Pearson Edexcel

Mark Scheme (Results)

October 2020

Pearson Edexcel International Advanced Level In Chemistry (WCH05)
Paper 1: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

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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.

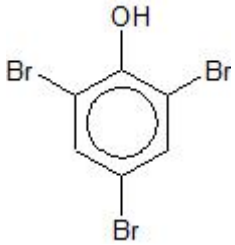
Full marks will be awarded if the candidate has demonstrated the above abilities.

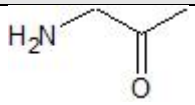
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	**The only correct answer is C** (fuming sulfuric acid) ***A*** *is not correct because this mixture is for the nitration of benzene* ***B*** *is not correct because this acid does not contain the electrophile* ***D*** *is not correct because this gaseous mixture will not work*	**(1)**

Question Number	Correct Answer	Mark
2	**The only correct answer is C** (burns with a smoky flame) **A** *is not correct because bromine water is not decolourised* **B** *is not correct because the mixture remains orange* **D** *is not correct because this is not evidence for unsaturation*	**(1)**

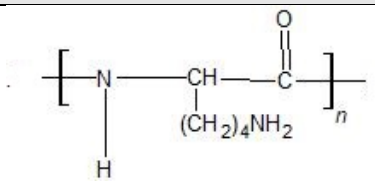
Question Number	Correct Answer	Mark
3	**The only correct answer is B**  ***A*** *is not correct because bromine does not substitute at every available position on the ring* ***C*** *is not correct because excess bromine substitutes at positions 2,4 and 6* ***D*** *is not correct because phenol reacts by substitution*	**(1)**

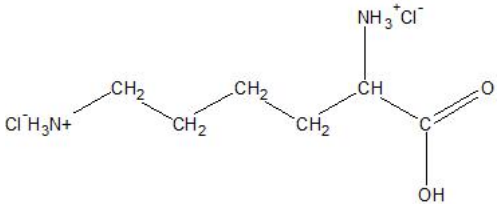
Question Number	Correct Answer	Mark
4	 **The only correct answer is D** **A** *is not correct because this is a cyclic amide* **B** *is not correct because this is an amide* **C** *is not correct because this is a substituted amide*	**(1)**

Question Number	Correct Answer	Mark
5(a)	**The only correct answer is A** (HNO_2) ***B*** *is not correct because this is the wrong acid* ***C*** *is not correct because these acids are used for nitration not diazotisation* ***D*** *is not correct because this acid can be present to stabilise the diazonium salt but not to produce it*	**(1)**

Question Number	Correct Answer	Mark
5(b)	**The only correct answer is D** (ice-cold alkaline solution) ***A*** *is not correct because the temperature is too high and the diazo compound would break down* ***B*** *is not correct because halogen carriers are used for substitution of the benzene ring and not azo dye formation* ***C*** *is not correct because the azo dye is not formed from reduction*	**(1)**

Question Number	Correct Answer	Mark
6	**The only correct answer is B** ($CH_2CHCONH_2$) ***A*** *is not correct because there is no C=C for addition polymerisation* ***C*** *is not correct because an addition and/or condensation polymer could form* ***D*** *is not correct because this molecule would not polymerise*	**(1)**

Question Number	Correct Answer	Mark
7(a)	 **The only correct answer is A** ***B*** *is not correct because there is no –NH-in the backbone of the chain* ***C*** *is not correct because there is no –NH- in the backbone of the chain and a single-bonded oxygen in inside the brackets* ***D*** *is not correct because the single-bonded oxygen should not be inside the brackets*	**(1)**

Question Number	Correct Answer	Mark
7(b)	 **The only correct answer is C** ***A*** *is not correct because the chlorine does not replace the OH to make an acyl chloride* ***B*** *is not correct because in excess both amine groups will react* ***D*** *is not correct because the chlorine does not replace the OH to make an acyl chloride*	**(1)**

Question Number	Correct Answer	Mark
7(c)	**The only correct answer is C** (ninhydrin). ***A*** *is not correct because this is used to detect aldehydes and ketones* ***B*** *is not correct because this is used to detect starch* ***D*** *is not correct because this is used to detect aldehydes*	**(1)**

Question Number	Correct Answer	Mark
7(d)	**The only correct answer is C (**proton transfer within the molecules results in ionic bonding) ***A*** *is not correct because London forces would not result in these properties* ***B*** *is not correct because hydrogen bonding would not result in these properties* ***D*** *is not correct because this is not true*	**(1)**

Question Number	Correct Answer	Mark
8	**The only correct answer is B (**aluminium forms a stable oxide coating) ***A*** *is not correct because aluminium does react under suitable conditions* ***C*** *is not correct because reference to non-standard conditions does not explain why it is corrosion-resistant* ***D*** *is not correct because the reaction is thermodynamically feasible*	**(1)**

Question Number	Correct Answer	Mark
9	**The only correct answer is D** (made from fossil fuels) **A** *is not correct because liquid methanol is easily stored* **B** *is not correct because liquid methanol is easily transported* **C** *is not correct because all fuels are flammable*	**(1)**

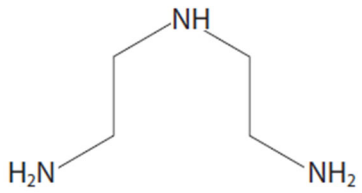
Question Number	Correct Answer	Mark
10	**The only correct answer is D** (promotion of electrons between split d orbitals) ***A*** *is not correct because electrons are not promoted to a higher quantum shell* ***B*** *is not correct because this is what happens in flame tests* ***C*** *is not correct because one orbital is not split but rather the d sub-shell*	**(1)**

Question Number	Correct Answer	Mark
11(a)	**The only correct answer is B** (ligand exchange) ***A*** *is not correct because there is no acidic and basic behaviour* ***C*** *is not correct because no oxidation has occurred* ***D*** *is not correct because no reduction has occurred*	**(1)**

Question Number	Correct Answer	Mark
11(b)	**The only correct answer is D** (6, 4) ***A*** *is not correct because this is ratio of the two chromium ions* ***B*** *is not correct because this is the numerical values of the charges* ***C*** *is not correct because the coordination number is different in the two species*	**(1)**

Question Number	Correct Answer	Mark
12	**The only correct answer is *C*** *(the process is gentler with temperature-sensitive substances).* ***A*** *is not correct because steam distillation is more expensive due to the additional equipment needed* ***B*** *is not correct because the neutrality of water is not an issue* ***D*** *is not correct because a safety valve is needed to release excess steam*	**(1)**

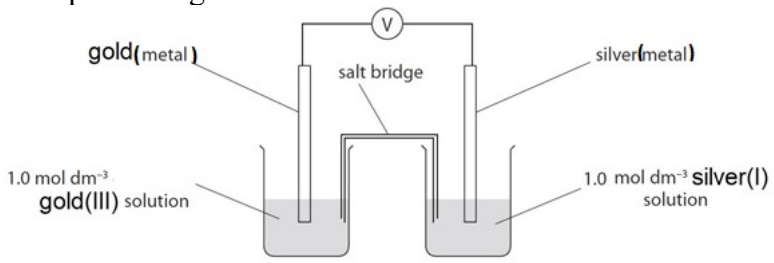
Question Number	Correct Answer	Mark
13	**The only correct answer is *D*** *(phenylamine < ammonia < butylamine)* ***A*** *is not correct because ammonia is a weaker base than butylamine* ***B*** *is not correct because phenylamine is a weaker base than ammonia* ***C*** *is not correct because butylamine is the strongest base/phenylamine is the weakest base*	**(1)**

Question Number	Correct Answer	Mark
14	 **The only correct answer is A** ***B*** *is not correct because ethane-1,2-diamine is bidentate* ***C*** *is not correct because the acetyl acetonate ion is bidentate* ***D*** *is not correct because the ethanedioate ion is bidentate*	**(1)**

Question Number	Correct Answer	Mark
15	**The only correct answer is A** *(directly proportional – directly proportional* **B** *is not correct because* $\ln K_c$ *is directly proportional to* $E^{\ominus}_{cell}$ **C** *is not correct because* ΔS_{system} *is directly proportional to* $E^{\ominus}_{cell}$ **D** *is not correct because both* ΔS_{system} *and* $\ln K_c$ *are directly proportional to* $E^{\ominus}_{cell}$	**(1)**

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	Diagram to include: Labelled salt bridge which must dip into solutions Allow filter paper soaked with KNO_3 Allow just KNO_3/ $NaNO_3$ **(1)** Voltmeter /V **(1)** Completed circuit with gold and silver electrodes Ignore absence of 1 mol dm^{-3} Allow just 'silver ions **(1)** Example of diagram  ALLOW half cells to be drawn the opposite way round	e.g Gold(I) sulfate Au^+ AgCl Gold ions With other metal ions Incorrect temperatures Electrodes not dipping into the solution	**(3)**

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	(Equation) $Au^{3+}(aq) + 3Ag(s) \rightarrow Au(s) + 3Ag^+(aq)$ **(1)** E^{θ}_{cell} (= +1.41 – 0.80) = (+) 0.61 (V) **(1)** Standalone marks		**(2)**

Question Number	Acceptable Answers	Reject	Mark
16(a)(iii)	**Either** The electrode potential/ E^{θ} for the reduction of gold(I) is more positive than that for the oxidation of gold(I) Allow reduction E^{θ} > oxidation E^{θ} **Or** E^{θ}_{cell} (= +1.69 – 1.29) = (+) 0.4(0) (V) which is positive so the reaction is feasible Allow answers using the anticlockwise rule. **(1)** (Equation) $3Au^{+} \rightarrow Au^{3+} + 2Au$ **(1)**	Reference to Ag scores (0)	**(2)**

Question Number	Acceptable Answers	Reject	Mark
16(b)(i)	Linear (shape) ALLOW unambiguous incorrect spellings such as lenear/linnear		**(1)**

Question Number	Acceptable Answers	Reject	Mark
16(b)(ii)	Zinc is the reducing reagent because it is oxidised/loses electrons Allow just Zinc is the reducing agent/ is oxidised/ zinc loses electrons/ Zinc's oxidation number or state increases/ goes from 0 to +2 **(1)** (Half equation) $Zn + 4CN^{-} \rightarrow [Zn(CN)_4]^{2-} + 2e(-)$ Allow $Zn \rightarrow Zn^{2+} + 2e(-)$ **(1)** Ignore state symbols even if incorrect		**(2)**

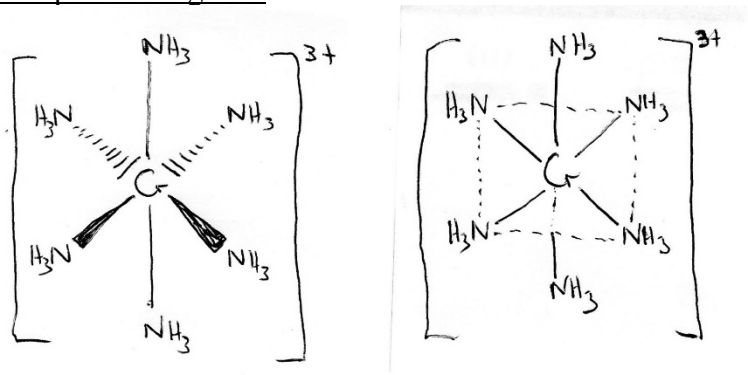
(Total for Question 16 = 10 Marks)

Question Number	Acceptable Answers	Reject	Mark
17(a)	A metal which forms one (or more stable) **ions** with an incompletely/partially filled d orbital/d subshell Ignore reference to different oxidation states/numbers Ignore reference to specific quantum levels e.g. 3	Just 'compounds' shell	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)	$4s^1$ ALLOW 4S1/$4s_1$ or combinations thereof	Answer given with any other configuration such as $3d^5$/$3d^{10}$/[Ar]	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(c)	Any two from CrO, Cr_2O_3, CrO_3 ALLOW CrO_2	$Cr_2O_7^{2-}$ CrO_4^-	**(1)**

Question Number	Acceptable Answers	Mark
17(d)	(**M1**) (The green precipitate formed by) Cr^{3+} will dissolve in excess sodium hydroxide solution to form a green solution **(1)** (**M2**) (The green precipitate formed by) Fe^{2+} turns brown on exposure to air (and doesn't dissolve in excess sodium hydroxide) **(1)** (**M3**) (The green precipitate formed by) Ni^{2+} doesn't dissolve in excess sodium hydroxide **(1)** ALLOW alternative method based on adding ammonia (**M1**) (The green precipitate formed by) Cr^{3+} will dissolve in excess ammonia (solution) to form a green solution **(1)** (**M2**) (The green precipitate formed by) Fe^{2+} doesn't dissolve in excess ammonia (solution) **(1)** (**M3**) (The green precipitate formed by) Ni^{2+} will dissolve in excess ammonia (solution) to form a blue solution **(1)**	**(3)**

Question Number	Acceptable Answers	Reject	Mark
17(e)(i)	3D image **(1)** Bonds clearly to the N of the ammonia molecules **(1)** <u>Examples of diagrams</u>  Ignore absence of square brackets and/or charge Ignore absence or presence of lone pair on nitrogen	NH_4 Incorrect charge Coordinate bond in the wrong direction	**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(e)(ii)	(Bond angle) 109.5° ALLOW 109 – 110° **(1)** Four areas of (bonded) electron density repel (to the maximum extent/minimal repulsion) **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(e)(iii)	(The ligand exchange reaction results in) an increase in moles/ moles change from 2 to 7/ $[Cr(NH_3)_6]^{3+} + EDTA^{4-} \rightarrow [Cr(EDTA)]^{-} + 6\ NH_3$ Allow Particles for 'moles' **(1)** The entropy (of the system) increases/ ΔS_{system} is positive Ignore references to stability of complex **(1)**		**(2)**

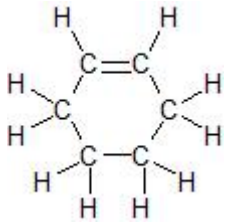
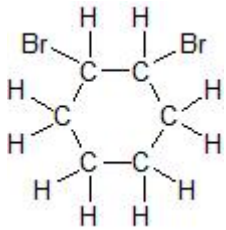
Question Number	Acceptable Answers	Reject	Mark
17(f)(i)	$2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$ ALLOW ⇌ Ignore state symbols even if incorrect		**(1)**

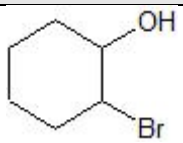
Question Number	Acceptable Answers	Mark
17(f)(ii)	Suitable calculation such as $n(Fe^{2+})$ = (0.0492 x 0.025=) 1.23 x 10^{-3} /0.00123 (mol) **(1)** 6:1 ratio so $n(Cr_2O_7^{2-})$= (1.23 x 10^{-3} ÷ 6) =2.05 x 10^{-4} (mol) / 0.000205 (mol) in 10.80 titre **(1)** $n(Cr_2O_7^{2-})$= 2.05 x 10^{-4} x (250 ÷ 10.80)=4.7454 x 10^{-3} (mol)/ 0.0047454 (mol) **(1)** $n(CrO_4^{2-})$ =(4.7454 x 10^{-3} x 2) = 9.4907 x 10^{-3} /0.0094907 (mol) **(1)** $m(Na_2CrO_4)$=(9.4907 x 10^{-3} x 162) = 1.5375 (g) **(1)** %(Na_2CrO_4)=(1.5375 x 100 ÷ 1.59) = 96.698 **(1)** Final answer without working scores (6) Allow TE at each stage M6 not awarded for an answer greater than 100% Ignore SF except 1 SF or > 5 SF	**(6)**

Question Number	Acceptable Answers	Reject	Mark
17(g)	Reference to the mechanism of action involving: Adsorption to the surface of the catalyst Allow active site(s) for 'surface' **(1)** Weakens the bonds in the reactants / (chemical) reaction at the surface of the catalyst **(1)** Desorption from the catalyst surface **(1)** Max (2) if the catalyst surface is not mentioned Allow (1) rescue mark if none other scored for general catalyst definition such as: lowers the activation energy by providing an alternative reaction therapy pathway	A**b**sorption	**(3)**

(Total for Question 17 = 22 Marks)

Question Number	Acceptable Answers	Reject	Mark
18(a)	$n(CO_2) = 7.20 \div 24 = 0.30$ (mol) **(1)** $n(H_2O) = 4.50 \div 18 = 0.25$ (mol) **(1)** Ratio C:H = 6:10 = 3:5 **(1)**		**(3)**

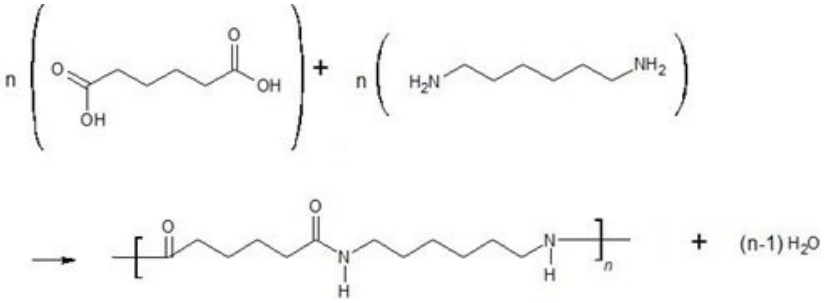
Question Number	Acceptable Answers	Reject	Mark
18(b)	X  **(1)** Y  **(1)** Penalise use of non-displayed formulae once only		**(2)**

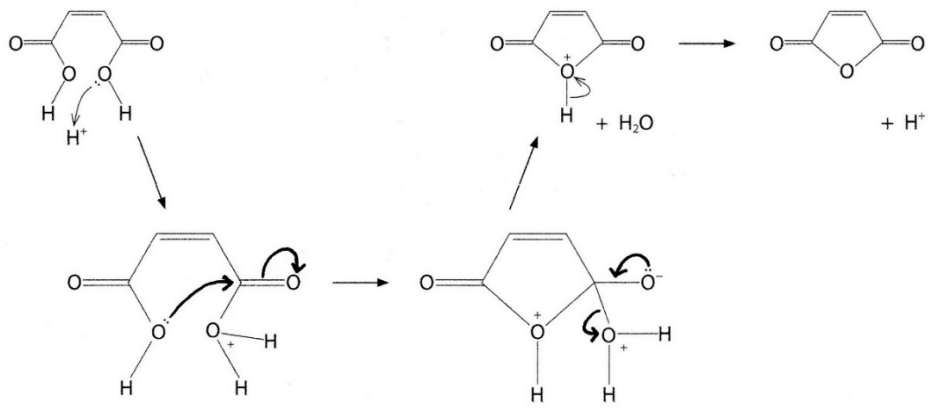
Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	 The OH and Br must be bonded to adjacent carbons		**(1)**

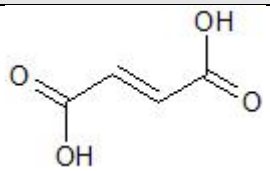
Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	Use of a polarimeter/use of plane polarised light **(1)** **Rotation** of the plane (of plane polarised light) **(1)**	 Bend for rotate	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(d)	Points can be made in either order **Absorption 1** C-H 3095-3010 (cm^{-1}) or C-H 2962-2853 (cm^{-1}) or C-H 1485-1365 (cm^{-1}) **(1)** **Absorption 2** C=C 1669-1645 (cm^{-1}) **(1)** Two correct absorptions without bonds scores **(1)**	Penalise single values once only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18 (e)(i)	Hexanedioic acid ALLOW Hexane-1,6-dioic acid/hexan-1,6-dioic acid/ hexandioic acid/ hexanedioic acid/1,6-dihexanoic acid Ignore punctuation	 Missing ‘di’	**(1)**

Question Number	Acceptable Answers	Reject	Mark
18(e)(ii)	A suitable diamine such as Hexane-1,6-diamine **(1)** Amide bond/CONH **(1)** A suitable equation with polymer having continuation bonds **(1)** Example of answer  Ignore brackets and 'n' Accept displayed, structural formulae or any combination thereof	C-O-N-H Bond from C to H in amide	**(3)**

Question Number	Acceptable Answers	Reject	Mark
18(e)(iii)	First two curly arrows **(1)** Second two curly arrows **(1)** ALLOW (1) for any two correct curly arrows Ignore dipoles and lone pairs even if incorrect Exemplar answer 		**(2)**

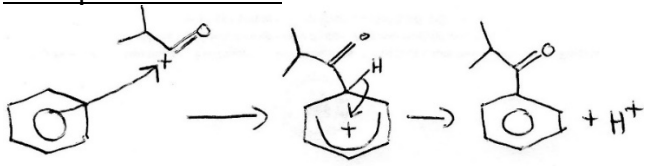
Question Number	Acceptable Answers	Reject	Mark
18(e)(iv)	 ALLOW Any diagram which clearly indicates 'trans' configuration **(1)** The hydroxy groups are on opposite side of C=C and so unlikely to condense ALLOW The OH groups are too far away (from each other) **(1)**		**(2)**

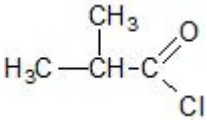
(Total for Question 18 =18 marks)
(Total for Section B = 50 marks)

Section C

Question Number	Acceptable Answers	Reject	Mark
19(a)	Carboxylic (acid) Allow carboxy(l)	Just 'COOH' Combination with any other functional group	**(1)**

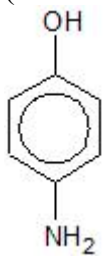
Question Number	Acceptable Answers	Reject	Mark
19(b)	$C_{13}H_{18}O_2$ Allow elements in any order	13C 18H 2O	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	Curly arrow from or within the circle of the benzene ring to the C+ **(1)** Intermediate structure with horseshoe covering at least 3 carbons and facing the tetrahedral carbon with some part of the positive charge being within the horseshoe **(1)** Curly arrow from the C—H to anywhere inside the benzene ring reforming the delocalised structure of molecule **A** to form H^+ ALLOW HCl for H^+ **(1)** <u>Exemplar mechanism</u>  Ignore regeneration of the catalyst	Curly arrow on outside of hexagon Partial bonds to H or CH_3 except for dot and wedge in 3-D structure	**(3)**

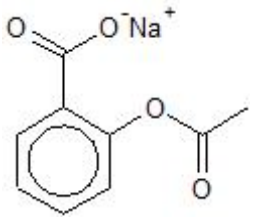
Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	 / $(CH_3)_2CHCOCl$/ 2-methylpropanoyl chloride Accept any formulae or combination of, except molecular formula	2-methylpropanyl chloride	(1)

Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	It would produce an alcohol/OH/hydroxy(l) (and not a hydrocarbon)		(1)

Question Number	Acceptable Answers	Reject	Mark
*19(d)(i)	The **lone pair** of electrons on the **oxygen** are incorporated into the delocalised ring of electrons **(1)** This increases the susceptibility of the ring to electrophilic attack **(1)** (Reaction conditions) are **dilute**/ **aqueous** nitric acid / $HNO_3(aq)$ **(1)** Ignore references to heat	Concentrated/ HNO_2 / with sulfuric acid	(3)

Question Number	Acceptable Answers	Reject	Mark
19(d)(ii)	(Intermediate **Q** name) 4-aminophenol ALLOW any reasonable name such as 4-hydroxyphenylamine/1-amino-4-hydroxybenzene **OR** (Intermediate **Q** structure)  Accept any formulae or combination of, except molecular formula Penalise incorrect connectivity only if horizontal If name and formula given, then both must be correct **(1)** (Step 2 reagents) Sn/tin **and** (concentrated) HCl **(1)** (Step 3 reagents) CH_3COCl/ethanoyl chloride ALLOW Ethanoic anhydride/ $(CH_3CO)_2O$ **(1)** Ignore references to heat for both steps Allow reagents to be indicated on the pathway	Dilute HCl/ Sulfuric acid Ethanoic acid/ With other reagents such as $AlCl_3/H_2SO_4$	**(3)**

Question Number	Acceptable Answers	Mark
19(e)(i)	**M1**: Aspirin concentration = 180 x 0.0161 = 2.898 g dm^{-3} **(1)** (Need 600 mg or 0.600 g so) **M2**: Volume required = (0.600 ÷ 2.898) x 1000 = 207.039 cm^3 **(1)** **OR** **M1:**Number of moles = (0.300 x 2) ÷180 = 0.003333 **(1)** **M2:** Volume required= 0.00333 ÷0.0161 = 0.0207039 (dm^3) **(1)** **M3:** 207 cm^3 /0.207 dm^3 **(1)** Answer must be to 3SF and include units TE throughout	**(3)**

Question Number	Acceptable Answers	Reject	Mark
19(e)(ii)	 Allow Kekulé structure for benzene ring Allow structure without charges Ignore the orientation and bond length of the substituents of the ring but they must be adjacent		(1)

Question Number	Acceptable Answers	Reject	Mark
19(e)(iii)	Ionic salts are (more) soluble (in water than the unionised aspirin)		(1)

Question Number	Acceptable Answers	Reject	Mark
*19(f)	Any **two** reasons from: Avoid/reduce side effects Allow references to 'not harmful' **(1)** Reduce the quantity of substance needed for the required dose **(1)** Reduce waste (of the undesired enantiomer) **(1)** Ignore reference to one isomer being inactive or one being active	Just 'saves money'	(2)

(Total for Section C = 20 marks)
(Total for paper = 90 marks)

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