Mark Scheme (Results)

January 2025

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

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General Marking Guidance

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

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 A** (C_2H_6) ***B*** *is incorrect because CO has a lone pair of electrons which can be donated to the central metal ion* ***C*** *is incorrect because the hydroxide ion has a lone pair of electrons which can be donated to the central metal ion* ***D*** *is incorrect because butylamine has a lone pair of electrons which can be donated to the central metal ion*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is D** (Cu^{2+}) ***A*** *is incorrect because the solution would be pale pink so will not absorb red* ***B*** *is incorrect because the solution would be pink so will not absorb red* ***C*** *is incorrect because the solution would be green so will not absorb green*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is D** (758 1646 3232 4950 7671) ***A*** *is incorrect because there is a big jump in the value between 1st and 2nd electron being removed so it is in Group 1* ***B*** *is incorrect because there is a big jump in the value between 3rd and* 4^{th} *electron being removed so it is in Group 3* ***C*** *is incorrect because there is a big jump in the value between* 2^{nd} *and* 3^{rd} *electron being removed so it is in Group 2*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is A** (blue) ***B*** *is incorrect because the* VO^{2+} *ion is blue not green* ***C*** *is incorrect because the* VO^{2+} *ion is blue not violet* ***D*** *is incorrect because the* VO^{2+} *ion is blue not yellow*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is B** (CO and NO are absorbed by the catalyst) ***A*** *is incorrect because the catalyst contains platinum* ***C*** *is incorrect because after the reaction, desorption of* CO_2 *and* N_2 *takes place* ***D*** *is incorrect because it is a heterogeneous catalytic reaction*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is B** (gold and titanium) ***A*** *is incorrect because scandium is not a transition metal* ***C*** *is incorrect because neither scandium nor zinc are transition metals* ***D*** *is incorrect because zinc is not a transition metal*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** (tetrahedral and square planar) ***A*** *is incorrect because* $[CuCl_4]^{2-}$ *is tetrahedral* ***B*** *is incorrect because* $[CuCl_4]^{2-}$ *is tetrahedral and* $Pt(NH_3)_2Cl_2$ *is square planar* ***D*** *is incorrect because* $Pt(NH_3)_2Cl_2$ *is square planar*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is B** (E^{o}_{cell} is proportional to $\ln K$ and ΔS_{total}) ***A*** *is incorrect because* E^{o}_{cell} is *not proportional to* $ln\,\Delta S_{total}$ ***C*** *is incorrect because* $ln\,E^{o}_{cell}$ is *not proportional to* K ***D*** *is incorrect because* E^{o}_{cell} is *not proportional to* $\Delta S_{surrounding}$	**(1)**

Question Number	Answer	Mark
9(a)	**The only correct answer is A** ($C_6H_5NH_2$ and $NaNO_2$) ***B*** *is incorrect because* $C_6H_5NO_2$ *will not react in this way* ***C*** *is incorrect because* $C_6H_5NO_2$ *will not react in this way and the nitrate should be nitrite* ***D*** *is incorrect because the nitrate should be nitrite*	**(1)**

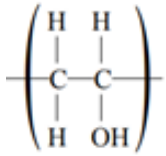
Question Number	Answer	Mark
9(b)	**The only correct answer is D** (phenol dissolved in an alkaline solution at 5°C) ***A*** *is incorrect because the reaction will not take place in acid and the temperature is too high* ***B*** *is incorrect because the temperature is too high* ***C*** *is incorrect because the reaction will not take place in acid*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is C** (dissolve in the minimum volume of hot solvent, filter to remove the insoluble impurities, then cool and filter to remove the soluble impurities) ***A*** *is incorrect because the hot solvent should be used first* ***B*** *incorrect because there is no cold filtering* ***D*** *is incorrect because the first filtration removes the insoluble impurities and the second filtration removes the soluble impurities*	**(1)**

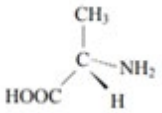
Question Number	Answer	Mark
11	**The only correct answer is B** (27.0 g) ***A*** *is incorrect because the mass of phenol has been multiplied by 0.8 and 0.75* ***C*** *is incorrect because only the yield in the second step has been used* ***D*** *is incorrect because only the yield in the first step has been used*	**(1)**

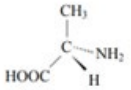
Question Number	Answer	Mark
12	**The only correct answer is D** (C_6H_{12}) ***A*** *is incorrect because this is an empirical not molecular formula* ***B*** *is incorrect because the molar mass of H_2 has been used instead of H* ***C*** *is incorrect because this is the closest formula using the ratio of mass of compound to mass of carbon dioxide*	**(1)**

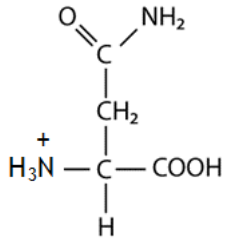
Question Number	Answer	Mark
13	**The only correct answer is A** (15.6 and 9.6) ***B*** *is incorrect because 0.5 moles of O_2 has been used not 0.65* ***C*** *is incorrect because 0.9 moles of O_2 has been used not 0.65 and the moles of C_4H_{10} have not been multiplied by 4* ***D*** *is incorrect because the volume of gaseous H_2O has been used not CO_2*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is B**  ***A*** *is incorrect because (poly)ethenol only has one OH in each repeat unit* ***C*** *is incorrect because (poly)ethenol only has one OH in each repeat unit* ***D*** *is incorrect because (poly)ethenol only has one OH in each repeat unit*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is A** ($H_2N(CH_2)_6NH_2$ and $HOOC(CH_2)_4COOH$) ***B*** *is incorrect because nitriles will not react in this way* ***C*** *is incorrect because these monomers will not make this polymer* ***D*** *is incorrect because the OH group will not react with the amine group*	**(1)**

Question Number	Answer	Mark
16(a)	**The only correct answer is C** **(** compound Y **)**  *__A__ is incorrect because it is not an amino acid* *__B__ is incorrect because it is not optically active* *__D__ is incorrect because it is not optically active*	**(1)**

Question Number	Answer	Mark
16(b)	**The only correct answer is C** (compound Y)  *__A__ is incorrect because it would give 3 proton NMR peaks and 3 ^{13}C peaks* *__B__ is incorrect because it would give 3 proton NMR peaks and 3 ^{13}C peaks* *__D__ is incorrect because it would give 3 proton NMR peaks and 3 ^{13}C peaks*	**(1)**

Question Number	Answer	Mark
17(a)	**The only correct answer is D**  *A is incorrect because the amine group has not been protonated* ***B*** *is incorrect because this is the zwitterion and would not be present at pH 2* ***C*** *is incorrect because the amide oxygen would not be protonated*	**(1)**

Question Number	Answer	Mark
17(b)	**The only correct answer is B** (doublet) *A is incorrect because on the adjacent C there is only one H so it would produce a doublet* ***C*** *is incorrect because on the adjacent C there is only one H so it would produce a doublet* ***D*** *is incorrect because on the adjacent C there is only one H so it would produce a doublet*	**(1)**

Section B

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	An answer that makes reference to the following points: • **A** (saturated/concentrated solution of) potassium nitrate / KNO_3 **(1)** • **B** platinum /Pt **(1)** • **C** (solution containing) iron(II) sulfate / $FeSO_4$ **and** iron(III) sulfate / $Fe_2(SO_4)_3$ **(1)** • concentration 1 mol dm^{-3}/ 1M with respect to Fe^{2+} **and** Fe^{3+} or 1 mol dm^{-3} of $FeSO_4$ **and** 0.5 mol dm^{-3} $Fe_2(SO_4)_3$ **(1)**	Allow sodium nitrate / $NaNO_3$/ sodium chloride / NaCl/potassium chloride/KCl Allow black Pt Accept iron nitrates and chlorides Allow just Fe^{2+} **and** Fe^{3+} If name and formula are given both must be correct but only penalise once. One ion and its correct concentration this will score 1 mark. Ignore any reference to pressure Ignore any state symbols	**(4)**

Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	An answer that makes reference to the following point: • ions can flow through a salt bridge (but not through a wire)	Allow the ions can move/pass Allow ions cannot flow through the wire Ignore to balance the ions Ignore wire will interfere with the reaction/products/cell Do not award electrons can flow through the salt bridge ions can travel through the wire	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(b)	An answer that makes reference to the following points: • correct species **(1)** • correct direction and balancing **(1)**	<u>Example of equation</u> $Zn + 2Fe^{3+} \longrightarrow Zn^{2+} + 2Fe^{2+}$ Ignore state symbols even if incorrect Allow ⇌ if Zn is on the LHS Penalise uncanceled species, including Pt only once	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(c)	An answer that makes reference to the following points: • the $E^{\ominus}_{cell}$ would increase/ become more positive **(1)** • $Zn^{2+}(aq) + 2\ e^- \rightleftharpoons Zn(s)$ equilibrium would shift to the LHS making the Zn^{2+}: Zn cell more negative (and so increasing the $E^{\ominus}_{cell}$) **(1)** **Or** as Zn^{2+} concentration has decreased the reaction $Zn + 2Fe^{3+} \rightarrow Zn^{2+} + 2Fe^{2+}$ will move to the right	Standalone marks Allow just (Zn cell) eqm shift to the left making it more negative Allow less positive/smaller	**(2)**

Question Number	Answer		Additional Guidance	Mark
19	An explanation that makes reference to the following points:			**(6)**
	• Step **1** $LiAlH_4$/lithium aluminium hydride/ lithium tetrahydridoaluminate **and** (dry) ether	**(1)**	Allow lithal Do not award $NaBH_4$	
	• Step **2** KBr and conc H_2SO_4 or HBr or PBr_3 / I_2 and (red) P or PI_3 or HI / PCl_5 or PCl_3	**(1)**	Accept phosphoric(V) acid for sulfuric acid Allow ≥ 50% for conc Allow HCl	
	• compound X bromoethane / C_2H_5Br iodoethane / C_2H_5I chloroethane / C_2H_5Cl	**(1)**	Dependent on the reagent used in step 2. Allow any type of formula	
	• Step **3** magnesium **and** (dry) ether	**(1)**	Do not award if other reagents are added	
	• Grignard reagent	**(1)**	CH_3CH_2MgX/ CH_3CH_2-Mg-X Do not award CH_3CH_2XMg Dependent on compound **X**	
	• Step 4 dry ice/carbon dioxide/CO_2 (and then hydrolyse using an acid/water)	**(1)**	Allow CO_2 and H^+/acid No TE Ignore refluxing/any temperature throughout	

Question Number	Answer	Additional Guidance	Mark
20(a)(i)	An answer that makes reference to the following points: • equation with correct species **(1)** • balanced **(1)**	<u>Example of equation</u> $2Cr^{3+} + 3H_2O_2 + H_2O \longrightarrow Cr_2O_7^{2-} + 8H^+$ Allow ⇌ Allow multiples Allow 1 mark for the correct equation with additional uncanceled H^+, H_2O and electrons.	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	An answer that makes reference to the following points: suitable metal • Mg / V / Zn / Fe / Ni / Cu **(1)** correct $E^{\ominus}$ cell • Mg = (+) 3.7 (V), V = (+) 2.51(V), Zn = (+) 2.09(V), Fe = (+)1.77(V), Ni = (+) 1.58 (V), Cu = (+) 0.99 (V) **(1)**	No other metals will score and no TE on other metals	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(iii)	An answer that makes reference to the following points: • $[Cr(NH_3)_6]^{3+}$ **(1)** • ligand exchange **(1)**	 Ignore omission of square brackets Ignore (aq) Allow ligand substitution / replacement	**(2)**

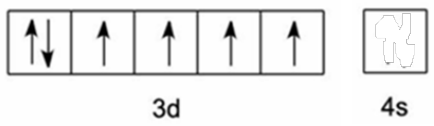
Question Number	Answer	Additional Guidance	Mark
20(a)(iv)	An answer that makes reference to the following points: • not redox because the oxidation number of chromium has not changed **(1)** • oxidation number is 6/+6/6+/VI in both $Cr_2O_7^{2-}$ and CrO_4^{2-} **(1)**	 Allow just 'no as the oxidation number of chromium has not changed'	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(i)	An answer that makes reference to the following point: • $KCr(SO_4)_2$	 Allow ions in any order Ignore correct charges on some/all of the ions	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	• M1 calculation of molar mass of $KCr(SO_4)_2$ **(1)** • M2 moles of $KCr(SO_4)_2$ **(1)** • M3 moles of water **(1)** • M4 calculation of no of moles of water of crystallisation **(1)** An alternative route using mass • M2 = 283.3 ÷ 56.74 × 100 = 499.3 (g) • M3 = 499.3 – 283.3 ÷ = 216 (g) • M4 = 216 ÷ 18 = 12	Example of calculation 39.1+ 52 + (32.1 × 2) + (16 × 8) = 283.3 ($g\ mol^{-3}$) Allow TE from formula in (b)(i) 56.74 ÷ 283.3 = 0.200 (mol) Allow TE from M1 (100 −56.74)(= 43.26) ÷ 18 = 2.403 (mol) Allow fractions 2.403 ÷ 0.200 = 12 Correct answer with some working scores 4	**(4)**

Question Number	Answer	Additional Guidance	Mark
20(c)(i)	• calculation of g dm^{-3} **(1)** • calculation of g cm^{-3} **and** calculation of ppb **(1)** Or • calculation of mol cm^{-3} **(1)** • calculation of g cm^{-3} **and** calculation of ppb **(1)** Other units can be used provided they are consistent and a comparison made. 699.4 (ppm) exceeds 400 (ppm) 6.994×10^{-9} (g cm^{-3}) exceeds $4.00\ 10^{-9}$ (g cm^{-3}) Alternative comparison using mol dm^{-3} • $4 \times 10^{-9} \div 52 = 7.692\ 10^{-11}$ mol dm^{-3} **(1)** • $7.692\ 10^{-11} \times 1000 = 7.692\ 10^{-8}$ which is smaller than 1.345×10^{-7} mol dm^{-3} **(1)**	<u>Example of calculation</u> 1.345×10^{-7} (mol dm^{-3}) $\times$ 52.0 = 6.994×10^{-6} (g dm^{-3}) 6.994×10^{-6} (g dm^{-3}) $\div 10^{3} = 6.994 \times 10^{-9}$ $= 6.994 \times 10^{-9} \times 10^{9} = 6.994$ (ppb) (which is greater than 4 ppb) 1.345×10^{-7} (mol dm^{-3}) $\div 10^{3} = 1.345 \times 10^{-10}$ $1.345 \times 10^{-10} \times 52.0 = 6.994 \times 10^{-9}$ $= 6.994 \times 10^{-9} \times 10^{9} = 6.994$ (ppb) (which is greater than 4 ppb) Ignore SF Correct answer with no working scores 2	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(c)(ii)	An answer that makes reference to the following points: • ($EDTA^{4-}$) is a hexadentate ligand/can form 6 dative (covalent) bonds/multiple dative (covalent) bonds with the Cr^{3+} **(1)** • ($EDTA^{4-}$) **complex** is more stable than (bidentate complexes)/ is a chelating agent/ traps the Cr^{3+}/can wrap around the Cr^{3+} (so the Cr^{3+} can be removed from the blood) **(1)**	Allow multidentate/ polydentate Allow coordinate bonds Ignore just you need fewer $EDTA^{4-}$ ions than diaminoethane molecules Allow leads to a (large) increase in total entropy/entropy of the system Allow there is an increase in disorder Ignore just $EDTA^{4-}$ is more stable	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(a)(i)	An answer that makes reference to the following point: • Fe^{2+} [Ar] 	The electrons in the doubled orbit must be pointing in opposite directions. They can be in any of the 3d orbitals. Allow half headed arrows or a combination of both	(1)

Question Number	Answer	Mark	Additional Guidance
21(a)(ii)	An answer that makes reference to the following points:	(3)	
	• (the oxygen in the air) oxidises the Fe^{2+}	(1)	Allow it is oxidised Ignore reacts with oxygen
	• (forming the brown) Fe^{3+}	(1)	Allow iron(III) sulfate forms Allow any mention of Fe^{3+}
	• Fe^{3+} is more stable (than Fe^{2+}) due to half-filled *d*-subshell/ due to half full (*d*) orbitals	(1)	Allow reverse argument Fe^{2+} has a pair of electrons in one orbital that repel each other and so an electron is easily lost Or pair of electrons in one orbital that repel each other and so it is less stable Ignore a half-filled *d* orbital Ignore half-filled d shell

Question Number	Answer	Additional Guidance	Mark
21(b)	• M1 calculation of moles of MnO_4^- in the titre **(1)** • M2 calculation of moles of Fe^{2+} in 25 cm^3 of solution **(1)** • M3 calculation of moles of Fe^{2+} in 250 cm^3 of solution **(1)** • M4 calculation of mass of $FeSO_4$ in 250 cm^3 of solution **(1)** • M5 calculation of % $FeSO_4$ in the moss killer **(1)** M6 answer to 2 or 3 SF **(1)** Marks are for the processes are shown and they may be in a different order M2 = × 5 M3 = × 10 M4 = × 151.9 M5 = ÷ 6.42 × 100	<u>Example of calculation</u> $17.70 \times 0.00740 \div 1000 = 1.3098 \times 10^{-4}$ / 0.00013098 (mol) $1.3098 \times 10^{-4} / 0.00013098 \times 5 = 6.549 \times 10^{-4}$ /0.0006549 (mol) $6.549 \times 10^{-4} \times 10 = 6.549 \times 10^{-3}$ /0.006549 (mol) $6.549 \times 10^{-3} \times 151.9 = 0.99479$(g) $0.99479 \div 6.42 \times 100 = 15.495$ (%) 15.5 (%)/15(%) This is not a standalone mark it can only be awarded if there has been an attempt to calculate a % Ignore intermediate rounding and incorrect truncating TE throughout The correct answer with or without working scores 6	**(6)**

Question Number	Answer	Additional Guidance	Mark
21(c)	An answer that makes reference to the following points: • the iron(II) ions are surrounded by water ligands/exist as an aqua complex **(1)** • which are polarised by the iron(II) ions so lose protons (to water molecules) **(1)**	Allow $[Fe(H_2O)_6]^{2+}$ Allow just protons are lost/ deprotonation takes place Allow any balanced equation showing deprotonation $[Fe(H_2O)_6]^{2+} \rightarrow [Fe(H_2O)_5OH]^{+} + H^{+}$ M2 is dependent on M1 or near miss as it must be clear that the protons are coming from the complex	**(2)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*22</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>

Indicative content
</td>
<td>
Guidance on how the mark scheme should be applied.

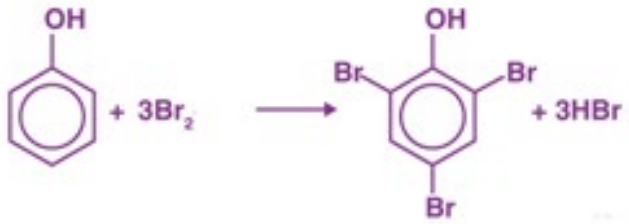
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some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

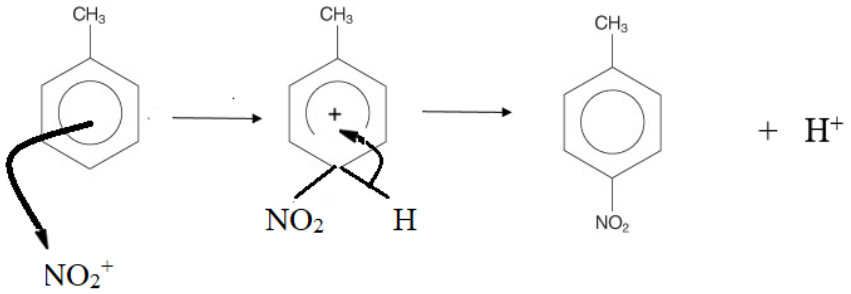
Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning
</td>
<td>(6)</td>
</tr>
</table>

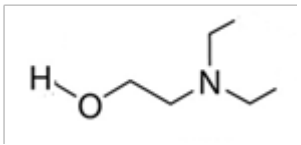
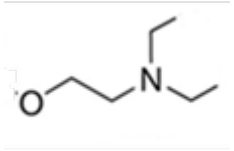
	Similarity • **IP1** both reactions are electrophilic substitution **Differences** • **IP2** $C_6H_6 + Br_2 \longrightarrow C_6H_5Br + HBr$ • **IP3**  • **IP4** benzene requires a named catalyst e.g $AlBr_3$/ $FeBr_3$ (and heat) • **IP5** phenol reacts with bromine water/ phenol reacts (with bromine) at room temperature • **IP6** phenol is more reactive because the lone pair of electrons on the oxygen atom (the lone pair on the OH will not score) are delocalised into the ring (making phenol more susceptible to electrophilic attack)	Allow $C_6H_6 + Br^+ \longrightarrow C_6H_5Br + H^+$ Can be shown by a correct mechanism Allow $C_6H_5OH + 3Br_2 \longrightarrow C_6H_2Br_3OH + 3HBr$ Ignore state symbols Two correct aromatic products identified regardless of the equations will score **ONE** IP for IP2 and IP3. If name and formula are given both must be correct. Allow $AlCl_3$/ Fe + Br_2 This can be shown via an equation Do not award bromine water Allow phenol reacts with bromine without a catalyst Ignore milder conditions Ignore just quicker/ easier to react Allow any indication that the lone pair on the O of the phenol becomes delocalised within the ring Ignore the electron pair on the OH becomes delocalised within the ring	

Section C

Question Number	Answer	Additional Guidance	Mark
23(a)	An answer that makes reference to the following point: • correct formula	 $C_{13}H_{20}N_2O_2$ Allow any order and non-subscripts	**(1)**

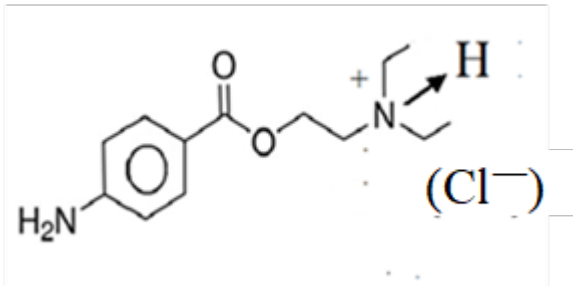
Question Number	Answer	Additional Guidance	Mark
23(b)(i)	An answer that makes reference to the following points: • CH_3Cl/ chloromethane **(1)** • $AlCl_3$ **(1)**	Standalone marks Allow CH_3Br/ bromomethane /CH_3l /iodomethane Allow $AlBr_3$ / $FeBr_3$ / $FeCl_3$	**(2)**

Question Number	Answer	Additional Guidance	Mark
23(b)(ii)	A description that makes reference to the following points: • equation to show the formation of the electrophile **(1)** • curly arrow from anywhere on the central ring to positive nitrogen **(1)** • structure of intermediate **(1)** • curly arrow from C-H bond to reform the ring **(1)** • equation showing regeneration of catalyst **(1)** Example of mechanism  	$HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$ Or $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$ Or $HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$ and $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$ Allow curly arrow from anywhere in the hexagon Do not award if the arrow is heading to the O Horseshoe facing the bottom tetrahedral carbon and covering at least three carbon atoms. Some part of the positive charge in the horseshoe $HSO_4^- + H^+ \rightarrow H_2SO_4$ Allow M5 as part of mechanism, with curly arrow from oxygen of HSO_4^- to H on benzene ring If the NO_2 is attached in a different position penalise M3 only. Likewise, if benzene is used M3 is penalised.	**(5)**

Question Number	Answer	Additional Guidance	Mark
23(b)(iii)	An answer that makes reference to the following points: • esterification **(1)** •  **(1)**	Allow addition- elimination Allow condensation Do not award condensation polymerisation Do not award  Accept HO for H-O Allow displayed /structural formulae Do not award molecular formula Penalise -H-O connectivity	**(2)**

Question Number	Answer	Additional Guidance	Mark
23(b)(iv)	An answer that makes reference to the following point: • Sn/tin **and** (concentrated) HCl/ hydrochloric acid	Ignore tin is a catalyst Do not award dilute HCl	**(1)**

Question Number	Answer	Additional Guidance	Mark
23(c)(i)	A description that makes reference to the following points: • alkyl groups attached (to the N) are electron releasing/ donating **(1)** • benzene ring attached (to the N) is electron withdrawing/ lone pair gets incorporated into (the delocalised electrons of) the benzene ring **(1)** • the basicity of the alkyl N is greater because the lone pair is more available to accept/attract a proton/form a dative covalent bond Or the basicity of the N attached to the benzene ring is weaker as the lone pair is less available to accept/attract a proton **(1)**	Allow positively inductive for electron releasing Allow basicity greater due to higher electron density (on the alkyl N) Allow basicity greater as it forms stronger bonds with proton Allow basicity lower due to lower electron density (on the aryl N) Allow basicity lower as it forms weaker bonds with proton	**(3)**

Question Number	Answer	Additional Guidance	Mark
23(c)(ii)	A description that makes reference to the following points:  	Allow just NH^+ with no covalent bond Allow normal covalent bond Allow + charge anywhere adjacent to the NH or the NH_3 or outside brackets if drawn Ignore lack or position of Cl^- Allow HCl added to the other NH_2 if in (c)(i) the NH_2 is thought to be more basic Allow HCl added to any N if they have not said which is more basic in (c)(i)	**(1)**

Question Number	Answer	Additional Guidance	Mark
23(c)(iii)	An answer that makes reference to the following points: • procaine hydrogen chloride is ionic **(1)** • the ions are hydrated by the water (and the compound is more soluble) **(1)**	Allow ion-dipole interaction Ignore reference to any type of intermolecular bonds	**(2)**

Question Number	Answer		Additional Guidance	Mark
23(d)	• mass of lidocaine in 1.5 cm^3	**(1)**	<u>Example of calculation</u> $(1.5 \div 2.2) \times 0.044$ (g) = 0.03 / 3 $x10^{-2}$ (g)	**(3)**
	• mol of lidocaine in 1.5 cm^3	**(1)**	0.03 (g) ÷ 234 = 1.2821×10^{-4} / 0.00012821 (mol)	
	• molecules of lidocaine in 1.5 cm^3	**(1)**	$1.2821 \times 10^{-4} \times 6.02 \times 10^{23} = 7.7179 \times 10^{19}$	
	Alternative 1 • mol of lidocaine in 2.2 cm^3 cartridge.	**(1)**	$0.044 \div 234 = 1.88 \times 10^{-4}$/ 0.00188 (mol)	
	• mol of lidocaine in 1.5 cm^3	**(1)**	$1.88 \times 10^{-4} \times 1.5 \div 2.2 == 1.282 \times 10^{-4}$ (mol)	
	• molecules of lidocaine in 1.5 cm^3	**(1)**	$1.2821 \times 10^{-4} \times 6.02 \times 10^{23} = 7.7179 \times 10^{19}$	
	Alternative 2 • mol of lidocaine in 2.2 cm^3 cartridge.	**(1)**	$0.044 \div 234 = 1.88 \times 10^{-4}$/ 0.000188 (mol)	
	• molecules of lidocaine in 2.2 cm^3 cartridge	**(1)**	$1.88 \times 10^{-4} \times 6.02 \times 10^{23} = 1.13176 \times 10^{20}$	
	• molecules of lidocaine in 1.5 cm^3	**(1)**	$1.13176 \times 10^{20} \times 1.5 \div 2.2 = 7.7179 \times 10^{19}$	
			Ignore intermediate rounding Ignore SF except 1SF in final answer Correct answer with or without working scores 3	

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