Mark Scheme (Results)

Summer 2022

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

Edexcel and BTEC Qualifications

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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 <u>meaning</u> 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.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1(a)	**The only correct answer is B** (Fe^{2+}) ***A*** *is incorrect because* Cl^- *and* $S_2O_8^{2-}$ *ions are both negative so likely to repel* ***C*** *is incorrect because* Cu^{2+} *cannot oxidise* I^- ***D*** *is incorrect because* Cu^+ *cannot oxidise* I^-	**(1)**

Question Number	Correct Answer	Mark
1(b)	**The only correct answer is D** (homogeneous) ***A*** *is incorrect because the catalyst is not a product of the reaction* ***B*** *is incorrect because the catalyst is not an enzyme* ***C*** *is incorrect because the catalyst is not in a different physical state to the reactants*	**(1)**

Question Number	Correct Answer	Mark
1(c)	**The only correct answer is D** (sulfuric acid) ***A*** *is incorrect because ammonia is produced in industry using an iron catalyst* ***B*** *is incorrect because nitic acid is produced in industry using a platinum / rhodium catalyst* ***C*** *is incorrect because sodium hydroxide is produced in industry by electrolysis of brine, without a catalyst*	**(1)**

(Total for Question 1 = 3 marks)

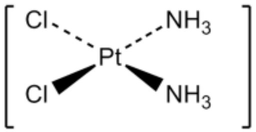
Question Number	Correct Answer	Mark
2(a)	**The only correct answer is A** ($H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$) ***B** is incorrect because it is the reverse of the reaction at the negative electrode* ***C** is incorrect because it is the reaction at the positive electrode* ***D** is incorrect because it is the reverse of the reaction at the positive electrode*	**(1)**

Question Number	Correct Answer	Mark
2(b)	**The only correct answer is C** (the catalyst is more efficient) ***A** is incorrect because the overall reaction is the same* ***B** is incorrect because the overall reaction is the same* ***D** is incorrect because the overall reaction is the same*	**(1)**

(Total for Question 2 = 2 marks)

Question Number	Correct Answer	Mark
3	**The only correct answer is C** (green) ***A** is incorrect because thiosulfate ions will reduce vanadate(V) to oxidation state = +3* ***B** is incorrect because thiosulfate ions will reduce vanadate(V) to oxidation state = +3* ***D** is incorrect because thiosulfate ions will not reduce vanadate(V) to oxidation state = +2*	**(1)**

(Total for Question 3 = 1 mark)

Question Number	Correct Answer	Mark
4	**The only correct answer is C**  ***A** is incorrect because it is not used in the treatment of cancer* ***B** is incorrect because it is not used in the treatment of cancer* ***D** is incorrect because it is the trans form of a complex used in the treatment of cancer*	**(1)**

(Total for Question 4 = 1 mark)

Question Number	Correct Answer	Mark
5	**The only correct answer is A** (NaOH(aq)) ***B** is incorrect because the* $Cr_2O_7^{2-} + H_2O \rightleftharpoons 2CrO_4^{2-} + 2H^+$ *would move to the left on addition of acid* ***C** is incorrect because zinc would reduce* $Cr_2O_7^{2-}$ ***D** is incorrect because hydrogen peroxide is used to oxidise* Cr^{3+} *to form* $Cr_2O_7^{2-}$	**(1)**

(Total for Question 5 = 1 mark)

Question Number	Correct Answer	Mark
6	**The only correct answer is C** (31.25) *__A__ is incorrect because an incorrect expression to find uncertainty is used and only one burette reading is taken into account* *__B__ is incorrect because only one burette reading is taken into account* *__D__ is incorrect because it is simply the % uncertainty multiplied by 100*	**(1)**

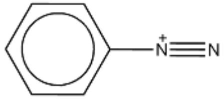
Question Number	Correct Answer	Mark
7(a)	**The only correct answer is B** (62.5 %) *__A__ is incorrect because the two carbonyl carbon atoms have not been included* *__C__ is incorrect because the hydrogen atoms have not been included* *__D__ is incorrect because two additional carbon atoms have been included*	**(1)**

(Total for Question 6 = 1 mark)

Question Number	Correct Answer	Mark
7(b)	**The only correct answer is B** (3) ***A** is incorrect because the carbons in the benzene ring are not all in the same environment* ***C** is incorrect because there are only 2 different carbon environments in the benzene ring* ***D** is incorrect because there are only 2 different carbon environments in the benzene ring*	**(1)**

Question Number	Correct Answer	Mark
7(c)	**The only correct answer is A** (a single type of monomer by an addition reaction) ***B** is incorrect because the polymer is not formed by a condensation reaction* ***C** is incorrect because the polymer is not formed by two different types of monomer* ***D** is incorrect because the polymer is not formed by two different types of monomer or a condensation reaction*	**(1)**

(Total for Question 7 = 3 marks)

Question Number	Correct Answer	Mark
8	**The only correct answer is D**  *__A__ is incorrect because it is the phenylammonium ion* *__B__ is incorrect because the bonding and charge is incorrect on the right hand nitrogen* *__C__ is incorrect because the structure is an amine with a positive charge*	**(1)**

(Total for Question 8 = 1 mark)

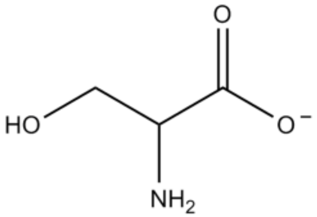
Question Number	Correct Answer	Mark
9(a)	**The only correct answer is B** (ether) *__A__ is incorrect because it would protonate the Grignard reagent* *__C__ is incorrect because it is non-polar* *__D__ is incorrect because it would react with the Grignard reagent to form a tertiary alcohol*	**(1)**

Question Number	Correct Answer	Mark
9(b)	**The only correct answer is D** (to ensure the solvent boils smoothly) ***A*** *is incorrect because the anti-bumping granules will not change the boiling temperature* ***B*** *is incorrect because this is the role of the condenser* ***C*** *is incorrect because the anti-bumping granules will not affect the flammability of the solvent*	**(1)**

Question Number	Correct Answer	Mark
9(c)	**The only correct answer is D** (negative and nucleophilic) ***A*** *is incorrect because the carbon atom is not positive or electrophilic* ***B*** *is incorrect because the carbon atom is not positive* ***C*** *is incorrect because the carbon atom is not electrophilic*	**(1)**

Question Number	Correct Answer	Mark
9(d)	**The only correct answer is A** (hexan-3-one) ***B*** *is incorrect because the product would be 2,4-dimethyloctan-4-ol* ***C*** *is incorrect because hexan-3-ol does not have a carbonyl bond* ***D*** *is incorrect because hexan-2-ol does not have a carbonyl bond*	**(1)**

(Total for Question 9 = 4 marks)

Question Number	Correct Answer	Mark
10(a)	**The only correct answer is D**  ***A*** *is incorrect because this ion would form in an acidic solution* ***B*** *is incorrect because this is the zwitterion* ***C*** *is incorrect because the OH group would not lose a proton*	**(1)**

Question Number	Correct Answer	Mark
10(b)	**The only correct answer is B** (ionic bonds) ***A*** *is incorrect because ionic bonds are far stronger than any hydrogen bonds* ***C*** *is incorrect because ionic bonds are far stronger than any London forces* ***D*** *is incorrect because the formation of a peptide bond forms a dipeptide*	**(1)**

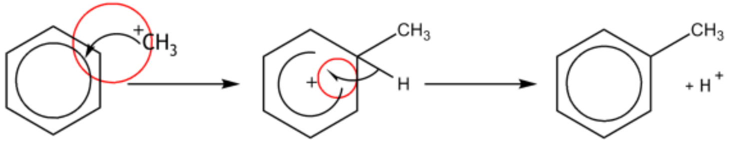
(Total for Question 10 = 2 marks)

Question Number	Correct Answer	Mark
11	**The only correct answer is A** (more reactive and higher electron density) ***B*** *is incorrect because phenol has a higher electron density* ***C*** *is incorrect because phenol is not less reactive* ***D*** *is incorrect because phenol is not less reactive and has a higher electron density*	**(1)**

(Total for Question 11 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Additional Guidance	Mark
12(a)(i)	An answer that makes reference to the following points: - circle around arrow from $^{+}CH_3$ to ring (wrong direction) **(1)** - circle around arrow from bond attached to H, to partial ring (single-headed arrow) **(1)**	$CH_3Cl + AlCl_3 \longrightarrow {}^{+}CH_3 + AlCl_4^-$  $H^+ + AlCl_4^- \longrightarrow HCl + AlCl_3$	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
12(a)(ii)	An answer that makes reference to the following points: • arrow should move from ring / arrow is going the wrong way **and** ring is electron-rich / as ring cannot accept electrons / as ${}^+CH_3$ does not have a lone pair (of electrons) / as ${}^+CH_3$ needs to gain electrons / as ${}^+CH_3$ is an electrophile **(1)** • arrow (from C-H bond) should be double-headed **and** as both electrons in the bond pair move (to complete the ring) / as moving a single electron would not complete the ring / as moving a single electrons would form (free) radicals **(1)**	If no other credit awarded, then 1 mark can be given for both corrections correctly identified	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
12(b)	An answer that makes reference to one of the following points: • to prevent further substitutions (of nitro groups)	Allow methylbenzene is (more) reactive (than benzene) **and** because a methyl group is electron releasing Allow ring in methylbenzene is (more) electron-rich (than benzene) Allow forms dinitrobenzene / trinitrobenzene Ignore further reactions / forms other products	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
12(c)	An answer that makes reference to the following point: • oxidation	Allow oxidation and reduction / oxidation and redox Ignore references to redox	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
12(d)	An answer that makes reference to the following point: • Sn **and** (concentrated) HCl	Accept correct names Allow Zn as alternative to Sn Ignore references to concentration or state of HCl Ignore any references to heat / temperature Ignore addition of NaOH after reaction with Sn and HCl	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
12(e)	An explanation that makes reference to three of the following points: • (carbonyl) carbon is electron-deficient / has a partial positive charge • nitrogen (on NH_2 group) has a lone pair (of electrons) • which move to (carbonyl) carbon (to form bond) / which form a bond with the (carbonyl) carbon • Cl is a good leaving group / bond to Cl breaks / C-Cl bond pair moves to Cl	Allow M1, M2 and M3 on a clearly annotated diagram Ignore references to delocalisation Ignore references to nucleophilic substitution / nucleophilic addition-elimination	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
12(f)	 - calculation of moles of 2-ethanoylaminobenzoic acid **(1)** - calculation of moles of benzene required, taking into account the overall percentage yield **(1)** - calculation of mass of benzene **(1)** - calculation of volume of benzene to 1/2/3 SF **(1)**	Example of calculation $5.92 \div 179 = 0.033073$ (mol) / $3.3073 \text{ x } 10^{-2}$ $0.033073 \times (100 \div 28.2) = 0.11728$ (mol) $0.11728 \times 78 = 9.1477$ (g) $9.1477 \div 0.879 = 10.407$ $= 10.4$ / 10 cm^3 Ignore absence of units but do not award incorrect units. Marks 2 – 4 can be in any order Allow TE throughout Answer of 10 cm^3 with no working scores M4 only Correct answer with some working scores 4	**(4)**

(Total for Question 12 = 14 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>13</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 four 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 and overall score of 3 marks (3 marks for indicative content and zero marks for linkages).

In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.</td>
<td></td>
</tr>
</table>

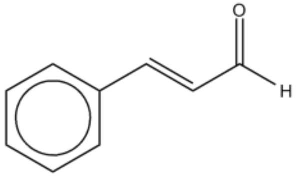
	Indicative Points Similarities **IP1** both alkalis initially react to give a green precipitate	Allow solid / crystals / ppt / ppte	
	IP2 $[Ni(H_2O)_6]^{2+} + 2OH^- \rightarrow [Ni(H_2O)_4(OH)_2] + 2H_2O$ / $[Ni(H_2O)_6]^{2+} + 2NH_3 \rightarrow [Ni(H_2O)_4(OH)_2] + 2NH_4^+$	Allow $Ni^{2+} + 2OH^- \rightarrow Ni(OH)_2$ $NiSO_4 + 2NaOH \rightarrow Ni(OH)_2 + Na_2SO_4$	
	IP3 these are deprotonation reactions	Allow acid-base reaction Ignore precipitation reaction / neutralisation reaction	
	Differences **IP4** with excess ammonia (the green precipitate dissolves to) form a blue solution **and** no change with sodium hydroxide	Do not award blue-green or blue-purple solution	
	IP5 $[Ni(H_2O)_6]^{2+} + 6NH_3 \rightarrow [Ni(NH_3)_6]^{2+} + 6H_2O$ / $[Ni(H_2O)_4(OH)_2] + 6NH_3 \rightarrow [Ni(NH_3)_6]^{2+} + 4H_2O(l) + 2OH^-$ / $Ni(OH)_2 + 6NH_3 \rightarrow Ni(NH_3)_6^{2+} + 2OH^-$	Allow $[Ni(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Ni(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$ Ignore state symbols in IP2 and IP5, even if incorrect Ignore omission of square brackets	
	IP6 with excess ammonia it is ligand exchange	Allow ligand substitution	
	Comment in equations allow use of round brackets instead of square brackets		

(Total for Question 13 = 6 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>14(a)</td>
<td>

calculation of mass of C and H (1)
calculation of mass of oxygen (1)
calculation of moles of C, H and O (1)
calculation of ratio and deduction of empirical formula (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>18.07 x (12÷44)
= 4.9282</td><td>3.30 x (2÷18)
= 0.36667</td><td>6.02 – (4.9282+0.36667)
=0.72513</td></tr>
<tr><td>Moles (mol)</td><td>4.9282 ÷12
=0.41068</td><td>0.36667÷1
= 0.3667</td><td>0.72513 ÷ 16
= 0.045320</td></tr>
<tr><td>Ratio</td><td>0.41068÷0.045320
= 9.06</td><td>0.36667÷0.045320
= 8.09</td><td>0.045320÷0.045320
= 1</td></tr>
</table>
C_9H_8O
Allow TE throughout
Ignore minor rounding errors in M1-M3
</td>
<td>(4)</td>
</tr>
</table>

Question Number	Acceptable Answers	Additional Guidance	Mark
14(b)	An explanation that makes reference to the following points: • correct structure of Q shown **(1)** • sooty flame indicates benzene ring / arene / phenyl group / high C : H ratio / aromatic **(1)** • orange precipitate with 2,4-dinitrophenylhydrazine indicates carbonyl group / C=O / aldehyde **or** ketone **(1)** • silver precipitate with Tollens' reagent indicates aldehyde **(1)** • decolourises bromine water indicates **C=C** bond / alkene (functional group) / unsaturated **(1)** • exists as a pair of geometric isomers indicates only 1 hydrogen atom on each carbon of the C=C bond / each carbon of the C=C has two different groups attached **(1)**	e.g  Accept cis structure Accept skeletal structure without terminal hydrogen Accept hybrid structures e.g. partially displayed Ignore 'it is an alkene' Ignore references to phenol Do not award benzene Allow 'cannot have -CH=CH_2 group' Allow '2 different groups on each side of the C=C bond'	**(6)**

(Total for Question 14 = 10 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
15(a)(i)	- $Cr_2O_7^{2-}$ orange **and** Cr^{3+} green	Do not award precipitate Do not award blue Ignore adjectives e.g. 'dark', 'pale' etc	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
15(a)(ii)	- colour change (from orange to green at end-point) is not distinctive / colour change (from orange to green at end-point) is not sharp enough (without indicator) / colour change (at end-point) not easy to detect (without indicator)	Allow solutions (very) dilute so colour change hard to see (without indicator) Allow intense red-violet colour is not masked by colours of chromium species Allow idea that (all) chromium / /iron species are coloured so the change is not easy to detect (without indicator)	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
15(a)(iii)	• calculation of moles of ammonium iron(II) sulfate **(1)** • calculation of moles of dichromate(VI) in titre **(1)** • calculation of moles of dichromate(VI) in original sample **(1)** • calculation of mass of potassium dichromate(VI) in original sample **(1)** • calculation of % by of potassium dichromate(VI) in 50 g of cement **(1)**	Example of calculation $3.24 \times 10^{-4} \times (10.90/1000) = 3.5316 \times 10^{-6}$ (mol) $3.5316 \times 10^{-6} \div 6 = 5.8860 \times 10^{-7}$ (mol) $5.8860 \times 10^{-7} \times 2 = 1.1772 \times 10^{-6}$ (mol) $1.1772 \times 10^{-6} \times 294.2 = 3.4633 \times 10^{-4}$ (g) $\frac{(3.4633 \times 10^{-4})}{50} \times 100 = 6.9266 \text{ x } 10^{-4}$ % Allow TE throughout, but for M5 TE % must be less than 100 % Ignore SF Correct answer with or without working scores **(5)**	**(5)**

Question Number	Acceptable Answers	Additional Guidance	Mark
15(b)	An explanation that makes reference to the following points: • as it reacts with the COOH group to form COO^- / sodium carboxylate / a salt **(1)** • sodium salts are (more) soluble in water (than the acid) **(1)**	Allow ions are solvated by water / interact with water (more readily) Allow 'forms ionic substances which are more soluble in water'	**(2)**

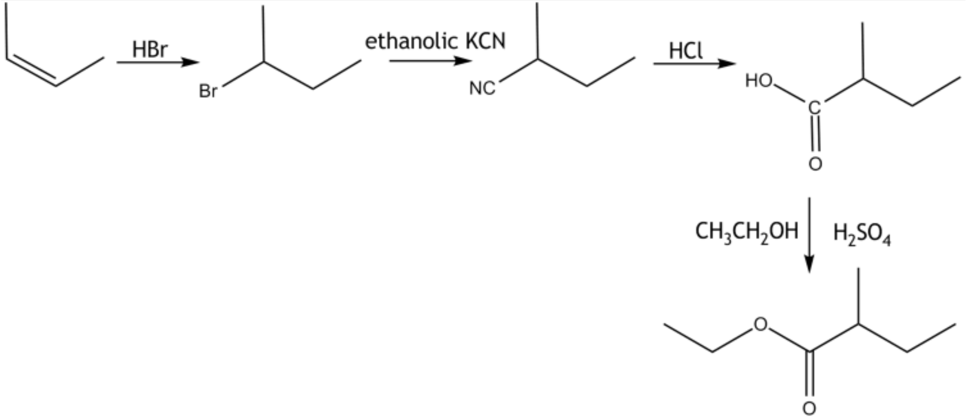
Question Number	Acceptable Answers	Additional Guidance	Mark
15(c)(i)	An explanation that makes reference to the following points: • lone pair(s) of electrons on nitrogen (atoms) **(1)** • lone pair on one of the nitrogen (atoms) on the left of the C=O **and** lone pair on one of the nitrogen (atoms) on the right of the C=O **(1)** • Which form **2** dative (covalent) bonds (to the chromium ion) **(1)**	Allow lone pairs shown on diagram for M1 and M2 Ignore references to lone pairs on oxygen Do not award M2 if four lone pairs are referenced unless it's clear that only 2 of them, one from either side of the carbonyl carbon, form the bonds Allow dative (covalent) bonds shown on diagram	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
15(c)(ii)	• chromium(VI) has an empty d subshell	Allow empty d orbitals (plural) Allow empty d orbital (singular) if clarified by correct electron configuration of ion Ignore idea that d orbitals do not split	**(1)**

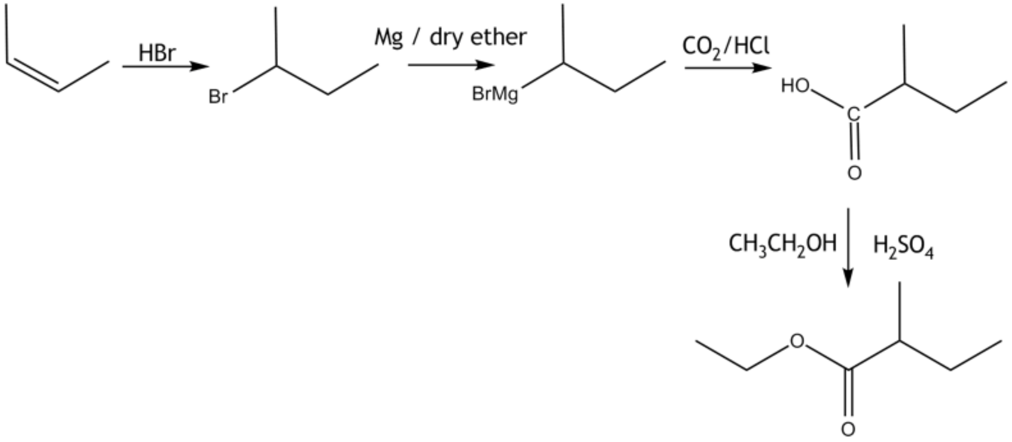
Question Number	Acceptable Answers	Additional Guidance	Mark
15(d)	An explanation that makes reference to the following points:		**(2)**
	- (reaction has) 5 particles on the left, but 7 on the right **(1)**	Allow more particles on the right hand side (than on the left hand side) / increase in number of moles (of particles) Do not award use of molecules for particles Do not award incorrect numbers of particles	
	- so there is a (pronounced) increase in entropy (of the system) / change in entropy (of the system) is positive / $\Delta S_{\text{(system)}}$ is positive **(1)**	Allow so there is a (pronounced) increase in disorder (of the system) Ignore there is a (pronounced) increase in total entropy M2 dependent on M1 or near miss e.g. use of 'molecules' in M1, increasing but incorrect number of particles in M1	

(Total for Question 15 = 15 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
16	An answer that makes reference to the following points: • formation of 2-bromobutane using HBr **(1)** • use of ethanolic KCN / alcoholic KCN / KCN(eth) **(1)** • formation of 2-methylbutanenitrile **(1)** • using HCl(aq) **(1)** • formation of 2-methylbutanoic acid **(1)** • formation of ethyl 2-methylbutanoate using ethanol and sulfuric acid **(1)** **OR** • formation of 2-bromobutane using HBr **(1)** • using magnesium in (dry) ether **(1)** • formation of sec-butyl magnesium bromide **(1)** • using CO_2 and HCl(aq) **(1)** • formation of 2-methylbutanoic acid **(1)** • formation of ethyl 2-methylbutanoate using ethanol and sulfuric acid **(1)**	See below Allow HCl and 2-chlorobutane Must be in context of attempted reaction with a haloalkane Allow CN^- / Ignore HCN Accept any strong mineral acid Allow H^+ Allow any strong mineral acid Allow H^+ Do not award just ‘acid’ Must be in context of attempted reaction with a haloalkane Allow H^+ / acid work up Do not award just ‘acid’ Accept any strong mineral acid Allow any strong mineral acid Allow H^+ Do not award just ‘acid’	**(6)**



OR



Note - the reaction of the Grignard with CO_2 and HCl can be shown as two separate steps. If this is the case ignore the structure of any intermediate species

(Total for Question 16 = 6 marks)

(TOTAL FOR SECTION B = 51 MARKS)

Question Number	Acceptable Answers	Additional Guidance	Mark
17(a)(i)	• calculation of moles of CuSCN **(1)**	Example of calculation 4.69 ÷ 121.6 = 0.038569 / 3.8569 x 10^{-2} (mol)	**(4)**
	• calculation of moles of Cu **(1)**	1:1 so = 0.038569 / 3.8569 x 10^{-2} (mol) M2 can be subsumed as part of M3	
	• calculation of mass of Cu **(1)**	0.038569 × 63.5 = 2.4491 (g)	
	• calculation of % of Cu **and** statement that it is a gilding metal **(1)**	(2.4491 ÷ 2.72) x 100 = 90.04 % Ignore SF except 1 SF Allow TE at each step Note – if TE for M4 gives answer outside range of 95-89 % then must be identified as NOT a gilding metal Do not award TE for M4 if answer > 100 % Allow calculation of % of Zn to show whether sample is a gilding metal	
	Note – allow 121.5 for M_r of CuSCN in M1 but do not award 64 for copper in M3		

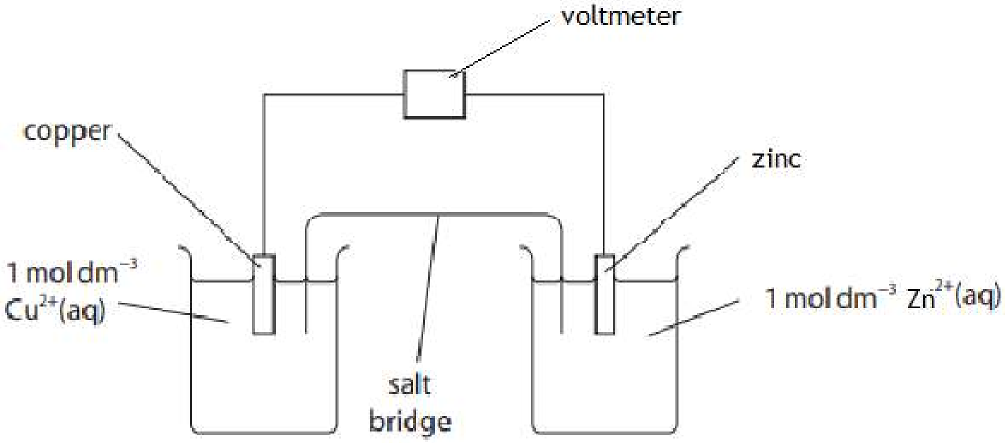
Question Number	Acceptable Answers	Additional Guidance	Mark
17(a)(ii)	An explanation that makes reference to the following points: • the E_{cell} data indicates that Cu^{2+} should not be reduced to Cu^{+} **and** Cu^{+} should be reduced to Cu **(1)** • Cu^{2+} can be reduced to Cu^{+} as the conditions must be non-standard **and** as the $E^{\ominus}$ values are so close **(1)** • but Cu^{+} is not reduced to Cu as the reaction must be kinetically hindered / have a high activation energy / very slow **(1)**	Accept $E_{cell} = -0.02$ V **and** $E_{cell} = +0.35$ V Allow addition of OH^{-} ions as alternative for conditions must be non-standard Allow 'not kinetically favoured'	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
17(b)	• white precipitate forms / precipitate of $Zn(H_2O)_4(OH)_2$ forms **(1)**	Accept sufficient NaOH will need to be added to neutralise the excess nitric acid Allow precipitate of $Zn(OH)_2$ forms / precipitate of zinc hydroxide forms M1 can be awarded from correct formulae and state symbol in equation, hence fully correct equation with state symbol for solid scores M1 and M2 Allow solid / crystals for ppt	**(4)**
	• $Zn(H_2O)_6^{2+} + 2OH^- \rightarrow Zn(H_2O)_4(OH)_2 + 2H_2O$ **(1)**	Allow $Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2$	
	• but as excess NaOH(aq) is added, precipitate will dissolve **(1)**		
	• due to formation of $Zn(OH)_4^{2-}$ **(1)**	Correct formulae for M4 can be shown as part of an equation, even if equation is not correct Ignore state symbols even if incorrect Ignore omission of square brackets Ignore comments on validity of procedure	

Question Number	Acceptable Answers	Additional Guidance	Mark
17(c)	An explanation that makes reference to the following points: • zinc ions disrupt layers / disrupt structure of copper ions **(1)** • (so) layers (of copper ions) are less likely to slide over each other **(1)**	Allow reference to atoms zinc ions are a different size to copper ions / zinc ions are larger than copper ions Do not award M1 if particles referred to as molecules or forces referred to as intermolecular forces Allow 'atoms are less likely to slide over each other' Allow reverse argument	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
17(d)(i)	A diagram that makes reference to the following points: • two correctly labelled electrodes **(1)** • both solutions and concentrations correct **(1)** • salt bridge labelled, touching both solutions and voltmeter shown **(1)**	Allow any soluble zinc and copper salts Allow name or formulae in M1 and M2 If the solution for the salt bridge is discussed it must be correct Ignore temperature and pressure	**(3)**

<u>Example of diagram</u>



Question Number	Acceptable Answers	Additional Guidance	Mark
17(d)(ii)		<u>Example of calculation</u>	**(3)**
	- calculation of E for zinc half cell / calculation of $E - E^{\ominus}$ **(1)**	$0.34 - 1.09 = -0.75$ (V)	
	- insert values in Nernst equation **and** rearrangement of Nernst equation **(1)**	$-0.75 = -0.76 + (0.0260/2) \times \ln[Zn^{2+}]$ $\ln[\text{ion}] = (0.01) \text{ x } (2/0.026)$ $\ln[\text{ion}] = 0.769230$	
	- calculation of [ion] **(1)**	$[\text{ion}] = 2.1581$ (mol dm^{-3}) Ignore SF except 1SF Allow TE throughout	
	Alternative Route		
	- calculation of $E^{\ominus}_{cell}$ **(1)**	$0.34 - -0.76 = 1.10$ (V)	
	- insert values in Nernst equation **and** rearrangement of Nernst equation **(1)**	$1.10 = 1.09 + (0.0260/\mathbf{2}) \times \ln[Zn^{2+}]$ $\ln[\text{ion}] = (0.01) \text{ x } (\mathbf{2}/0.026)$ $\ln[\text{ion}] = 0.769230$	
	- calculation of [ion] **(1)**	$[\text{ion}] = 2.1581$ (mol dm^{-3}) Ignore SF except 1SF Allow TE throughout	

(Total for Question 17 = 19 marks)

(TOTAL FOR SECTION C = 19 MARKS)

TOTAL FOR PAPER = 90 MARKS

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