Pearson Edexcel

Mark Scheme (Results)

Summer 2025

Pearson Edexcel International Advanced Level
In Chemistry (WCH15)
Paper 01 Transition Metals and Organic Nitrogen Chemistry

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Summer 2025
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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

Question Number	Answer	Mark
1	**The only correct answer is D** ($Zn + 2V^{3+} \rightarrow Zn^{2+} + 2V^{2+}$) ***A*** *is incorrect because Ag cannot reduce* V^{3+} *as* $E^{\ominus}_{cell}$ *is negative* ***B*** *is incorrect because* Cu^{+} *cannot reduce* V^{3+} *as* $E^{\ominus}_{cell}$ *is negative* ***C*** *is incorrect because* Fe^{2+} *cannot reduce* V^{3+} *as* $E^{\ominus}_{cell}$ *is negative*	**(1)**

Question Number	Answer	Mark
2(a)	**The only correct answer is C** (pale green → pale pink) ***A*** *is incorrect because this is the reverse colour change* ***B*** *is incorrect because this is the colour change of the manganate(VII) ions* ***D*** *is incorrect because pale pink is the final colour*	**(1)**

Question Number	Answer	Mark
2(b)	**The only correct answer is A** (1.90×10^{-1}) ***B*** *is incorrect because the number of moles has been divided by 5 instead of multiplied* ***C*** *is incorrect because this is the number of moles of iron(II)* ***D*** *is incorrect because this is the number of moles in 1* cm^3	**(1)**

Question Number	Answer	Mark
2(c)	**The only correct answer is D** (0.53%) ***A*** *is incorrect because this is the percentage error of one reading if the burette reading was 25.0* cm^3 ***B*** *is incorrect because this is the percentage error for one reading of the burette* ***C*** *is incorrect because this is the percentage error for two readings if the burette reading was 25.0* cm^3	**(1)**

Question Number	Answer	Mark
2(d)	**The only correct answer is D** (manganese VII → II, iron II → III) ***A*** *is incorrect because this shows the manganese being oxidised and iron being reduced* ***B*** *is incorrect because this shows the manganese being oxidised* ***C*** *is incorrect because this shows the iron being reduced*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is B** ($O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$) ***A*** *is incorrect because this is the equation for the overall reaction* ***C*** *is incorrect because this is an equation for a neutralisation reaction* ***D*** *is incorrect because this reaction produces hydrogen and oxygen*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is A** ([Ar] $3d^{10}$) ***B*** *is incorrect because this is the electronic configuration of the Zn atom* ***C*** *is incorrect because one electron has been removed from the 3d subshell and one from the 4s* ***D*** *is incorrect because two electrons have been removed from the 3d subshell rather than from the 4s*	**(1)**

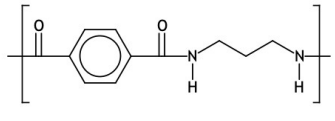
Question Number	Answer	Mark
5	**The only correct answer is C** (purple) ***A*** *is incorrect because this is the colour of a* VO^{2+} *ion* ***B*** *is incorrect because this is the colour of a* V^{3+} *ion* ***D*** *is incorrect because this is the colour of a* VO_2^{+} *ion*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A** (all can act as bidentate ligands) ***B*** *is incorrect because this is true for* H_2O, OH^- *and* NH_3 ***C*** *is incorrect because this is true for* H_2O, OH^- *and* NH_3 ***D*** *is incorrect because this is true for* H_2O, OH^- *and* NH_3	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** (*N*-butylethanamide) ***A*** *is incorrect because ethanamide is not produced in the reaction* ***B*** *is incorrect because butanamide is not produced in the rection* ***D*** *is incorrect because the ethyl and butyl groups are transposed*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is D** (Sn, concentrated HCl and reflux) ***A*** *is incorrect because this is an oxidising reagent* ***B*** *is incorrect because this reagent does not reduce aromatic nitro compounds to amines* ***C*** *is incorrect because there will be no reaction*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is B** (pH 6) ***A*** *is incorrect because both the amine and acid groups would be protonated* ***C*** *is incorrect because the amine and acid groups would not be protonated* ***D*** *is incorrect because the amine and acid groups would not be protonated*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is C** () ***A*** *is incorrect because a nitrogen is replaced with a carbon in the chain and an extra carbonyl is included* ***B*** *is incorrect because the repeat unit includes an extra carbonyl group* ***D*** *is incorrect because the repeat unit includes an extra amine group*	**(1)**

Question Number	Answer	Mark
11(a)	**The only correct answer is B** (nitrile) ***A*** *is incorrect because the phenyl group remains unchanged in the product* ***C*** *is incorrect because the nitrogen is triple bonded to the carbon* ***D*** *is incorrect because the nitrogen is not adjacent to a carbonyl group*	**(1)**

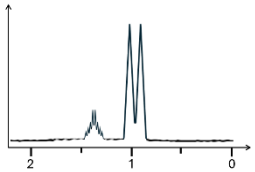
Question Number	Answer	Mark
11(b)	**The only correct answer is C** (nucleophilic addition) ***A*** *is incorrect because the carbon is an area of low electron density* ***B*** *is incorrect because the carbon is an area of low electron density* ***D*** *is incorrect because no group is lost*	**(1)**

Question Number	Answer	Mark
11(c)	**The only correct answer is B** (HCN and KCN) ***A*** *is incorrect because the reaction requires slightly acidic conditions* ***C*** *is incorrect because these reagents convert aromatic amines into diazonium compounds* ***D*** *is incorrect because these are the nitrating reagents for aromatic compounds*	**(1)**

Question Number	Answer	Mark
11(d)	**The only correct answer is C** (72.7%) ***A*** *is incorrect because only 8 carbons have been included* ***B*** *is incorrect because only 9 carbons have been included* ***D*** *is incorrect because an extra carbon has been included*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is D** (134) ***A*** *is incorrect because the simplest formula has been used which has too few carbon atoms* ***B*** *is incorrect because this is the* M_r *of (unsubstituted) benzene* ***C*** *is incorrect because the formula from A has been doubled and no longer conforms to the general formula*	**(1)**

Question Number	Answer	Mark
13(a)	**The only correct answer is B** (Two) ***A*** *is incorrect because there are two carbon environments* ***C*** *is incorrect because there are two carbon environments* ***D*** *is incorrect because there are two carbon environments*	**(1)**

Question Number	Answer	Mark
13(b)	**The only correct answer is B** () ***A*** *is incorrect because this is the spectrum for 2,3-dimethylbut-2-ene* ***C*** *is incorrect because this is the spectrum for propane* ***D*** *is incorrect because this is the spectrum for 2-methylbutane*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
14(a)	An answer that makes reference to the following points: • salt bridge **(1)** • allows ions to flow between the half cells **(1)**	 Allow filter paper soaked with (saturated) potassium nitrate solution Ignore implication that the salt bridge is made of KNO_3 Ignore other salts Allow completes the circuit Allow lets ions to flow around the circuit Allow movement of ions from one side to the other Ignore flow of charges Ignore balance the charge/ions Ignore prevents charge build up Do not award allows electrons to flow NB "Allows movement of ions" is insufficient	**(2)**

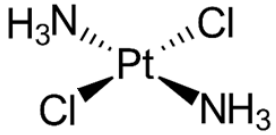
Question Number	Answer	Additional Guidance	Mark
14(b)	An answer that makes reference to the following points: • correct species in order **(1)** • correct notation of salt bridge, phase boundaries and state symbols **(1)**	Example of cell diagram: $Pt(s) \mid [Ti^{2+}(aq), Ti^{3+}(aq)] \mid\mid Ag^{+}(aq) \mid Ag(s)$ Electrons should be penalised here Allow one (aq) on LHS Allow a double dash line between the two half cells Allow single (dash) line in place of comma Ignore missing and extra brackets Do not award a single solid line between the two half cells TE on M1 (i.e. if ions are in the wrong order or incorrect) Allow 1 mark for the reverse answer, otherwise completely correct i.e. $Ag(s) \mid Ag^{+}(aq) \mid\mid [Ti^{3+}(aq), Ti^{2+}(aq)] \mid Pt(s)$	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(c)	An answer that makes reference to the following points: • selection of correct $E^{\ominus}$ value from Data Booklet **(1)** • calculation of the $E^{\ominus}_{cell}$ value **(1)**	Example of a calculation: (22) +0.80 V +0.80 – (–0.37) = (+)1.17(V) Correct answer with no working scores 2 −1.17(V) scores 1 mark	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(d)	An answer that makes reference to the following points: • ($E^{\ominus}_{cell}$ emf will) decrease • Pt electrode unchanged (as it is inert) • silver electrode gets larger/thicker • concentration of Ti^{2+} will decrease • concentration of Ag^{+} will decrease • concentration of Ti^{3+} will increase	Accept less positive Allow closer to zero Allow "no difference seen" Accept mass increase of the silver electrode Allow silver is deposited on the silver electrode Allow concentrations of ions will decrease if no other concentration change mentioned for 1 point Ignore concentrations change Ignore incorrect explanations of correct changes All 6 points correct scores 3 marks 4 or 5 points correct scores 2 2 or 3 points correct score 1 Independent to Q14c, no TE	**(3)**

(Total for Question 14 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
15(a)	• square planar		**(1)**

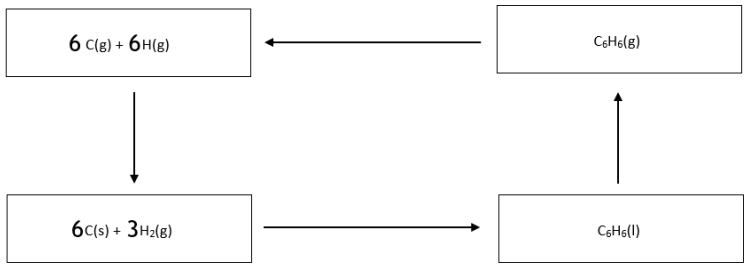
Question Number	Answer	Additional Guidance	Mark
15(b)	• correct diagram	Example of a diagram:  Allow **all** straight lines instead of wedges Allow arrows showing the dative bonds if pointing to the centre Ignore correct charges/roman numerals on Pt^{2+} **and** Cl^- Ignore bond angles even if incorrect Ignore reversed wedges NB Bonds must go from the nitrogen atoms to the Pt	**(1)**

Question Number	Answer	Additional Guidance	Mark
15(c)	An explanation that makes reference to the following points: • there is a high(er) concentration of water (than chloride ions) in the body cells **(1)** • so the equilibrium moves to the right **(1)**	Accept H_2O is a stronger ligand (than Cl^-) Allow water forms a stronger dative bond (with Pt ion) Ignore Cl^- is a good leaving group Do not award chlorine/Cl Allow favours the forward reaction / RHS Allow because water is a smaller ligand Allow complex is more soluble Ignore stability	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(d)(i)	An answer that makes reference to the following point: • bidentate (ligand)	Ignore multidentate Do not award polydentate	**(1)**

Question Number	Answer	Additional Guidance	Mark
15(d)(ii)	An explanation that makes reference to the following points: • ΔS_{sys} is positive **(1)** • (because) the number of particles increases **(1)**	Accept entropy increases Allow entropy is positive Allow species/ions Do not award molecules Allow M2 for 2 reactants and 3 products Allow M2 for more moles on the product side Allow the bonds between the DNA and *cis*-platin are stronger for 1 mark.	**(2)**

(Total for Question 15 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
16(a)(i)	An answer that makes reference to the following point: • completion of cycle by addition of balancing numbers **(1)**	<u>Example of a completed cycle</u>:  Labelling of arrows is not required	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(a)(ii)	An answer that makes reference to the following points: • calculation of value for **6** carbon-carbon bonds **(1)** • calculation of carbon-carbon bond **(1)**	<u>Example of a calculation</u>: ((3 × 436) + (6 × 715) = + 49 + (6 C-C + 6 × 413) + 31) **6** C−C = 5598 − 2558 = 3040 (C−C = 3040 ÷ **6**) = (+)506.67 / 506.7 / 507 (kJ mol^{-1}) TE on M1 if answer is positive Ignore units even if incorrect Ignore SF except 1SF Correct answer with no working scores 2	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(a)(iii)	An explanation that makes reference to the following points: • the mean value of the C−C and C=C is 479.5/480 **(1)** • so the actual value is higher (by 27 kJ mol^{-1} per bond) because of **delocalisation** **(1)**	Allow the bond/value is intermediate Ignore references to bond length and explanations Allow more endothermic due to **delocalisation** Allow bonds are stronger due to **delocalisation** Allow more stable due to **delocalisation**	**(2)**

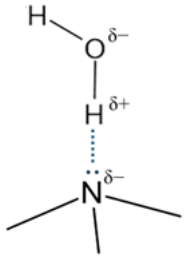
Question Number	Answer	Additional Guidance	Mark
16(b)	An answer that makes reference to the following points: • (s/p)-orbitals overlap (head-on / end-to-end) to form σ-bonds **(1)** • p-orbitals (of the carbon atoms) overlap sideways to form π-bonds **(1)**	Allow reference to hybrid / sp^2 orbitals for M1 Ignore number of sigma bonds Allow p-orbitals (of the carbon atoms) overlap above and below the ring to form π-bonds Ignore numbers of π-bonds, even if incorrect Do not award pi-orbitals Annotated diagrams can score both marks If no other marks awarded then head-on and sideways overlap of p-orbitals scores 1 mark	**(2)**

Question Number	Answer		Additional Guidance	Mark
16(c)	An answer that makes reference to the following points:			**(2)**
	• benzene undergoes (electrophilic) substitution reactions **or** benzene only forms one isomer of 1,2-dibromobenzene	**(1)**	Allow benzene does not decolourise bromine water Allow a halogen carrier is required for benzene to react (e.g. $FeBr_3$) Allow the Kekulé formula would undergo (electrophilic) addition reaction Allow benzene would form 3 isomers when disubstituted with bromine / Kekulé forms 4 isomers when disubstituted with bromine Allow enthalpy of hydrogenation is less exothermic for benzene	
	• all the carbon-carbon / C−C bond lengths in benzene are the same	**(1)**	Allow x-ray diffraction shows molecule is a perfect hexagon Allow IR spectrum shows specific wavenumbers (due to the aryl structure) Ignore references to bond angles and boiling point Ignore "all bond lengths are the same" Do not award "bond lengths are similar"	

(Total for Question 16 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
17(a)(i)	• skeletal structure	Example of a diagram: N Ignore non-skeletal structures Ignore bond angles	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(a)(ii)	• tertiary / 3°	No TE from (a)(i)	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(a)(iii)	An answer that makes reference to the following points: • diagram showing one water molecule correctly aligned to H−bond with an angle 170-190° • lone pair on nitrogen atom lined up with hydrogen bond • one dipole on water (showing both δ+ and δ−) • δ− charge on nitrogen	Example of a diagram:  Allow any depiction of H−bond dashes/dots etc. Ignore $H^{\delta+}$ / $C^{\delta+}$ in TMA TE on structure in 17(a)(i), if a primary or secondary amine is drawn then the H−bond may be from the amine hydrogen to the water oxygen lone pair. Ignore bond lengths and angles of other bonds 4 points scores 2 marks 2 or 3 points score 1 mark	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(a)(iv)	• balanced ionic equation	$(CH_3)_3N + H^+ \rightarrow (CH_3)_3NH^+$ $(CH_3)_3N + H_2O \rightarrow (CH_3)_3NH^+ + OH^-$ Allow molecular formula: $C_3H_9N + H^+ \rightarrow C_3H_9NH^+ / C_3H_{10}N^+$ $C_3H_9N + H_2O \rightarrow C_3H_9NH^+ / C_3H_{10}N^+ + OH^-$ TE on structure in 17a(i) Allow equilibria equations	(1)

Question Number	Answer		Additional Guidance	Mark
17(b)	• calculation of M_r	(1)	<u>Example of a calculation</u>: $M_r = 75$	(2) Expert
	• mass calculated with answer to 2 or 3 SF	(1)	$3.90 \times 10^{-6} \times 5.00 \times 75 = 0.0014625$ $= 1.5 \times 10^{-3}$ / 0.0015 (g) Accept 1.46×10^{-3} / 0.00146 (g) TE on M1 calculation	
	Alternative method: • calculation of moles	(1)	$3.90 \times 10^{-6} \times 5.00 = 1.95 \times 10^{-5}$	
	• multiplication by M_r and answer to 2 or 3 SF	(1)	$1.95 \times 10^{-5} \times 75 = 1.5 \times 10^{-3}$ / 0.0015 (g) Correct answer to 2 or 3 SF scores 2 Units, if given, should match the value	

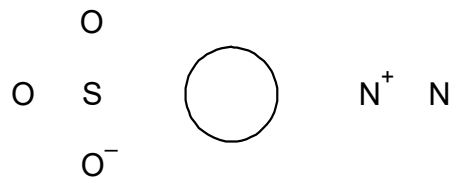
Question Number	Answer	Additional Guidance	Mark
17(c)(i)	An explanation that makes reference to the following points: • (inert) gas carries samples through the column / the gas is a mobile phase **and** compounds are attracted to the contents of the column / the contents in the column are the stationary phase • compounds that are strongly attracted to the stationary phase take longer to pass through the column / compounds that are not attracted to the stationary phase take less time to pass through the column	Ignore the temperature of the oven can affect the separation Ignore affinity to the mobile phase / carrier gas Do not award reaction with the gas Accept adsorbed / absorbed to the contents of the column Allow dissolves in the stationary phase Ignore references to the nature of the stationary phase Accept references to being adsorbed / absorbed to the contents of the column Ignore different attractions leads to different/longer retention time	**(2)**

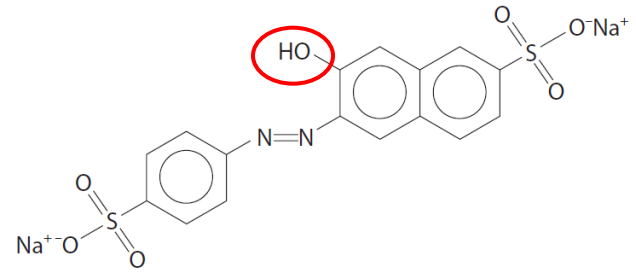
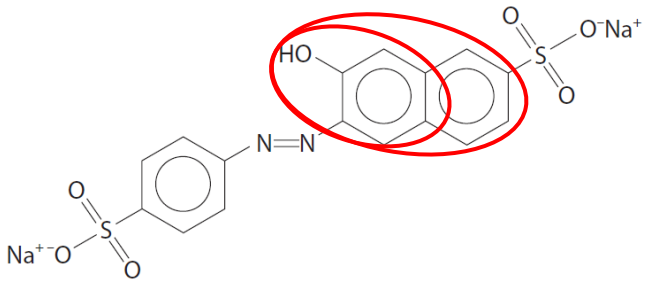
Question Number	Answer	Additional Guidance	Mark
17(c)(ii)	• (retention) time	Ignore units of time	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(c)(iii)	• mass spectrometry	Allow mass spectroscopy Allow MS	**(1)**

(Total Question 17 = 11 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)	An answer that makes reference to the following points: • $NaNO_2$ **and** HCl **(1)** • 0 – 5°C **(1)**	Accept names sodium nitrite and hydrochloric acid Allow nitrous acid / HNO_2 (ignore extra HCl) Ignore concentration Do not award other acids Do not award HNO_3 Allow 0 – 10°C Allow individual values in the range Allow ice bath Do not award answers below 0°C	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)	An answer that makes reference to the following points: • diagram of diazonium ion	Example of a diagram:  Ignore any Na^+ / Cl^- ions Do not award positive charge on wrong nitrogen atom Do not award N_2^+	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(c)	• correct group circled	Example of a correct diagram:  Accept inclusion of the neighbouring benzene ring(s) e.g.  	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(d)(i)	• recrystallisation	Allow crystallisation	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(d)(ii)	• M_r and moles of compound **A** **(1)** Either • moles of sunset yellow **(1)** • mass of sunset yellow **(1)** **or** • mass of sunset yellow assuming 100% yield • mass of sunset yellow	Example of a calculation: 23 + (3 × 16) + 32.1 + (6 ×12) + 4 + 14 + 2 = 195.1 moles of compound A = 5.00/195.1 = 0.025628 Allow M_r = 195 (1:1 relationship) 0.679 × 0.025628 = 0.017401 mol 0.017401 × 452.2 = 7.8689 (g) Ignore SF except 1SF TE on moles from M1 and M2 0.025628 × 452.2 = 11.589 g TE on moles from M1 = 11.589 × 0.679 = 7.8689 (g) TE on M2 Ignore SF except 1SF Correct answer with no working scores 3 marks	**(3)**

(Total Question 18 = 8 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*19</td>
<td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>

The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td>
<td>
Guidance on how the mark scheme should be applied.

The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

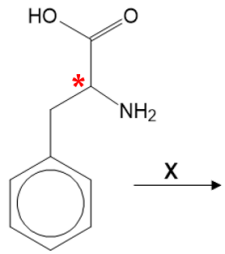
In general it would be expected that
5 or 6 indicative points would get 2 reasoning marks
3 or 4 indicative points would get 1 reasoning mark
0, 1 or 2 indicative points would get zero reasoning marks

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).
</td>
<td>(6)</td>
</tr>
</table>

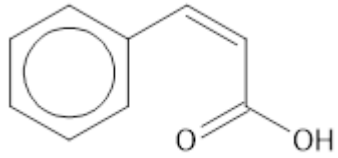
	Indicative points **IP1** (shape changes from) tetrahedral ($[CuCl_4]^{2-}$) to octahedral ($[Cu(H_2O)_6]^{2+}$ / $Cu(NH_3)_4(H_2O)_2]^{2+}$) **IP2** the Cl^- ion is larger so more water ligands can fit around the copper ion **IP3** $[Cu(H_2O)_6]^{2+}$and $[Cu(OH)_2(H_2O)_4]$ and $[Cu(NH_3)_4(H_2O)_2]^{2+}$ **IP4** the copper(II) hydroxide precipitates as the solution becomes alkaline **IP5** yellow to blue solution **or** ppt to deep blue is a ligand exchange reaction **IP6** water ligands replace chloro ligands and ammine ligands replace water ligands because the basic strength / availability of lone pairs is in the sequence $Cl^- < H_2O < NH_3$	Ignore hydroxide structure is octahedral Ignore diagrams Allow co-ordination number changes from 4 to 6 due to difference in ligand size Allow ligands in any order Allow $Cu(OH)_2$ Ignore missing square brackets Accept deprotonation (of water ligands) occurs Allow $[Cu(H_2O)_6]^{2+} + 2NH_3 \rightarrow [Cu(OH)_2(H_2O)_4] + 2NH_4^+$ Allow precipitation being due to neutral complex Allow ligand substitution Do not award blue solution to ppt as a ligand exchange reaction (no IP5) Allow explanation of just one change Allow colour changes are due to differing energy gap between the split d-orbitals Ignore bond angles throughout Ignore unbalanced equations	

(Total for Question 19 = 6 marks)
TOTAL FOR SECTION B = 51 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
20(a)(i)	• asterisk on the correct carbon	An example of a correct diagram:  Allow any indication of correct carbon e.g. circled or an arrow No credit for 2 asterisks	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	• elimination		**(1)**

Question Number	Answer	Additional Guidance	Mark
20(a)(iii)	• diagram showing correct structure	Example of a structure:  Allow any kind of structure including mixed Connectivity of OH must be correct Allow C_6H_5 instead of benzene on the end	**(1)**

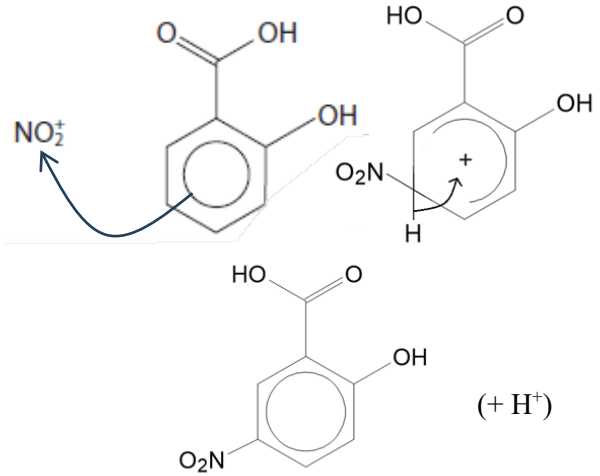
Question Number	Answer	Additional Guidance	Mark
20(a)(iv)	An explanation that makes reference to the following points: • potassium manganate((VII)) / $KMnO_4$ **(1)** • sulfuric acid / H_2SO_4 **(1)**	Allow potassium permanganate M2 dependent on M1 or near miss e.g. sodium dichromate Ignore concentration Do not award HCl Ignore phosphoric acid & steam Ignore references to conditions / state symbols / temperature even if incorrect Acidified potassium manganate((VII)) scores 1 Acidified $KMnO_4$ scores 1 H^+/MnO_4^- scores 1	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(v)	• these reaction conditions would be harmful within a cell	Allow other sensible suggestions e.g. plants don't contain (all) the necessary reagents e.g. the temperature is too low in a plant e.g. pH is too low e.g. enzymes may be denatured Ignore too many steps, yield, activation energy, harmful without qualification, pressure	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(b)	• 2-hydroxybenzoic acid	Accept 2-hydroxybenzenecarboxylic acid Allow 2-hydroxybenzeneoic acid Allow 2-hydroxylbenzoic acid Ignore missing and extra hyphens Do not award 2-hydroxybenzanoic acid	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(c)	Any two of the following: • 3750−3200 (cm^{-1}) O−H **phenol** **(1)** • 3030 (cm^{-1}) C−H (stretching, arene) **(1)** • 1700 – 1680 (cm^{-1}) C=O (carboxylic acids, aryl) **(1)** • 1600 / 1580 / 1500 / 1450 (cm^{-1}) C=C (stretching arene) **(1)** • 750 (cm^{-1}) C−H (bending, arene, 4 adjacent hydrogen atoms) **(1)**	Allow single values within ranges throughout **except C=O at 1700 cm^{-1}** Ignore references to O−H in alcohols and acids, phenol must be specified	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(d)(i)	• $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$	Allow $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$ Allow 2 step reaction: $HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$ $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$ Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
20(d)(ii)	An answer that makes reference to the following points: • electrophilic substitution (1) • arrow from ring to NO_2^+ (1) • carbocation intermediate (1) • arrow from bond to H back into the ring (1) • final structure with NO_2 in correct position and connectivity (1)	An example of a mechanism:  Allow arrow from anywhere in the hexagon for M2 Ignore position of NO_2 in M2 to M4 Correct Kekulé structures score full marks Ignore reformation of the sulfuric acid catalyst even if incorrect Penalise one mark for any extra curly arrows from M2-M5	(5)

Question Number	Answer	Additional Guidance	Mark
20(d)(iii)	An explanation that makes reference to the following points: • the lone pair of electrons from the phenol **oxygen** (atom) are delocalised into the benzene ring **(1)** • the ring becomes more electron dense **(1)** • so (the ring) is more susceptible to electrophilic attack **(1)**	 Allow **oxygen** (of OH) on the ring Do not award charge density increases Do not award electrophilic addition	**(3)**

Question Number	Answer	Additional Guidance	Mark
20(e)	• calculation of in g dm^{-3} **(1)** • conversion to mol dm^{-3} **(1)** Alternative method: • calculation of moles in volume **(1)** • conversion to mol dm^{-3} **(1)**	<u>Example of a calculation</u>: $1 \div 1475 \times 1000 = 0.67797$ (g dm^{-3}) $0.67797 \div 183 =$ $0.0037047 / 3.7047 \times 10^{-3} / 3.7 \times 10^{-3}$ (mol dm^{-3}) $1 \div 183 = 0.0054645$ (mol in 1475 cm^3) $0.0054645 \div 1.475 = 3.7 \times 10^{-3}$ (mol dm^{-3}) TE throughout Correct answer with no working scores 2 Ignore SF in final answer	**(2)**

(Total for Question 20 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

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