Mark Scheme (Results)

October 2018

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

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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.

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 (a)	**The only correct answer is A** ***B*** *is not correct because Fe(III) acts as an oxidising agent* ***C*** *is not correct because Cr(II) loses electrons so is oxidised* ***D*** *is not correct because Cr(II) loses electrons so is oxidised*	(1)

Question Number	Correct Answer	Mark
1 (b)	**The only correct answer is B** ***A*** *is not correct because they should both be positive* ***C*** *is not correct because they should both be positive* ***D*** *is not correct because they should both be positive*	(1)

Question Number	Correct Answer	Mark
1 (c)	**The only correct answer is D** ***A*** *is not correct because carbonate ions might react* ***B*** *is not correct because hydroxide ions might react* ***C*** *is not correct because iodide ions might react*	(1)

Question Number	Correct Answer	Mark
1 (d)	**The only correct answer is A** *B is not correct because dividing by 10 for 100 cm^3 but not dividing by 2 for $Fe_{2(}SO_4)_3$* *C is not correct because dividing by 10 for 100 cm^3 but multiplying by 2 and not dividing by 2* *D is not correct because dividing by 2 for $Fe_{2(}SO_4)_3$ but not dividing by 10*	(1)

Question Number	Correct Answer	Mark
2	**The only correct answer is C** *A is not correct because Fe has an oxidation state of +6* *B is not correct because Cr has an oxidation state of +6* *D is not correct because W has an oxidation state of +6*	(1)

Question Number	Correct Answer	Mark
3	**The only correct answer is A** ***B** is not correct because it is oxidised at the negative electrode* ***C** is not correct because it is oxidised not reduced* ***D** is not correct because it is oxidised not reduced at the negative electrode*	(1)

Question Number	Correct Answer	Mark
4 (a)	**The only correct answer is C** ***A** is not correct because this is the second step* ***B** is not correct because this is the second step with an incorrect product* ***D** is not correct because this is the first step*	(1)

Question Number	Correct Answer	Mark
4 (b)	**The only correct answer is C** ***A** is not correct because the 3d subshell does split* ***B** is not correct because the 3d subshell is full* ***D** is not correct because there is no movement of electrons in the 3d subshell*	(1)

Question Number	Correct Answer	Mark
5	**The only correct answer is B** ***A*** *is not correct because orbitals are occupied singly before pairing* ***C*** *is not correct because the 4s electrons are lost first to form an ion* ***D*** *is not correct because the 4s electrons are lost first to form an ion*	(1)

Question Number	Correct Answer	Mark
6	**The only correct answer is A** ***B*** *is not correct because X ray diffraction provides no evidence for this* ***C*** *is not correct because X ray diffraction provides no evidence for this* ***D*** *is not correct because it is not a true statement*	1

Question Number	Correct Answer	Mark
7	**The only correct answer is B** ***A*** *is not correct because this is the reverse order* ***C*** *is not correct because phenylamine has a lower pH than ammonia* ***D*** *is not correct because diethylamine has a higher pH than ethylamine*	(1)

Question Number	Correct Answer	Mark
8 (a)	**The only correct answer is D** ***A*** *is not correct because this is not a reducing agent* ***B*** *is not correct because this does not produce the amine* ***C*** *is not correct because this is an oxidising* agent	(1)

Question Number	Correct Answer	Mark
8 (b)	**The only correct answer is D** ***A*** *is not correct because this is not used to separate phenylamine* ***B*** *is not correct because this is not used to separate phenylamine* ***C*** *is not correct because this is not used to separate phenylamine*	(1)

Question Number	Correct Answer	Mark
8 (c)	**The only correct answer is C** ***A*** *is not correct because this has an extra amine group* ***B*** *is not correct because use of phenol would leave an -OH in the molecule* ***D*** *is not correct because this is a product of the reaction of 1,4-diaminobenzene with nitrous acid in hydrochloric acid*	(1)

Question Number	Correct Answer	Mark
9	**The only correct answer is D** ***A*** *is not correct because this is the mass of the intermediate* ***B*** *is not correct because this is the overall percentage* ***C*** *is not correct because this is the overall percentage by mass*	(1)

Question Number	Correct Answer	Mark
10	**The only correct answer is A** ***B*** *is not correct because this is not the correct momomer* ***C*** *is not correct because this is not the correct momomer* ***D*** *is not correct because this is not the correct momomer*	(1)

Question Number	Correct Answer	Mark
11 (a)	**The only correct answer is A** ***B*** *is not correct because 2,4-dinitrophenylhydrazine does react with X* ***C*** *is not correct because 2,4-dinitrophenylhydrazine does react with Y* ***D*** *is not correct because 2,4-dinitrophenylhydrazine does react with Z*	(1)

Question Number	Correct Answer	Mark
11 (b)	**The only correct answer is D** ***A*** *is not correct because W does not react with either* ***B*** *is not correct because X reacts with acidified potassium dichromate(VI) but not Tollens' reagent* ***C*** *is not correct because Y does not react with either*	(1)

Question Number	Correct Answer	Mark
11 (c)	**The only correct answer is D** ***A*** *is not correct only W does not react* ***B*** *is not correct only W does not react* ***C*** *is not correct only W does not react*	(1)

Question Number	Correct Answer	Mark
12	**The only correct answer is B** ***A*** *is not correct has a chiral carbon* ***C*** *is not correct has a chiral carbon* ***D*** *is not correct has a chiral carbon*	(1)

(Total for Section A = 20 marks)

Section B

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>13(a)</td><td>
<table>
<tr><th></th><th>E / V</th></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td>$Fe^{3+}(aq) + e^{(-)} \rightleftharpoons Fe^{2+}(aq)$</td><td>(+0.77)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>$(Cl_2(aq) + 2e^- \rightleftharpoons 2Cl^-(aq))$</td><td>+1.36</td></tr>
</table>
ALLOW
Single arrow instead of reversible arrows

IGNORE
Missing state symbols</td><td>Incorrect state symbols

1.36 without + (+)0.68 / (+)2.72</td><td>1</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
13(b)(i)	Zn / Zinc / Zn(s) / Zinc(s)	Zn^{2+} / Zinc(II)	1

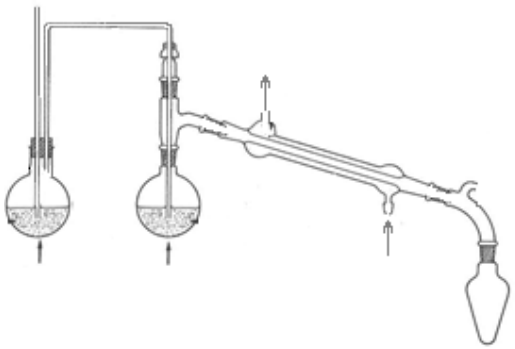
Question Number	Acceptable Answers	Reject	Mark
13(b)(ii)	$SO_3^{2-}(aq)$ / sulfate(IV) (ions) / sulfite (ions) ALLOW $SO_3^{2-}(aq) + H_2O(l)$ IGNORE H^+ missing state symbols	$SO_4^{2-}(aq)$ / Sulfate(VI) /sulfate	1

Question Number	Acceptable Answers	Reject	Mark
13(c)(i)	+2 / 2+ This can be scored if there is no answer in the space and V^{2+} is shown as the product in the equation, even if the equation is incorrect ALLOW V^{2+} /+II / II+ (1) $VO_2^+ + 4H^+ + 3e^- \rightarrow V^{2+} + 2H_2O$ Must be a half-equation not a full equation with zinc ALLOW Multiples (1) IGNORE State symbols even if incorrect No TE for equations on incorrect values of oxidation state.	2 / II / V(II)	2

Question Number	Acceptable Answers	Reject	Mark
13(c)(ii)	**M1** (Recognition of oxidation by air) (Vanadium(II) / V^{2+} / Vanadium(III) / V^{3+} / solution) is oxidised by / reacts with oxygen (in the air) This can be scored if an equation is given showing reaction of V^{2+} or V^{3+} with O_2 (1) **M2** (Formation of V(III) from V(II)) $4V^{2+} + O_2 + 4H^+ \rightarrow 4V^{3+} + 2H_2O$ ALLOW $V^{2+} \rightarrow V^{3+} + e^-$ / $V^{3+} + e^- \rightleftharpoons V^{2+}$ **and** V^{2+} becomes V^{3+} which is green (1) **M3** (Formation of V(IV)) $4V^{3+} + O_2 + 2H_2O \rightarrow 4VO^{2+} + 4H^+$ (1) IGNORE State symbols even if incorrect ALLOW $2V^{2+} + O_2 \rightarrow 2VO^{2+}$ Scores 1 (of **M2** and **M3**) **M4** (Calculation of E_{cell} values) E_{cell} for M2 equation = (+)1.49 (V) **and** E_{cell} for M3 equation = (+)0.89 (V) (1)	V(III) from VO^{2+}	4

Question Number	Acceptable Answers	Reject	Mark
13(c)(iii)	E_{cell} is (+)0.23 (V) so the oxidation of VO^{2+} to VO_2^+ is feasible ALLOW E_{cell} is (slightly) positive (1) EITHER the activation energy is too large / kinetically inert OR concentration of oxygen is too low (1) IGNORE Non-standard conditions Mark each as stand alone	Rate is slow	2

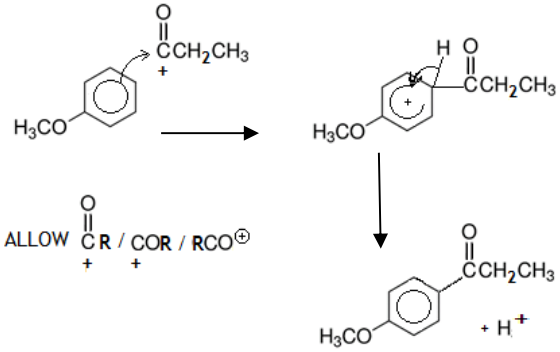
(Total for Question 13 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
14(a)	 Downward pointing condenser with a collection vessel (and correct water orientation) OR Delivery tube to container in ice bath (1) Labels Water on the left AND Mixture for distillation / tarragon leaves / Estragole (1) ALLOW Description of tarragon leaves as a solution in water or an organic solvent	Closed system Anethole	2

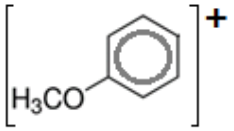
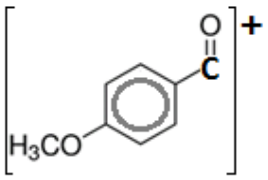
Question Number	Acceptable Answers	Reject	Mark
14(b)(i)	$C_{10}H_{12}O$ Ignore names e.g. Anethole	$C_{10}H_{11}OH$	1

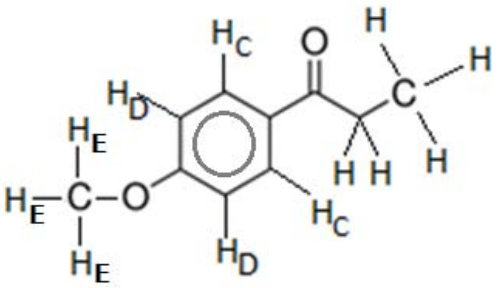
Question Number	Acceptable Answers	Reject	Mark
14(b)(ii)	Restricted rotation around a carbon-carbon double bond ALLOW No rotation around a carbon-carbon double bond (1) Two different groups attached to each carbon (1) Mark independently		2

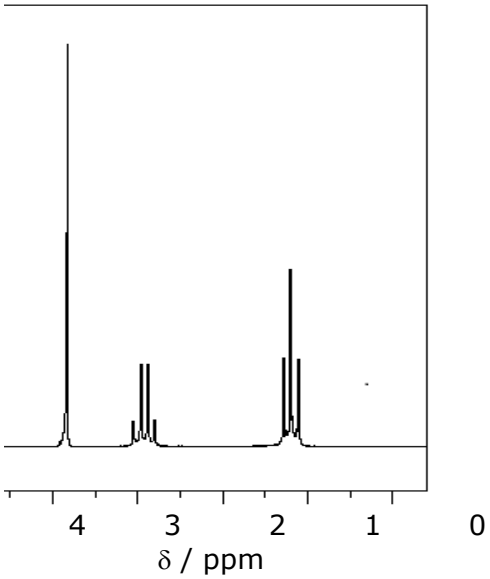
Question Number	Acceptable Answers	Reject	Mark
14(c)(i)	Propanoyl chloride Ignore formulae as working ALLOW 1-propanoyl chloride	Propanyl chloride Propyl chloride	1

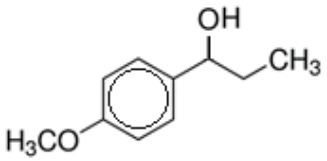
Question Number	Acceptable Answers	Reject	Mark
14(c)(ii)	**First mark** $RCOCl + AlCl_3 \longrightarrow RCO^+ + AlCl_4^-$ OR $CH_3CH_2COCl + AlCl_3 \longrightarrow CH_3CH_2CO^+ + AlCl_4^-$ ALLOW any acyl chloride or halogenoalkane from (c)(i) (1)  **Second mark** Curly arrow from on or within the circle towards the C of $CH_3CH_2CO^+$ / RCO^+ ALLOW curly arrow from anywhere within the hexagon ALLOW curly arrow to any part of the $CH_3CH_2CO^+$ including to the + charge ALLOW TE for any R group attached to CO^+ (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 dotted horseshoe (1) IGNORE Incorrect orientation of product at this marking point **Fourth mark** Curly arrow from C—H bond to anywhere in the hexagon, reforming the **correct** delocalised structure (and H^+) (1) IGNORE any involvement of $AlCl_4^-$ in the final step Correct Kekulé / skeletal structures score full marks	Curly arrow on or outside the hexagon Dotted bonds to H and RCO unless part of a 3-D shape Curly arrow from H	4

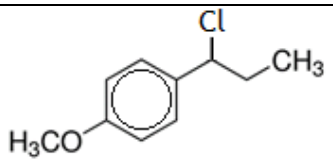
Question Number	Acceptable Answers	Reject	Mark
14(c)(iii)	**Lone** pair (of electrons) on the **oxygen** (of the methoxy- group) AND Overlaps with the π / delocalised electrons in the benzene ring / delocalised system OR Feeds into / donates to / interacts with the delocalised electrons / delocalised system / π system of the benzene ring ALLOW Increases the electron density of the benzene ring (1) Making it more susceptible to electrophilic attack / attack by propanoyl cation / RCO^+ ALLOW Making it a better nucleophile (1) Mark each point independently		2

Question Number	Acceptable Answers	Reject	Mark
14(d)	A is  OR $[CH_3OC_6H_4]^+$ (1) B is  OR $[CH_3OC_6H_4CO]^+$ (1) ALLOW Kekulé structures ALLOW Reversed answers scores 1 If the reversed answers are given and some indication (e.g. masses of the ions) are given in the boxes allow both marks IGNORE Absence of brackets / position of + Note Allow skeletal / displayed formulae for both A and B	Penalise structures without positive charge once only	2

Question Number	Acceptable Answers	Reject	Mark
14(e)(i)	 **Three** hydrogens with E ALLOW Any other unambiguous identification of the **three** hydrogens	Any other hydrogens labelled	1

Question Number	Acceptable Answers	Reject	Mark
14(e)(ii)	 M1 Two peaks, one centred between δ0.1 to δ1.9 and one between δ1.75 and δ3.0 (1) Triplet centred between δ0.1 to δ1.9 AND Quartet in the region δ1.75 to δ3.0 (1) Peak between δ0.1 to δ1.9 shown with peak area of 3 and at δ1.75 to δ3.0 with peak area of 2. This could be anywhere on the page. (1) IGNORE Relative peak height and relative size/height of parts of multiplet.		3

Question Number	Acceptable Answers	Reject	Mark
14(f)	(Reduction using) Lithium tetrahydridoaluminate((III)) / Lithium aluminium hydride / Lithal / $LiAlH_4$ in (dry) ether ALLOW Sodium tetrahydridoborate((III)) / Sodium borohydride / $NaBH_4$ (1) IGNORE Heat / reflux / distillation  ALLOW Skeletal formula (1) (Substitution using) PCl_5 OR NaCl / KCl and **concentrated** / **conc.** H_2SO_4 ALLOW PCl_3 / $SOCl_2$ / **concentrated** hydrochloric acid (Substitution using) PBr_3 / P and Br_2 (giving bromoalkane) (Substitution using) PI_3 / (red) P and I_2 (giving iodoalkane) (1)	Hydrogen and nickel Just acid Just HCl	5

	 Or bromo- or iodo- compounds as appropriate (1) (Elimination using) **ethanolic / alcoholic / EtOH / alc.** sodium/potassium hydroxide **AND** Heat / boil / heat under reflux (1) Marking consequential on correct intermediates but ALLOW for max 3 a two step synthesis using step 1 as above and then Conc. H_2SO_4 / H_3PO_4 / Al_2O_3 **AND** Heat / boil / heat under reflux / 170°C giving anethole		

(Total for Question 14 = 22 marks)

Question Number	Acceptable Answers	Reject	Mark
15(a)(i)	Moles of thiosulfate = $21.60 \times 10^{-3} \times 3 \times 10^{-3}$ = 6.48×10^{-5} / 0.0000648 (mol) (1) Moles of Cu^{2+} in 100 cm^3 = moles of thiosulfate x 10 = 6.48×10^{-4} / 0.000648 (mol) (1) If M1 is scored, then there is no further attempt, the second mark can be scored in (a)(ii) Ignore SF except 1 SF Correct answer with no working scores 2		2

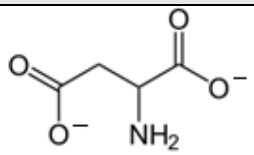
Question Number	Acceptable Answers	Reject	Mark
15(a)(ii)	Mass of Cu = $6.48 \times 10^{-4} \times 63.5$ = 0.041148 / 4.1148×10^{-2} (g) = 0.041 / 4.1×10^{-2} (g) Answer must be to 2 SF TE on (a)(i) x 63.5 and answer to 2 SF		1

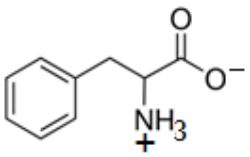
Question Number	Acceptable Answers	Reject	Mark
15(b)	First two marks are stand alone In 0.500g Mass of water = 0.07(0) AND Moles of water = $\frac{0.07(0)}{18}$ = 0.0038889 (mol) / 3.8889×10^{-3} (mol) (1) n = $\frac{\text{moles of water}}{\text{moles of } Cu^{2+}}$ = $\frac{0.0038889}{6.48 \times 10^{-4}}$ = 6(.0014) (1) Method 1 moles of sulfate = 2 x moles of Cu^{2+} = 0.001296 / 1.296×10^{-3} (mol) Mass of sulfate = moles of sulfate x 96.1 = 0.12455 (g) (1) Mass of M = 0.500 – mass of copper - mass of sulfate – mass of water = 0.500 - 0.12455 – 0.070 – 0.041148 = 0.26430 (g) (1) Atomic mass of M = $\frac{\text{mass of M}}{\text{moles of M}}$ = $\frac{0.264}{2 \times 6.48 \times 10^{-4}}$ = 203.94 So compound is $Tl_2Cu(SO_4)_2.6H_2O$ (1) Method 2		5

	mol compound = mol Cu = 6.48×10^{-4} AND M_r of compound = $0.5 \div 6.48 \times 10^{-4}$ = 771.6 (g mol^{-1}) M_r anhydrous = 771.6 – (6 x 18) = 663.6 (g mol^{-1}) (1) *M*r $Cu(SO_4)_2$ = 63.5 + 96.1 x 2 = 255.7 (g mol^{-1}) (1) 2 x *A*r(M) = 663.6 – 255.7 = 407.9 *A*r(M) = 203.95 (g mol^{-1}) Therefore $Tl_2Cu(SO_4)_2.6H_2O$ (1) Method 3 mol compound = mol Cu = 6.48×10^{-4} (mol) AND Mass of anhydrous compound = 0.500 – 0.70 = 0.43 (g) M_r of anhyd. compound = $0.43 \div 6.48 \times 10^{-4}$ = 663.6(g mol^{-1}) (1) *M*r $Cu(SO_4)_2$ = 63.5 + 96.1 x 2 = 255.7 (1) 2 x *A*r(M) = 663.6 – 255.7 = 407.9 *A*r(M) = 203.95 Therefore $Tl_2Cu(SO_4)_2.6H_2O$ (1) Other methods may be possible. ALLOW TE on 15(a)(ii) for mass and moles of copper where appropriate. Correct answer with some correct working scores 5.		

(Total for Question 15 = 8 marks)

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	(2-)aminobutan(e)dioic acid (2-)aminobutan(e)-1,4-dioic acid (2-)aminebutan(e)dioic acid (2-)aminebutan(e)-1,4-dioic acid IGNORE Punctuation marks (e.g. hyphens, commas, full stops etc) in either version of the answer so for example 2 aminobutandioic acid would score.	Answers with dibutan(e) in the name e.g. aminodibutanoic acid	1

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	 ALLOW Structural formulae / displayed formulae e.g. $^{-}OOCCH_2CHNH_2COO^{-}$	Neutral structure Single negative ion	1

Question Number	Acceptable Answers	Reject	Mark
16(a)(iii)	Diagram (1)  ALLOW NH_3^+ Phenylalanine molecules are held to each other by ionic bonds / strong electrostatic attractions between oppositely charged ions (so high melting temperature) / held in (giant) ionic lattice (1) IGNORE Strong electrostatic attractions between molecules without mention of ionic bonds or between oppositely charged ions Reference to hydrogen bonds	Internal ionic bonds specifically mentioned but assume intermolecular if not specific.	2

Question Number	Acceptable Answers	Reject	Mark
16(b)(i)	Methanol / CH_3OH		1

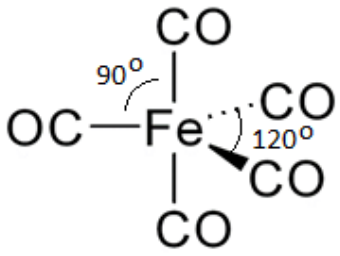
Question Number	Acceptable Answers	Reject	Mark
16(b)(ii)	Put spots of the amino acid mixture / hydrolysis products (and known amino acids) AND on a tlc plate / filter paper / chromatography paper AND in a (suitable) solvent / run with a (suitable) solvent ALLOW Labelled diagram (1) Use ninhydrin (to make amino acids visible) ALLOW Iodine vapour in place of ninhydrin (1) Compare distance travelled of mixture components with known amino acids OR Compare R_f / formula of R_f / description of R_f with data book values (1)	Just already separated amino acids Amino acids dissolved in mobile phase solvent just 'paper' Ni as an abbreviation Just 'compare with data book values' Just 'Calculate R_f values'	3

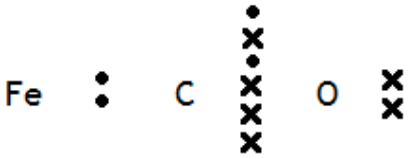
Question Number	Acceptable Answers	Reject	Mark
16(b)(iii)	Heat causes hydrolysis OR Amino acids are not sweet ALLOW Decomposition / breakdown / unstable on heating IGNORE Methanol is toxic Changes to flavour without mention of sweetness	Just 'cooking' without 'heat' Decomposition / breakdown / unstable without heat	1

(Total for Question 16 = 10 marks)
(Total for Section B = 50 marks)

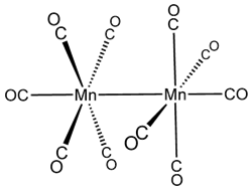
Section C

Question Number	Acceptable Answers	Reject	Mark
17(a)	Two calculations which must be accompanied by a correct statement about toxicity. Several approaches are possible. e.g. Mass of CO released = 0.35 x 28 = 9.8 (g) (1) Mass per m^3 = $\frac{9.8}{200}$ = 0.049 (g) / 49 (mg) Which is greater than the toxicity limit (1) OR Max. mass = 43.2 x 200 = 8640(mg) (1) Maximum moles allowed = $\frac{8640}{1000 \times 28}$ = 0.30857143 Which is less than was released (so not within the limits) (1) OR Max. moles per m^3 = $\frac{43.2 \times 10^{-3}}{28}$ = 0.0015429 / 1.5429 x 10^{-3} (mol) / 1.5429 (mmol) (1) Moles per m^3 released = $\frac{0.35}{200}$ = 0.00175 (mol) Which is more that the toxicity limit (1) OR Moles per m^3 released = $\frac{0.35}{200}$ = 0.00175 (mol) (1) Mass per m^3 released = 0.00175 x 28 = 0.049 (g) / 4.9 x 10^{-2} (g) / 49 (mg) Which is more than the toxicity limit (1) ALLOW TE only on a suitable attempt at a calculation of mass or moles in M1 Other approaches may be possible		2

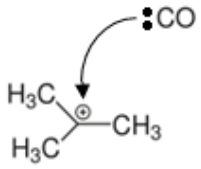
Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	If the name of a shape is given award M1 for the name if correct. Do not negate with and incorrect diagram. Trigonal bipyramid(al) ALLOW Pyramidal / bipyramidal if a correct diagram is given ALLOW If no name is given, a three dimensional diagram showing three bonds in plane (straight lines) and two bonds out of plane, either a wedge and dots (which may also be wedged, but ignore the direction of this wedge) or two oppositely directed wedges (one fat at Fe and another fat at CO) (1)  One angle labelled 120° and one angle labelled 90°, which may be shown as the symbol 'r'. (1) ALLOW If no other mark has been scored, a diagram with no dots and wedges which has at least one correct 90° and one correct 120° angle scores (1) IGNORE Point of attachment of CO to Fe	Square based pyramids Just 'pyramidal' or 'bipyramidal' Any additional angles which are labelled incorrectly but not the correct 180° angle	2

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	 Dative covalent bond from C to Fe AND lone pair on O (1) Triple bond between C and O with one dative covalent bond. (1) ALLOW Crosses for carbon and dots for oxygen Dative covalent bond to Fe, double bond between C and O and two lone pairs on O scores (1) IGNORE Circles for electron shells / lines as well as dots and crosses to show bonds / lone pairs on the Fe		2

Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	Moles of CO = $\frac{4.8}{24}$ = 0.2 moles (1) Mass of CO = 0.2 x 28 = 5.6 g AND Mass of Mn = 7.8 – 5.6 g = 2.2 (1) Moles of Mn = $\frac{2.2}{54.9}$ = 0.04007286 AND Ratio is 0.04 : 0.2 1 : 5 (So $Mn(CO)_5$) (1) If Ar Mg used instead (24 / 24.3) final answer of 0.091667 : 0.2 / 0.090535 : 0.2 or 1:2 can score M1 and M2. ALLOW TE for incorrect mass of manganese in M2 for ratio M3.		3

Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	Empirical formula mass = 194.9 390 = 2 x 194.9 so molecular formula = $Mn_2(CO)_{10}$ ALLOW Just $Mn_2(CO)_{10}$ without working or a structure with 2Mn and 10CO (1)  ALLOW Any sensible structure of two Mn and ten CO covalently bonded at any angle to each other (1) IGNORE Connectivity of the CO group Use of M / Mg as a slip if structure is correct		2

Question Number	Acceptable Answers	Reject	Mark
17(d)(i)	Sulfuric acid is a catalyst (1) IGNORE Sulfuric acid / H^+ is an electrophile **Hydrogen ion** (reacts with 2-methylpropene and) is regenerated at the end / in the last step of the reaction / takes part in the reaction but is still present at the end (1) M2 dependent on M1.	Just 'sulfuric acid is chemically unchanged after the reaction' 'Not participating in the overall reaction'	2

Question Number	Acceptable Answers	Reject	Mark
17d(ii)	 Lone pair of electrons on C (1) Arrow from a lone pair on the C of CO to C or to + on C of correct organic cation ALLOW Arrow from the C of CO to C or the + on C of correct organic cation if the first mark has not been scored Arrow from a lone pair on O of CO to C or the + on C of correct organic cation if the first mark has not been scored (1) IGNORE Number bonds between C and O in carbon monoxide. Product, even if incorrect Mark independently	CO^- From CO^- From CO^-	2

Question Number	Acceptable Answers	Reject	Mark
17(d)(iii)	Sulfuric acid is corrosive OR Difficult to recover the sulfuric acid IGNORE Irritant Burns skin / toxic / discussion of yield	Just cost	1

Question Number	Acceptable Answers	Reject	Mark
17(e)	The (two) reactants are / carbon monoxide is adsorbed onto the surface / active sites of the catalyst (1) The activation energy for the reaction is lowered / bonds are weakened in the reactant molecules (1) The products are desorbed from / diffuse from / leave the catalyst (1)	absorbed	3

(Total for Question 17 = 20 marks)
(Total for Section C = 20 marks)
Total for Paper = 90 marks

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