GradeMax

Pearson

Mark Scheme (Results)

October 2025

Pearson Edexcel International Advanced Level in Chemistry
WCH15/01

GradeMax

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General Marking Guidance

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

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

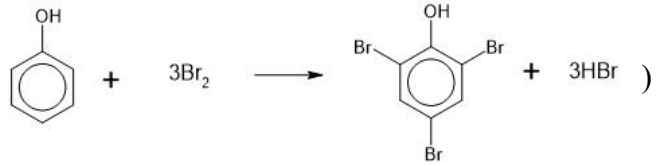
Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Answer	Mark
1	**The only correct answer is D** () ***A*** *is incorrect because phenol undergoes tri-substitution with bromine and there is a byproduct of hydrogen bromide* ***B*** *is incorrect because bromobenzene is not a product of the reaction* ***C*** *is incorrect because there is a byproduct of hydrogen bromide*	**(1)**

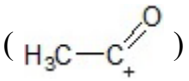
Question Number	Answer	Mark
2	**The only correct answer is A** (1 and 2) ***B*** *is incorrect because positions 1 and 2 on the ring are not equivalent to positions 1 and 4* ***C*** *is incorrect because positions 1 and 2 on the ring are not equivalent to positions 1 and 3* ***D*** *is incorrect because positions 1 and 3 on the ring are not equivalent to positions 1 and 4*	**(1)**

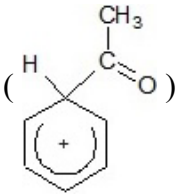
Question Number	Answer	Mark
3(a)	**The only correct answer is D** (sideways overlap which is both above and below the plane of the ring) ***A*** *is incorrect because the p orbitals overlap sideways and this occurs both above and below the plane of the ring* ***B*** *is incorrect because the p orbitals overlap sideways* ***C*** *is incorrect because the p-orbital overlap occurs both above and below the plane of the ring*	**(1)**

Question Number	Answer	Mark
3(b)	**The only correct answer is C** (the carbon-hydrogen bond lengths are all the same) ***A*** *is incorrect because the enthalpy of hydrogenation is less exothermic due to the greater stability of the delocalised benzene ring* ***B*** *is incorrect because the carbon to carbon bond lengths are all due to delocalisation of the pi bonds* ***D*** *is incorrect because delocalisation means that all the carbon-carbon bonds are equivalent and have the same infrared peaks*	**(1)**

Question Number	Answer	Mark
4(a)	**The only correct answer is C** (CH_3COCl) ***A*** *is incorrect because ethanoic acid does not react with benzene* ***B*** *is incorrect because propanone does not react with benzene* ***D*** *is incorrect because ethanamide does not react with benzene*	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is D** (PCl_5) ***A*** *is incorrect because aluminium chloride is a commonly used halogen carrier catalyst* ***B*** *is incorrect because iron(III) bromide is a commonly used halogen carrier catalyst* ***C*** *is incorrect because iron(III) chloride is a commonly used halogen carrier catalyst*	**(1)**

Question Number	Answer	Mark
4(c)	**The only correct answer is B** () ***A*** *is incorrect because the electrophile oxygen atom does not have a negative charge and has a double bond to the central carbon* ***C*** *is incorrect because the positive charge should be on the central carbon* ***D*** *is incorrect because the central carbon does not have a lone pair of electrons*	**(1)**

Question Number	Answer	Mark
4(d)	**The only correct answer is B** () ***A*** *is incorrect because the correct structure does not have a complete delocalised ring of electrons* ***C*** *is incorrect because the correct structure does not have a positive charge on the tetrahedral carbon atom* ***D*** *is incorrect because the 'horseshoe' of delocalised electrons should include the five carbon atoms of the ring excluding the tetrahedral carbon atom*	**(1)**

Question Number	Answer	Mark
5(a)	**The only correct answer is B** (492) ***A*** *is incorrect because this is the value calculated when one electron is transferred instead of two* ***C*** *is incorrect because this is the value calculated when one electron is transferred instead of two and the temperature value used is in degrees Celsius not Kelvin* ***D*** *is incorrect because this is the value calculated when the temperature value used is in degrees Celsius not Kelvin*	**(1)**

Question Number	Answer	Mark
5(b)	**The only correct answer is A** (6.1×10^7) ***B*** *is incorrect because this is the value of K calculated on the basis of one electron transferred instead of two* ***C*** *is incorrect because this is the value of ln K* ***D*** *is incorrect because this is the value of ln K calculated on the basis of one electron transferred instead of two*	**(1)**

Question Number	Answer	Mark
6(a)	**The only correct answer is C** (arrow C) ***A*** *is incorrect because electrons do not flow through the membrane* ***B*** *is incorrect because electrons do not flow through the membrane and they move from the negative electrode to the positive electrode* ***D*** *is incorrect because electrons move from the negative to the positive electrode*	**(1)**

Question Number	Answer	Mark
6(b)	**The only correct answer is A** ($H_2(g) + 2OH^-(aq) \rightleftharpoons 2H_2O(l) + 2e^-$) ***B*** *is incorrect because this equation shows the simultaneous reduction of hydrogen and the oxidation of oxygen* ***C*** *is incorrect because this equation shows the simultaneous reduction of hydrogen and the oxidation of oxygen* ***D*** *is incorrect because this is the oxidation equation for the fuel cell with an acidic electrolyte*	**(1)**

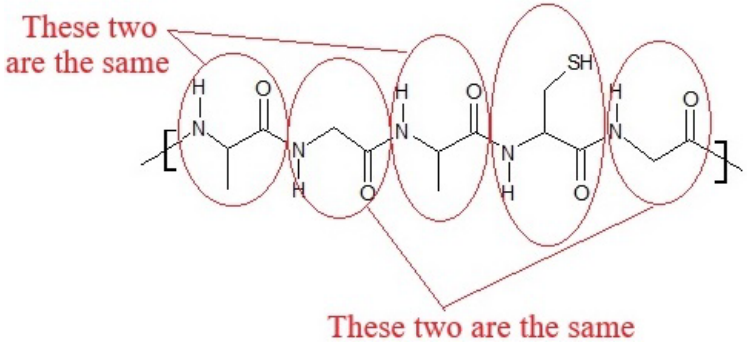
Question Number	Answer	Mark
6(c)	**The only correct answer is D** (100%) ***A*** *is incorrect because this is the percentage by mass of hydrogen in water* ***B*** *is incorrect because this is the percentage using atomic numbers* ***C*** *is incorrect because this is the percentage using atomic numbers and doubling it*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is A** (chromium and copper) ***B*** *is incorrect because manganese does follow the expected pattern with* $3d^5$ *for the fifth element in the d-block* ***C*** *is incorrect because scandium does follow the expected pattern with* $3d^1$ *for the first element in the d-block* ***D*** *is incorrect because scandium does follow the expected pattern with* $3d^1$ *for the first element in the d-block and so does zinc with* $3d^{10}$ *for the tenth element in the d-block*	**(1)**

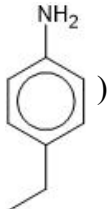
Question Number	Answer	Mark
8	**The only correct answer is C** (ligand exchange) ***A*** *is incorrect because deprotonation involves loss of hydrogen ions* ***B*** *is incorrect because the carbon monoxide is replacing the oxygen molecule in the complex* ***D*** *is incorrect because oxygen is being replaced by the carbon monoxide but this is not the best description*	**(1)**

Question Number	Answer	Mark
9(a)	**The only correct answer is A** (addition only) ***B*** *is incorrect because the lack of reaction with carbonates and water means that there are no carboxylic acid or acyl chloride groups which are required for condensation polymerisation* ***C*** *is incorrect because the lack of reaction with carbonates and water means that there are no carboxylic acid or acyl chloride groups which are required for condensation polymerisation* ***D*** *is incorrect because the ability to react by electrophilic addition indicates the presence of a carbon-carbon double bond which can undergo addition polymerisation*	**(1)**

Question Number	Answer	Mark
9(b)	**The only correct answer is D** (70.6%) ***A*** *is incorrect because the carbon atoms in the carbonyl bonds have been omitted* ***B*** *is incorrect because the number of hydrogen atoms on each of the benzene rings has been miscounted as six instead of four* ***C*** *is incorrect because a hydrogen atom has been included at each of the repeat unit 'ends'*	**(1)**

Question Number	Answer	Mark
9(c)	**The only correct answer is B** (3) ***A*** *is incorrect because there are three different amino acids and not two* ***C*** *is incorrect because there are two amino acids which are duplicated and not just one* ***D*** *is incorrect because two amino acids are duplicated* *Amino acids 1 and 3 are the same, and amino acids 2 and 5 are the same – as shown* 	**(1)**

Question Number	Answer	Mark
9(d)	**The only correct answer is B** (there are hydrogen bonds between the chains) ***A*** *is incorrect because the covalent bonds within the polymer chains are not broken on melting* ***C*** *is incorrect because the hydrogen bonding between the chains is the most important factor affecting melting temperature* ***D*** *is incorrect because the properties of the monomer and of the polymer are different*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is A** () ***B*** *is incorrect because this amine can form from the initial reaction between phenylamine and chloroethane* ***C*** *is incorrect because this amine can form from further nucleophilic substitution occurring between the initial product, option B, and chloroethane* ***D*** *is incorrect because this quaternary amine salt can form from further nucleophilic substitution occurring between the second product, option C, and chloroethane*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>11(a)</td><td>

- calculation of mass of carbon and hydrogen **(1)**
- calculation of mass of oxygen **(1)**
- calculation of moles of carbon, hydrogen and oxygen **(1)**
- determination of empirical formula from molar ratio **(1)**

</td><td>

<u>Example of calculation</u>

<table>
<tr><td>Element</td><td>C</td><td>H</td><td>O</td></tr>
<tr><td>Mass / g</td><td>4.95 × (12 ÷ 44)
= 1.35</td><td>0.90 × (2 ÷ 18)
= 0.100</td><td>2.25 – (1.35 + 0.10)
= 0.80</td></tr>
<tr><td>Moles / mol</td><td>(1.35 ÷ 12)
= 0.1125</td><td>(0.100 ÷ 1)
= 0.100</td><td>(0.80 ÷ 16)
= 0.050</td></tr>
<tr><td>Ratio</td><td>(0.1125 ÷ 0.050)
= 2.25</td><td>(0.100 ÷ 0.050)
= 2</td><td>(0.050 ÷ 0.050)
= 1</td></tr>
</table>

$C_9H_8O_4$

Correct answer scores 4
9:8:4 alone scores 3
C_2H_2O scores 3

Allow 1 mark for $C_9H_8O_x$ if no other mark awarded

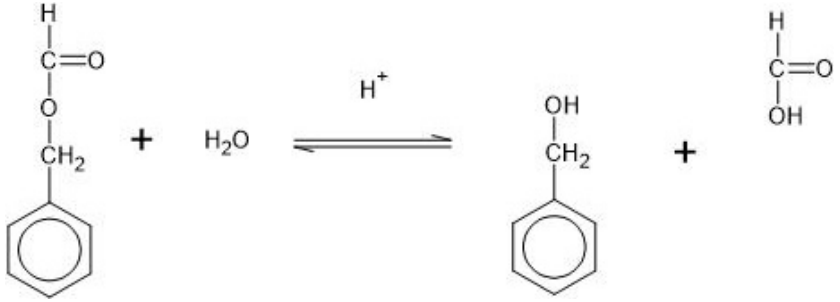
TE from M1 to M2
TE from M1 and M2 to M3
TE from M3 to M4 if no truncation and rounding is correct

</td><td>(4)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
11(b)(i)	An answer that makes reference to the following points: • **K** spectrum has C=O peak at 1700 – 1680 (cm^{-1}) **(1)** • **L** spectrum has C=O peak at 1740 – 1720 (cm^{-1}) or **L** spectrum has C−H peak at 2900−2820 and 2775−2700 (cm^{-1}) **(1)**	Allow ketone for K Allow aldehyde for L Penalise omission of bonds once only Penalise −C=O/−C−H once only Penalise incorrect additional peaks Ignore additional correct peaks Aldehyde C−H (stretch) at 2900−2820 and 2775−2700 (cm^{-1}) present for **L** and absent in **K** for 2 marks	**(2)**

	Answer	Additional Guidance	Mark
11(b)(ii)	An answer that makes reference to the following points: • **M** fragment ion **(1)** • **N** fragment ion **(1)**	<u>Example of fragment ions</u> $C_6H_5CH_2O^+$ $m/z = 107$ or HCO^+ $m/z = 29$ or $C_6H_5^+$ $m/z = 77$ or $HCOOCH_2^+$ $m/z = 59$ or $C_6H_5CH_2^+$ $m/z = 91$ $CH_3C_6H_4CO^+$ $m/z = 119$ or OH^+ $m/z = 17$ or CH_3^+ $m/z = 15$ or $C_6H_4COOH^+$ $m/z = 121$ Allow (1) if no other mark awarded for two correct formulae or two correct m/z values Allow 1 if two correct fragments but both without charges	**(2)**

Question Number	Answer	Additional Guidance	Mark
11(b)(iii)	An explanation that makes reference to the following points: • the proton environment of the methyl protons / hydrogens in molecule **O** they are next to an oxygen **and** whereas in molecule **P** they are next to a C=O group **(1)** • so the chemical shift of the peak for molecule **O** it is 2.8 – 4.3 **and** **(1)** for molecule **P** is 1.6 – 2.8 (which will distinguish them)	Allow the environment to be shown in a diagram Allow a single value or a range within these ranges Accept H-C-O for **O** and H-C-C=O for **P** Allow CH_3-O / CH_3-CO Allow methyl group for proton environment Ignore references to phenyl protons M2 is independent of M1 If only **O** / **P** is described with a correct range then 1 mark can be awarded	**(2)**

Question Number	Answer	Additional Guidance	Mark
11(b)(iv)	An answer that makes reference to the following point: • equation which identifies **M**	Example of equation  Accept any clear displayed / structure / skeletal formulae or combination thereof Allow irreversible arrow Ignore missing acid catalyst Ignore vertical connectivity	**(1)**

(Total for Question 11 = 11 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*12(a)</td>
<td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

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

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

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

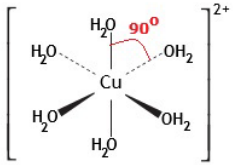
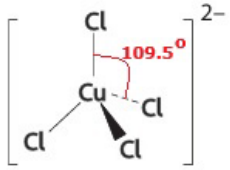
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some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

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

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

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

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** 3D diagram of octahedral complex ion with 90° angles	 Penalise incorrect connectivity of ligands Allow 180° if labelled correctly on diagram	
	IP2 suitable example such as $[Cu(H_2O)_6]^{2+}$ **and** reference to coordination number of six	Penalise missing/incorrect charge here Look at diagram if no formula given	
	IP3 description / 3D diagram of tetrahedral complex ion with 109.5° angles	 	
	IP4 suitable example such as $[CuCl_4]^{2-}$ **and** reference to coordination number of four / four bonds / four ligands	Penalise missing/incorrect charge here Look at diagram if no formula given	
	IP5 larger ligands such as chloride ions (more likely) to form tetrahedral **and** smaller ligands such as water / ammonia (more likely) to form octahedral shape	Allow chlorine ions Ignore chlorine atoms Do not award chlorine molecules / Cl_2	
	IP6 identification of co-ordinate / dative (covalent) bonding	Penalise hydrogen bonds Ignore covalent bonding for $[Cu(H_2O)_6]^{2+}$	
	Continued Additional Guidance: Allow one of IP2 and IP4 for two suitable examples without reference to coordination number Coordination numbers only need to be mentioned once for both IP2 and IP4 to be given.	Penalise lack of /incorrect wedges in diagrams once only Penalise lack of / incorrect bond angles once only Allow correct bond angles anywhere in text	

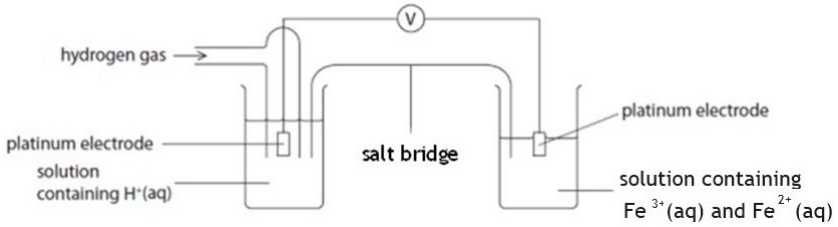
Question Number	Answer	Additional Guidance	Mark
12(b)(i)	An answer that makes reference to the following points: • silver / Ag **(1)** • because $E^{\ominus}_{cell}$ = (+)0.20 (V) **and** (positive so thermodynamically) feasible **(1)** • but no further because to further reduce (to V^{3+}) has an $E^{\ominus}_{cell}$ = −0.46 (V) **(1)**	Do not allow Ag^{+} but allow electrode potential equation Must have + sign or use word positive for M2 Allow (1) for M2 and M3 if no reference is made to feasibility (of reaction) but both $E^{\ominus}_{cell}$ values given	**(3)**

Question Number	Answer	Additional Guidance	Mark
12(b)(ii)	A description that makes reference to the following points: • equation **and** comment to refer to the decrease / reduction of oxidation number (from five) to four **(1)** • equation **and** comment to refer to the increase / oxidation of oxidation number (from four) back to five **(1)**	$V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$ Allow reduced/decrease to vanadium(IV) oxide $V_2O_4 + ½O_2 \rightarrow V_2O_5$ Allow (1) for two correct equations without reference to oxidation states Allow (1) for general description of vanadium oxidation number changes with description of redox Allow multiples throughout	**(2)**

Question Number	Answer	Additional Guidance	Mark
12(c)	A description that makes reference to the following points: • adsorption of carbon monoxide/CO to the surface of the (platinum) catalyst **(1)** (Any two for 1 mark) • which results in the weakening of bonds • reaction / oxidation occurs • to form carbon dioxide / products **(1)** • which then desorbs (from the catalytic surface)	Reference to same state/phase negates a mark Do not award absorption Allow deadsorbed Ignore refs to NO_x	**(2)**

Question Number	Answer	Additional Guidance	Mark
12(d)(i)	An answer that makes reference to the following point: • equation for the second step	<u>Example of equation</u> $10Mn^{3+} + 5C_2O_4^{2-} \rightarrow 10Mn^{2+} + 10CO_2$ Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
12(d)(ii)	An explanation that makes reference to the following points: • (very) slow initial rate which increases **and** as the catalyst/Mn^{2+} is formed **(1)** • then decreases (and levels off) **and** as the reactant concentration decreases to zero **(1)**	Allow a labelled/annotated diagram to score both marks Do not award when all the reactants are used up the reaction starts to slow down for M2 Do not award less Mn^{2+} is produced Allow (1) for both descriptions of the changes in rate Marks are independent	**(2)**

Question Number	Answer	Additional Guidance	Mark
12(e)	(Hydrogen half-cell) • (M1) 1 mol dm^{-3} HCl **and** platinum (black) electrode **(1)** • (M2) hydrogen (gas) at 100 kPa at 298 K **(1)** (Iron half-cell) • (M3) 1 mol dm^{-3} $Fe^{3+}(aq)$ **and** 1 mol dm^{-3} $Fe^{2+}(aq)$ **(1)** • (M4) identify two suitable iron compounds **(1)** (Connections) • (M5) salt bridge **and** platinum electrode for iron half-cell **(1)** • (M6) voltmeter **and** complete circuit **(1)**	Example of diagram  Allow $H^+(aq)$ / HNO_3 Allow 0.5M sulfuric acid Allow 1atm Allow written anywhere Hydrogen gas must be able to enter the tube Allow use of iron(II) and iron(III) compounds such as the chloride / nitrate if sulfates are used, 1 mol dm^{-3} $FeSO_4$ and 0.5 mol dm^{-3} $Fe_2(SO_4)_3$ Allow filter paper soaked with (saturated) potassium nitrate solution Allow salt bridge made of KNO_3 Penalise failure to have the platinum electrode / salt bridge / hydrogen delivery tube dipping into the solution here No line marking top of each solution loses M6 Ignore labelled positive and negative electrodes and electron flow even if incorrect Allow concentrations to be mentioned once in M1 and M3	**(6)**

(Total for Question 12 = 22 marks)

Question Number	Answer		Additional Guidance	Mark
13(a)(i)	• calculation of number of moles of $KMnO_4$	**(1)**	Example of calculation $n = (0.342 \times 10^6 \div 158) = 2164.6$ (mol)	**(3)**
	(Method 1) • calculation of number of moles of MnO_2	**(1)**	Ratio $KMnO_4$:K_2MnO_4 is 2:3 then K_2MnO_4:MnO_2 is 1:1 $n = (2164.6 \times 1.5 =) 3246.8$ (mol)	
	• calculation of mass of manganese in the ore **and** calculation of percentage by mass		$m = (3246.8 \times 54.9 =) 178\,250$ (g) $\% = (178\,251 \div 10^6 \times 100 =) 17.8250 / 17.83 / 17.8 / 18$	
	(Method 2) • calculation of mass of manganese in $KMnO_4$	**(1)**	$m = (2164.6 \times 54.9 =) 118\,834$ (g)	
	• calculation of mass of manganese in the ore **and** calculation of percentage by mass	**(1)**	Ratio $KMnO_4$:K_2MnO_4 is 2:3 then K_2MnO_4:MnO_2 is 1:1 $m = (118\,834 \times 1.5 =) 178\,250$ (g) $\% = (178\,251 \div 10^6 \times 100 =) 17.8250 / 17.83 / 17.8 / 18$	
			Ignore SF except 1SF TE throughout if % is less than 100 Correct answer without working scores (3) Ignore incorrect rounding/truncation on this question	

Question Number	Answer	Additional Guidance	Mark
13(a)(ii)	An answer that makes reference to the following point: • there is no need for an indicator because the manganate(VII) colour change is visible (at the end-point)	Allow colour change examples (e.g. pink to/from purple or pink to/from colourless)	**(1)**

Question Number	Answer	Additional Guidance	Mark
13(b)	• calculation of number of moles of thiosulfate **(1)** • calculation of number of moles of iodine **(1)** • calculation of number of moles of oxygen **(1)** • calculation of mass of oxygen **(1)** • calculation of concentration in mg dm^{-3} **(1)**	<u>Example of calculation</u> $n = (0.0100 \times 11.45 \div 1000) = 1.1450 \times 10^{-4}$ (mol) $n = (1.1450 \times 10^{-4} \div 2 =) 5.7250 \times 10^{-5}$ (mol) Ratio I_2:MnO_2 is 1:1 then MnO_2:O_2 is 2:1 $n = (5.7250 \times 10^{-5} \div 2 =) 2.8625 \times 10^{-5}$ (mol) $m = (2.8625 \times 10^{-5} \times 32 =) 9.1600 \times 10^{-4}$ (g) $c = (9.1600 \times 10^{-4} \times 1000) \div (100 \div 1000 =)$ $c = 9.16 / 9.2$ (mg dm^{-3}) Ignore SF except 1SF Ignore intermediate units even if incorrect TE throughout Correct final answer without working scores (5) Penalise incorrect rounding/truncation once only	**(5)**

Question Number	Answer		Additional Guidance	Mark
13(c)(i)	An explanation that makes reference to the following points: • the equilibrium (position) shifts to the chromate((VI)) ions • because hydrogen ions/protons are removed (as they react with hydroxide)	**(1)** **(1)**	Allow the equilibrium (position) shifts to the right/products Allow $H^+ + OH^- \rightarrow H_2O$ Ignore any references to the formation of water Ignore references to reaction rate changes	**(2)**

Question Number	Answer		Additional Guidance	Mark
13(c)(ii)	An explanation that makes reference to the following points: • barium / sulfonate salts are more soluble in water • because they can form ion-dipole interactions (with water molecules) or • diphenylamine is less soluble in water • because the hydrogen bonding formed by the amine group is less effective at overcoming the repulsion between the non-polar aromatic rings and the polar solvent water molecules	**(1)** **(1)** **(1)** **(1)**	Allow miscible in water Accept explanations relating to sulfonate/$-SO_3^-$ ion also forming of hydrogen bonds Allow because of the energy of solution / solvation of the ions Ignore contains ions so is soluble Allow as because they cannot form ion-dipole interactions with water molecules as no ions are present	**(2)**

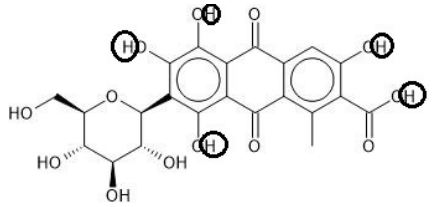
Question Number	Answer	Additional Guidance	Mark
13(d)(i)	An answer that makes reference to the following points: • colour is violet **and** wavelength is between 400 – 430 (nm) **(1)** • the complementary/violet coloured light is absorbed by the **electrons** (undergoing f-f / f-d transitions) **(1)** • the (yellow) colour observed is that reflected/transmitted **(1)**	Allow any single value or range of values within this stated range Ignore the orbitals stated in the transitions Allow description of the 'opposite' colour on the colour wheel Do not award references to emission of light / colour but penalise once only in parts (d)(i) and (d)(ii)	**(3)**

Question Number	Answer	Additional Guidance	Mark
13(d)(ii)	An answer that makes reference to the following point: • the energy absorbed is not in the visible spectrum	Accept wavelength absorbed is less than 400nm / more than 800nm Allow the energy gap is not in the visible spectrum. Ignore any references to orbitals not split Do not award references to emission of light / colour but penalise once only in parts (d)(i) and (d)(ii) Ignore light is not absorbed Ignore references to coordination number, ion charge, ligand type.	**(1)**

(Total for Question 13 = 17 marks)
TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
14(a)	• calculation of moles of carminic acid **(1)** • calculation of total number of carminic acid molecules **(1)** • calculation of number of carminic acid molecules per insect **(1)**	<u>Example of calculation</u> N = (450 ÷ 492) = 0.91463 (mol) N = (0.91463 × 6.02×10^{23}) N = 5.5061×10^{23} N = ($5.5061 \times 10^{23} \div 70\,000$ =) 7.8659×10^{18} TE throughout Ignore SF except 1 SF Correct answer scores 3 marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
14(b)	• carboxylic acid proton circled **(1)** • four phenol group hydrogens circled **(1)**	<u>Example of labelled diagram</u>  Circling of any non-phenolic OH groups loses M2 Allow circling of acidic/phenolic OH groups Do not award inclusion of other atoms	**(2)**

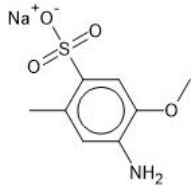
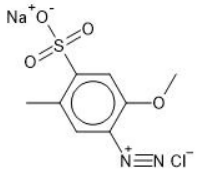
Question Number	Answer	Additional Guidance	Mark
14(c)	An answer that makes reference to the following points: • bidentate **(1)** • because each carminic acid forms two dative (covalent) / coordinate bonds (with the aluminium ion) **(1)**	Allow can donate two (lone) pairs of electrons Allow molecule/ion Ignore has two pairs of electrons alone	**(2)**

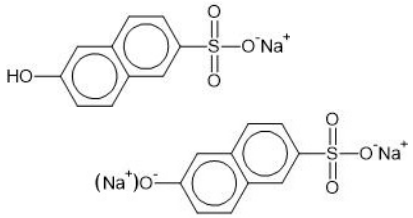
Question Number	Answer	Additional Guidance	Mark
14(d)	An explanation that makes reference to the following points: • the derivative has an amine group which can accept a proton / become $-NH_3^+$ **(1)** • the derivative has a carboxylic acid group which can lose a proton / become $-CO_2^-$ **(1)**	Allow reference to any of the phenol groups deprotonating to give $-O^-$ Allow a diagram of the zwitterion with reference to the transfer of a proton for M1 and M2 If no other mark awarded, allow (1) for • a zwitterion has a negatively charged group and a positively charged group • the molecule can both accept a proton and lose a proton to form a zwitterion • identification of the NH_2 and COOH as the relevant groups (for the zwitterion) Ignore references to pH	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(e)(i)	• calculation in ppm	Example of calculation 85 (ppm) Allow 85 mg kg^{-1} Note that the answer may be given on the graph	**(1)**

Question Number	Answer	Additional Guidance	Mark
14(e)(ii)	An explanation that makes reference to the following points: • (it is only certain that there is) a linear relationship between absorbance and lycopene content up to 75 mg kg^{-1} **(1)** • above 75 mg kg^{-1}, the extrapolation of the line is not justified. **(1)**	Allow reference to absorbance of 1.75 throughout Allow line beyond plotted points may not be linear for M2 If no other mark is awarded allow line beyond 75 is extrapolated for 1 mark Allow line beyond 75 may not be linear – for 2 marks Ignore incorrect references to lower end of range	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(e)(iii)	An explanation that makes reference to the following points: • the two solvents are immiscible **(1)** • the solute is more soluble in the extracting / one solvent **(1)**	Allow two layers are formed Allow two solvents don't mix	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(f)	An answer that makes reference to the following points: (Step **1**) • use of (conc.) HCl **and** tin/Sn **and** reflux **(1)** • structure of intermediate **X** **(1)** (Step **2**) • use of sodium nitrite/$NaNO_2$ and HCl **(1)** • temperature 0 – 5°C / ice-cold **(1)** • structure of intermediate **Y** **(1)**	Allow heat Ignore temperatures Do not award use of other acids / $LiAlH_4$  Allow use of nitrous acid / HNO_2 Allow use of H_2SO_4 for HCl Allow 0 – 10°C 	**(6)**

	(Step **3**) **(1)** • structure of the 'phenol'/ 6-hydroxy-2-naphthalene sulfonic acid	Ignore omission of chloride ion  Allow Penalise horizontal connectivity once only Penalise missing methyl group once only Ignore references to pressure Ignore omission of sodium ion throughout	

(Total for Question 14 = 20 marks)

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