

Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH05/01)



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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	Correct Answer	Reject	Mark
	6		1
			L
Question	Correct Answer	Reject	Mark
Number			, ion
2	Α		1
	•	·	
Question	Correct Answer	Reject	Mark
Number			
3	В		1
	-	-	
Question	Correct Answer	Reject	Mark
Number			
4	L		
Question	Correct Answer	Poject	Mark
Number	Correct Answer	Reject	Mark
5	D		1
U	5		
Question	Correct Answer	Reject	Mark
Number			
6	D		1
Question	Correct Answer	Reject	Mark
Number	-		
7	A		1
Question	Correct Anounce	Deject	Morte
Question	Correct Answer	Reject	Mark
8	<u> </u>		1
0	C		1 -
Question	Correct Answer	Reiect	Mark
Number			
9	В		1
Question	Correct Answer	Reject	Mark
Number			
10	A		1
Question	Correct Answer	Reject	Mark
Number	P		1
	D		
Question	Correct Answer	Reject	Mark
Number		Reject	Plank
12	В		1

Question Number	Correct Answer	Reject	Mark
13	С		1
Question Number	Correct Answer	Reject	Mark
14	С		1

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	Α		1

Question Number	Correct Answer	Reject	Mark
17	В		

Question Number	Correct Answer	Reject	Mark
18	D		

Question Number	Correct Answer	Reject	Mark
19	В		

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)	$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$		1
	OR		
	$Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$		
	OR ionic equations including sulfate ions OR multiples		

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)	Iron/steel oxidized	2
	Hydrogen can escape through the slit OR So pressure does not build up (1) IGNORE Acid spray		

Question Number	Acceptable Answer	Reject	Mark
21(a)(iii)	Transfer the reaction mixture to a (250 cm³) volumetric/graduated flask ALLOW standard flask(1)(Rinse conical flask and) add washings 		3
	Make solution up to the mark (with distilled water/sulfuric acid) and then mix	Using other liquids	
	ALLOW any indication of mixing (1) IGNORE Filtration		

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

Question Number	Acceptable Answer	Reject	Mark
21(a)(v)	Amount $MnO_4^- = 22.15 \times 0.0195 / 1000$ $= 4.31925 \times 10^{-4} \text{ ans}^*$ Amount $Fe^{2+} = 5 \times ans^*$ (1) $= 2.159625 \times 10^{-3} \text{ ans}^{**}$ 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	Answer not to 3 SF	4
	ALLOW Use of Ar(Fe) = 56 when Amount MnO_4^- = 22.15 x 0.0195 /1000 (1) = 4.31925 x 10 ⁻⁴ ans* Amount Fe ²⁺ = 5 x ans* (1) = 2.159625 x 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	

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		3
	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	

Question Number	Acceptable Answer	Reject	Mark
21(b)(i)	Anodic area: $Fe^{2^+} + 2e(^-) \rightleftharpoons Fe$ $(E^{\circ} = -0.44 \text{ V})$ OR $Fe \rightleftharpoons Fe^{2^+} + 2e(^-)$ (1) Cathodic area: $O_2 + 2H_2O + 4e(^-) \rightleftharpoons 4OH^ (E^{\circ} = +0.40 \text{ V})$ (1) ALLOW $V_2O_2 + 2H^+ + 2e(^-) \rightleftharpoons H_2O$ $(E^{\circ} = +1.23 \text{ V})$ 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)	$E^{\circ}_{cell} = (+)0.40 - (-0.44) =$ (+)0.84 (V) ALLOW $E^{\circ}_{cell} = (+)1.23 - (-0.44) =$ (+)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° (allow more reactive) and so reduces the Fe ²⁺ OR		1
	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	Just 'sacrificial	

Total for Question 21 = 20 marks

Question Number	Acceptable Answer		Reject	Mark
22(a)(i)	$[Cu(H_2O)_6]^{2+}$	(1)	Cu ²⁺ (aq)	3
		(1)		
	Cu(H ₂ O) ₄ (OH) ₂ ALLOW Cu(OH) ₂	(1)		
	$[Cu(NH_3)_4(H_2O)_2]^{2+}$		[Cu(NH ₃) ₆] ²⁺	
	ALLOW [Cu(NH ₃) ₄] ²⁺	(1)		
	ALLOW			
	Ligand in any order Omission of square brackets			

Question Number	Acceptable Answer	Reject	Mark
22(a)(ii)	(3)d orbitals / (3)d subshell split (by the attached ligands) (1)	Orbital / shell / subshells split d—d splitting	4
	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	Emitted	
	ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen (1)	'Reverse' for 'complementary'	
	Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state		

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

Question Number	Acceptable Answer	Reject	Mark
22(b)	Any 5 of the following:		5
	Step 1: Minimum amount of solvent to minimise the amount of solid complex left in solution (when it recrystallizes) ALLOW 		
	Step 2:(hot)So maximum amount / most of complexremains in (hot) solutionORTo avoid the premature formation thecrystals in the funnel(1)(filter)To remove insoluble / undissolvedimpurities(1)		
	Step 3: To ensure that maximum amount of solid crystallizes ALLOW To obtain a better yield (of crystals) (1)	Speed up crystallization	
	Step 4: To remove soluble /dissolved impurities (1)	Remove insoluble impurities	
	So that the hitered solid is dry		
	ALLOW So that filtration is fast (1)		

Total for Question 22 = 14 marks

WCH05

Question Number	Acceptable Answer				Reject	Mark	
23(a)					_		2
		С	Н	Cl			
	%	37.8	6.30	55.9			
	mol	37.8/12 = 3.15	6.3/1 = 6.3	55.9/35.5 = 1.575	(1)		
	ratio	2	4	1	(1)		
	(hence IGNOR Molecu	e C₂H₄Cl) E ılar formul	а				

Question Number	Acceptable Answer	Reject	Mark
23(b)(i)	C ₄ H ₈ Cl ₂		1

Question Number	Acceptable Answer	Reject	Mark
23(b)(ii)	All three correct scores 2 Any two correct scores 1	Just `chlorine	2
	(The following combinations of chlorine isotopes occur in Q :)	has isotopes'	
	 ³⁵Cl and ³⁵Cl (with MS peak at 126) ³⁵Cl and ³⁷Cl (with MS peak at 128) ³⁷Cl and ³⁷Cl (with MS peak at 130) ALLOW Any representations of pairs of chlorine atoms 	Any reference to carbon-13	
	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		

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)	Н Н О О // H—С—С—С H H О—Н		5
	(2-oxobutanoic acid) (1)		
	H—C—C—C \ H H O—H		
	(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)		

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

Question Number	Acceptable Answer	Reject	Mark
23(b)(vi)	butane-1,3-diol ALLOW butan-1,3-diol (1)		3
	HO HC—CH ₂ + 2Na → H ₃ C H ₂ C—OH		
	Na ^{+ -} O HCCH ₂ + H ₂ H ₃ C H ₂ CO ⁻ Na ⁺		
	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		

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

Section C

Question Number	Acceptable Answer	Reject	Mark
24(a)(i)	+ CH_2 or CH_2 CH ₂ -CH or CH_2 CH ₂ -CH Or CH_2 ALLOW Positive charge on any part of the		1
	carbocation Structural / fully displayed / skeletal formulae		

Question Number	Acceptable Answer	Reject	Mark
24(a)(ii)	CIL		1
	,CH₂−CĤ		
	x		
	X = Cl / Br / I		
	OR		
	structural / fully displayed / skeletal		
	formulae		
	OR		
	3- chloro/bromo/iodo prop(-1-)ene	name without `3'	
	No TE on incorrect electrophile in (a)(i)		

Question Number	Acceptable Answer	Reject	Mark
24 (a)(iii)	СH2 Сн		3
	$\begin{array}{c} \begin{array}{c} & H_2C'\\ H_2 \\ H_1 \\ H_2C'\\ H_1 \\ H_1 \\ H_2C'\\ H_1 \\ H_1 \\ H_2C'\\ H_1 \\ H_1 $		
	$H_{2}CH_{2}$ $H_{2}CH$ $H_{2}CH$ $H_{2}CH$ $H_{2}CH$ $H_{2}CH$ $H_{2}CH$		
	(+ +) $(+ +)$ $(+ +)$ $(+ +)$ $(+ +)$ $(+ +)$		
	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)	Curly arrow on or outside the hexagon	
	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	Partial bonds to H or CH ₃ except for dot and wedge in 3-D structure	
	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		

Question Number	Acceptable Answer	Reject	Mark
24(b)(i)	Stand alone marks		2
	Geometric / E-Z / cis-trans isomerism (1)	Optical isomerism	
	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		

Question Number	Acceptable Answer	Reject	Mark
24(b)*(ii)	If no other mark is scored 'both eugenol and isoeugenol have eight peaks' scores 1		4
	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)		
	OREugenol has areas / heights in the ratio2:1:2:1:1:1:3(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)		

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)	Just 'V ₂ O ₅ oxidizes'	2
	Mechanism with H ₂ O ₂ oxidizing V ₂ O 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		

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 ₂ O ₃ ^{2–} per mole CH ₃ O) (1) Stand alone mark		2
	In the sequence $ROCH_3 \equiv CH_3I \equiv IBr \equiv HIO_3 \equiv 3I_2 \equiv 6S_2O_3^{2^-}$ (1)	Partial sequences	

Question Number	Acceptable Answer		Reject	Mark
24(c)(ii)	Mr (vanillin) = 152	(1)		3
	EITHER % CH ₃ O in pure vanillin = 100 x 31/152			
	= 20.3947% % purity of the vanillin = 100 x 20.09 / 20.3947	(1)		
	= 98.5058%	(1)		
	OR 20.09% weighs 31 So 100% weighs 100 x 31/20.09 = 154.31 So apparent molar mass = 154.3 Therefore % purity is	1 (1)		
	152 x 100/154.51 - 98.5058 %	(1)		
	OR Apparent mass CH_3O = 100 x 20.09/152 = 30.5368	(1)		
	$100 \times 30.5368 / 31 = 98.5058\%$	(1)		
	Correct answer with no working scores 3			
	IGNORE SF except 1 SF			

Total for Question 24 = 20 marks Total for Section C = 20 marks

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