Organic Synthesis

Mark Scheme 3

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Transition Metals & Organic Nitrogen Chemistry
Sub Topic	Organic Synthesis
Booklet	Mark Scheme 3

Time Allowed: **57 minutes**

Score: **/47**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

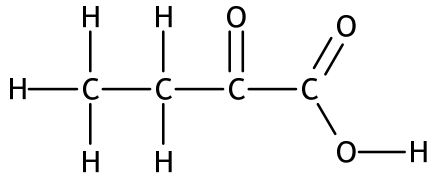
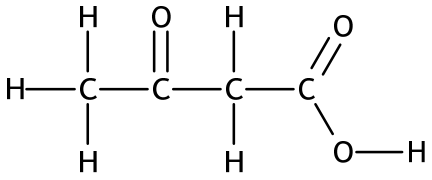
<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>1(a)</td><td>
<table>
<tr><td></td><td>C</td><td>H</td><td>Cl</td></tr>
<tr><td>%</td><td>37.8</td><td>6.30</td><td>55.9</td></tr>
<tr><td>mol</td><td>37.8/12 = 3.15</td><td>6.3/1 = 6.3</td><td>55.9/35.5 = 1.575</td></tr>
<tr><td>ratio</td><td>2</td><td>4</td><td>1</td></tr>
</table>
(1)
(1)

(hence C_2H_4Cl)
IGNORE
Molecular formula</td><td></td><td>2</td></tr>
</table>

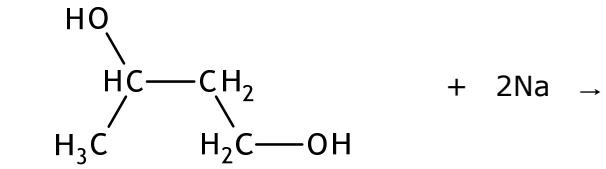
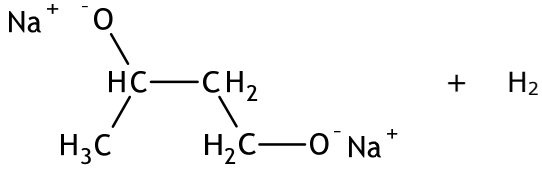
Question Number	Acceptable Answer	Reject	Mark
1(b)(i)	$C_4H_8Cl_2$		1

Question Number	Acceptable Answer	Reject	Mark
1(b)(ii)	All three correct scores 2 Any two correct scores 1 (The following combinations of chlorine isotopes occur in **Q**:) ^{35}Cl and ^{35}Cl (with MS peak at 126) ^{35}Cl and ^{37}Cl (with MS peak at 128) ^{37}Cl and ^{37}Cl (with MS peak at 130) ALLOW Any representations of pairs of chlorine atoms If none of the above marks is scored then A molecule of **Q** has **two** chlorine atoms and the **two** isotopes are present scores 1	Just 'chlorine has isotopes' Any reference to carbon-13	2

Question Number	Acceptable Answer	Reject	Mark
1(b)(iii)	^{35}Cl is more abundant than ^{37}Cl	^{35}Cl is more stable	1

Question Number	Acceptable Answer	Reject	Mark
1(b)*(iv)	 (2-oxobutanoic acid) **(1)**  (3-oxobutanoic acid) **(1)** ALLOW CH_3 and OH **Explanation** (in any order) R must be a diol / have 2 OH group **(1)** Each **OH group** reacts with sodium to give 0.5 mol of H_2 **(1)** Because the amount of H_2 is halved both OH groups are oxidized but one is oxidized to a carboxylic acid / COOH and the other to a ketone group ALLOW Because the amount of H_2 is halved only one of the two OH groups remains **(1)**		5

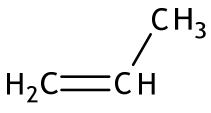
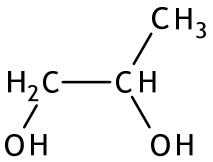
Question Number	Acceptable Answer	Reject	Mark
1(b)(v)	(yellow precipitate) is iodoform / triiodomethane / CHI_3 **(1)** IGNORE "Iodoform test" positive iodoform test given by $CH_3CO(-R)$/ methyl ketone (so S must be 3-oxobutanoic acid / structure identified from (b)(iv)) ALLOW $CH_3CHOH(-R)$ /secondary 2-ol if this structure is given in 23b(iv) **(1)**		2

Question Number	Acceptable Answer	Reject	Mark
1(b)(vi)	butane-1,3-diol ALLOW butan-1,3-diol (1)   Any reasonable representation of the organic product (1) Balanced equation (1) These two marks may be awarded for equation involving **any** diol **COMMENT** Do not penalise O-Na for final structure		3

Total for Question 1 = 16 marks

Question Number	Acceptable Answer	Reject	Mark
2(a)	Molar mass of TO_2 = 100 x 32 / 36.82 **(1)** = 86.9093 **(1)** Molar mass of T = 86.9093 – 32 = 54.9 (g mol^{-1}) (hence T is manganese / Mn) **(1)** **OR** Amount of O (in 100g) = 36.82 /16 = 2.3013 mol **(1)** ∴ mol T = 1.1506 weighs 100 – 36.82 = 63.18 g **(1)** 1 mol T weighs 63.18 / 1.1506 = 54.909 g (hence T is manganese / Mn) **(1)** **OR** Percentage of Mn 100 – 36.82 = 63.18 **(1)** Number of moles of Mn = 63.18/54.9 = 1.15 **(1)** Number of moles of oxygen = 36.82/16 = 2.3 (hence TO_2 is MnO_2) **(1)** ALLOW Calculations based on moles of O_2 Correct answer with no working scores **zero**		3

Question Number	Acceptable Answer	Reject	Mark
2(b)(i)	Molecular ion labelled in any way on the mass spectrum **and** Molar mass = 76 (g mol^{-1})		1

Question Number	Acceptable Answer	Reject	Mark
2(b)(ii)	**M**  / CH_2CHCH_3 / propene ALLOW prop-1-ene **(1)** **N**  / $CH_2OHCHOHCH_3$ / propane-1,2-diol ALLOW propan-1,2-diol / 1,2-propan(e)-diol **(1)** IGNORE C_3H_6 and $C_3H_8O_2$		2

Question Number	Acceptable Answer	Reject	Mark
2(c)(i)	IGNORE H_2O ligands in c)i) & c)ii) $Mn^{2+}(aq) + 2OH^-(aq) \rightarrow Mn(OH)_2(s)$ Equation **(1)** States **(1)** ALLOW use of T for Mn states mark for non-ionic equation OR for unbalanced equation with correct species		2

Question Number	Acceptable Answer	Reject	Mark
2(c)(ii)	$MnO_2.nH_2O \rightarrow MnO_2 + nH_2O$ OR $Mn(OH)_4 \rightarrow MnO_2 + 2H_2O$ LHS (1) RHS (1) ALLOW use of T for Mn ALLOW for 1 mark $Mn(OH)_2 + ½O_2 \rightarrow MnO_2 + H_2O$		2

Question Number	Acceptable Answer	Reject	Mark
2(d)	K^+ IGNORE 'potassium ion' **(1)** $KMnO_4$ **(1)** TE on cation given for MP1	Just 'K'	2

Total for Question 2 = 12 marks

Question Number	Acceptable Answer	Reject	Mark
3(a)(i)	$[Cu(H_2O)_6]^{2+}$ ALLOW $[Cu(H_2O)_4]^{2+}$ **(1)** $Cu(H_2O)_4(OH)_2$ ALLOW $Cu(OH)_2$ **(1)** $[Cu(NH_3)_4(H_2O)_2]^{2+}$ ALLOW $[Cu(NH_3)_4]^{2+}$ **(1)** ALLOW Ligand in any order Omission of square brackets	$Cu^{2+}(aq)$ $[Cu(NH_3)_6]^{2+}$	3

Question Number	Acceptable Answer	Reject	Mark
3(a)(ii)	(3)d orbitals / (3)d subshell split (by the attached ligands) **(1)** Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy (d orbital(s) / levels) ALLOW d—d transitions occur /electrons are excited **(1)** Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light **(1)** Reflected / transmitted / remaining light is coloured / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen **(1)** Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell / subshells split d—d splitting Emitted ‘Reverse’ for ‘complementary’	4

Question Number	Acceptable Answer	Reject	Mark
3(a)(iii)	The (different) ligands split the (3)d orbitals / subshell to a different extent **(1)** (So) the energy absorbed / reflected / transmitted is different OR Radiation (ALLOW light) is at a different frequency **(1)**	Orbital / shell / subshells unless penalised in 22(a)(ii) Emitted unless penalised in 22(a)(ii)	2

Question Number	Acceptable Answer	Reject	Mark
3(b)	Any 5 of the following: **Step 1**: Minimum amount of solvent to minimise the amount of solid complex left in solution (when it recrystallizes) ALLOW To form a saturated solution (of **C**) OR So the solution is as concentrated as possible **(1)** **Step 2**: (**hot**) So maximum amount / most of complex remains in (hot) solution OR To avoid the premature formation the crystals in the funnel **(1)** (**filter**) To remove **insoluble / undissolved** impurities **(1)** Step 3: To ensure that **maximum** amount of solid crystallizes ALLOW To obtain a better yield (of crystals) **(1)** Step 4: To remove **soluble / dissolved** impurities **(1)** So that the filtered solid is dry ALLOW So that filtration is fast **(1)**	 Speed up crystallization Remove insoluble impurities	5

Total for Question 3 = 14 marks

Question Number	Acceptable Answers	Reject	Mark
4(a)	Volume of CO_2 is less than volume of oxygen (and only other product is water). OR Fewer moles / molecules of gaseous products (than reactants).		1

Question Number	Acceptable Answers	Reject	Mark
4(b)	Potassium hydroxide / KOH absorbs **CO_2** OR **CO_2** reacts with potassium hydroxide / KOH OR **CO_2** dissolves in potassium hydroxide / KOH		1

Question Number	Acceptable Answers	Reject	Mark
4(c)	So $10x = 40$ $x = 4$ **(1)** So $10 + 10(x + (y/4)) - 10x = 20$ $10(y/4) = 10$ $y = 4$ **(1)** $C_xH_y = C_4H_4$ **(1)** Correct formula with no working or explanation scores 3		3

Total for Question 4 = 5 marks