Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Level in Chemistry
Paper 01A: Transition Metals and Organic Chemistry

WCH15/01A

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General Marking Guidance

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

Using the Mark Scheme

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

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

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

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

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

Quality of Written Communication

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

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

Section A

Question Number	Answer	Mark
1a	**The only correct answer is B** (−1.63V) ***A*** *is not correct because the electrode potential for the* Fe^{3+}/Fe^{2+} *electrode system has been added to the* E^{o}_{cell} *value instead of being subtracted* ***C*** *is not correct because the value should have a negative sign* ***D*** *is not correct because the value should have a negative sign and the electrode potential for the* Fe^{3+}/Fe^{2+} *electrode system has been added to the* E^{o}_{cell} *value instead of being subtracted*	**(1)**

Question Number	Answer	Mark
1b	**The only correct answer is C** (platinum and titanium) ***A*** *is not correct because the* $Fe^{3+}|Fe^{2+}$ *electrode system requires a platinum electrode* ***B*** *is not correct because the* $Fe^{3+}|Fe^{2+}$ *electrode system requires a platinum electrode and the* $Ti^{2+}|Ti$ *electrode system requires a titanium electrode.* ***D*** *is not correct because the* $Ti^{2+}|Ti$ *electrode system requires a titanium electrode.*	**(1)**

Question Number	Answer	Mark
1c	**The only correct answer is C** (2 mol dm^{-3} and 1 mol dm^{-3}) ***A*** *is incorrect because the cell solution must be 1 mol* dm^{-3} *with respect to both* Fe^{2+} *and* Fe^{3+} *therefore the dilution on mixing and the two* Fe^{3+} *ions in each iron(III) sulfate must be taken into account* ***B*** *is incorrect because the cell solution must be 1 mol* dm^{-3} *with respect to both* Fe^{2+} *and* Fe^{3+} *therefore the dilution on mixing and the two* Fe^{3+} *ions in each iron(III) sulfate must be taken into account* ***D*** *is incorrect because the cell solution must be 1 mol* dm^{-3} *with respect to both* Fe^{2+} *and* Fe^{3+} *therefore the dilution on mixing and the two* Fe^{3+} *ions in each iron(III) sulfate must be taken into account*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is C** (overall reactions are the same) ***A*** *is incorrect because the acid and alkali are not acting as catalysts* ***B*** *is incorrect because* E^o *values for the half-equations are not the same.* ***D*** *is incorrect because the temperature and pressure as stated will not affect* E^o_{cell}	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is C** ($Fe(s) \mid Fe^{2+}(aq) \parallel Sn^{2+}(aq) \mid Sn(s)$) ***A*** *is incorrect because the oxidised part of* $Sn(s) \mid Sn^{2+}(aq)$ *should be next to the cell junction* ***B*** *is incorrect because the oxidised part of* $Fe(s) \mid Fe^{2+}(aq)$ *should be next to the cell junction* ***D*** *is incorrect because the oxidised part of both half-cells should be next to the cell junction*	**(1)**

Question Number	Answer	Mark
4(a)	**The only correct answer is A** (H_2SO_4) ***B*** *is incorrect because chloride ions could be oxidised* ***C*** *is incorrect because bromide ions would be oxidised* ***D*** *is incorrect because this would introduce additional chromium species into the mixture*	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is B** (17.91g) ***A*** *is incorrect because there should be only one mol of chromium ions per mol of dichromate ions* ***C****is incorrect because there should be only one mol of chromium ions per mol of dichromate ions* ***D*** *is incorrect because there should be only one mol of chromium ions per mol of dichromate ions*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is B** (copper) ***A*** *is incorrect because calcium is in Group 2 and is neither a d-block nor transition element* ***C*** *is incorrect because scandium is not a transition element.* ***D*** *is incorrect because zinc is not a transition element*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is D** (ΔS_{system} is positive for the reaction of $[Cu(H_2O)_2(NH_3)_4]^{2+}$ with EDTA.) ***A*** *is incorrect because solubility does not affect the equilibrium position* ***B*** *is incorrect because solubility does not affect the equilibrium position* ***C*** *is incorrect because the enthalpy change does not affect the equilibrium position*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** (amphoteric) ***A*** *is incorrect because zinc hydroxide reacts with an acid* ***B*** *is incorrect because zinc hydroxide reacts with an alkali.* ***D*** *is incorrect because zinc hydroxide reacts with an acid and an alkali*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is B** (blue, yellow) ***A*** *is incorrect because the chloride complex is not green* ***C*** *is incorrect because the colours are reversed.* ***D*** *is incorrect because the chloride complex is not green and the butylamine complex is not yellow*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is D** ($Pt(NH_3)_2Cl_2$ is square planar and $CrCl_4^-$ is tetrahedral) *A is incorrect because* $CrCl_4^-$ *is tetrahedral* *B is incorrect because* $Pt(NH_3)_2Cl_2$ *is square planar* *C is incorrect because* $Pt(NH_3)_2Cl_2$ *is square planar and* $CrCl_4^-$ *is tetrahedral*	**(1)**

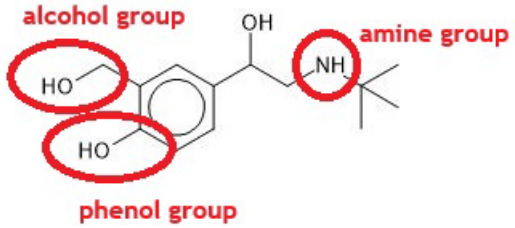
Question Number	Answer	Mark
10	**The only correct answer is B** (cyclohexene) **A** *is incorrect because* 1 mol cyclohexane *gives* 6 CO_2 *and* 6H_2O, *question gives* 6 CO_2 *and* 5H_2O **C** *is incorrect because* 1 mol benzene *gives* 6 CO_2 *and* 3H_2O, *question gives* 6 CO_2 *and* 5H_2O **D** *is incorrect because* 1 mol ethylbenzene *gives* 8 CO_2 *and* 5H_2O *question gives* 6 CO_2 *and* 5H_2O	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is D** (carbon dioxide giving carboxylic acids) *A is incorrect because Grignard reagents react with water giving alkanes* *B is incorrect because Grignard reagents react with aldehydes giving primary alcohols* *C is incorrect because Grignard reagents react with ketones giving tertiary alcohols only*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is A** (all insoluble impurities are removed by filtering the hot solution) ***B*** *is incorrect because not soluble impurities pass through the filter paper with the dissolved solid* ***C*** *is incorrect because solubility changes with temperature* ***D*** *is incorrect because solubility changes with temperature*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is A** (result in a kinetic barrier to intermediate formation) ***B*** *is incorrect because the delocalised electrons attract electrophiles* ***C*** *is incorrect because both ethene and benzene have endothermic enthalpies of formation and this is not a factor in their reactivity* ***D*** *is incorrect because catalysts have no effect on the thermodynamics of a reaction*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is A** (1.95g) ***B*** *is incorrect because the 70% yield in step 1 has not been used* ***C*** *is incorrect because the 60% yield in step 2 has not been used* ***D*** *is incorrect because both yields have not been used*	**(1)**

Question Number	Answer	Mark
15(a)	**The only correct answer is B** (amide) ***A*** *is incorrect because there is an alcohol group as shown* ***C*** *is incorrect because there is an amine group as shown* ***D*** *is incorrect because there is a phenol group as shown* 	**(1)**

Question Number	Answer	Mark
15(b)	**The only correct answer is B** ($C_{13}H_{21}NO_3$) ***A*** *is incorrect because there is one too many hydrogen atoms* ***C*** *is incorrect because there is one more hydrogen atoms* ***D*** *is incorrect because there are two more hydrogen atoms*	**(1)**

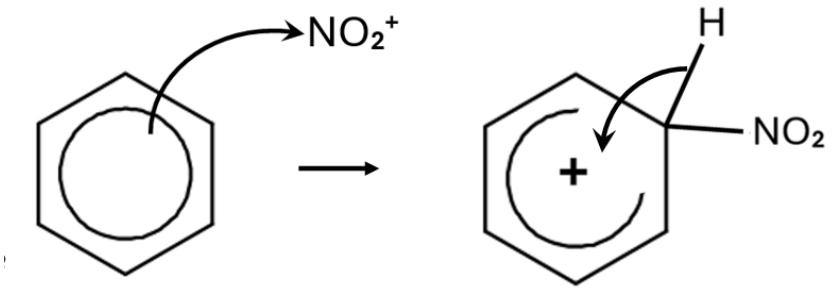
Question Number	Answer	Mark
16	**The only correct answer is A** (phenylamine, ammonia, butylamine) ***B*** *is incorrect because phenylamine has the lowest pH* ***C*** *is incorrect because butylamine has the highest pH and phenylamine the lowest* ***D*** *is incorrect because phenylamine has a lower pH than ammonia*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

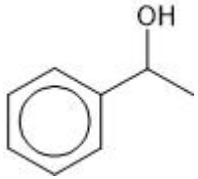
Question Number	Answer	Additional Guidance	Mark
17(a)	An explanation that makes reference to three of the following points • benzene reacts by (electrophilic) substitution (not electrophilic addition) **(1)** • there are only 3 isomers of disubstituted benzenes (not 4) **(1)** • (from X-ray diffraction data) benzene C−C bond lengths are the same / midway between a single and double bond length **(1)** <u>1 mark from energetics</u> • benzene's (standard) enthalpy (change) of hydrogenation is less exothermic (than if it had 3 C=C double bonds) **(1)** **or** benzene's (standard) enthalpy (change) of combustion is less exothermic (than if it had 3 C=C double bonds) **(1)** • in infrared spectroscopy, the wavenumber for C=C in benzene is different (to an alkene) **(1)**	Allow benzene does not react by addition with bromine Allow benzene does not decolourise bromine water Allow benzene needs a catalyst to react with bromine Allow some disubstituted compounds are the same (e.g. 1,2 and 1,6) Ignore just bond length is the same Allow benzene is more stable by 152 kJ mol^{-1} approximately 150 kJ mol^{-1} Allow 3 x (–)120 = (–)360 vs (–)208 Allow less negative Ignore just benzene is more thermodynamically stable Ignore lower than Ignore just bond energy / enthalpy alone Ignore reference to different C−H absorptions Ignore reference to NMR	**(3)**

Question Number	Answer		Additional Guidance	Mark
17(b)	An explanation that makes reference to the following points:			**(4)**
	• correct equation for generation of electrophile	**(1)**	$H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_2O + HSO_4^-$ **or** $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$ **and** $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$ **or** $2H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$	
	• curly arrow from on or within the circle to the **N** of NO_2^+	**(1)**	Allow curly arrow from anywhere within the hexagon No TE on wrong electrophile	
	• intermediate structure with horseshoe covering at least 3 carbon atoms and open opposite the tetrahedral carbon ***and*** at least part of the positive charge within the horseshoe	**(1)**	Allow use of Kekule structures throughout	
	• curly arrow from C-H **bond** to anywhere within the hexagon reforming the delocalised structure	**(1)**	Must be clearly from the bond Ignore any use of HSO_4^- / regeneration of catalyst	



Question Number	Answer	Additional Guidance	Mark
17(c)(i)	An explanation that makes reference to the following points: • correct organic product **(1)** • rest of equation correct **(1)**	 $C_6H_5OH + 3Br_2 \rightarrow C_6H_2Br_3OH + 3HBr$ scores (1) Allow Kekulé structures Correct equation forming a mono or disubstituted product scores (1) Correct equation to form 1,3,5-tribromobenzene from benzene scores (1) Correct equation to form 2,4,6-trichlorophenol scores (1)	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(c)(ii)	An explanation that makes reference to the following points: • the lone pair of electrons on the **oxygen** (of the phenol group) **delocalises** into the ring **(1)** • increased electron density (in the ring) makes the ring more susceptible to electrophilic attack **(1)**	Ignore just incorporates / merges / interacts / donates Allow π electron system / π bond for ring Ignore OH is electron donating but Do not award OH^- / hydroxide for this mark Allow just increases electron density (in the ring) Ring / π electron system / π bond must be mentioned once somewhere in the answer but if ring missing from both parts, allow (1) for two otherwise correct points	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(d)	• structure of compound **Z**	Example of structure  Allow Kekulé structures Allow displayed/ structure or hybrid formulae Ignore vertical connectivity to OH	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(e)	An answer that makes reference to the following points: • correct reagents and reaction conditions for Step **1** **(1)** • correct reagent for Step **2** (and conditions) **(1)**	<u>Example of calculation</u> Sn / tin **and** (conc) HCl / (conc) hydrochloric acid **and** reflux Ignore (aq) Ignore use of NaOH Comment : Ignore Sn is a catalyst CH_3COCl / ethanoyl chloride (and room temperature)	**(2)**

Total for Question 17 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	A description that makes reference to the following points: • colourless **to** pale pink	Allow (pale) green for colourless Allow pink Do not award purple / magenta Ignore ‘clear’	**(1)**

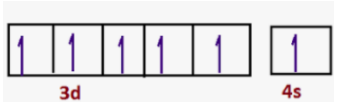
Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	An answer that makes reference to five of the following points: • calculation of moles of MnO_4^- in $29.15cm^3$ **(1)** • use of 1:5 ratio (to calculate Fe^{2+} in $25cm^3$) **(1)** • multiply by 10 (to give Fe^{2+} in $250cm^3$) **(1)** • conversion to g (from mol) **(1)** • calculation of percentage by mass **and** answer to 3SF **(1)** If A_r (Fe) = 56 is used mass = 1.59159 (g) and % iron = 77.3% 3.08% scores (4) (÷5 instead of x5 in M2) 1.54% scores (3) (missed steps 2 and 3) 66.0 scores (4) (use of $25cm^3$ instead of $29.15cm^3$)	<u>Example of calculation</u> $n = (29.15 \times 0.0195 \times 10^{-3}) = 5.68425 \times 10^{-4}$/ 0.000568425 (mol) $n = (5 \times 5.68425 \times 10^{-4}) = 2.842125 \times 10^{-3}$ /0.002842125 (mol) $n = (10 \times 2.842125 \times 10^{-3}) = 2.842125 \times 10^{-2}$/ 0.02842125 (mol) $m = (2.842125 \times 10^{-2} \times 55.8) = 1.58591$ (g) % = (100 x 1.58591/2.06) = 76.9857 = 77.0% Correct answer to 3 SF with no working scores (5) TE at each stage Early rounding at different stage can give answers between 75.8% and 77.2%. If answer is not 77.0% but within this range, check that the working rounds correctly to the answer given before awarding 5 marks.	**(5)**

Question Number	Answer	Additional Guidance	Mark
18(a)(iii)	An explanation that makes reference to the following points: • brown suspension is manganese(IV) oxide / MnO_2 **(1)** • Mn(VII) to Mn(II) / MnO_4^- to MnO_2 needs 5 electrons (per Mn) but Mn(VII) to Mn(IV) / MnO_4^- to MnO_2 only needs 3 electrons **(1)** • so more MnO_4^- is needed / titre is greater **(1)**	Accept an equation showing formation of MnO_2 using electrode reaction 6 Allow an equation showing formation of MnO_2 using electrode reaction 2 or from a combination of electrode reactions 1 and 2 $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ Do not award if brown suspension is $Fe(OH)_3$ Accept explanation in terms of decreasing oxidation numbers Allow just MnO_4^- to MnO_2 needs fewer electrons Allow MnO_4^- can only oxidise 3 Fe^{2+} Comment: if electrode reaction 2 used then allow reference to 2 electrons, not 3 Ignore comments about E_{cell} and / or feasibility	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)	3 correct scores 2 marks 2 correct scores 1 mark 1 correct scores 0 marks	<table><tr><th>Apparatus</th><th>Value measured</th><th>Uncertainty on each reading</th><th>Percentage uncertainty on value measured / %</th></tr><tr><td>Balance</td><td>2.06 g</td><td>±0.005 g</td><td>0.49</td></tr><tr><td>Burette</td><td>29.15 cm^3</td><td>±0.05 cm^3</td><td>0.34</td></tr><tr><td>Pipette</td><td>25.0 cm^3</td><td>±0.06 cm^3</td><td>0.24</td></tr><tr><td>Volumetric flask</td><td>250.0 cm^3</td><td>±0.3 cm^3</td><td>0.12</td></tr></table> Min 2SF for all answers	(2)

(Total for Question 18 = 11 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)(i)	An answer that makes reference to the following points: • correct electronic configuration **(1)**	$3d^5\ 4s^1$ Allow $4s^1\ 3d^5$ Ignore $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ but must be correct	(1)

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	An explanation that makes reference to two of the following points: (It is $4s^1$ rather than $4s^2$ because)		**(2)**
	• $3d^5$/ half-filled (3)d sub-shell is (more) stable **(1)**	Allow half-filled (3)d orbitals are (more) stable Comment: Allow half filled (3)d orbital is more stable Ignore it is more stable alone Ignore (3)d block Ignore half-filled 3d shell	
	• the paired electrons repel (in $4s^2$) or all (six) electrons are in separate orbitals, minimising repulsion **(1)**	Allow all (6) electrons are unpaired, minimising repulsion Allow electrons in boxes diagram so long as labelled or described 3d (and 4s)	
	• the energy required to promote / excite an electron from 4s to 3d is small **(1)**	Allow the energy difference between 4s and 3d is small Allow energy levels are similar TE from 19(a)(i) for use of $4d^5$  is more stable because it minimises repulsion scores (2)	

Question Number	Answer	Additional Guidance	Mark
19(b)(i)	An explanation that makes reference to the following points: • calculation of $E^{\ominus}_{cell}$ for step 1 **(1)** • calculation of $E^{\ominus}_{cell}$ for step 2 **(1)** • both values are positive so are spontaneous / feasible **(1)**	<u>Example of calculation</u> $E^{\ominus}_{cell}$ = 1.33 – –0.76 = (+)2.09 (V) $E^{\ominus}_{cell}$ = – 0.41 – –0.76 = (+)0.35 (V) Allow >0 for positive Allow this mark even if one or both of their $E^{\ominus}_{cell}$ values are wrong, so long as they are positive Allow Entropy arguments $\Delta S_{total} = \frac{nF\ E_{cell}}{T}$ **and** ΔS_{total} is positive **or** $\Delta G = -nFE_{cell}$ **and** ΔG is negative If no other mark is scored, data scores (1) however shown Correct data from data booklet $E^{\ominus}$ $Zn^{2+}(aq)\vert Zn(s) = -0.76$ V $E^{\ominus}$ $Cr^{3+}(aq), Cr^{2+}(aq)\vert Pt = -0.41$ V $E^{\ominus}$ $[Cr_2O_7^{2-}(aq) + 7H^+(aq)], [2Cr^{3+}(aq) + 7H_2O(l)]\vert Pt = +1.33$ V	**(3)**

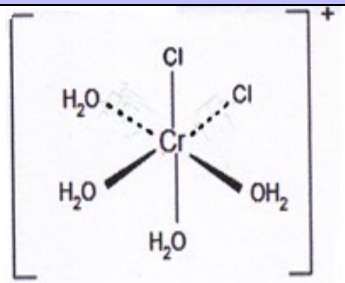
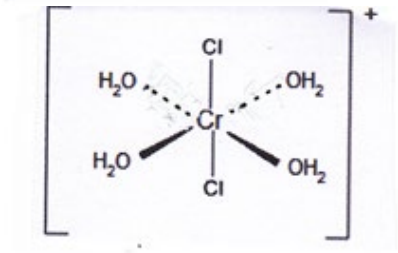
Question Number	Answer	Additional Guidance	Mark
19(b)(ii)	An answer that makes reference to the following points: • orange to green to blue **(1)**	Ignore shades of green / blue Do not award any other colours	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(i)	An answer that makes reference to the following points: • bidentate (ligand) **(1)**	Allow polydentate / multidentate Do not award di / tri / tetra / hexa dentate	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)	An answer that makes reference to the following points: • dative (covalent) / coordinate (bonds) **(1)**	Allow coordination for coordinate Ignore just covalent	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(iii)	An answer that makes reference to two of the following points: • chromium (ions) are (covalently) bonded to each other **(1)** • each ethanoate ligand forms (dative) bonds to different / both metal ions **(1)** • ethanoate ions are not normally bidentate ligands / ethanoate ions are normally monodentate ligands **(1)**	Allow there are two chromium (ions) / metal **ions** in the complex Do not award chromium atoms Ignore charge on chromium ion, even if wrong Ignore comments about shape and coordination number Note: If metals referred to in M1 and M2, ions needs to be seen only once If chromium is referred to in M1 and M2, ions are not needed but penalise atoms only once.	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(c)(iv)	An explanation that makes reference to the following points: • the ligands split the d-orbital**s** / d sub-shell differently **(1)** • so when an electron is promoted / excited **and** a different light energy / frequency / wavelength is absorbed (so a different complimentary colour is seen) **(1)**	Allow the ligands cause a different energy gap in the d sub-shell Allow ΔE for energy gap Ignore different oxidation / coordination numbers Do not award d-orbital Allow d-d transition Allow a photon of a different energy is absorbed Ignore just light / colour absorbed Ignore reference to complimentary colour / colour observed / seen / transmitted alone Do not award light emitted Do not award reference to de-excitation of electrons	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(i)	An answer that makes reference to two of the following points: • chloride ligands in *cis* position **(1)** • chloride ligands in *trans* position **(1)**	  Allow in either order Penalise connectivity of H_2O once only Penalise O_2H and Cl_2 once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(ii)	An explanation that makes reference to the following points: • calculation of mol AgCl **(1)** • ratio of Cr^{3+} to (free) Cl^- **(1)** • so, $[CrCl(H_2O)_5]^{2+}$ / (ion) **Y** (is formed) **(1)**	<u>Example of calculation</u> n = 6.88/143.4 = 0.047978 (mol) ratio = (0.024 ÷ 0. 047978) = 1:2 Allow (0.047978 ÷ 0.024) = 2(:1) M3 can be awarded without working Allow minor slips in the complex formula if identified as **Y** TE throughout	**(3)**

Total for Question 19 = 18 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*20</td>
<td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

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

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

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

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

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

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

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

Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning
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<td>(6)</td>
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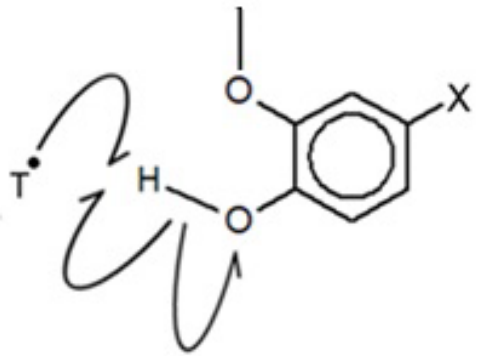
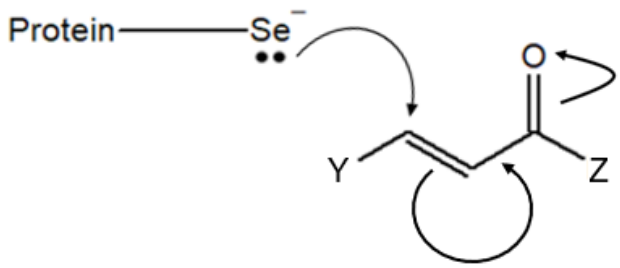
	Indicative content (Similarities) **IP1** platinum / Pt and Vanadium(V) oxide / V_2O_5 / both are **heterogeneous** catalysts **IP2** reactants **adsorb** / are **adsorbed** onto the catalyst surface **IP3** Products desorb / are desorbed from the catalyst surface (Differences) **IP4** (in the catalytic converter / with rhodium) reactant bonds are weakened **and** $2CO + 2NO \rightarrow 2CO_2 + N_2$ **IP5** (in the Contact Process) vanadium(V) oxide / V_2O_5 is reduced (by sulfur dioxide) **and** $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$ **IP6** vanadium(IV) oxide / V_2O_4 is then oxidised (by oxygen back to V_2O_5) **and** $V_2O_4 + ½\ O_2 \rightarrow V_2O_5$	Reference to **both** catalysts applies to **IP1**, **IP2** and **IP3** but this need not be explicit. Do not award **IP1** if V_2O_5 is homogeneous Allow chemisorption Allow diffuse away for desorb Allow deadsorption Allow any reference to leaving the catalyst Reference to surface required in **IP2** or **IP3** If **IP2** and **IP3** are not awarded, allow **IP3** for adsorbed and desorbed with reference only to **either** rhodium / catalytic converter **or** V_2O_5 / Contact process Ignore bonds break Ignore bond weakening for V_2O_5 If **IP5** and **IP6** are not awarded, allow **IP6** for either V_2O_5 is first reduced then oxidised **or** decreases then increases in oxidation number **or** for the two equations	

(Total for Question 20 = 6 marks)

TOTAL FOR SECTION B = 49 MARKS

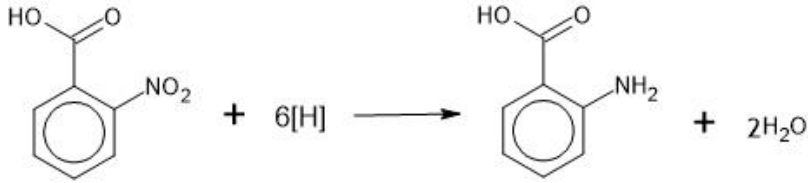
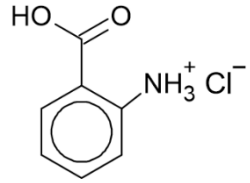
Section C

Question Number	Answer	Additional Guidance	Mark
21(a)	An answer that makes reference to the following points: A completed mechanism showing • curly half headed arrows to show homolytic fission of the O—H bond **and** the movement of the single unpaired electron from T• to between T and H to form a T—H bond **(1)**	<u>Example of completed mechanism</u>  Allow curly half-arrows originating from opposite sides of the O–H bond Left-hand curly half-arrow must terminate between T• and H Right hand curly half-arrow must terminate on or near to O atom of H–O Ignore any dipoles, even if incorrect Ignore any arrows on right hand side structure	**(1)**

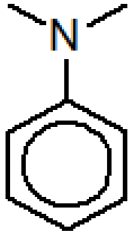
Question Number	Answer	Additional Guidance	Mark
21(b)	An answer that makes reference to the following points: A completed mechanism showing • curly arrow from lone pair on Se^- to correct C of the C=C bond **(1)** • curly arrow from C=C bond to C—C bond **and** curly arrow from C=O bond to O **(1)**	<u>Example of completed mechanism</u>  Penalise + on C of C=C Penalise additional arrows for M2 only Penalise fish-hook arrows once only Ignore any dipoles	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(c)	An explanation that makes reference to the following points: $([Co(curc)_2]^+)$ • coordination number 4 • square planar **(1)** $(Fe(curc)(C_2H_5OH)_2(NO_3)_2)$ • coordination number 6 • octahedral **(1)** 2 or 3 points scores (1) all 4 points scores (2)	Allow just identification of the cobalt complex Allow forms 4 dative / coordinate bonds Allow tetrahedral Allow just identification of the iron complex Allow forms 6 dative / coordinate bonds Ignore bond angles, even of wrong Ignore errors in writing of formulae If the complexes are not identified then score (1) for four correct points.	**(2)**

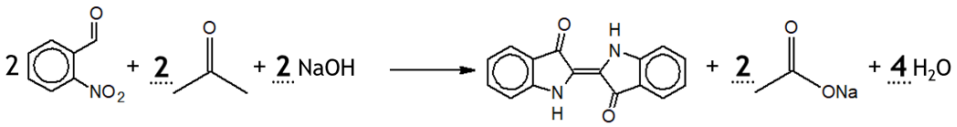
Question Number	Answer	Additional Guidance	Mark
21(d)(i)	An answer that makes reference to the following points: • $K_2Cr_2O_7$ / potassium dichromate (VI) **(1)** **and** H_2SO_4 / sulfuric acid **(1)** • (heat under) reflux	Accept $Na_2Cr_2O_7$ / sodium dichromate (VI) Comment: Allow $KMnO_4$ / potassium manganate(VII) **and** H_2SO_4 Allow H_3PO_4 Do not award HCl Ignore HUR	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(d)(ii)	An answer that makes reference to the following points: • correct structure of 2-aminobenzoic acid **(1)** • correct balancing of [H] and H_2O **(1)**	<u>Example of correct equation</u>  $C_6H_4(NO_2)COOH + 6[H] \rightarrow C_6H_4(NH_2)COOH + 2H_2O$ scores (1) Allow any correct combination of skeletal or displayed formulae Allow M2 if missing ring in hexagon Allow Kekulé structures Ignore equations using Sn and / or HCl but if HCl used in an equation, allow M1 for  	**(2)**

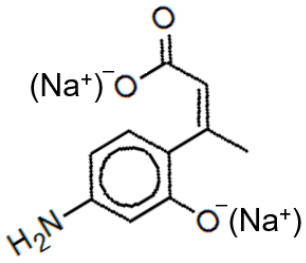
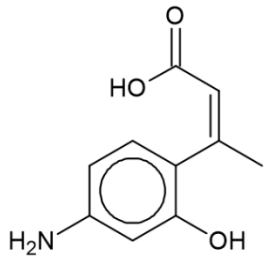
Question Number	Answer	Additional Guidance	Mark
21(d)(iii)	• $NaNO_2$ / sodium nitrite / sodium nitrate(III) **and** HCl / hydrochloric acid	Allow HNO_2 / nitrous acid / nitric(III) acid **and** HCl / hydrochloric acid Ignore conditions, including concentration of HCl Do not award $NaNO_3$/sodium nitrate((V))	**(1)**

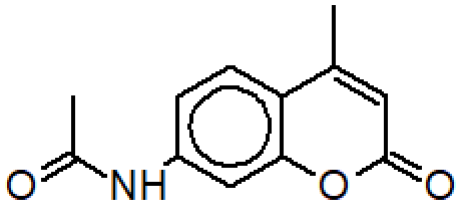
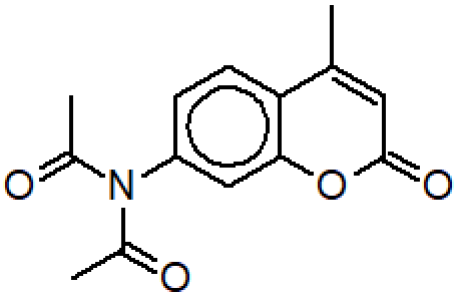
Question Number	Answer	Additional Guidance	Mark
21(d)(iv)	• correct structure for *N, N*-dimethylphenylamine	<u>Example of correct structure</u>  Allow any correct combination of skeletal, structural or displayed formulae Allow Kekulé benzene Ignore name, even if incorrect Ignore quaternary salt	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(d)(v)	• (the) **diazonium** (ion / chloride / salt) decomposes / reacts with water (above 5ºC)	Allow (the) **diazonium** (ion / chloride / salt) undergoes (nucleophilic) substitution (at higher temperatures) Allow it (decomposes to) form 2-hydroxybenzoic acid / phenol (and N_2 at higher temperatures) Ignore just further reaction further substitution	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(e)(i)	An answer that makes reference to two of the following points: A completed equation showing • 2 moles of propanone and 2 moles of sodium ethanoate **(1)** • 2 moles of NaOH and 4 moles of H_2O **(1)**	Example of equation  M2 dependent on M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(e)(ii)	An answer that makes reference to three of the following points: • M_r of 2-nitrobenzaldehyde **and** M_r indigotin **(1)** • moles of indigotin **and** moles of 2-nitrobenzaldehyde **(1)** • moles 2-nitrobenzaldehyde required at 83.5% yield **(1)** • Mass of 2-nitrobenzaldehyde required **(1)**	<u>Example of calculation</u> $M_r = (7 \times 12 + 5 \times 1 + 14 + 3 \times 16) = 151(.0)$ $M_r = (16 \times 12 + 1 \times 10 + 2 \times 14 + 2 \times 16) = 262(.0)$ $n = (5.00 \div 262 = 0.019084)$ **and** $n = (2 \times 0.\ 019084) = 0.038168$ (mol) $n = \frac{100}{83.5} \times 0.038168 = 0.045710$ (mol) $m = 0.045710 \times 151 = 6.9022$ / 6.90 / 6.9 (g) Allow 6.87 to 6.92 NB operations for M1, M2 and M3 can be done in any order Ignore SF except 1 SF throughout TE throughout Correct answer with no working scores **(4)** 4.802 to 4.816 (multiplied by 83.5% instead of dividing) scores **(3)** 3.436 to 3.454 (missed x 2 in M2) scores **(3)** 1.727 /1.73 / 1.7 (÷2 instead of x2) scores **(3)** If no other mark scored, allow **(1)** for (5 ÷ 262=) 0.0190 to 0.191	**(4)**

Question Number	Answer	Additional Guidance	Mark
21(fi)	• hydrolysed ester linkage **and** correct carbon frame and amine group **(1)** • deprotonated carboxyl **and** phenol groups **(1)**	Example of structure  scores (2) Allow *E* or *Z* isomer Allow Kekulé structures  scores (1) Allow any correct combination of skeletal, structural or displayed formulae	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(fii)	• correct condensation product **(1)**	Example of structure  Allow Kekulé structures Allow any correct combination of skeletal or displayed formulae Ignore connectivity of NH Allow  Ignore incorrect balancing if structure given in an equation	**(1)**

(Total for Question 21 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 90 MARKS