GradeMax

Pearson

Mark Scheme (Results)

Summer 2026

Pearson Edexcel International Advanced Level In Chemistry
WCH15/01

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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** (oxidised at the negative electrode) ***B*** *is incorrect because the oxidation occurs at the negative electrode* ***C*** *is incorrect because the reaction is an oxidation* ***D*** *is incorrect because the reaction is an oxidation and occurs at the negative electrode*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is C** (only **2** and **3** are correct) ***A*** *is incorrect because haemoglobin is an iron(II) complex* ***B*** *is incorrect because haemoglobin is an iron(II) complex and carbon monoxide replaces oxygen in haemoglobin by ligand exchange* ***D*** *is incorrect because haemoglobin does contain a polydentate ligand*	**(1)**

Question Number	Answer	Mark
3(a)	**The only correct answer is D** (Ni^{2+}) ***A*** *is incorrect because* Cr^{3+} *produces a green precipitate which does not redissolve in excess ammonia* ***B*** *is incorrect because* Cu^{2+} *would produce a blue precipitate* ***C*** *is incorrect because* Fe^{2+} *produces a green precipitate which does not redissolve in excess ammonia*	**(1)**

Question Number	Answer	Mark
3(b)	**The only correct answer is D** (the total number of particles on the right-hand side of the equation is greater than on the left-hand side) ***A*** *is incorrect because the bonds between the transition metal ion and the ligands are of similar strength* ***B*** *is incorrect because the reaction is not extremely exothermic* ***C*** *is incorrect because the activation energy affects the rate of the reaction and not the extent of the reaction*	**(1)**

Question Number	Answer	Mark
3(c)	**The only correct answer is A (90º)** **B is incorrect because the complex is octahedral so the angle is not 107º** **C is incorrect because the complex is octahedral so the angle is not 109.5º** **D is incorrect because the complex is octahedral so the angle is not 120º**	**(1)**

Question Number	Answer	Mark
4(a)	**The only correct answer is D** (6 6) ***A*** *is incorrect because +2 is the oxidation number of copper in each complex* ***B*** *is incorrect because these are the numerical values of the charges on the complex* ***C*** *is incorrect because these are the numbers of ligands in the complex*	**(1)**

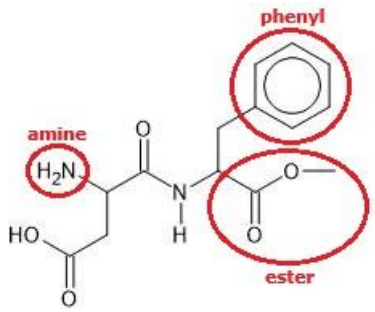
Question Number	Answer	Mark
4(b)	**The only correct answer is D** (octahedral tetrahedral) ***A*** *is incorrect because hexaquacopper(II),* $[Cu(H_2O)_6]^{2+}$*, is octahedral and tetrachlorocuprate(II),* $[CuCl_4]^{2-}$*, is tetrahedral* ***B*** *is incorrect because hexaquacopper(II),* $[Cu(H_2O)_6]^{2+}$*, is octahedral* ***C*** *is incorrect because tetrachlorocuprate(II),* $[CuCl_4]^{2-}$*, is tetrahedral*	**(1)**

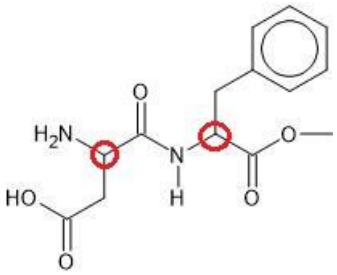
Question Number	Answer	Mark
5(a)	**The only correct answer is B** ($(CH_3)_2CHCH_2MgBr$) ***A*** *is incorrect because this reaction would make 1-phenylpentan-1-ol* ***C*** *is incorrect because this reaction would make 2-methyl-1-phenylbutan-1-ol* ***D*** *is incorrect because this reaction would make 2,2-dimethyl-1-phenylpropan-1-ol*	**(1)**

Question Number	Answer	Mark
5(b)	**The only correct answer is B** (nucleophilic addition) ***A*** *is incorrect because the carbonyl group does not react with electrophiles* ***C*** *is incorrect because the carbonyl group does not react with electrophiles nor undergoes substitution* ***D*** *is incorrect because the carbonyl group does not undergo substitution*	**(1)**

Question Number	Answer	Mark
6(a)	**The only correct answer is D** (1700 – 1630 cm^{-1}) ***A*** *is incorrect because this is the N-H stretch of the amine group* ***B*** *is incorrect because this is the C-H stretch of alkane groups* ***C*** *is incorrect because this is the C=O stretch of the carboxylic acid group*	**(1)**

Question Number	Answer	Mark
6(b)	**The only correct answer is D** (quintet (multiplet of five) triplet) ***A*** *is incorrect because* H^X *has four hydrogens on adjacent carbons so would be expected to be a quintet and* H^Y *has two hydrogens on adjacent carbons so would be expected to be a triplet* ***B*** *is incorrect because* H^X *has four hydrogens on adjacent carbons so would be expected to be a quintet* ***C*** *is incorrect because* H^Y *has two hydrogens on adjacent carbons so would be expected to be a triplet*	**(1)**

Question Number	Answer	Mark
7(a)	**The only correct answer is C** (ketone) ***A*** *is incorrect because the amine functional group is present as shown* ***B*** *is incorrect because the ester functional group is present as shown* ***D*** *is incorrect because the phenyl functional group is present as shown* 	**(1)**

Question Number	Answer	Mark
7(b)	**The only correct answer is C** (two) ***A*** *is incorrect because there are two chiral carbon atoms as shown* ***B*** *is incorrect because there are two chiral carbon atoms as shown* ***D*** *is incorrect because there are two chiral carbon atoms as shown* 	**(1)**

Question Number	Answer	Mark
8(a)	**The only correct answer is A** (49.99 g) ***B*** *is incorrect because this mass would give a 2 mol* dm^{-3} *solution of iron(III)* ***C*** *is incorrect because this mass would be the correct mass to dissolve if 1* dm^3 *of solution was used* ***D*** *is incorrect because this mass is the relative formula mass of iron(III) sulfate*	**(1)**

Question Number	Answer	Mark
8(b)	**The only correct answer is D** (chromium(II) ions act as a reducing agent and iron(III) ions are reduced) ***A*** *is incorrect because the chromium(II) ions act as a reducing agent and the iron(III) ions are reduced* ***B*** *is incorrect because the iron(III) ions are reduced* ***C*** *is incorrect because the chromium(II) ions act as a reducing agent*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is B** (mass spectrometry) ***A*** *is incorrect because infrared spectroscopy provides evidence for the delocalised model for the structure of benzene* ***C*** *is incorrect because thermochemistry provides evidence for the delocalised model for the structure of benzene* ***D*** *is incorrect because X-ray diffraction provides evidence for the delocalised model for the structure of benzene*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is B** (p – p π) ***A*** *is incorrect because a π bond is formed* ***C*** *is incorrect because the orbitals which overlap are p-orbitals and a π bond is formed* ***D*** *is incorrect because the orbitals which overlap are p-orbitals*	**(1)**

Question Number	Answer	Mark
11(a)	**The only correct answer is B** (8.8 g) ***A*** *is incorrect because 7.1 g is the value if the ratio of molecular masses are inverted* ***C*** *is incorrect because 10.7 g is the value if the ratio of molecular masses are inverted and the yield is 100%* ***D*** *is incorrect because 13.3 g is the value if the yield is 100%*	**(1)**

Question Number	Answer	Mark
11(b)	**The only correct answer is C** (57%) ***A*** *is incorrect because this is the ratio of the molar masses of the reactant and product multiplied by half of the yield of step 1* ***B*** *is incorrect because this is the ratio of the molar masses of the reactant and product multiplied by the yield of step 1* ***D*** *is incorrect because this is the yield of the first step only*	**(1)**

Question Number	Answer	Mark
11(c)	**The only correct answer is A** (concentrated H_2SO_4 and concentrated HNO_3) ***B*** *is incorrect because concentrated hydrochloric acid does not produce a* NO_2^+ *ion with nitric acid* ***C*** *is incorrect because this is not the reagent for this reaction* ***D*** *is incorrect because these are the reagents to form a diazonium ion*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
12(a)	An answer that makes reference to the following point: • vanadium(II) ion electronic structure **(1)** • zinc atom electronic structure **(1)**	 V^{2+}: $(1s^2\ 2s^2\ 2p^6)\ 3s^2\ 3p^6\ 3d^3$ Zn: $(1s^2\ 2s^2\ 2p^6)\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$	**(2)**

Question Number	Answer	Additional Guidance	Mark
12(b)(i)	An explanation that makes reference to the following points: • there is no large jump between successive ionisation energies **(1)** • because the **4s** and **3d** sub-shells / electrons have similar energy levels or because the energy released when forming a complex ion / the ion being hydrated by water overcomes the (small) increase in ionisation energy **(1)**	 Allow reference to the ionisation energies are similar Reference to similarity of 4s and 3d required Allow orbital(s) for subshell Do not award shell for sub-shell	**(2)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>12(b)(ii)</td><td>An answer that makes reference to the following points:

• all 6 correct = 2

• 3–5 correct = 1</td><td><table><tr><th>Oxidation number of vanadium</th><th>Formula of the ion</th><th>Colour of ion</th></tr><tr><td></td><td></td><td></td></tr><tr><td>+4</td><td>VO^{2+}</td><td>blue</td></tr><tr><td>+3</td><td>V^{3+}</td><td>green</td></tr><tr><td>+2</td><td>V^{2+}</td><td>violet</td></tr></table></td><td>(2)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>12(b)(iii)</td><td>An explanation that makes reference to the following points:

• (water) ligands cause the d orbitals to split (2 in an upper group and 3 in the lower) (1)

• (visible) light / photons is absorbed promoting an electron from the lower to the higher energy level / causing d-d transition (1)

• light not absorbed is reflected or transmitted / the complementary colour is seen (1)</td><td>Do not award reference to a singular orbital – must be plural
Do not award 4d / 5d etc

Do not award reference to electrons ‘falling back down’ from an excited state
Ignore ‘colour’ is absorbed

Allow unabsorbed for not absorbed
Do not award light emitted</td><td>(3)</td></tr>
</table>

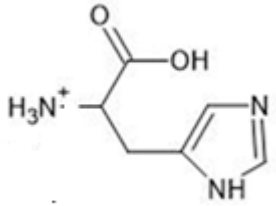
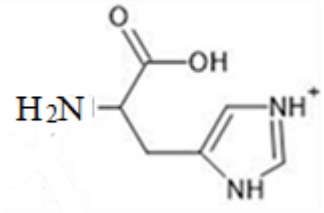
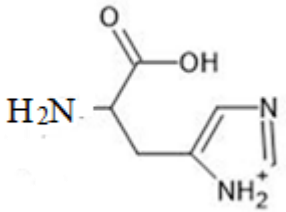
Question Number	Answer	Additional Guidance	Mark
12(b)(iv)	An answer that makes reference to the following point: • (as V^{2+} is violet) the light absorbed is yellow	Allow reference to yellow being the colour which is opposite to violet in the colour wheel Allow violet and yellow are complementary colours Allow wavelength / frequency for light Ignore reference to light emitted Do not award additional colours listed as absorbed	**(1)**

Question Number	Answer	Additional Guidance	Mark
12(c)	An answer that makes reference to the following points: • colourless **(1)** • Zn^{2+} has a full (3) **d** sub-shell (so electrons cannot be promoted) **(1)**	Allow no colour Allow all the 3d orbitals are full / every 3d orbital is full Ignore just $3d^{10}$ Do not award d shell Do not award the Zn 3d sub-shell cannot be split	**(2)**

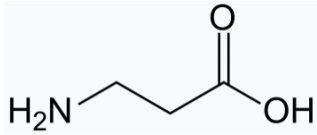
(Total for Question 12 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
13(a)(i)	An answer that makes reference to the following point: • $C_6H_9N_3O_2$	 Allow elements in any order Do not award the COOH group written separately ie $C_5H_8N_3COOH$	**(1)**

Question Number	Answer	Additional Guidance	Mark
13(a)(ii)	• calculation of the molecular mass **(1)** • calculation of percentage of two elements **(1)** • calculation of percentage of the other two elements **(1)**	<u>Example of calculation</u> $(12 \times 6) + (1 \times 9) + (14 \times 3) + (16 \times 2) = 155$ Allow TE on (a)(i) Percentage of carbon = $(12 \times 6) \div 155 \times 100 = 46.5\%$ Percentage of hydrogen = $(1 \times 9) \div 155 \times 100 = 5.8\%$ Percentage of nitrogen = $(14 \times 3) \div 155 \times 100 = 27.1\%$ Percentage of oxygen = $(16 \times 2) \div 155 \times 100 = 20.6\%$ Allow TE on M1 Correct answers with no working scores (3) Penalise use of atomic number in place of relative atomic mass once only Penalise incorrect rounding / truncation once only Ignore SF	**(3)**

Question Number	Answer	Additional Guidance	Mark
13(b)	• structure of protonated histidine	Examples of structure Allow 1, 2, or 3 nitrogen atoms protonated + sign anywhere on the NH group Ignore presence or absence of hydrogen ions Do not award any other groups protonated / deprotonated Do not award use of H_2    	**(1)**

Question Number	Answer	Additional Guidance	Mark
13(c)	An explanation that makes reference to the following points: • because (as a solid) histidine exists as zwitterions **(1)** • which are held together by strong ionic bonds / strong ionic interactions or a large amount of energy is needed to overcome the ionic bonds **(1)**	Allow ions containing + and − charges for zwitterion If no other mark awarded then score one for: histidine forms **more** hydrogen bonds (than octanoic acid) or the nitrogen atoms in histidine can form hydrogen bonds	**(2)**

Question Number	Answer	Additional Guidance	Mark
13(d)(i)	• skeletal diagram of β-alanine	 Ignore bonds lengths and angles Penalise incorrect horizontal connectivity of the OH and NH_2 groups	**(1)**

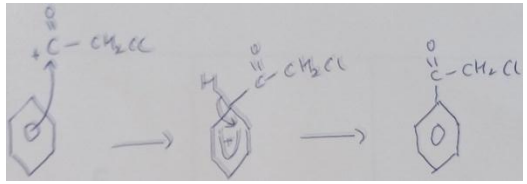
Question Number	Answer	Additional Guidance	Mark
13(d)(ii)	• mass in 1 dm^3 **(1)** • mass of 1 dm^3 of blood **(1)** • calculation of ppm **(1)**	Example of calculation $m = 6.3 \times 10^{-6} \times 226 = 1.4238 \times 10^{-3}$ (g) $m = 1.06 \times 1000 = 1060$ (g) ppm = $1.4238 \times 10^{-3} \div 1060$ then $\times 10^6 = 1.343$ (ppm) Correct answer with or without working score 3 Ignore SF except 1SF Allow TE for M3 Ignore incorrect truncation of the 4th SF	**(3)**

Question Number	Answer	Additional Guidance	Mark
13(e)	An answer that makes reference to the following points: • (lone pair of electrons on an) N / O of carnosine forms dative covalent bonds with Co^{2+} **(1)** • carnosine is multidentate / carnosine is tridentate/ forms more than one dative covalent bond **(1)** • is a chelating agent / traps the Co^{2+} / can wrap around the Co^{2+} (so the Co^{2+} can be removed from the blood) **(1)**	Do not award reference to 'the ammonia' acting as a ligand Allow coordinate for dative covalent Allow any '-dentate' that indicates multiple coordinate bonds forming Allow leads to a (large) increase in total entropy / entropy of the system Allow there is an increase in disorder If no other mark scored award one for 'ligand substitution occurs' provided it is not linked to ammonia	**(3)**

Question Number	Answer	Additional Guidance	Mark
13(f)	An answer that makes reference to the following point: • CH_3Cl / CH_3Br / CH_3I	Accept names chloromethane / bromomethane / iodomethane If name and formulae are given, then both must be correct. Ignore other reagents / catalysts / conditions Do not award Grignard reagent	**(1)**

(Total for Question 13 = 15 marks)

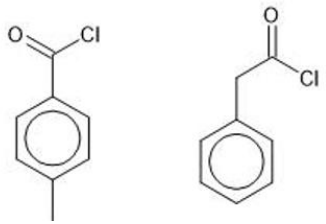
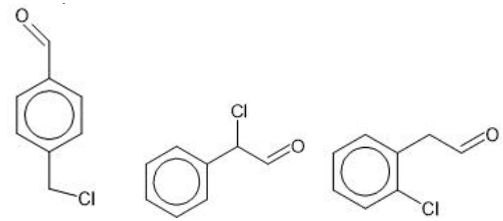
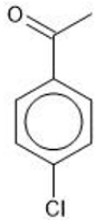
Question Number	Answer		Additional Guidance	Mark
14(a)(i)	An answer that makes reference to the following points:			**(2)**
	• (catalyst is) $AlCl_3$ / $FeCl_3$	**(1)**	Allow $FeBr_3$ /$AlBr_3$	
	• (electrophile is) CH_2ClCO^+	**(1)**	Allow positive sign anywhere on the structure Award correct electrophile seen in part (ii) if no electrophile has been written on the answer line in (i) Ignore any equation generating the electrophile Do not award $^+CH_2COCl$	

Question Number	Answer	Additional Guidance	Mark
14(a)(ii)	An answer that makes reference to the following points: • arrow from on or within the circle to the positive carbon **(1)** • structure of intermediate ion **(1)** • curly arrow from C-H bond of the intermediate to within ring and correct organic product **(1)**	<u>Example of diagram</u>  Allow arrow from within the hexagon Allow TE on incorrect electrophile $^{+}CH_2COCl$ only from (a)(i) for M1 'Horseshoe' facing tetrahedral carbon and covering at least three carbons. Some part of the positive sign within the horseshoe Allow TE for intermediate that follows on from M1 M3 only awarded for an intermediate that has the carbonyl carbon joined to the benzene ring	**(3)**

Question Number	Answer	Additional Guidance	Mark
14(b)(i)	An answer that makes reference to the following point: • hydrogen chloride / HCl	 Allow hydrochloric acid Ignore state symbols If name and formula are given then both must be correct	**(1)**

Question Number	Answer	Additional Guidance	Mark
14(b)(ii)	An answer that makes reference to the following point: • reduction / get reduced	 Ignore redox / gains electrons Ignore reduction-oxidation	**(1)**

Question Number	Answer	Additional Guidance	Mark
14(b)(iii)	An answer that makes reference to the following points: • CHI_3 **(1)** • (pale) yellow (precipitate) **(1)**	 Ignore name / iodoform Do not award any additional products listed Ignore cream Ignore any coloured solution including yellow solution Do not award bright yellow	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(b)(iv)	• possible structure for Compound B **(1)** • possible structure for Compound C **(1)** • possible structure for Compound D **(1)** Penalise missing hydrogens on displayed portions of formulae once only. Penalise missing chlorines on compounds C and D once only	<u>Examples of structures</u>  Must be an acyl chloride  Must be an aldehyde  Must have the CH_3 adjacent to C=O Allow substituent groups anywhere on the ring for B, C and D	**(3)**

Question Number	Answer	Additional Guidance	Mark
14(c)(i)	An answer that makes reference to the following point: • carbonyl	Allow aldehyde **and** ketone Ignore C=O Do not award methyl carbonyl Do not award carboxyl	**(1)**

Question Number	Answer	Additional Guidance	Mark
14(c)(ii)	A description that makes reference to the following points: • filter off (to collect the precipitate) **(1)** (followed by) • dissolve in a minimum amount of hot solvent **(1)** • cool to crystallise **and** filter the precipitate **(1)** • wash **and** dry the recrystallised precipitate **(1)** • carry out a melting temperature determination **and** look up the melting temperature in a Data Booklet / compare the melting temperature to known data **(1)**	Precipitate or crystals need to be mentioned at least once in M3 or M4 Allow drying using desiccator, (cool) oven or blotting with filter paper Allow 1 from M2, M3 and M4 for 'recrystallisation' if none of these marks are scored Stand alone mark Do not award boiling temperature	**(5)**

(Total for Question 14 = 18 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*15</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>
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</td>
<td>
Guidance on how the mark scheme should be applied.

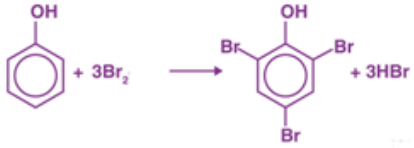
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some 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>
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	Indicative content (Similarities) **IP1** both react with electrophiles **IP2** hex-1-ene **and** phenol do not require a catalyst (Differences) **IP3** with hex-1-ene the reaction is addition **and** with phenol the reaction is substitution **IP4** the benzene ring in phenol is (kinetically) stable due to the delocalised electrons (and so undergoes substitution) **IP5** the equation for the reaction of phenol **and** the equation for the reaction of hex-1-ene **IP6** hex-1-ene the π-electrons are between two carbons / in fixed positions / localised (so undergoes addition)	Allow hex-1-ene **and** phenol react at room temperature / react with bromine water Allow a description of the lone pair of electrons on the oxygen of the OH group delocalising into ring which increases the electron density Allow reference to thermodynamic stability  $C_6H_{12} + Br_2 \longrightarrow C_6H_{12}Br_2$ Allow in hex-1-ene the π-electrons are not delocalised Ignore comments on the relative rates of the reaction in phenol and hex-1-ene Penalise comparison to cyclohexene rather than hex-1-ene once only	

(Total for Question 15 = 6 marks)

TOTAL FOR SECTION B = 51 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
16(a)(i)	• any three numbers correct **(1)** • the rest correct **(1)**	Example of balanced equation $2MnCl_2 + 5NaClO + 6NaOH \rightarrow 2NaMnO_4 + 9NaCl + 3H_2O$	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(a)(ii)	An explanation that makes reference to the following points: • (because the oxidation number of) manganese goes from (+)2 to (+)7 so Mn is oxidised **(1)** • (while the oxidation number of) chlorine goes from +1 to −1 so Cl is reduced **(1)**	Ignore any reference to electron transfer Allow use of Roman numerals Do not allow manganate for manganese Allow numbers written as charges If no other marks are awarded allow (1) for the correct change in oxidation number for both Mn and Cl If no other marks are awarded allow (1) for the correct statement that Mn is oxidised and Cl reduced	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(b)(i)	An answer that makes reference to the following points: • equation for disproportionation of manganese(V) ions **(1)** • equation for disproportionation of manganese(VI) ions **(1)**	$3MnO_4^{3-} + 4H_2O \rightarrow 2MnO_2 + MnO_4^- + 8OH^-$ $3MnO_4^{2-} + 2H_2O \rightarrow MnO_2 + 2MnO_4^- + 4OH^-$ Allow multiples for both equations Ignore state symbols even if incorrect Penalise uncancelled electrons once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(b)(ii)	An answer that makes reference to the following points: • calculation of E_{cell} values for both disproportionation reactions **(1)** • positive E_{cell} value means thermodynamically feasible **and** more positive E_{cell} value means the reaction is more feasible **(1)**	Statement that a positive E_{cell} is thermodynamically feasible needs to be seen only once $E_{cell} = 0.93(V) - 0.27(V) = (+)0.66(V)$ $E_{cell} = 0.60(V) - 0.56(V) = (+)0.04(V)$ Allow a positive sign and feasible with the answers from M1 for the first half of M2 Allow 'larger' for more positive, so long as values are given with a positive sign	**(2)**

Question Number	Answer		Additional Guidance	Mark
16(c)(i)	• for each mole of arsenic(III) oxide reaction the increase in oxidation number is $2 \times 2 = 4$	**(1)**	Accept electrons transferred for oxidation number change	**(3)**
	• use of the 5:4 ratio	**(1)**	4 mol of manganate(VII) is reduced by 5 mol of arsenic(III) oxide so the change in oxidation number is $(4 \times 5) \div 4 = 5$	
	• 7 – answer from M2	**(1)**	So the final oxidation number for manganese is $7 - 5 = 2$ so +2 / II / Mn^{2+} / Mn(II) An answer of 4.5 from missing that there are 2 As atoms in As_2O_3 scores (2) with appropriate workings Allow equation for M1 and some evidence towards M2 $5As_2O_3 + 10H_2O \rightarrow 5As_2O_5 + 20H^+ + 20e^-$	

Question Number	Answer	Additional Guidance	Mark
16(c)(ii)	• calculation of molar mass of As_2O_3 **and** calculation of moles of As_2O_3 in the standard solution **(1)** • calculation of moles of As_2O_3 in $25cm^3$ **(1)** • calculation of moles of $KMnO_4$ in 23.65 cm^3 **(1)** • calculation of concentration of $KMnO_4$ **(1)**	<u>Example of calculation</u> $(2 \times 74.9) + (3 \times 16) = 197.8$ $1.05 \div 197.8 = 0.0053084$ / 5.3084×10^{-3} / 0.00531 / 5.31×10^{-3} (mol) $0.0053084 \div 10 = 0.00053084$ / 5.3084×10^{-4} / 0.000531 / 5.31×10^{-4} (mol) $0.00053084 \times 4 \div 5 = 0.00042467$ / 4.2467×10^{-4} (mol) $0.00042467 \div 23.65 \times 1000 = 0.017956$ / 0.0180 (mol dm^{-3}) Allow TE throughout Ignore SF except 1 SF Correct answer with no working scores (4)	**(4)**

Question Number	Answer	Additional Guidance	Mark
16(d)(i)	• calculation of moles of potassium manganate(VII) **(1)** • calculation of moles of methylbenzene **(1)** • indication that moles of potassium manganate(VII) is greater than two times the moles of methylbenzene **(1)** **and** indication that potassium manganate is in excess / methylbenzene is limiting	<u>Example of calculation</u> $10 \div 158 = 0.063291$ / 0.0633 / 6.3291×10^{-2} / 6.33×10^{-2} (mol) $2.5 \div 92 = 0.027174$ / 0.0272 / 2.7174×10^{-2} / 2.72×10^{-2} (mol) 0.0633 is more than **2** × 0.0272 / 0.0544 or 0.0272 is less than 0.06329 ÷ **2** / 0.031645 Ignore SF except 1 SF Allow TE for M3 if moles are incorrectly calculated in M1 or M2	**(3)**

Question Number	Answer	Additional Guidance	Mark
16(d)(ii)	An answer that makes reference to the following point: • addition of a strong acid	Accept use of named acids / formula of acids Allow protonation / adding a hydrogen ion Ignore concentration Do not award hydrolysis / hydrogenation Do not award adding hydrogen	**(1)**

(Total for Question 16 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS

TOTAL FOR PAPER = 90 MARKS