Unit 5 - Mark scheme

Question number	Answer	Mark
1(a)	C $[Pt(NH_3)_2Cl_2]$	1

Question number	Answer	Mark
1(b)	A $[CuCl_2]^-$	1

Question number	Answer	Mark
1(c)	D $[Cr(H_2O)_6]^{2+}$	1

Question number	Answer	Mark
2	B VO_2^+	1

Question number	Answer	Mark
3	C sodium hydroxide	1

Question number	Answer	Mark
4	B ethanoate ion, CH_3COO^-	1

Question number	Answer	Mark
5(a)	D the colour change of the reduction of the manganate(VII) ions is sufficient	1

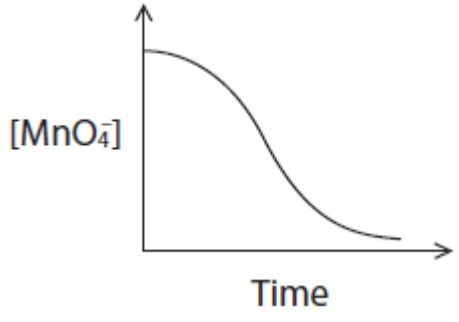
Question number	Answer	Mark
5(b)	B uncertainty 0.06%	1

Question number	Answer	Mark
5(c)	D 0.014	1

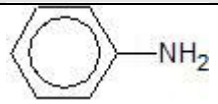
Question number	Answer	Mark
6	A $\frac{1}{2}O_2(g) + H_2O(l) + 2e^- \rightarrow 2OH^-(aq)$	1

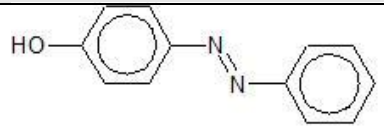
Question number	Answer	Mark
7(a)	C this label indicates the intermediate species	1

Question number	Answer	Mark
7(b)	B they can gain and then lose electrons	1

Question number	Answer	Mark
8	 C	1

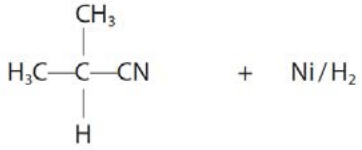
Question number	Answer	Mark
9	A $C_6H_5–NH_2 < H–NH_2 < CH_3–NH_2$	1

Question number	Answer	Mark
10(a)	A HNO_2 	1

Question number	Answer	Mark
10(b)	 B	1

Question number	Answer	Mark
11	C $CH_3COCl + NH_3 \rightarrow CH_3CONH_2 + HCl$	1

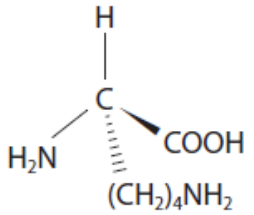
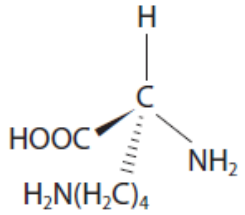
Question number	Answer	Mark
12	A 3	1

Question number	Answer	Mark
13	 A	1

Question number	Answer	Mark
14	D it avoids the decomposition of the organic molecule when it distils	1

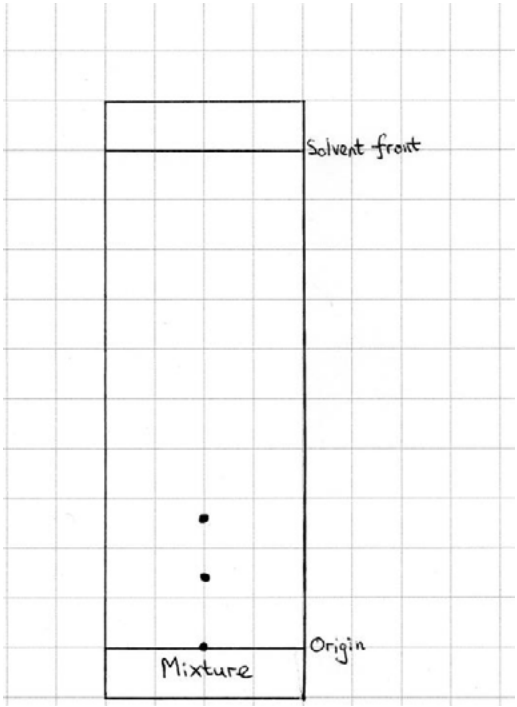
Question number	Answer	Additional guidance	Mark
15(a)	A suitable equation such as: • $NH_2CH_2COOH + NaOH \rightarrow NH_2CH_2COO^{(-)}Na^{(+)} + H_2O$	 Allow zwitterion ionic equation displayed formulae Ignore state symbols even if incorrect Do not award O-Na	1

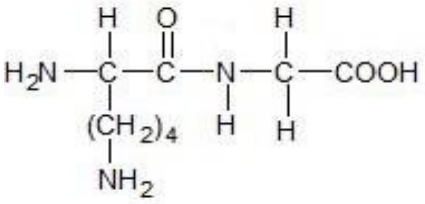
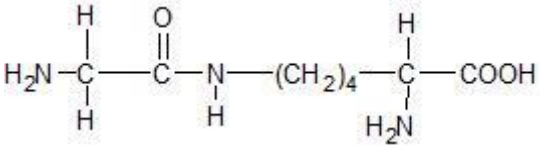
Question number	Answer	Additional guidance	Marks
15(b)	• number of moles of lysine **and** number of moles of HCl (1) • volume of HCl in cm^3 (1)	Example of calculation: n(1.825 ÷ 146=) 0.0125 (mol) n(0.0125 × 2=) 0.025 (mol) V = (0.025 ÷ 0.100) × 1000 = 250 cm^3 Allow answer in dm^3 Allow 1 mark for 125 cm^3	**2**

Question number	Answer	Additional guidance	Marks
15(c)(i)	 (1)  (1)	Structures must be 3-dimensional Allow any orientation	**2**

Question number	Answer	Additional guidance	Marks
15(c)(ii)	A description which includes: • the plane of plane-polarised (monochromatic) light (1) • will be rotated equally but in opposite directions by the two enantiomers/left by one (laevo-rotatory) enantiomer and to the right by the other (dextro-rotatory) enantiomer. (1)	Allow omission of one plane Allow use of d and l/(+) and (−) Do not award use of D and L	**2**

Question number	Answer	Additional guidance	Marks
15(c)(iii)	• glycine does not have a chiral carbon/centre or asymmetric carbon or is superimposable on its mirror image		1

Question number	Answer	Additional guidance	Marks
15(d)	A suitable diagram such as:  	Allow spots of any reasonable size and anywhere within the range for lysine 0.1-0.2 and for glycine 0.2-0.3	1

Question number	Answer	Additional guidance	Marks
15(e)	A diagram such as: • 	Allow: 	1

Question number	Answer	Additional guidance	Marks
16(a)	• 298 K and 100 kPa (of gases)	Accept 25 °C Accept 1 atm	1

Question number	Answer	Additional guidance	Marks
16(b)(i)	• $E^{\ominus}_{cell}$ = (+0.34 − −0.76=) (+)1.10 (V)		1

Question number	Answer	Additional guidance	Marks
16(b)(ii)	An answer to include observations such as: • blue colour of copper(II) sulfate becomes paler • (pink/brown) copper metal deposited (on the electrode surface) • zinc electrode decreases in size.	Observations can be in any order Three observations scores 2 Two observations scores 1	2

Question number	Answer	Additional guidance	Marks
16(c)	A justification that makes reference to the following points: • Iron $E^{\ominus}_{cell}$ = (−0.44 − +0.77 =) −1.21 (V) (1) **and** Copper $E^{\ominus}_{cell}$ = (+0.52 − +0.15 =) +0.37 (V) • $2Cu^{+} \rightarrow Cu^{2+} + Cu$ (1) • comment on copper electrode potential is positive so disproportionation is feasible and iron electrode potential is negative so disproportionation is not feasible. (1)	Ignore: $3Fe^{2+} \rightarrow Fe + 2Fe^{3+}$ Ignore state symbols	3

Question number	Answer	Additional guidance	Marks
16(d)	• High activation energy/physical barrier prevents reaction Reaction is (very) slow Reaction conditions may not be standard		1

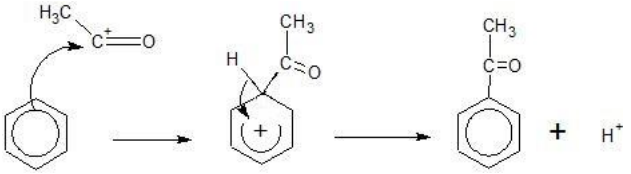
<table>
<tr><th>Question number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>17(a)</td><td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

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><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></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><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></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 an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).
</td><td>6</td></tr>
</table>

Question number	Answer	Additional Guidance
17(a) *Cont.*	**Indicative content:** Spectroscopy: (IP 1 and 2) either X-ray diffraction • all C-C bond lengths in benzene are equal • but if it was a cyclic triene then they would alternate in 'short' and 'long' lengths or which is consistent with equivalent C-C bonds with a delocalised ring of electrons or (infrared spectroscopy) • benzene has peaks at 1600, 1580, 1500, 1450 (cm^{-1}) for an aromatic C=C • alkene C=C has a peak at 1669 – 1645 (cm^{-1}). Thermochemistry: (IP 3 and 4) • enthalpy of hydrogenation is less exothermic than expected for a cyclic triene or enthalpy of combustion data • which is consistent with the delocalisation stability of the ring from the ring of electrons Type of reaction: (IP 5 and 6) • benzene undergoes substitution reactions • alkenes undergo addition reactions/decolourise bromine water.	Ignore references to equal/120° bond angles Allow for one indicative point The infrared spectrum for benzene has a peak for an aromatic C=C at a different wavenumber/absorption/frequency to an alkene C=C Allow benzene is more stable by ~150 kJ mol^{-1} Stated enthalpies (of hydrogenation) −205 to −210 kJ mol^{-1} for benzene and −360 kJ mol^{-1} for 3 (localised C=C) double bonds Allow di-substitution There are only 3 isomers of di-substituted compounds (not 4) or some di-substituted compounds are the same, e.g. 1,2 and 1,6

Question number	Answer	Additional guidance	Marks
17(b)(i)	An answer that makes reference to the following points: • electron pair movement from ring to electrophile (1) • formula of intermediate ion (1) • movement of electron pair to reinstate delocalised ring (1) • formulae of products. (1)	Allow arrow that starts from anywhere from within the hexagon 'Horseshoe' to cover at least three carbon atoms and facing the tetrahedral carbon with some part of the positive sign to be inside the 'horseshoe'. Exemplar mechanism:  Do not award dotted bonds unless clearly part of a 3-D structure	4

Question number	Answer	Additional guidance	Marks
17(b)(ii)	• $CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$	Accept use of $FeCl_3/Fe + 3Cl_2$	1

Question number	Answer	Additional guidance	Marks
17(c)	An explanation that make reference to the following points: • lone pair of electrons on the oxygen atom increases the electron density of the ring (1) • more susceptible to attack by electrophiles. (1)		2

Question number	Answer	Additional guidance	Marks
17(d)(i)	• (reactant) (conc) HNO_3 (1) • (catalyst) (conc) H_2SO_4 (1)	Ignore name Allow name Penalise reference to dilute acid once only	2

Question number	Answer	Additional guidance	Marks
17(d)(ii)	• calculation of molar masses (1) • number of moles of benzene and maximum mass of nitrobenzene (1) • percentage yield of nitrobenzene to 2/3 SF (1)	Example of calculation: M_r of benzene = 78 **and** M_r of nitrobenzene = 123 n(0.936 ÷ 78=) 0.012 (mol) m(0.012 × 123=) 1.476 (g) % = ((0.642 ÷ 1.476) × 100= 43.4959) = 43.5/43% Do not award 44%	3

Question number	Answer		Additional guidance	Marks
18(a)	An answer that makes reference to the following points:		Accept displayed/skeletal formulae	**8**
	• react iodoethane with **aqueous** hydroxide ions	(1)	Accept aqueous sodium hydroxide/ potassium hydroxide	
	• $C_2H_5I + OH^- \rightarrow C_2H_5OH + I^-$	(1)	$C_2H_5I + NaOH \rightarrow C_2H_5OH + NaI$	
	• oxidation of C_2H_5OH with acidified dichromate(VI) under **distillation** conditions	(1)	Accept reference to sodium/ potassium dichromate(VI)	
	• $C_2H_5OH + [O] \rightarrow CH_3CHO + H_2O$	(1)		
	• react iodoethane with magnesium (in **ethoxyethane)**	(1)		
	• $C_2H_5I + Mg \rightarrow C_2H_5MgI$	(1)		
	• reaction of ethylmagnesium iodide with ethanal to form butan-2-ol	(1)		
	• $C_2H_5MgI + CH_3CHO + H_2O \rightarrow C_2H_5CH(OH)CH_3 + Mg(OH)I$	(1)	Allow this to be shown as two separate equations	

Question number	Answer		Additional guidance	Marks
18(b)(i)	• calculation of number of moles of butan-2-ol	(1)	Example of calculation: n=(1.850 ÷ 74 =) 0.025 (mol)	4
	• calculation of number of moles of carbon dioxide and water	(1)	$n(CO_2) = 4 \times 0.025 = 0.100$ (mol) and $n(H_2O) = 5 \times 0.025 = 0.125$ (mol)	
	• calculation of carbon dioxide mass/mass increase of solid X	(1)	$m(CO_2) = 0.100 \times 44 = 4.40$ (g)	
	• calculation of mass of water/mass increase of solid Y	(1)	$m(H_2O) = 0.125 \times 18 = 2.25$ (g)	

Question number	Answer		Additional guidance	Marks
18(b)(ii)	Prediction: • suitable example by name or formula.	(1)	Allow structural /displayed / skeletal formula. Any molecule with the molecular formula $C_4H_{10}O$	2
	Reason: • the same molecular formula as butan-2-ol / is an isomer of butan-2-ol.	(1)	Do not award just '$C_4H_{10}O$'	

Question number	Answer		Additional guidance	Marks
19(a)	• copper is **oxidised** from 0 to +2	(1)	Look at the equation in the question for the correct oxidation number changes if not given on the answer lines Award maximum of one mark if the terms oxidised and reduced are not used or used the wrong way round	2
	• nitrogen is **reduced** from (+)5 to (+)4	(1)		

Question number	Answer	Additional guidance	Mark
19(b)	An answer which makes reference to the following points: • (precaution) carry out in a fume cupboard (1) • (hazard) toxic nitrogen dioxide/NO_2 gas. (1)	Accept the points in either order Do not award 'well-ventilated laboratory/ face masks' Allow poisonous	**2**

Question number	Answer	Additional guidance	Marks
19(c)		Example of calculation:	**6**
	• calculation of the number of moles of thiosulfate (1)	$n(S_2O_3^{2-}) = (22.65 \times 0.100 \div 10000=)$ $= 2.265 \times 10^{-3}$ /0.002265 (mol)	
	• evaluation of the number of moles of iodine (1)	$n(I_2) = (2.265 \times 10^{-3} \div 2=)$ $= 1.1325 \times 10^{-3}$ / 0.0011325 (mol)	
	• evaluation of the number of moles of copper ions in the 10.0 cm^3 aliquot (1)	$n(Cu^{2+}) = (1.1325 \times 10^{-3} \times 2=)$ $= 2.265 \times 10^{-3}$ / 0.002265 (mol)	
	• evaluation of the number of moles of copper ions in 250 cm^3 (1)	$n(Cu^{2+}) = (2.265 \times 10^{-3} \times 25)$ $= 5.6625 \times 10^{-2}$ / 0.056625 (mol)	
	• evaluation of mass of copper ions in sample (1)	$m(Cu^{2+}) = (5.6625 \times 10^{-2} \times 63.5=)$ $= 3.5956875$ (g)	
	• evaluation of percentage of copper in sample to 2/3 SF (1)	% = (3.5956875 ÷ 5.0000 × 100= 71.91375=) = 72/71.9 % Penalise inappropriate rounding once only Correct answer with no working scores 6 marks	

Question number	Answer		Additional guidance	Marks
19(d)	An answer that makes reference to the following points:			6
	• colours of the precipitates formed	(1)	Blue precipitate with copper(II) ions **and** white precipitate with zinc ions	
	• addition of excess sodium hydroxide has no effect on copper precipitate	(1)		
	• but the zinc precipitate dissolves to form colourless solution	(1)	Do not award 'clear'	
	• equation for the formation of a precipitate for either copper(II) or zinc ions	(1)	Example of equations: $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(H_2O)_4OH)_2(s) + 2H_2O(l)$ or $[Zn(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s) + 6H_2O(l)$ or $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ or $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$	
	• equation for the dissolving of the zinc precipitate	(1)	$Zn(OH)_2(s)+2OH^-(aq)\rightarrow[Zn(OH)_4]^{2-}(aq)$	
	• all state symbols correct.	(1)		

Question number	Answer	Additional guidance	Marks
19(e)	An explanation that makes reference to: • copper forms an ion with an incomplete d subshell (1) • but the only ion that zinc forms has a completely filled d subshell. (1)		**2**

Question number	Answer	Additional guidance	Marks
19(f)	A explanation that makes reference to: • the atoms/cations are of different size (in brass) (1) • therefore the layers do not slide over one another so easily. (1)	Ignore movement of the electrons Accept a labelled diagram	**2**