Pearson

Mark Scheme (Results)

Summer 2026

Pearson Edexcel International Advanced Level In Chemistry
WCH15/01A

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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(a)	**The only correct answer is D** (soak a filter paper in a saturated solution of potassium nitrate) ***A*** *is incorrect because the chloride ions could react with the silver nitrate forming a precipitate and the concentration may not be high enough to allow the ions to flow easily* ***B*** *is incorrect because the chloride ions could react with the silver nitrate forming a precipitate* ***C*** *is incorrect because the concentration may not be high enough to allow the ions to flow easily*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is A** (+1.56 V) ***B*** *is incorrect because the calculation has been reversed* ***C*** *is incorrect because electrode potentials have been added together* ***D*** *is incorrect because the electrode potentials have been added together incorrectly*	**(1)**

Question Number	Answer	Mark
1(c)	**The only correct answer is C** ($Ag^+(aq)$ is an oxidising agent and Zn(s) a reducing agent) ***A*** *is incorrect because the* Ag(s) and $Zn^{2+}(aq)$ are products not reactants ***B*** *is incorrect because the oxidising agent* is $Ag^+(aq)$ and the reducing agent is Zn(s) ***D*** *is incorrect because the* Ag(s) and $Zn^{2+}(aq)$ are products not reactants	**(1)**

Question Number	Answer	Mark
2	***The only correct answer is C*** ($E^{\ominus}_{cell}$ is directly proportional to the total entropy change, ΔS_{total}) ***A*** *is incorrect because* $E^{\ominus}_{cell}$ *is not directly proportional to the entropy change of the system,* ΔS_{system} ***B*** *is incorrect because* $E^{\ominus}_{cell}$ *is not directly proportional to the equilibrium constant* ***D*** *is incorrect because* $E^{\ominus}_{cell}$ *is not directly proportional to the entropy change of the surroundings,* $\Delta S_{surroundings}$	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is B** ($C_6H_5NH_2 > NH_3, > C_4H_9NH_2$) ***A*** *is incorrect because* $C_6H_5NH_2$ *is the least basic, and* $C_4H_9NH_2$ *is the most basic* ***C*** *is incorrect because* $C_4H_9NH_2$ *is more basic than* NH_3 ***D*** *is incorrect because* $C_6H_5NH_2$ *is the least basic followed by* NH_3, *and* $C_4H_9NH_2$ *is the most basic*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is B** (butylamine) ***A*** *is incorrect because the compound is square planar* ***B*** *is incorrect because ethanoyl chloride is planar around the C=O* ***D*** *is incorrect because benzene is a planar molecule*	**(1)**

Question Number	Answer	Mark
5(a)	**The only correct answer is C** (**2**, **3** and **4** only) ***A*** *is incorrect because complex ion* ***1,*** *$[Zn(OH)_4]^{2-}$ is colourless* ***B*** *is incorrect because complex ion 2, $[Fe(EDTA)]^-$ is also coloured* ***D*** *is incorrect because complex ion* ***1,*** *$[Zn(OH)_4]^{2-}$ is colourless and complex ion 2, $[Fe(EDTA)]^-$ is also coloured*	**(1)**

Question Number	Answer	Mark
5(b)	**The only correct answer is D** (**1**, **3** and **4** only) ***A*** *is incorrect because complex ion* ***2****, $[Fe(EDTA)]^-$ has an iron ion in an oxidation state of +3* ***B*** *is incorrect because complex ion* ***1****, $[Zn(OH)_4]^{2-}$has a zinc ion in an oxidation state of +2* ***C*** *is incorrect because complex ion* ***1****, $[Zn(OH)_4]^{2-}$ has a zinc ion in oxidation state of +2 and* ***2****, $[Fe(EDTA)]^-$ has an iron ion in an oxidation state of +3*	**(1)**

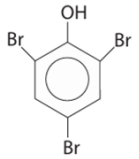
Question Number	Answer	Mark
5(c)	**The only correct answer is C** (**2**, **3** and **4** only) ***A*** *is incorrect because complex ion 1, $[Zn(OH)_4]^{2-}$ is not formed by ligand exchange* ***B*** *is incorrect because complex ion 2, $[Fe(EDTA)]^-$ is formed by ligand exchange* ***D*** *is incorrect because complex ion 2, $[Fe(EDTA)]^-$ is formed by ligand exchange and complex ion 1, $[Zn(OH)_4]^{2-}$ is not formed by ligand exchange*	**(1)**

Question Number	Answer	Mark
5(d)	**The only correct answer is B** (complex ion **2**) ***A*** *is incorrect because there are the same number of particles on each side of the equation as 4 water ligands are deprotonated* ***C*** *is incorrect because there are fewer particles on the RHS as 6 water ligands are replaced by 4 chloride ions* ***D*** *is incorrect because there are the same number of particles on each side of the equation as 6 water ligands are replaced by 6 ammonia molecules*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A** (3) ***B*** *is incorrect because the isomers have the halogen atoms in the 1, 2 and 1,3 and 1,4 positions* ***C*** *is incorrect because the isomers have the halogen atoms in the 1, 2 and 1,3 and 1,4 positions* ***D*** *is incorrect because the isomers have the halogen atoms in the 1, 2 and 1,3 and 1,4 positions*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is D** $(CH_3CH_2CH_3)_2N^+(C_2H_5)_2$ ***A*** *is incorrect because this product is formed by the reaction of one molecule of bromoethane with propylamine* ***B*** *is incorrect because this product is formed by the reaction of two molecules of bromoethane with propylamine* ***C*** *is incorrect because this product is formed by the reaction of three molecules of bromoethane with propylamine*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is D** ($HOOC(CH_2)_4COOH$ and $H_2N(CH_2)_6NH_2$) ***A*** *is incorrect because this monomer will form a nylon 5 polymer* ***B*** *is incorrect because this monomer will form a nylon 7 polymer* ***C*** *is incorrect because these monomers will form a nylon 6,4 polymer*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is C**  ***A*** *is incorrect because more than one substitution takes place in excess bromine* ***B*** *is incorrect because more than two substitutions take place and 3 and 5 are not substituted with excess bromine* ***D*** *is incorrect because positions 3 and 5 are not substituted with excess bromine*	**(1)**

Question Number	Answer	Mark
10(a)	**The only correct answer is C** (amide) ***A*** *is incorrect because the compound does not contain a primary amine functional group* ***B*** *is incorrect because the compound does not contain a ketone functional group* ***D*** *is incorrect because the compound does not contain an aldehyde functional group*	**(1)**

Question Number	Answer	Mark
10(b)	**The only correct answer is D** (8) ***A*** *is incorrect because there are three methyl carbons bonded to the nitrogen atoms* ***B*** *is incorrect because two carbons have been omitted* ***C*** *is incorrect because one carbon has been omitted*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is A** (X-ray diffraction) ***B*** *is incorrect because proton NMR spectroscopy does not provide direct evidence of bond length* ***C*** *is incorrect because infrared spectroscopy does not provide direct evidence of bond length* ***D*** *is incorrect because calorimetry does not provide direct evidence of bond length*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is B** ($C_6H_5SO_3H$) ***A*** *is incorrect because this formula is missing a hydrogen atom on one of the oxygen atoms* ***C*** *is incorrect because this formula has an extra hydrogen on one of the oxygen atoms* ***D*** *is incorrect because the sulfur atom not an oxygen atom is bonded to the benzene ring*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is A** ($CH_3CH(OH)CH_2CHO$) ***B*** *this compound is incorrect because it contains a carboxylic acid group that has a broad peak in the range 3300-2500* cm^{-1} ***C*** *this compound is incorrect because it does not have an alcohol group so there is no broad peak in the range 3300-2500* cm^{-1} ***D*** *this compound is incorrect because it contains a ketone group that has a peak in the range 1720-1700* cm^{-1}	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is B** (forms hydrogen bonds with water molecules) ***A*** *is incorrect because the London forces are not strong enough to cause solubility* ***C*** *is incorrect because heat does not break the polymer down* ***D*** *is incorrect because the detergent does not break the polymer down*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

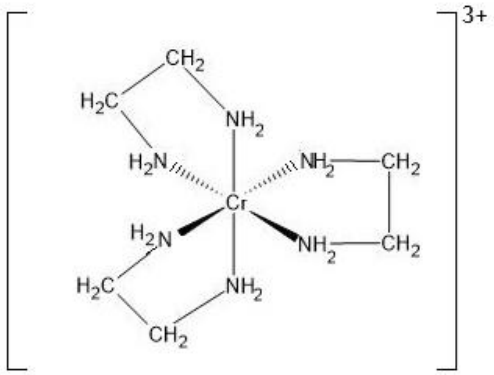
Section B

Question Number	Answer	Additional Guidance	Mark
15(a)(i)	An answer that makes reference to the following points: • both correct values (+ sign not needed)	$Cr^{3+}(aq) + e^- \rightleftharpoons Cr^{2+}(aq)$ **– 0.41** $Cr_2O_7^{2-}(aq) + 14H^+ 6e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$ **+ 1.33**	**(1)**

Question Number	Answer	Additional Guidance	Mark
15(a)(ii)	• correct species **(1)** • balancing and arrow **(1)**	Example of equation $8Cr^{3+} + 7H_2O \rightarrow Cr_2O_7^{2-} + 14H^+ + 6Cr^{2+}$ Ignore state symbols even if incorrect Allow multiples Do not award uncancelled electrons/ eqm sign M2 dependent on M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(a)(iii)	An explanation that makes reference to the following points: • calculation of E^{o}_{cell} **(1)** • negative value so the reaction is not feasible **(1)**	E^{o}_{cell} = (– 0.41 – (+) 1.33 =) –1.74(V) Allow $E^{o}_{cell} \leq 0$ so not feasible Allow $E^{o}_{cell} \leq 0$ so reverse reaction would take place. Ignore any reference to entropy TE on table values in (a)(i)	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(b)(i)	An explanation that makes reference to the following points: • each **nitrogen** atom on the ethane-1,2-diamine has a lone pair of electrons **(1)** • (so can form) two dative (covalent) bonds (to the metal ion) **(1)**	Ignore just reference to amine group Accept two coordinate bonds	**(2)**

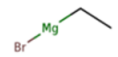
Question Number	Answer	Additional Guidance	Mark
15(b)(ii)	• three 1,2-diamoethane molecules bonded to the Cr^{3+} **(1)** • attached by two Ns at each end **(1)**	Example of diagram  Allow skeletal formula	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(c)(i)	An explanation that makes reference to the following points: • the **end-point** is hard to detect **(1)** • (because) the colour change is too slow/gradual **or** the iron (II) and chromium(III) ions are both green/have similar colours **or** the iron (II) and iron(III) ions are coloured (and make the colour change hard to see) **(1)**	Ignore colour change hard to detect Allow indicator makes the end point easier to see Allow the iron (III) and dichromate(VI) ions have similar colours Allow iron (II) is green and iron (III) yellow/orange brown Ignore any reference to the colours of chromium(III) and dichromate(VI) ions being similar in colour	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(c)(ii)	• M1 calculation of moles of $Cr_2O_7^{2-}$ in the titre **(1)** • M2 calculation of moles of Fe^{2+} in 25 cm^3 of solution **and** calculation of moles of Fe^{2+} in 250 cm^3 of solution **(1)** • M3 calculation of mass of $FeSO_4$ in the hydrated salt **(1)** • M4 calculation of the mass of water in the hydrated salt **(1)** • M5 calculation of moles of water in the hydrated salt **(1)** • M6 calculation of x **(1)** Alternative method for M3 to M6 • M3 using mass of mass of iron sulfate in 250 cm^3 of solution (5.81(g)) **(1)** and • M4 calculation of molar mass of hydrated iron sulfate **(1)** • M5 calculation of the mass of water in the hydrated salt **(1)** • M6 calculation of x **(1)**	<u>Example of calculation</u> n =(16.60 × 0.024 ÷1000=) 3.984×10^{-4} / 0.0003984 (mol) n =(3.984×10^{-4} / 0.0003984 × 6 =) 2.3904×10^{-3} / 0.0023904 (mol) n =($2.3904 \times 10^{-3} \times 10$ =) 2.3904×10^{-2} /0.023904 (mol) m=($2.3904 \times 10^{-2} \times 151.9$ =) 3.6310 (g) m=(5.81 – 3.631 =) 2.1789 (g) n=(2.1789 ÷ 18 =) 0.12105 (mol) n =(0.12105 ÷ 0.023904 = 5.06 =) 5 *M*r = 5.81 (g) ÷ 2.3904×10^{-2} = 243 ($g\ mol^{-3}$ m = 243 – 151.9 = 91.9 n = 91.9 ÷ 18 = 5.10 = 5 TE throughout but do not award M6 if the value is over 11 Correct answer with some correct working scores 6	**(6)**

(Total for Question 15 = 17 marks)

Question Number	Answer	Additional Guidance	Mark
16(a)	An answer that makes reference to the following points: • bromoalkane **(1)** • dry ether/ ethoxyethane/ diethyl ether **(1)**	Standalone marks Allow chloroalkane / iodoalkane Allow any halogenoalkane identified by name or formula including aromatics eg bromobenzene Allow halogenoalkane Ignore reference to heat / reflux/ magnesium Do not award if other additional reagents are used such as HCl unless it is added in a second step.	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(b)(i)	An answer that makes reference to the following points: Reaction 1 • Grignard reagent structure **(1)** • product name **(1)** Reaction 2 • Grignard reagent structure **(1)** • reagent structure **(1)**	<table><tr><th></th><th>Structure of Grignard reagent</th><th>Structure of the other reagent</th><th>Structure of product</th><th>Name of product</th></tr><tr><td>Reaction 1</td><td>  </td><td></td><td></td><td>3-ethylhexan-3-ol</td></tr><tr><td>Reaction 2</td><td>  </td><td>O=C=O</td><td></td><td></td></tr></table> Allow 3-ethyl-3-hexanol/ ethyl-3-hexan-3-ol/ Allow displayed, structural formulae Allow any halogen Allow CO_2/ dry ice Allow MgX Ignore missing or extra dashes in the name Penalise charges on the Mg and Br once only Do not award 3-ethylhexan**E**-3ol	**(4)**

Question Number	Answer		Additional Guidance	Mark
16(b)(ii)	• M1 maximum mass of benzoic acid a 60 kg person could consume per day	**(1)**	Example of calculation m= (60 × 5 ÷ 1000 =) 0.3 g / 300 mg	**(3)**
	either • M2 calculation of mass of benzoic acid in the drink per dm^3	**(1)**	m = (1.85×10^{-3} × 122 =) 0.2257 g dm^{-3} / 225.7 mg dm^{-3}	
	• M3 calculation of the volume of drink that could be consumed **and** the maximum number of cans drunk	**(1)**	v = (300 ÷ 225.7 =) 1.329 dm^3 / 1329 cm^3 n = (1329 ÷ 330 =) 4.028 so 4 (cans)	
	Alternative calculations • M2 moles of benzoic acid a 60 kg person could consume per day	**(1)**	0.3 ÷ 122 = 2.459×10^{-3} (mol)	
	• M3 calculation of the volume of drink that could be consumed **and** the maximum number of cans drunk	**(1)**	v = $2.459 \times 10^{-3} \div 1.85\times10^{-3}$ = 1.329 1.329 dm^3 /1329 cm^3 n = (1329 ÷ 330 =) 4.028 so 4 (cans)	
	or • M2 moles of benzoic acid in 1 can	**(1)**	m = (1.85×10^{-3} × 330 ÷ 1000) = 6.105×10^{-4} (mol)	
	• M3 mass of benzoic acid in 1 can **and** the maximum number of cans drunk	**(1)**	6.105×10^{-4} × 122 × 1000 = 74.481 mg 300 mg ÷ 74.481 = 4.028 so 4 (cans) Allow TE throughout e.g. wrong molar mass Correct answer with some working score (3)	

(Total for Question 16 = 9 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*17</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><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></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><td></td><td>Number of marks awarded for structure of answer and sustained lines of reasoning</td></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).

Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning
</td>
<td>(6)</td>
</tr>
</table>

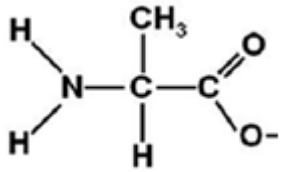
	Indicative content **IP1** both Sc and Cu are d-block elements as their outer/ last electron is being added to the (3)d subshell/orbital **IP2 (**only Cu is a transition metal as it has a stable) ion with an incomplete/ partially filled (3)d subshell/ orbital **IP3** Sc (is not a transition metal as it only**)** forms Sc^{3+} / (only forms an ion with one oxidation number) scandium (III) **and** with an empty d subshell/orbital **IP4** Cu (is a transition metal and shows variable oxidation numbers) Cu^{2+} and Cu^{+} / copper(I) and copper(II) **IP5** Sc^{3+} has no d electrons (so 3d electrons cannot be promoted/) **and** so, no light is absorbed/ all light reflected so the compounds are white **IP6** Cu compounds are coloured because (the ligands cause) the 3d subshells to split **and** (visible light is absorbed when) electrons are promoted (to the higher energy level) and complementary light is reflected	Allow electron configurations [Ar] $3d^{10}4s^{1}$ and [Ar] $3d^{1}4s^{2}$ (or s before d) This can be shown by the electronic configuration of Cu^{2+} Allow Sc does not have an ion with a partially filled (3)d subshell The empty d subshell may be seen in IP3 or IP5 Allow electronic configuration of Sc^{3+} [Ar] $3d^{0}$ Ignore just no 3d orbital Do not award any other Sc ion for IP3 only Ignore Sc^{2+}/ Sc^{+1} ions are unstable Ignore reference to Cu^{3+} Allow no d-d transitions Allow colourless Comment Ignore d subshell cannot split Allow any indication that that electrons are promoted or energy gaps (of the 3d orbitals) Allow d-d transitions Single d orbital is only penalised in IP6 (singular) Do not award any indication of emission/ colour due to electrons dropping back	

(Total for Question 17 = 6 marks)

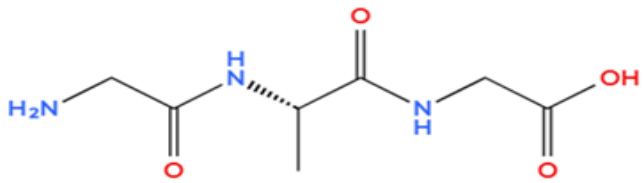
Question Number	Answer	Additional Guidance	Mark
18(a)	An answer that makes reference to the following points: • alanine has 4 peaks with a ratio of 3:1:1:2 **(1)** • glycine has 3 peaks with a ratio of 2:2:1 **(1)**	Allow annotation of structures Allow any order Allow hydrogen environments for peaks Ignore ppm If neither mark is scored, the correct number of peaks for both compounds scores (1)	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)	An answer that makes reference to the following points: • alanine solution contains a racemic/ mixture/has equal amounts of both optical isomers (so the effects of the molecules on plane- polarised light cancel out) **(1)** • glycine solution is not optically active/ does not have a chiral centre/ does not have an asymmetric carbon **(1)**	Allow racemate	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(c)(i)	• 2-aminopropanoic acid	Ignore an omission of hyphen Ignore spaces Do not award amine	**(1)**

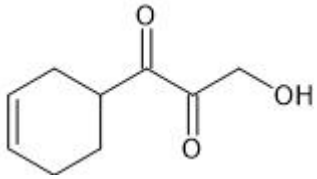
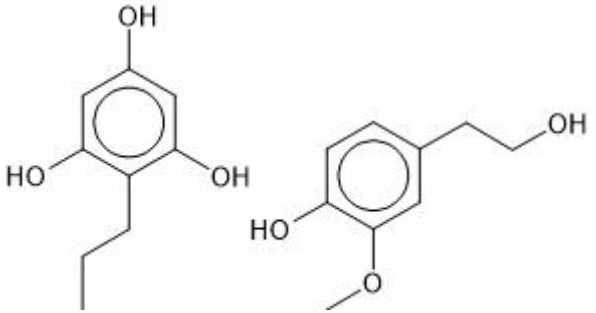
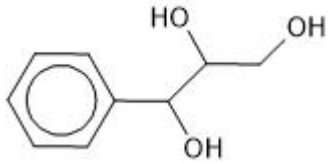
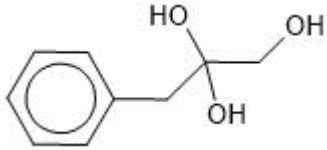
Question Number	Answer	Additional Guidance	Mark
18(c)(ii)	• structure of alanine	<u>Example of diagram</u>  Allow displayed/structural formula COO^{-} / CO_2^{-} charge can be anywhere on functional group Ignore connectivity to the CH_3	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(d)	An answer that makes reference to the following points: • glycine exists as zwitterions / ions containing + and − charges **(1)** • strong ionic forces of attraction/ lots of energy needed to overcome the ionic bonds **(1)**	Accept diagram but if zwitterion and diagram given diagram must be correct Allow just strong ionic bonds If neither mark is awarded, reference to hydrogen bonds/ ion-dipole interactions (between the glycine molecules) scores (1) Ignore London forces, permanent dipole forces.	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(e)	• two correct peptide bonds **(1)** • rest of structure correct **(1)**	<u>Example of diagram</u>  Allow any type of formula (except molecular) or combination. Ignore connectivity of the CH_3/NH_2 but penalise HO Continuation bonds at either end will **not** score M2	**(2)** Choose an item.

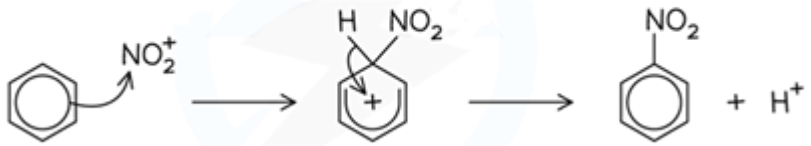
(Total for Question 18 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)	• M1 calculation of moles of H_2O **and** mass of hydrogen in X **(1)** • M2 calculation of moles of CO_2/ moles of C **and** calculation mass of C in X **(1)** • M3 calculation of mass of O in X **and** calculation of moles of O in X **(1)** • M4 calculation to get the empirical formula **(1)** • M5 calculation of molar mass of the empirical formula **(1)** • M6 calculation of the molecular formula **(1)** If no other marks are scored award 1 for moles of H_2O (0.27833) and moles of CO_2 (0.41783)	<u>Example of calculation</u> n = (5.01 ÷ 18 =) 0.27833 (mol) m/n = (0.27833 × 2 =) 0.55667 (g) n = (10028 ÷ 24000 =) 0.41783 (mol) m = (0.41783 × 12 =) 5.014 (g) m = (7.80(g) – 5.014(g) – 0.55667(g) =) 2.2293 (g) n = (2.2293 (g) ÷16 =) 0.13933 (mol) H= 0.55667 ÷ 0.13933 = 3.995 = 4 C = 0.41783 ÷ 0.13933 = 2.999 = 3 O = 0.13933 ÷ 0.13933 = 1 C_3H_4O M = (C_3H_4O =) 56 (g mol^{-1}) M = (168 ÷56 = 3) so $C_9H_{12}O_3$ Correct answer with some correct working scores 6	**(6)**

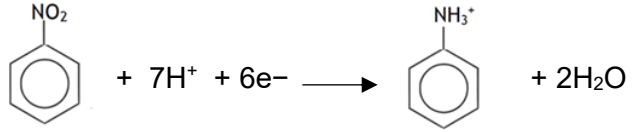
Question Number	Answer	Additional Guidance	Mark
19(b)	An answer that makes reference to the following points: • benzene ring (allow cyclohexene) **(1)** cannot be awarded if there are less than 6 Cs in the formula **(1)** • At least one OH group and the formula is correct  The above diagram will score both marks	<u>Example of diagrams</u>    Allow any arrangement of aliphatic or aromatic OH group(s) Allow up to 2 ethers Allow any number of sidechains in any position as long as the formula is correct	**(2)**

(Total for Question 19 = 8 marks)
TOTAL FOR SECTION B = 50 MARKS

Section C

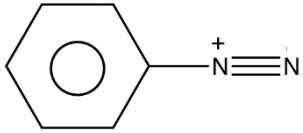
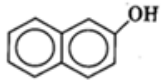
Question Number	Answer	Additional Guidance	Mark
20(a)(i)	An explanation that makes reference to the following points: • formation of the electrophile **(1)**	Example of mechanism $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + NO_2^+ + H_2O$ Allow 2 steps $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + H_2NO_3^+$ $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$	**(5)**
	• curly arrow from the circle to the N of the NO_2^+ **(1)**	 Allow the arrow from anywhere within the hexagon Ignore position of the + charge on the NO_2^+ Only penalise missing charge on NO_2 once in M1 or M2	
	• correct intermediate. The horseshoe should extend at least 3 Cs and be open where the N is attached and a part of the + must be within the horseshoe **(1)**		
	• curly arrow from the bond to the ring and organic product **(1)**		
	• reformation of the catalyst **(1)**	$HSO_4^- + H^+ \rightarrow H_2SO_4$ Allow HSO_4^- reacting with the intermediate to regenerate the catalyst	

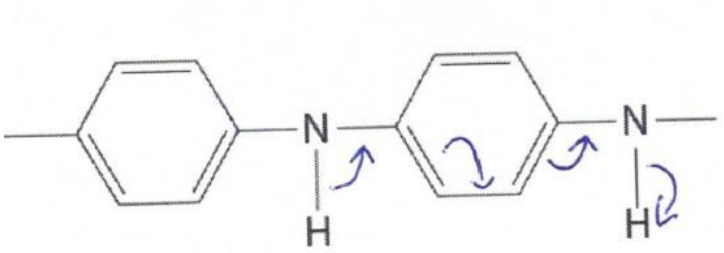
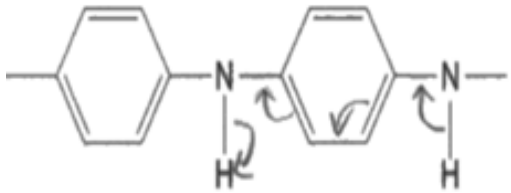
Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	An explanation that makes reference to the following points: • if the temperature is lower the reaction is too slow **(1)** • if the temperature is higher further/more/multiple substitutions take place **(1)**	 Ignore just reaction stops Allow reference to di/tri nitration Ignore side reactions Ignore any reference to explosions Ignore just further reactions Ignore decomposition	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(iii)	An explanation that makes reference to the following points: • correct equation **(1)**	Example of equation $7H^+ + 6e^- \rightarrow 2H_2O$ Allow $9H^+ + 6e^- \rightarrow 2H_3O^+$ 	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(a)(iv)	An answer that makes reference to the following point: • NaOH/ sodium hydroxide	Allow any suitable base If name and formula are given, both must be correct Ignore just OH^- Ignore any reference to concentration	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(a)(v)	• M1 calculation of mass of benzene **(1)** • M2 calculation of moles of benzene **(1)** • M3 calculation of moles of phenylamine **(1)** • M4 calculation of mass of phenylamine **(1)**	<u>Example of calculation</u> m = (0.879 × 5.0 =) 4.395 (g) n = (4.395 ÷ 78 =) 0.05635 (mol) n = (0.05635 × 0.43 × 0.38 =) 9.20696×10^{-3} (mol) m = ($9.20606 \times 10^{-3} \times 93$ =) 0.8562 (g) Ignore SF except 1SF Correct answer with no working scores (4) TE on wrong molar masses	**(4)**

Question Number	Answer		Additional Guidance	Mark
20(b)	An answer that makes reference to the following points:			**(5)**
	• react with HCl and $NaNO_2$	**(1)**	Allow HNO_2 Allow hydrochloric acid and sodium nitrite Allow H^+/H_2SO_4 for HCl	
	• temperature between 0-5 °C	**(1)**	Allow any range or temperature between 0 - 10 °C Do not award stated temps below 0 °C Allow ice bath/ ice and water mixture	
	• correct structure of diazonium ion	**(1)**	 + must be on the left N Ignore Cl^- Do not award N_2^+ attached to the benzene ring	
	• add to 2-naphthol	**(1)**		
	• in an alkaline solution/ NaOH	**(1)**	Allow deprotonated 2-naphthol Ignore temperature Ignore final product	

Question Number	Answer	Additional Guidance	Mark
20(c)	• two correct curly arrows **(1)** • all four correct curly arrows **(1)**	Example of diagram  Or reverse  If more than 4 curly arrows are given use the list principle.	**(2)**

(Total for Question 20 = 20 marks)

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