Pearson

Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in Chemistry
Paper 01: Transition Metals and Organic Nitrogen 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** (an electrode of vanadium metal) ***B*** *is incorrect because this a condition required for all gases to give the standard electrode potential* ***C*** *is incorrect because the concentration of vanadium(II) chloride in this solution would be 1.00 mol* dm^{-3} ***D*** *is incorrect because this is a condition required to give the standard electrode potential*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is B** (+0.46 V) ***A*** *is incorrect because this is the sum of the electrode potential values* ***C*** *is incorrect because this is the negative value* ***D*** *is incorrect because this is the negative value of the sum of the electrode potential values*	**(1)**

Question Number	Answer	Mark
3(a)	**The only correct answer is C** (the pipette and volumetric flask have the same percentage uncertainty measurement) ***A*** *is incorrect because the percentage uncertainty measurement of the balance is double that of the other two* ***B*** *is incorrect because the percentage uncertainty measurement of the balance is greater than the other two* ***D*** *is incorrect because the uncertainty of the flask is ten times larger than the pipette but the percentage uncertainty measurements are the same*	**(1)**

Question Number	Answer	Mark
3(b)	**The only correct answer is C** (pale yellow) ***A*** *is incorrect because this would be the colour of iodine solution with starch added* ***B*** *is incorrect because this would be the colour of the solution at the start of the titration* ***D*** *is incorrect because this would be the colour of the iodine solution at the start of the titration*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is C** ($[Ar]3d^6$) ***A*** *is incorrect because this would be the electronic structure if the metal atom lost two d-electrons to form the ion* ***B*** *is incorrect because this would be the electronic structure of the metal ion if it was iron(III) not iron(II)* ***D*** *is incorrect because this is the electronic structure of an iron atom*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is A** (VO^{2+}) ***B*** *is incorrect because* VO_2^+ *along with* VO_4^{3-} *and* $V_4O_{12}^{4-}$ *are V(V) but* VO^{2+} *is V(IV)* ***C*** *is incorrect because* VO_4^{3-} *along with* VO_2^+ *and* $V_4O_{12}^{4-}$ *are V(V) but* VO^{2+} *is V(IV)* ***D*** *is incorrect because* $V_4O_{12}^{4-}$ *along with* VO_4^{3-} *and* VO_2^+ *are V(V) but* VO^{2+} *is V(IV)*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is B** ($[Ni(H_2NCH_2CH_2NH_2)_3]^{2+} > [Ni(CH_3NH_2)_6]^{2+} > [Ni(NH_3)_6]^{2+} > [Ni(H_2O)_6]^{2+}$) ***A*** *is incorrect because this is the order of decreasing stability* ***C*** *is incorrect because this is the order of decreasing stability but with* $[Ni(CH_3NH_2)_6]^{2+}$ *and* $[Ni(NH_3)_6]^{2+}$ *swapped* ***D*** *is incorrect because although this is the correct order generally* $[Ni(CH_3NH_2)_6]^{2+}$ *is more stable than* $[Ni(NH_3)_6]^{2+}$	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is B** (a square planar complex with two isomeric forms) ***A*** *is incorrect because the compound has both cis- and trans- isomers* ***C*** *is incorrect because the compound is square planar and has both cis- and trans- isomers* ***D*** *is incorrect because the compound is square planar*	**(1)**

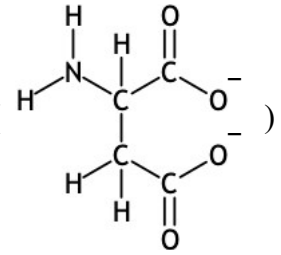
Question Number	Answer	Mark
8	**The only correct answer is D** (statements **1**, **2** and **3** are correct) ***A*** *is incorrect because all three statements are correct* ***B*** *is incorrect because all three statements are correct* ***C*** *is incorrect because all three statements are correct*	**(1)**

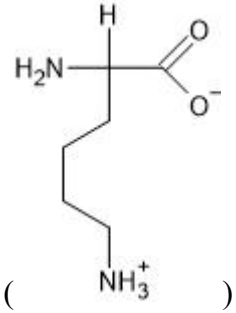
Question Number	Answer	Mark
9	**The only correct answer is C** (Graph 3) ***A*** *is incorrect because this is a graph of the concentration of products against time for a reaction which is not autocatalytic* ***B*** *is incorrect because this is a graph of rate of reaction against time for a reaction which is not autocatalytic* ***D*** *is incorrect because this is a graph of the concentration of products against time for an autocatalytic reaction*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is A** (electrophilic addition and electrophilic substitution) ***B*** *is incorrect because this compound does not undergo nucleophilic addition* ***C*** *is incorrect because this compound does not undergo nucleophilic substitution* ***D*** *is incorrect because this compound does not undergo nucleophilic addition or nucleophilic substitution*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is B** (3) ***A*** *is incorrect because there are three isomers, 1,2-dibromobenzene, 1,3-dibromobenzene and 1,4-dibromobenzene* ***C*** *is incorrect because there are three isomers, 1,2-dibromobenzene, 1,3-dibromobenzene and 1,4-dibromobenzene* ***D*** *is incorrect because there are three isomers, 1,2-dibromobenzene, 1,3-dibromobenzene and 1,4-dibromobenzene*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is D** (London forces and permanent dipole-permanent dipole interactions) ***A*** *is incorrect because there are no hydrogens attached to the nitrogen in triethylamine so no hydrogen bonds* ***B*** *is incorrect because there are no hydrogens attached to the nitrogen in triethylamine so no hydrogen bonds* ***C*** *is incorrect because the nitrogen atom is electronegative so there is a dipole in triethylamine*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is B** () ***A*** *is incorrect because the carboxylic acid group on the side chain will also react with sodium hydroxide and the amine group will not be protonated* ***C*** *is incorrect because the carboxylic acid group on the side chain will also react with sodium hydroxide* ***D*** *is incorrect because both the carboxylic acid groups will be neutralised by sodium hydroxide solution*	**(1)**

Question Number	Answer	Mark
14	 **The only correct answer is A** ( ) ***B*** *is incorrect because there is an overall charge of +2 and a zwitterion is neutral overall* ***C*** *is incorrect because there is an overall charge of +1 and a zwitterion is neutral overall* ***D*** *is incorrect because there is an overall charge of −1 and a zwitterion is neutral overall*	**(1)**

Question Number	Answer	Mark
15(a)	**The only correct answer is D** (4 6) ***A*** *is incorrect because there are two pairs of equivalent carbons in 1-chloro-4-nitrobenzene, but all 6 are unique in 1-chloro-2-nitrobenzene* ***B*** *is incorrect because there are two pairs of equivalent carbons in 1-chloro-4-nitrobenzene, but all 6 are unique in 1-chloro-2-nitrobenzene* ***C*** *is incorrect because there are two pairs of equivalent carbons in 1-chloro-4-nitrobenzene, but all 6 are unique in 1-chloro-2-nitrobenzene*	**(1)**

Question Number	Answer	Mark
15(b)	**The only correct answer is A** (ethanoic acid) ***B*** *is incorrect because hydrochloric acid is used in the second step to convert the nitro group to an amine group* ***C*** *is incorrect because nitric acid is used in the first step* ***D*** *is incorrect because sulfuric acid is used in the first step*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is C** (C_3H_5) ***A*** *is incorrect because the masses had been divided by the atomic mass of carbon and the molecular mass of* H_2 ***B*** *is incorrect because the masses had been divided by the atomic masses of carbon and hydrogen* ***D*** *is incorrect because* C_6H_{10} *is a molecular formula*	**(1)**

Question Number	Answer	Mark
17(a)	**The only correct answer is B** (immiscible with water and dissolves the compound fully) ***A*** *is incorrect because the solvent must be immiscible with water* ***C*** *is incorrect because the solvent must be immiscible with water and the compound must be fully soluble in the solvent* ***D*** *is incorrect because the compound must be fully soluble in the solvent*	**(1)**

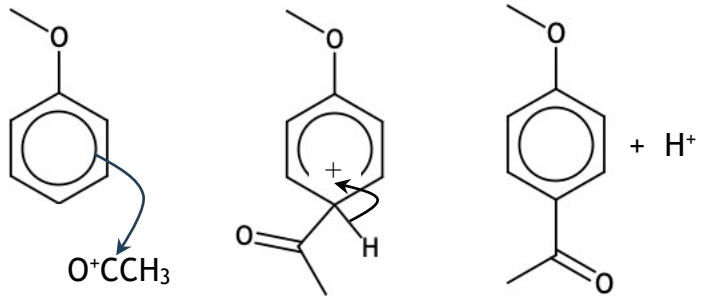
Question Number	Answer	Mark
17(b)	**The only correct answer is C** (insoluble impurities are removed by filtering a hot solution) ***A*** *is incorrect because the soluble impurities are removed by cold filtration* ***B*** *is incorrect because the insoluble impurities are removed by hot filtration* ***D*** *is incorrect because the soluble impurities are removed by cold filtration*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	• calculation of moles of methoxybenzene **and** calculation of moles of ethanoyl chloride **(1)** • statement that methoxybenzene / compound with lowest number of moles is the limiting reagent **(1)**	<u>Example of calculation</u> 5.25 ÷ 108 = 0.048611 (mol) **and** 4.50 ÷ 78.5 = 0.057325 (mol) Allow TE on numbers of moles Allow reverse argument M2 dependent on M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	• calculation of M_r of the isomers **(1)** Either • calculation of moles of isomer 1 **(1)** • calculation of percentage yield of isomer 1 **(1)** OR • calculation of maximum mass **(1)** • calculation of percentage yield of isomer 1 **(1)**	<u>Example of calculation</u> $(9 \times 12) + (10 \times 1) + (2 \times 16) = 150$ Allow $108 + 78.5 – 36.5 = 150$ $3.2 \div 150 = 0.021333$ (mol) $0.021333 \div 0.04861 \times 100 = 43.885(\%)$ $0.04861 \times 150 = 7.2915$ $3.2 \div 7.2915 \times 100 = 43.887(\%)$ Ignore SF except 1 SF Allow TE throughout provided yield is < 100% If isomer 2 is calculated instead isomer 1 allow max 2 for M1 and M3 If isomer 2 is calculated as well as isomer 1 without saying which is major allow max 2 for the calculation of either isomer For isomer 2 using Either Moles of isomer 2 = $0.24 \div 150 = 0.0016$ (mol) Percentage of isomer 2 = $0.0016 \div 0.04861 \times 100 = 3.2914(\%)$ Or Maximum mass of isomer 2 = $0.04861 \times 150 = 7.2915$ Percentage yield of isomer 2 $= 0.24 \div 7.2915 \times 100 = 3.2915$ (%)	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)	• equation for generation of electrophile **(1)**	$CH_3COCl + AlCl_3 \rightarrow CH_3C^+O + AlCl_4^-$ Do not award delta +	**(5)**
			
	• arrow from the circle of delocalised electrons to the positive carbon of the electrophile **(1)**	Allow an arrow from anywhere within the hexagon to the carbonyl carbon of the electrophile TE from M1	
	• intermediate with disrupted p-electron system, with horseshoe pointing towards the carbon with constituent added and positive charge within the horseshoe **(1)**	Do not award if the electrophile has not been added to the correct position	
	• arrow from bond to H into ring to restore p-electron system **(1)**	Allow arrow to anywhere within the hexagon	
	• equation showing regeneration of the catalyst **(1)**	$H^+ + AlCl_4^- \rightarrow AlCl_3 + HCl$ Accept interaction of $AlCl_4^-$ with intermediate / curly arrow from Cl to H resulting in formation of $AlCl_3$ and HCl / H^+ Allow use of Kekulé structures	

Question Number	Answer	Additional Guidance	Mark
18(c)	An answer that makes reference to the following point: • the presence of the CH_3O^- group makes it harder for the incoming ethanoyl group to join the carbon next to it	Accept because of steric hindrance / too large Allow just CH_3O^- repels OC^+CH_3 Allow the intermediate carbocation is more stable Ignore just distance from methoxy group Ignore comments about activation of the benzene ring	**(1)**

(Total for Question 18 = 11 marks)

Question Number	Answer	Additional Guidance	Mark
19	An explanation that makes reference to the following points: • the enthalpy of hydrogenation of cyclohexa-1,4-diene is twice that of cyclohexene (as both contain double bonds which are isolated / which do not interact with another double bond / are not conjugated / are not delocalised) **(1)** • benzene is stabilised by 152 kJ mol^{-1} (compared to 3 × 120 kJ mol^{-1}) **and** cyclohexa-1,3-diene is stabilised by 8 kJ mol^{-1} (compared to 2 × 120 kJ mol^{-1}) **(1)** • benzene and cyclohexa-1,3-diene are conjugated / contain double bonds with a single bond in between / have some delocalisation / have some overlap of the pi clouds / p-orbitals / resonance structure **(1)** • but benzene / the continuous delocalisation / the ring is much more effective / more stable / pi system around the ring **(1)**		**(4)**

(Total for Question 19 = 4 marks)

Question Number	Answer	Additional Guidance	Mark
20(a)(i)	• formula of both cobalt compounds correct **(1)** • rest of equation correct and balanced **(1)**	$[Co(H_2O)_6]^{2+} + 2NH_3 \rightarrow [Co(H_2O)_4(OH)_2] + 2NH_4^+$ Ignore lack of square brackets Ignore state symbols even if incorrect M2 dependent on M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	An answer that makes reference to the following points: • type of reaction is deprotonation **(1)** • role of ammonia is base **(1)**	 Ignore precipitation Allow alkali	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)	An answer that makes reference to the following points: • C is $[Co(NH_3)_6]^{2+}$ **(1)** • D is $[Co(NH_3)_6]^{3+}$ **(1)**	Ignore missing square brackets for both complex ions	**(2)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*20(c)</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

Ignore references to coordination number
</td>
<td>(6)</td>
</tr>
</table>

	Indicative content **IP1** ligands split the d-orbitals / d-subshell into two groups **IP2** electrons absorb wavelengths / frequencies / photons of (visible) light as they are promoted from one group of orbitals to the other **IP3** the remaining (wavelengths / frequencies / photons of light) are transmitted / reflected making the solutions coloured **IP4** (in C) the ammonia ligands split the two groups of orbitals by a different amount than in A (where water is the ligand) **IP5** (in D) the cobalt is in a different oxidation number which splits the two groups of orbitals by a different amount **IP6** so, different wavelengths / frequencies / photons of light are absorbed which means the solutions are a different colour	Accept degenerate d-orbitals splitting to become nondegenerate by ligands Penalise reference to splitting of single d-orbital in IP1 only Do not award absorption of colour Do not award reference to electron de-excitation Ignore just energy for light Wavelengths / frequencies / photons need only be mentioned once in IP2 and IP3 Allow complementary colours are reflected / transmitted / not absorbed Do not award emitting light Allow different number of electrons in the d-orbitals for different oxidation number Comment: parts of some ideas may be given in different parts of the answer. e.g. the explanation for colours required for part of IP2 also covers part of IP6	

(Total for Question 20 = 12 marks)

Question Number	Answer		Additional Guidance	Mark
21(a)	• calculation of number of moles of cerium(IV) sulfate	**(1)**	Example of calculation 12.46 ÷ 332.2 = 0.037508 (mol)	**(6)**
	• calculation of concentration of cerium(IV) sulfate solution	**(1)**	0.037508 × 4 = 0.15003 (mol dm^{-3})	
	• calculation of number of moles of cerium(IV) ions in the titration	**(1)**	0.15003 × 18.4 ÷ 1000 = 0.0027606 (mol)	
	• calculation of number of moles of tin ions in the titration	**(1)**	0.0552 × 25 ÷ 1000 = 0.00138	
	• ratio of cerium(IV) to tin(IV)	**(1)**	Ce:Sn = (0.0027606 ÷ 0.00138 =) 2.0004 : 1	
	• complete the charge on the product tin ion **and** the equation	**(1)**	Charge on tin ion: 4+ $2Ce^{4+}(aq) + (1)Sn^{2+} \rightarrow 2Ce^{3+} + (1)Sn^{4+}$ Final charge and equation with no working scores (1) Allow TE throughout provided the charge on Sn ion is < 6+	

Question Number	Answer	Additional Guidance	Mark
21(b)	An answer that makes reference to the following points: (Advantage) • solutions are self-indicating **(1)** (Disadvantage) • intense colour of manganate(VII) solution makes reading the burette difficult **(1)**	Allow an indicator is not needed Allow description of colour change for MnO_4^- at end point Allow hard to read the meniscus Allow burette with white markings required	**(2)**

(Total for Question 21 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
22(a)	An answer that makes reference to the following points: • correct half cells with reactant and product in the correct order and separated by a comma, on the correct sides, with or without state symbols **(1)** • rest of the cells correct including platinum electrodes separated by a phase change from the half-cell, a salt bridge and state symbols **(1)**	$(2)I^-((aq))$, $I_2((aq))$ $S_2O_8^{2-}((aq))$, $(2)SO_4^{2-}((aq))$ $Pt(s) \mid 2I^-(aq), I_2(aq) \parallel S_2O_8^{2-}(aq), 2SO_4^{2-}(aq) \mid Pt(s)$ Allow square brackets Allow dashed lines for the salt bridge Allow 1 mark if only error is vertical lines instead of commas Allow 1 mark for fully correct cell diagram but the wrong way round	**(2)**

Question Number	Answer	Additional Guidance	Mark
22(b)(i)	An answer that makes reference to the following point: • $S_2O_8^{2-}(aq) + 2e^- \rightarrow 2SO_4^{2-}(aq)$	Do not award $\rightleftharpoons$	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(b)(ii)	• calculation of reduction potential, E_{red}	Example of calculation $1.47 = E_{red} - 0.54$ $E_{red} = 1.47 + 0.54$ $E_{red} = (+)2.01$ (V)	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(b)(iii)	An answer that makes reference to the following points: • $E^{\ominus}_{cell}$ is proportional to $\Delta S^{\ominus}_{total}$ **(1)** • so the total entropy change is positive as $E^{\ominus}_{cell}$ is positive **(1)** • a positive $\Delta S^{\ominus}_{total}$ means the reaction is (thermodynamically) feasible **(1)**	Allow $\Delta S^{\ominus}_{total} = \frac{nFE^{\ominus}_{cell}}{T}$ Allow $\Delta S^{\ominus}_{total}$ is proportional to $E^{\ominus}_{cell}$ Allow $E^{\ominus}_{cell}$ increases when total entropy increases Allow (R)lnK is proportional to $E^{\ominus}_{cell}$ If no other mark is awarded allow (1) for $E^{\ominus}_{cell}$ is positive so the reaction is feasible	**(3)**

Question Number	Answer	Additional Guidance	Mark
22(b)(iv)	An explanation that makes reference to the following points: • because the activation energy for the reaction is high **(1)** • as the reactants repel (because they are both negatively charged) **(1)**	Allow reverse argument Allow activation energy is reduced when a catalyst is used Allow reference to high kinetic energy barrier Allow description of high activation energy	**(2)**

Question Number	Answer	Additional Guidance	Mark
22(c)(i)	An explanation that makes reference to the following points: • $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ **(1)** • $2Fe^{2+} + S_2O_8^{2-} \rightarrow 2SO_4^{2-} + 2Fe^{3+}$ **(1)** • so addition of either ion will result in a reaction which forms the other ion (so either ion can act as a catalyst) **(1)**	Ignore state symbols even if incorrect M3 dependent on M1 and M2 Allow both ions are regenerated Ignore "The ions (Fe^{2+} and Fe^{3+}) have positive charges so reactants can have opposite charges and so will not repel each other."	**(3)**

Question Number	Answer	Additional Guidance	Mark
22(c)(ii)	An answer that makes reference to the following points: Either • the reduction potential / $E^{\ominus}$ value is more positive than the reduction potential of iodine / $E^{\ominus}$ value for the conversion of I_2 to I^- **(1)** • the reduction potential / $E^{\ominus}$ value is less positive than the reduction potential calculated in (b)(ii) / $E^{\ominus}$ value calculated in (b)(ii) **(1)** • so both $E^{\ominus}_{cell}$ values for the two reactions will be positive so the reaction is feasible / will occur / be spontaneous **(1)** or • the reduction potential for Fe^{3+}/Fe^{2+} (+ 0.77) lies between the reduction potentials for I_2 (+0.54) **(1)** • and between $S_2O_8^{2-}$ (+2.01 or TE from value calculated in (b)(ii)) **(1)** • so (according to the anticlockwise rule) Fe^{2+} will react with $S_2O_8^{2-}$ **and** Fe^{3+} will react with I^- **(1)** or • cell calculation for Fe^{2+} with $S_2O_8^{2-}$ **(1)** • cell calculation for Fe^{3+} with I^- **(1)** • both $E^{\ominus}_{cell}$ values shown with + signs so the reaction is feasible / will occur / be spontaneous **(1)**	2.01 – (+0.77) = +1.24v TE from (b)(ii) 0.77 – (+0.54) = +0.23v	**(3)**

(Total for Question 22 = 15 marks)

TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
23(a)(i)	An answer that makes reference to the following points: • (reagent) potassium cyanide / KCN **(1)** • (conditions) ethanolic / alcoholic (solution/solvent) **(1)**	Allow sodium cyanide / NaCN Do not award in acid / H^+ / HCN Ignore references to heat M2 dependent on M1	**(2)** -

Question Number	Answer	Additional Guidance	Mark
23(a)(ii)	An answer that makes reference to the following points: • organic formulae **(1)** • balanced equation **(1)**	 Allow displayed / structural / skeletal / hybrid formulae $CH_3CN + HCl + 2H_2O \rightarrow CH_3COOH + NH_4Cl$ Accept ionic equation	**(2)**

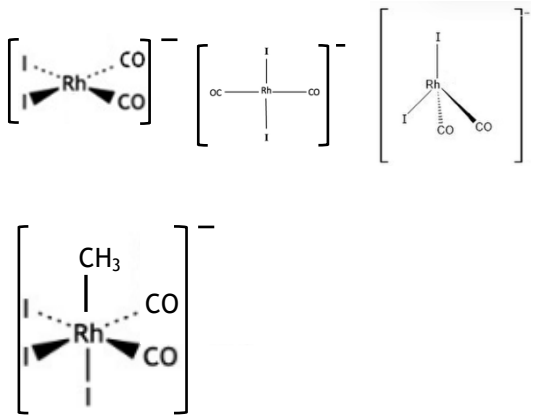
Question Number	Answer	Additional Guidance	Mark
23(a)(iii)	An answer that makes reference to the following point: • alkaline hydrolysis produces the ethanoate / carboxylate ion (not the ethanoic acid) or to protonate the ethanoate / carboxylate ion	Allow use of formulae to illustrate answer Ignore just protonate the salt	**(1)**

Question Number	Answer	Additional Guidance	Mark
23(b)(i)	An answer that makes reference to the following points: • equation **(1)** • in dry ether **(1)**	$CH_3I + Mg \rightarrow CH_3MgI$ Accept displayed formulae showing covalent bonds to the Mg Ignore references to heat	**(2)**

Question Number	Answer	Additional Guidance	Mark
23(b)(ii)	An answer that makes reference to the following point: • carbon dioxide	Accept CO_2 Ignore references to hydrolysis by acid	**(1)**

Question Number	Answer	Additional Guidance	Mark
23(c)(i)	An answer that makes reference to the following point: Either • the complex reacts in **Step 2** and is regenerated in **Step 5** (so is not used up) or • the rhodium changes from oxidation number +1 to +3 in **Step 2** and goes back +3 to +1 in **Step 5**	Ignore just complex is regenerated or complex is not used up without comment on the steps	**(1)**

Question Number	Answer	Additional Guidance	Mark
23(c)(ii)	An answer that makes reference to the following points: • the oxidation number of rhodium is (+)1 / (+)I **(1)** • iodide / iodide has an oxidation number of −1 **and** carbon monoxide is neutral / 0 **and** the ion has an overall 1− charge **(1)**	Allow 2 × iodide is −2 Some or all values may be shown as annotations on a diagram / equation for the ion or as a mathematical sum e.g. $-1 = (-1 \times 2) + x$	**(2)**

Question Number	Answer	Additional Guidance	Mark
23(c)(iii)	An answer that makes reference to the following points: • diagram of $[Rh(CO)_2I_2]^-$ **(1)** • coordination number of $[Rh(CO)_2I_2]^-$ is 4 **(1)** • diagram of $[Rh(CO)_2I_3CH_3]^-$ **(1)** • coordination number of $[Rh(CO)I_3(COCH_3)]^-$ is 5 **(1)**		**(4)**

Question Number	Answer	Additional Guidance	Mark
23(c)(iv)	An answer that makes reference to the following point: • two / 2		**(1)**

Question Number	Answer	Additional Guidance	Mark
23(c)(v)	An explanation that makes reference to the following points: Either • both $[Rh(CO)_2I_2]^-$ and HI must appear once up to and including the rate determining step **(1)** • both appear before or in Step 2 **(1)** or • $[Rh(CO)_2I_2]^-$ is not in step 1 so this cannot be the RDS **(1)** • But $[Rh(CO)_2I_2]^-$ is in step 2 so this is the RDS **(1)**	Accept slowest step for RDS	**(2)**

Question Number	Answer	Additional Guidance	Mark
23(c)(vi)	An explanation that makes reference to the following points: • (methanol is zero order because) methanol appears before step 2 but (does not appear in the rate equation as) it is in excess **(1)** • (and carbon monoxide is zero order because) carbon monoxide appears after Step 2 **(1)**		**(2)**

(Total for Question 23 = 20 marks)

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