Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH05/01)

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Summer 2015
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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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		1

Question Number	Correct Answer	Reject	Mark
2	A		1

Question Number	Correct Answer	Reject	Mark
3	B		1

Question Number	Correct Answer	Reject	Mark
4	C		1

Question Number	Correct Answer	Reject	Mark
5	D		1

Question Number	Correct Answer	Reject	Mark
6	D		1

Question Number	Correct Answer	Reject	Mark
7	A		1

Question Number	Correct Answer	Reject	Mark
8	C		1

Question Number	Correct Answer	Reject	Mark
9	B		1

Question Number	Correct Answer	Reject	Mark
10	A		1

Question Number	Correct Answer	Reject	Mark
11	B		1

Question Number	Correct Answer	Reject	Mark
12	B		1

Question Number	Correct Answer	Reject	Mark
13	C		1

Question Number	Correct Answer	Reject	Mark
14	C		1

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	A		1

Question Number	Correct Answer	Reject	Mark
17	B		

Question Number	Correct Answer	Reject	Mark
18	D		

Question Number	Correct Answer	Reject	Mark
19	B		

Question Number	Correct Answer	Reject	Mark
20	D		

Total for Section A = 20 marks

Section B

Question Number	Acceptable Answer	Reject	Mark
21(a)(i)	$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$ OR $Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$ OR ionic equations including sulfate ions OR multiples		1

Question Number	Acceptable Answer	Reject	Mark
21(a)(ii)	Otherwise the Fe^{2+} formed will oxidize ALLOW So air / oxygen cannot enter the flask To prevent reaction with air /oxygen (1) Hydrogen can escape through the slit OR So pressure does not build up (1) IGNORE Acid spray	Iron/steel oxidized	2

Question Number	Acceptable Answer	Reject	Mark
21(a)(iii)	Transfer the reaction mixture to a ($250\ cm^3$) volumetric/graduated flask ALLOW standard flask (1) (Rinse conical flask and) add washings to the volumetric flask (1) Make solution up to the mark (with distilled water/sulfuric acid) and then mix ALLOW any indication of mixing (1) IGNORE Filtration	Using other liquids	3

Question Number	Acceptable Answer	Reject	Mark
21(a)(iv)	$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ OR multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answer	Reject	Mark
21(a)(v)	Amount MnO_4^- = 22.15 x 0.0195 /1000 (1) = 4.31925×10^{-4} ans* Amount Fe^{2+} = 5 x ans* (1) = 2.159625×10^{-3} ans** Mass of iron in wire = 10 x ** x 55.8 (1) = 1.20507 (g) ans*** % purity = 100 x ans*** / 1.25 = 96.40566 = 96.4 % (1) Ignore rounding errors until final answer Correct answer (96.4%) with or without working scores 4 ALLOW Use of Ar(Fe) = 56 when Amount MnO_4^- = 22.15 x 0.0195 /1000 (1) = 4.31925×10^{-4} ans* Amount Fe^{2+} = 5 x ans* (1) = 2.159625×10^{-3} ans** Mass of iron in wire = 10 x ** x 56 (1) Mass of iron in wire = 1.20939 % purity = 96.7512 = 96.8 % (1) Ignore intermediate rounding until final answer Correct answer (96.8%) with or without working scores 4 TE on each stage in the calculation % purity > 100 scores max 2	Answer not to 3 SF Answer not to 3 SF	4

Question Number	Acceptable Answer	Reject	Mark
21(a)(vi)	Colourless / pale yellow to (pale) pink / first permanent pink	Purple Just '(pale) pink'	1

Question Number	Acceptable Answer	Reject	Mark
21(a)(vii)	(More manganate(VII) is needed to oxidize Fe^{2+}, so) titre will be larger (1) Stand alone mark Because the Mn oxidation number changes from 7 to 4 (rather than 2) OR Mn accepts fewer electrons per mole (1) (Brown precipitate is) manganese(IV) oxide / MnO_2 ALLOW $Mn(OH)_4$ (1) IGNORE References to inaccurate / inconsistent titre values	$Mn(OH)_2$	3

Question Number	Acceptable Answer	Reject	Mark
21(b)(i)	Anodic area: $Fe^{2+} + 2e(^-) \rightleftharpoons Fe$ ($E^\ominus = -0.44$ V) OR $Fe \rightleftharpoons Fe^{2+} + 2e(^-)$ (1) Cathodic area: $O_2 + 2H_2O + 4e(^-) \rightleftharpoons 4OH^-$ ($E^\ominus = +0.40$ V) (1) ALLOW $\frac{1}{2}O_2 + 2H^+ + 2e(^-) \rightleftharpoons H_2O$ ($E^\ominus = +1.23$ V) Penalise omission of electrons or use of cell diagrams once only Anode and cathode reversed max 1. IGNORE State symbols even if incorrect Single arrow in equations		2

Question Number	Acceptable Answer	Reject	Mark
21(b)(ii)	$E^\ominus_{cell}$ = (+)0.40 − (−0.44) = (+)0.84 (V) ALLOW $E^\ominus_{cell}$ = (+)1.23 − (−0.44) = (+)1.67 (V) Correct answer with no working scores 1		1

Question Number	Acceptable Answer	Reject	Mark
21(b)(iii)	Dissolved salt makes the water a better conductor (of ions) OR The solution acts like a salt bridge OR Makes it an (effective) electrolyte OR Improves the flow of ions through the solution ALLOW Improves the flow of electrons through the metal	Improves the flow of ions through the metal Improves the flow of electrons through the solution	1

Question Number	Acceptable Answer	Reject	Mark
21(b)(iv)	Magnesium has a more negative $E^\ominus$ (allow more reactive) and so reduces the Fe^{2+} OR suppresses the oxidation of iron OR forces the iron (in the absence of oxygen) to act as the cathode ALLOW Mg corrodes / oxidizes in preference to / faster than (the Fe / steel) OR Magnesium acts as a sacrificial anode	Just 'sacrificial protection'	1

Total for Question 21 = 20 marks

Question Number	Acceptable Answer	Reject	Mark
22(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
22(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
22(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
22(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 22 = 14 marks

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>23(a)</td><td>
<table>
<tr><th></th><th>C</th><th>H</th><th>Cl</th><th></th></tr>
<tr><td>%</td><td>37.8</td><td>6.30</td><td>55.9</td><td></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><td>(1)</td></tr>
<tr><td>ratio</td><td>2</td><td>4</td><td>1</td><td>(1)</td></tr>
</table>
(hence C_2H_4Cl)
IGNORE
Molecular formula</td><td></td><td>2</td></tr>
</table>

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

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>23(b)(ii)</td><td>All three correct scores 2
Any two correct scores 1

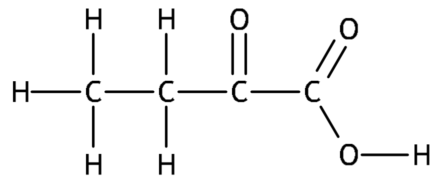
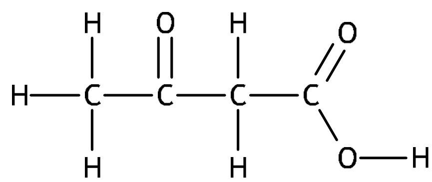
(The following combinations of chlorine isotopes occur in Q:)

^{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

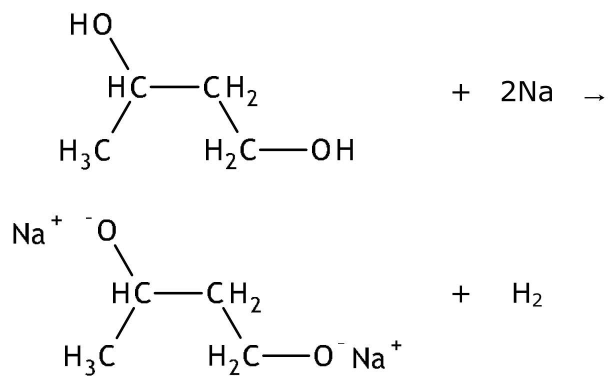
If none of the above marks is scored then
A molecule of Q has two chlorine atoms and the two isotopes are present scores 1</td><td>Just ‘chlorine has isotopes’

Any reference to carbon-13</td><td>2</td></tr>
</table>

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

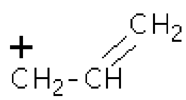
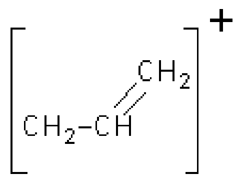
Question Number	Acceptable Answer	Reject	Mark
23(b)*(iv)	 (2-oxobutanoic acid) (1)  (3-oxobutanoic acid) (1) ALLOW CH_3 and OH Explanation (in any order) R must be a diol / have 2 OH group (1) Each OH group reacts with sodium to give 0.5 mol of H_2 (1) Because the amount of H_2 is halved both OH groups 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

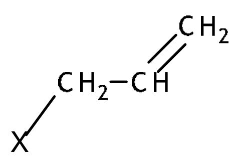
Question Number	Acceptable Answer	Reject	Mark
23(b)(v)	(yellow precipitate) is iodoform / triiodomethane / CHI_3 (1) IGNORE "Iodoform test" positive iodoform test given by CH_3CO(-R)/ methyl ketone (so S must be 3-oxobutanoic acid / structure identified from (b)(iv)) ALLOW CH_3CHOH(-R) /secondary 2-ol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

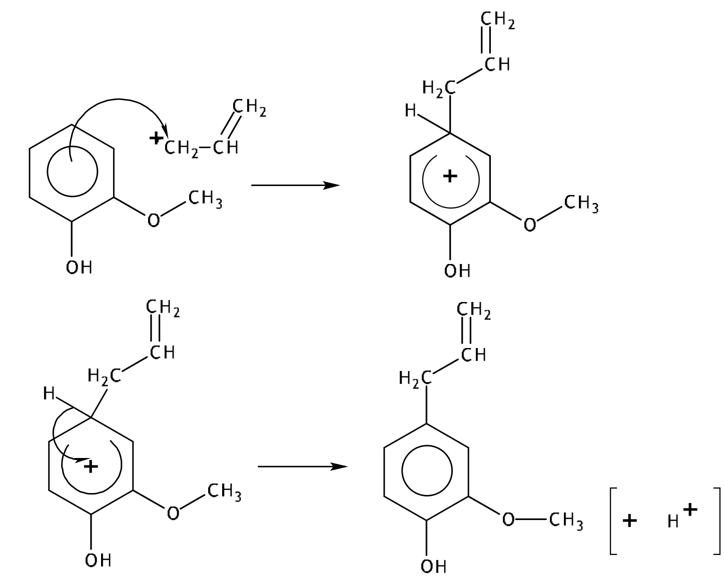
Question Number	Acceptable Answer	Reject	Mark
23(b)(vi)	butane-1,3-diol ALLOW butan-1,3-diol (1)  Any reasonable representation of the organic product (1) Balanced equation (1) These two marks may be awarded for equation involving *any* diol COMMENT Do not penalise O-Na for final structure		3

Total for Question 23 = 16 marks
Total for Section B = 50 marks

Section C

Question Number	Acceptable Answer	Reject	Mark
24(a)(i)	 or  ALLOW Positive charge on any part of the carbocation Structural / fully displayed / skeletal formulae		1

Question Number	Acceptable Answer	Reject	Mark
24(a)(ii)	 X = Cl / Br / I OR structural / fully displayed / skeletal formulae OR 3- chloro/bromo/iodo prop(-1-)ene No TE on incorrect electrophile in (a)(i)	name without ‘3’	1

Question Number	Acceptable Answer	Reject	Mark
24 (a)(iii)	 TE on incorrect electrophile in (a)(i) If benzene used instead of substituted benzene OR If final product not 1,2,4 only MP1 & 2 scored Curly arrow from on / within the circle to positive C ALLOW Curly arrow from anywhere within the hexagon Arrow to **any** part of the electrophile including to the + charge (which can be anywhere on electrophile), OR Arrow to a point at least half the distance between ring and electrophile (1) Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe. IGNORE substituent errors (incorrect position on ring or bond to substituent) at this marking point ALLOW dotted horseshoe (1) Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure of a correct stable molecule. Ignore any involvement of $AlCl_4^-$ in the final step (1) Correct Kekulé structures score full marks	Curly arrow on or outside the hexagon Partial bonds to H or CH_3 except for dot and wedge in 3-D structure	3

Question Number	Acceptable Answer	Reject	Mark
24(b)(i)	Stand alone marks Geometric / *E*-*Z* / cis-trans isomerism (1) Because isoeugenol has (two) different groups attached to each of the carbon atoms of the double bond ALLOW Because eugenol has two hydrogen atoms on one of the carbon atoms in the C=C (1) IGNORE References to the barrier to free rotation about the C=C	 Optical isomerism	2

Question Number	Acceptable Answer	Reject	Mark
24(b)*(ii)	If no other mark is scored 'both eugenol and isoeugenol have eight peaks' scores 1 Candidates are only expected to interpret the spectra using knowledge of the (n+1) rule. EITHER The only (significant) difference is likely to be (in the peak areas / heights) due to the protons on the alkene chain (1) This mark may be awarded if the use of the alkene chain is indicated but not stated Both will have three sets of peaks due to the three sets of protons on the alkene chain (1) The alkene chain will give two doublets and a quintet in both isomers (1) In isoeugenol the doublets will have different peak areas / heights under the peaks / peak heights in ratio 1:3 whereas in eugenol the doublets will be the same height (1) OR Eugenol has areas / heights in the ratio 2:1:2:1:1:1:1:3 (1) and isoeugenol has peak areas / heights in the ratio 3:1:1:1:1:1:1:3 (1) The alkene chain will give two doublets and a quintet in both isomers (1) In isoeugenol the doublets will have different peak areas / heights under the peaks / peak heights in ratio 1:3 whereas in eugenol the doublets will be the same height (1) OR The only (significant) difference likely to be in the splitting pattern of the peaks due to the protons on the alkene chain (1) In eugenol the protons at the end of the alkene chain are in different environments so eugenol will have four sets of peaks whereas isoeugenol will have three sets of peaks (1)		4

24(b)*(ii) (cont)	In eugenol the alkene chain will give three doublets and a quintet (1) In isoeugenol the alkene chain will give two doublets and a quintet (1)		

Question Number	Acceptable Answer	Reject	Mark
24(b)(iii)	V_2O_5 oxidizes isoeugenol / alkene substituent (to the aldehyde & ketone) (and V(V) is reduced to a lower oxidation state) OR Explanation in terms of isoeugenol reducing V_2O_5 (1) H_2O_2 oxidizes vanadium back to the +5 oxidation state (1) Mechanism with H_2O_2 oxidizing V_2O_5 as the first step scores max 1 If no other mark is scored 'vanadium(V) is reduced then oxidized' scores 1 Ignore any reference to adsorption and desorption on the surface.	Just 'V_2O_5 oxidizes'	2

Question Number	Acceptable Answer	Reject	Mark
24(b)(iv)	Vanillin has an aldehyde group, suggesting a peak in the range 1740-1720 (cm^{-1}) whereas methyl vanillyl ketone has a ketone group suggesting a peak in the range 1700-1680 (cm^{-1}) (The peaks occur at different wavenumbers so the ketone peak could be seen) (1) These are general ranges and might overlap in the particular spectra OR Vanillin is an aromatic aldehyde OR Concentration of the ketone might be too small for the peak to be observed (1)		2

Question Number	Acceptable Answer	Reject	Mark
24(c)(i)	6 (moles of $S_2O_3^{2-}$ per mole CH_3O) (1) Stand alone mark In the sequence $ROCH_3 \equiv CH_3I \equiv IBr \equiv HIO_3 \equiv 3I_2 \equiv 6S_2O_3^{2-}$ (1)	Partial sequences	2

Question Number	Acceptable Answer	Reject	Mark
24(c)(ii)	Mr (vanillin) = 152 (1) EITHER % CH_3O in pure vanillin = 100 x 31/152 = 20.3947% (1) % purity of the vanillin = 100 x 20.09 / 20.3947 = 98.5058% (1) OR 20.09% weighs 31 So 100% weighs 100 x 31/20.09 = 154.31 So apparent molar mass = 154.31 (1) Therefore % purity is 152 x 100/154.31 = 98.5058% (1) OR Apparent mass CH_3O = 100 x 20.09/152 = 30.5368 (1) Therefore % purity is 100 x 30.5368 /31 = 98.5058% (1) Correct answer with no working scores 3 IGNORE SF except 1 SF		3

Total for Question 24 = 20 marks

Total for Section C = 20 marks