*** *is not correct because uses mole ratio the wrong way round* ***D*** *is not correct because uses mole ratio the wrong way round and* MnO_4^- *concentration as 0.0100 mol* dm^{-3}	**(1)**

Question Number	Incorrect answers	Mark
(6)	**The only correct answer is A** ***B*** *is not correct because this is the oxidation number of C in* $C_2O_4^{2-}$ ***C*** *is not correct because this is the oxidation number of C in* CO_2 ***D*** *is not correct because this is the change in oxidation number of one Mn*	**(1)**

Question Number	Incorrect answers	Mark
(7)	**The only correct answer is D** ***A*** *is not correct because would form a precipitate of silver carbonate* ***B*** *is not correct because would form a precipitate of silver chloride* ***C*** *is not correct because would form a precipitate of silver iodide*	**(1)**

Question Number	Incorrect answers	Mark
(8)	**The only correct answer is C** ***A*** *is not correct because do not form hydroxide ions which are alkaline and turn phenolphthalein pink* ***B*** *is not correct because do not form hydroxide ions which are alkaline and turn phenolphthalein pink* ***D*** *is not correct because do not form hydroxide ions which are alkaline and turn phenolphthalein pink*	**(1)**

Question Number	Incorrect answers	Mark
9(a)	**The only correct answer is A** ***B*** *is not correct because will only reduce chlorine* ***C*** *is not correct because will not reduce anything in that list* ***D*** *is not correct because this is the strongest oxidising agent*	**(1)**

Question Number	Incorrect answers	Mark
9(b)	**The only correct answer is D** ***A*** *is not correct because iodine will also react in this way* ***B*** *is not correct because bromine will also react in this way* ***C*** *is not correct because chlorine oxidises chromium(III) to chromium(VI)*	**(1)**

Question Number	Incorrect answers	Mark
(10)	**The only correct answer is C** ***A*** *is not correct because are provided by X-ray diffraction* ***B*** *is not correct because are provided by X-ray diffraction* ***D*** *is not correct because are provided by X-ray diffraction*	**(1)**

Question Number	Incorrect answers	Mark
(11)	**The only correct answer is D** ***A*** *is not correct because incorrect products* ***B*** *is not correct because incorrect products* ***C*** *is not correct because incorrect products*	**(1)**

Question Number	Incorrect answers	Mark
(12)	**The only correct answer is A** ***B*** *is not correct because nucleophile is incorrect* ***C*** *is not correct because base is incorrect* ***D*** *is not correct because base and electrophile are incorrect*	**(1)**

Question Number	Incorrect answers	Mark
(13)	**The only correct answer is B** ***A*** *is not correct because the 3 carbon atoms in the middle of the alkyl chain are chiral* ***C*** *is not correct because the 3 carbon atoms in the middle of the alkyl chain are chiral* ***D*** *is not correct because the 3 carbon atoms in the middle of the alkyl chain are chiral*	**(1)**

Question Number	Incorrect answers	Mark
(14)	**The only correct answer is B** ***A*** *is not correct because this is 70% of the moles of nitrobenzene* ***C*** *is not correct because this is 70% of 2.46 g* ***D*** *is not correct because the* M_r*s have been mixed up*	**(1)**

Question Number	Incorrect answers	Mark
(15)	**The only correct answer is C** ***A*** *is not correct because both phenol groups react with bromine water* ***B*** *is not correct because both amine groups react with copper(II) sulfate solution* ***D*** *is not correct because neither molecule has an aldehyde group to react with Tollens' reagent*	**(1)**

Question Number	Incorrect answers	Mark
(16)	**The only correct answer is D** ***A*** *is not correct because would not give the absorbance due to OH at 3300 to 2500* cm^{-1} ***B*** *is not correct because would not give the absorbance due to OH at 3300 to 2500* cm^{-1} ***C*** *is not correct because would give OH absorbance at 3750 to 3200* cm^{-1}	**(1)**

Question Number	Incorrect answers	Mark
(17)	**The only correct answer is B** ***A*** *is not correct because the amine groups should be in positions 3, 5 relative to the methyl group, not 2,6* ***C*** *is not correct because the amine groups should be in positions 3, 5 relative to the methyl group, not 2,3* ***D*** *is not correct because the amine groups should be in positions 3, 5 relative to the methyl group, not 2,5*	**(1)**

Question Number	Incorrect answers	Mark
(18)	**The only correct answer is C** ***A*** *is not correct because the potassium salt of the carboxylic acid should be formed* ***B*** *is not correct because the potassium salt of the carboxylic acid should be formed and the potassium salt of the alcohol does not form* ***D*** *is not correct because the potassium salt of the alcohol does not form*	**(1)**

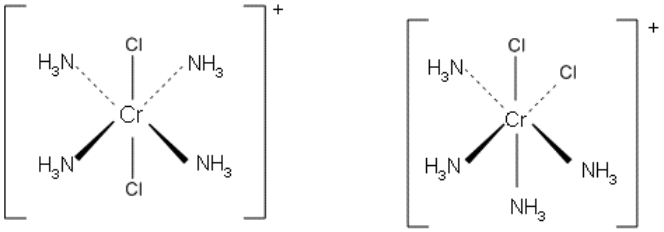
Question Number	Incorrect answers	Mark
(19)	**The only correct answer is B** ***A*** *is not correct because there are 6 amino acids in the structure but 1st, 3rd and 5th are the same and 4th and 6th are the same so only 3 different amino acids* ***C*** *is not correct because there are 6 amino acids in the structure but 1st, 3rd and 5th are the same and 4th and 6th are the same so only 3 different amino acids* ***D*** *is not correct because there are 6 amino acids in the structure but 1st, 3rd and 5th are the same and 4th and 6th are the same so only 3 different amino acids*	**(1)**

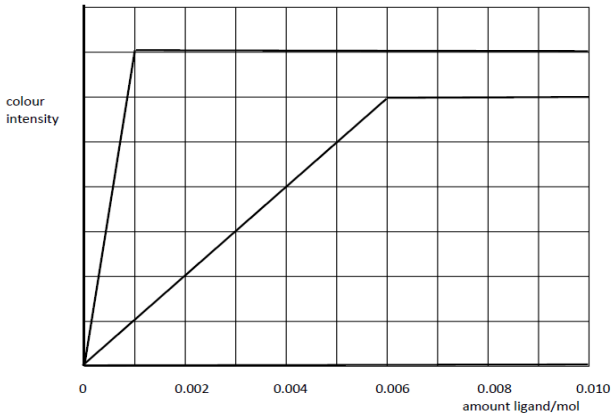
Total for Section A = 20 MARKS

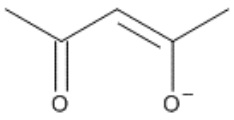
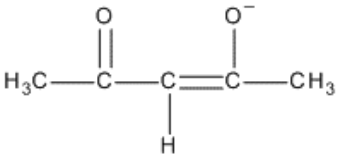
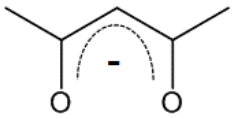
Section B

Question Number	Acceptable Answers	Reject	Mark
20(a)	**Shape** – tetrahedral **(1)** **Explanation** – (4) pairs of (valence) electrons / (4) bond pairs **and** arranged to minimise repulsion ALLOW (4) pairs of (valence) electrons / (4) bond pairs **and** arranged with maximum separation **(1)** ALLOW Only TE on square planar with a description of either 4 bonding pairs or 4 bonding pairs and 2 lone pairs **and** maximum separation/minimum repulsion IGNORE incorrect bond angle	 Just 'electrons repel' Just '(Dative) bonds' / atoms/ ligands/ Cl repel	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(b)	**Forming precipitate** $[Cr(H_2O)_6]^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s) + 6H_2O(l)$ OR $[Cr(H_2O)_6]^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(H_2O)_3(s) + 3H_2O(l)$ ALLOW $Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s)$ **(1)** **Dissolving precipitate** $Cr(OH)_3(s) + 3OH^-(aq) \rightarrow [Cr(OH)_6]^{3-}(aq)$ OR $Cr(OH)_3(H_2O)_3(s) + 3OH^-(aq) \rightarrow [Cr(OH)_6]^{3-}(aq) + 3H_2O(l)$ ALLOW $Cr(OH)_3(s) + OH^-(aq) \rightarrow [Cr(OH)_4]^-(aq)$ ALLOW $Cr(OH)_3(H_2O)_3(s) + OH^-(aq) \rightarrow [Cr(OH)_4]^-(aq) + 3H_2O(l)$ ALLOW $Cr(OH)_3(H_2O)_3(s) + OH^-(aq) \rightarrow [Cr(OH)_4(H_2O)_2]^-(aq) + H_2O(l)$ **(1)** **Notes** ALLOW (1) for two correct non-ionic equations with NaOH / $Na^+ + OH^-$ ALLOW (1) for two unbalanced equations with correct species and state symbols IGNORE square brackets around neutral species IGNORE the order of ligands in formulae with OH and H_2O IGNORE charges inside the brackets If no other mark is awarded, allow (1) for $[Cr(H_2O)_6]^{3+}(aq) + 6OH^-(aq) \rightarrow [Cr(OH)_6]^{3-}(aq) + 6H_2O(l)$ OR $[Cr(H_2O)_6]^{3+}(aq) + 4OH^-(aq) \rightarrow [Cr(OH)_4]^-(aq) + 6H_2O(l)$ OR $[Cr(H_2O)_6]^{3+}(aq) + 4OH^-(aq) \rightarrow [Cr(OH)_4(H_2O)_2]^-(aq) + 4H_2O(l)$	Incorrect or missing state symbols once only	**(2)**

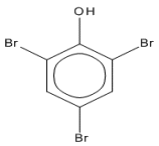
Question Number	Acceptable Answers	Reject	Mark
20(c)	 Any trans isomer **(1)** Any cis isomer **(1)** IGNORE connectivity of Cr-NH_3 IGNORE charges on Cr and Cl	Cl_2 once only NH_4 once only additional isomer once only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(d)	 Mark independently A rise to 0.001 mol ligand **(1)** Horizontal line of any length with any value for colour intensity greater than original line **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(e)	 ALLOW structural, displayed or skeletal formulae or any combination of these e.g.  ALLOW delocalised structure  ALLOW structure in brackets with charge outside IGNORE lone pairs IGNORE additional structures as working	Charge on double bonded oxygen Charge on both oxygens	**(1)**

(Total for Question 20 = 9 marks)

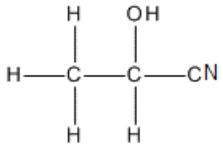
Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	**White** precipitate forms ALLOW solid / crystals / ppt for precipitate IGNORE antiseptic smell / colour change IGNORE cloudy IGNORE name of ppt even if incorrect	Incorrect colour of ppt	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	$C_6H_5OH + 3Br_2 \rightarrow 3HBr +$  **First mark** - organic product ALLOW Kekule structure ALLOW substitution of Br to any 3 positions on the ring / $C_6H_2(Br)_3OH$ / $C_6H_2Br_3OH$ / $C_6H_2(OH)Br_3$ / $C_6H_2OHBr_3$ **(1)** IGNORE connectivity to OH IGNORE name even if incorrect **Second mark** Rest of equation correct Phenol may be drawn **(1)** **Note** Mono or di substitution scores (1) for balanced equation	Molecular formula e.g. $C_6H_3OBr_3$	**(2)**

Question Number	Acceptable Answers	Reject	Mark
***21(a)(iii)**	**First mark** The **lone pair** (of electrons) **on the O** (of OH) **and** EITHER Overlaps with the π/delocalised electrons in the benzene ring / delocalised system OR Feeds into / donates into / interacts with (benzene) ring / delocalised electrons / delocalised system ALLOW Increases the electron density of the (benzene) ring **(1)** **Second mark** (Increased electron density) makes the ring more susceptible to electrophilic attack / attack by Br^+/ $Br^{\delta+}$ ALLOW Phenol is a better nucleophile **(1)**	Ring is more electronegative	**(2)**

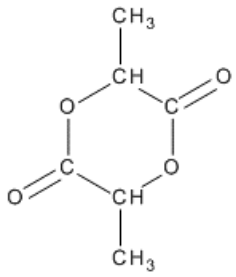
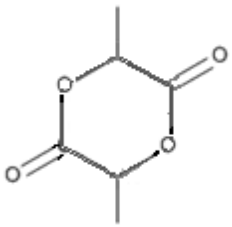
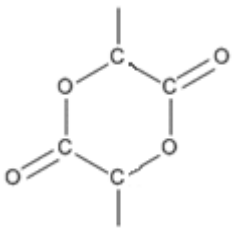
Question Number	Acceptable Answers	Reject	Mark
21(a)(iv)	4-chloro-3,5-**di**methylphenol ALLOW 3,5-**di**methyl-4-chlorophenol ALLOW Hydroxybenzene instead of phenol ALLOW phen-1-ol IGNORE Missing / incorrect hyphens / commas / spaces		**(1)**

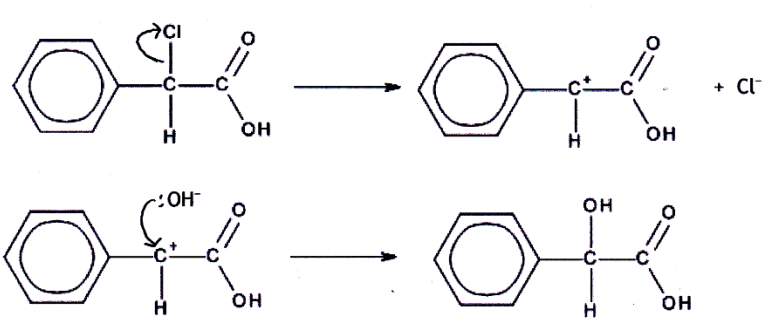
Question Number	Acceptable Answers	Reject	Mark
***21(b)**	Correct answer with no working scores (4) mol CO_2 produced = 185/24000 = 0.0077083 **(1)** mol benzoic acid = 2 x 0.0077083 = 0.015417 ALLOW 0.01542 / 0.0154/ 0.015 TE on mol CO_2 **(1)** mass benzoic acid = 0.015417 x 122 = 1.8808 (g) ALLOW 1.88124 / 1.8788 / 1.83 (g) TE on mol benzoic acid **(1)** % phenol = $\frac{2.5 - 1.8808}{2.5}$ x 100 = 24.767(%) = 25 (%) ALLOW 24.75 / 24.8 / 26.8 from earlier rounding TE on mass benzoic acid provided answer is <100% **(1)** IGNORE SF except 1 SF		**(4)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	**First step** hydrogen cyanide /HCN **and** potassium cyanide / KCN /cyanide ions / CN^- IGNORE pH in the range 5-9 / acidic medium / alkaline medium OR hydrogen cyanide / HCN **and** alkali / hydroxide ions / OH^- / pH 8-9 OR potassium cyanide / KCN / cyanide ions /CN^- **and** acid / H^+ / pH 5-6 **(1)** IGNORE ethanol / alcohol as solvent IGNORE heat / reflux **Intermediate compound –** stand alone  ALLOW unambiguous structural formula IGNORE name, even if incorrect **(1)** **Second step –** from correct intermediate or a compound containing CN IGNORE concentrations **EITHER** (Strong) acid / sulfuric acid/H_2SO_4 / hydrochloric acid / HCl /hydrogen ions / H^+ **and** boil / heat / reflux **OR** Alkali / sodium hydroxide/NaOH/ potassium hydroxide /KOH/hydroxide ions /OH^- **and** boil / heat / reflux **followed by** (strong) acid / sulfuric acid/H_2SO_4 / hydrochloric acid / HCl / hydrogen ions / H^+ **(1)**	Any third reagent including named acid or base Any third reagent Any third reagent C=N Alkali and acid added at same time	**(3)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	4 / four (peaks)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iii)	2(.0) – 4(.0) (δ /ppm for TMS) ALLOW any number or range of numbers within the range ALLOW the range in reverse order e.g. 4(.0) – 2(.0) (δ /ppm for TMS)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iv)	  Allow  ALLOW structural, displayed or skeletal formulae IGNORE additional structures as working IGNORE bond angles and bond lengths		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	 ALLOW C_6H_5 for benzene ring **First mark** Curly arrow from C-Cl bond to or just beyond Cl **(1)** IGNORE dipole **Second mark** Correct intermediate **and** Cl^- ALLOW carboxylate ion ALLOW Cl^- shown anywhere in answer **(1)** **Third mark** Curly arrow from O of OH^- to C^+ ALLOW the arrow to start anywhere on OH^-, including the charge **(1)** IGNORE missing lone pair	Partial charge on C / Cl Circle missing from ring	**(3)**

Question Number	Acceptable Answers	Reject	Mark
***21(d)(ii)**	**First mark** – stand alone A racemic mixture / racemate is formed OR Equal amounts / an equimolar mixture of both optical isomers /enantiomers / D-L isomers /(+) and (-) isomers **(1)** IGNORE just 'mixture is not optically active' / 'mixture does not rotate plane of plane-polarised light' **Second mark** Intermediate / carbocation is (trigonal) planar **around** reaction site / C^+ / central carbon ALLOW Intermediate / carbocation is planar **around** the active site **(1)** **Third mark** – conditional on mention of planar (equal probability of) attacked (by nucleophile) from either side / above and below / both sides / opposite sides (of the plane) **(1)**	Carbonyl / molecule / reactant is planar Just 'the intermediate is planar' / the molecule is planar	**(3)**

Question Number	Acceptable Answers	Reject	Mark
21(d)(iii)	**Step 1**: Minimum amount of solvent to minimise the amount of mandelic acid /solid left in the solution (when it recrystallises) OR To form a saturated solution (of mandelic acid) OR To ensure that (some) acid crystallises on cooling ALLOW So the solution is as concentrated as possible **(1)** IGNORE Just 'to increase the yield' **Step 2**: (**hot**) So maximum amount / most of the solid/mandelic acid remains in (hot) solution OR To avoid the (premature) formation of crystals (in the funnel) **(1)** (**filter**) To remove **insoluble** / **undissolved / solid** impurities **(1)** **Step 3**: To ensure that maximum amount of solid crystallises ALLOW To obtain a better / maximum yield (of crystals) ALLOW So that all of the product crystallises IGNORE Just 'to crystallise the product' **(1)** **Step 4**: To remove **soluble** / **dissolved** impurities **(1)** IGNORE To speed up the process To dry the crystals	Speed up crystallisation Remove insoluble impurities	**(5)**

(Total for Question 21 = 27 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	There is (extra) stability with a full (3)d subshell / (set of 3)d orbital**s** / (3)d^{10} arrangement of electrons IGNORE reference to half-filled 4s orbital / repulsion in $4s^2$ IGNORE just 'more stable' without some reason	Just 'Full (3)d orbital' / (3)d shell Reference to ions once only in (a)(i) and (a)(ii)	**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Copper has a higher nuclear charge / more protons (so it attracts the outermost electron closer) IGNORE higher effective nuclear charge IGNORE copper has a higher charge density IGNORE d electrons fill an inner subshell IGNORE just 'stronger attraction between nucleus and (outer) electrons'		**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(b)	Correct answer with no working scores (2) **First mark** – correct numbers in expression $E = 0.34 + \frac{8.31 \times 298}{9.65 \times 10^4 \times 2} \times \ln 0.100$ **(1)** **Second mark** – evaluation = 0.34 - 0.0295 = (+)0.31046 / 0.3105 / 0.310/ 0.31 (V) ALLOW TE on incorrect numbers in correct formula e.g if $[Cu^{2+}] = 0.01$ final answer is 0.28091 No TE on incorrect formula **(1)** IGNORE SF except 1 SF	(+)0.311 (V)	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	**First mark** - $E^{\ominus}_{cell}$ $E^{\ominus}_{cell}$ = 0.15 — 0.54 = —0.39 (V) **(1)** **Second mark** – feasibility $E^{\ominus}_{cell}$ is negative so reaction is not feasible If $E^{\ominus}_{cell}$ in M1 is positive: ALLOW $E^{\ominus}_{cell}$ is positive so reaction is feasible **(1)** **Third mark** - reason Copper(I) iodide / CuI is a solid / precipitate / ppt OR concentration of $Cu^{+}(aq)$ decreases so $E^{\ominus}$ for the copper half-cell increases (to more than 0.54 V and $E^{\ominus}_{cell}$ becomes positive) ALLOW Excess iodide ions (moves equilibrium to the right) so $E^{\ominus}$ for the iodine / iodide half-cell decreases (to less than 0.15 V and $E^{\ominus}_{cell}$ becomes positive) **(1)** IGNORE non-standard conditions / reference to activation energy		**(3)**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	**Correct answer to 3 SF** with no working scores (4) mol $S_2O_3^{2-}$ used = 10.90 x 0.150 /1000 = 0.001635 / 1.635 x 10^{-3} **(1)** mol Cu^{2+} = 0.001635 / 1.635 x 10^{-3} TE on mol $S_2O_3^{2-}$ used TE on mol I_2 if mol $S_2O_3^{2-}$ missing **(1)** **EITHER** mass Cu^{2+} in 25.0 cm^3 = 0.001635 x 63.5 = 0.10382 (g) TE on mol Cu^{2+} **(1)** mass Cu^{2+} in 1.0 dm^3/coin = 0.10382 x 1000 /25.0 = 4.1529 (g) **and** answer to **3 SF** = 4.15 (g) TE on mass Cu^{2+} in 25.0 cm^3 **(1)** **OR** moles Cu^{2+} in 1.0 dm^3 = 0.001635 x 1000 /25.0 = 0.0654 (mol dm^{-3}) TE on mol Cu^{2+} in 25.0 cm^3 **(1)** mass Cu^{2+} in 1.0 dm^3 / coin = 0.0654 x 63.5 = 0.10382 (g) **and** answer to **3 SF** = 4.15 (g) TE on moles Cu^{2+} in 1.0 dm^3 **(1)**		**(4)**

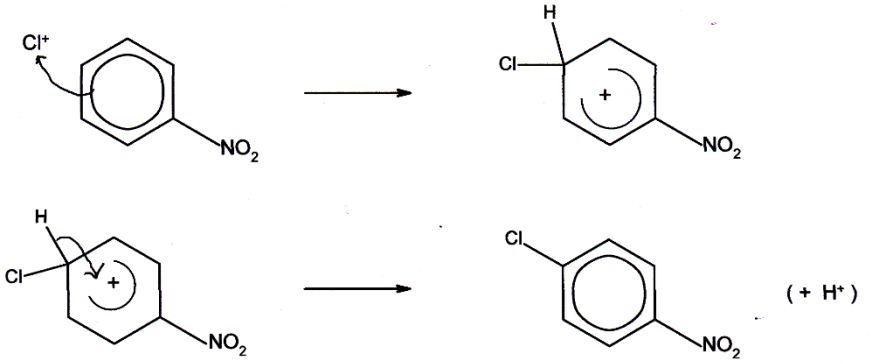
Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	**First mark** - equation $Ag^{2+}(aq) + Ag(s) \rightarrow 2Ag^{+}(aq)$ **(1)** ALLOW ⇌ but equation must be written in direction shown IGNORE missing / incorrect state symbols **Second mark** – explanation, conditional on M1 No, this is the reverse of disproportionation / comproportionation / Ag^{+} is oxidised and reduced in the reverse reaction OR No, it must be an **element** in a single species that is both oxidised and reduced / 2 different species are oxidised and reduced OR 2 different oxidation states are not produced ALLOW No, as only 1 species is produced No TE on incorrect equation **(1)** IGNORE just 'not disproportionation'		**(2)**

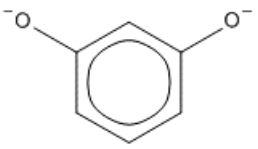
Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	ALLOW oxidation numbers written by correct species in equation **EITHER** Au: 0 to (+)3 **and** oxidation **(1)** N: (+)5 to (+)2 **and** reduction **(1)** **OR** All oxidation numbers Au: 0 and (+)3 N: (+)5 and (+)2 **(1)** Au is oxidised and N is reduced **(1)** No TE on incorrect oxidation numbers ALLOW oxidation numbers as Roman numerals / 3+, 2+, 5+ and as charges e.g. Au^{3+} IGNORE oxidation numbers of other elements		**(2)**

(Total for Question 22 = 15 marks)

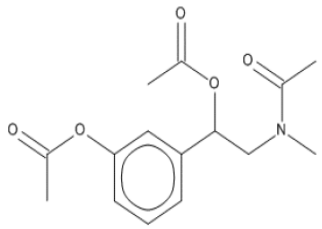
Total for Section B = 51 MARKS

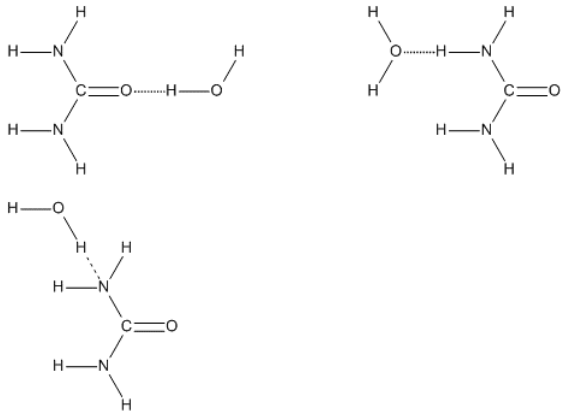
Section C

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	**First mark** - formation of electrophile $Cl_2 + AlCl_3 \rightarrow Cl^+ + AlCl_4^- / [AlCl_4]^- / {}^{\delta+}Cl\text{-}AlCl_4{}^{\delta-}$ **(1)** **Mechanism** **Note** - If benzene used instead of nitrobenzene / if final product is not 1-chloro-4-nitrobenzene, do not award the mark for the intermediate  **Second mark** Curly arrow from on or within the circle to Cl^+ ALLOW Curly arrow from anywhere **within** the hexagon ALLOW Curly arrow to any part of the Cl^+, including to the + charge ALLOW Cl with no charge if M1 not awarded, but do not allow any other electrophile **(1)** **Third mark** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms **and** facing the tetrahedral carbon **and** some part of the positive charge must be within the horseshoe ALLOW dashed / dotted line for horseshoe **(1)** **Fourth mark** Curly arrow from C-H bond to anywhere in the hexagon reforming the delocalised structure / **(1)** Correct Kekulé structures score full marks IGNORE any involvement of $AlCl_4^-$ in the final step	Any Friedel-Crafts catalyst except $AlCl_3$ Curly arrow on or outside the hexagon Dotted bonds to H and Cl unless clearly part of a 3D structure	**(4)**

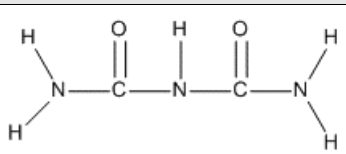
Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	 ALLOW O^- Na^+ / ONa ALLOW OH ALLOW Kekulé structure	 O−Na C−NaO OH−C C−HO	**(1)**

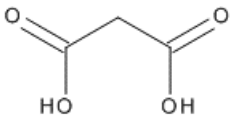
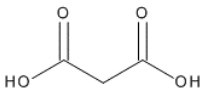
Question Number	Acceptable Answers	Reject	Mark
23(a)(iii)	$C_{12}H_9N_3O_4$ ALLOW symbols in any order e.g. $C_{12}H_9O_4N_3$ IGNORE any working before the formula		**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(b)	 **First mark** Ethanoylation of NH group **(1)** **Second mark** Ethanoylation of both OH groups ALLOW Ethanoylation of alkyl OH group only or phenol group only **(1)** ALLOW Structural, displayed or skeletal formula or any combination		**(2)**

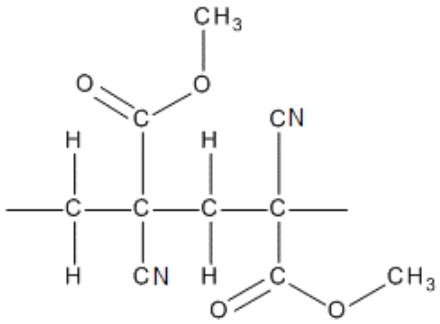
Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	Examples of diagrams  **First mark** – stand alone Hydrogen bonds can form between urea and water - this may be labelled on the diagram **(1)** IGNORE Hydrogen bonds between urea molecules **Second mark** – position of hydrogen bond Between the O–H in water and N–H /O=C in urea ALLOW any of the three positions described or shown in a diagram **(1)** IGNORE bond angle in diagram Hydrogen bonds between urea molecules **Third mark** – linear hydrogen bond Linear N–H····O /O–H····O / N····H–O bond ALLOW bond angle stated as 180° ALLOW this mark if one hydrogen bond is shown linear ALLOW 180° bond angle in hydrogen bond between urea molecules **(1)** **Note** Full marks can only be awarded if a diagram is shown		**(3)**

Question Number	Acceptable Answers	Reject	**Mark**
23(c)(ii)	$2NH_3 + CO_2 \rightarrow (H_2N)_2CO + H_2O$ ALLOW molecular formula or other correct structural formula for urea e.g. CON_2H_4, NH_2CONH_2, $CO(NH_2)_2$ ALLOW multiples IGNORE state symbols, even if incorrect		**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(iii)	 ALLOW Terminal NH_2 and central NH IGNORE bond lengths and angles IGNORE structural formula – $NH_2CONHCONH_2$	NH_2-C	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(iv)	 OR  IGNORE connectivity of OH IGNORE additional formulae as working	Structural or displayed formulae	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	Alkene, nitrile and ester All 3 scores 2 Any 2 scores 1 IGNORE alkyl / alkane IGNORE Cyanide / cyano IGNORE formulae eg C=C		**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	**First mark** – type of polymerisation Addition (polymerisation) **(1)** IGNORE Additional words e.g. nucleophilic  **Second mark** – carbon skeleton 4 carbon atoms linked by single bonds and extension bonds **(1)** **Third mark** Rest of structure correct Conditional on MP2 ALLOW if number of repeat units has been penalised in M2 ALLOW Structural, displayed, skeletal formulae or any combination of these ALLOW CN and $COOCH_3$ on top or bottom of carbon chain **(1)** IGNORE square brackets and n s IGNORE bond lengths and angles IGNORE connectivity of side chains e.g. to CN and $COOCH_3$ if given as structural formulae	Condensation and addition Penalise 1 or more than 2 repeat units in M2 only	**(3)**

Total for Section C = 19 MARKS

TOTAL FOR PAPER = 90 MARKS

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