

Mark Scheme (Results)

Summer 2015

GCE Chemistry (6CH05/01)

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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	C		1

Question Number	Correct Answer	Reject	Mark
4	B		1

Question Number	Correct Answer	Reject	Mark
5	C		1

Question Number	Correct Answer	Reject	Mark
6	B		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	D		1

Question Number	Correct Answer	Reject	Mark
9	C		1

Question Number	Correct Answer	Reject	Mark
10	D		1

Question Number	Correct Answer	Reject	Mark
11	C		1

Question Number	Correct Answer	Reject	Mark
12	A		1

Question Number	Correct Answer	Reject	Mark
13	D		1

Question Number	Correct Answer	Reject	Mark
14	D		1

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	D		1

Question Number	Correct Answer	Reject	Mark
17	D		1

Question Number	Correct Answer	Reject	Mark
18	A		1

Question Number	Correct Answer	Reject	Mark
19	B		1

Question Number	Correct Answer	Reject	Mark
20	B		1

Section B

Question Number	Acceptable Answers	Reject	Mark
21a(i)	<p>Ni: $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^8 4s^2$ (1)</p> <p>Cu: $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^{10} 4s^1$ (1)</p> <p>ALLOW capital letters, subscripts for superscripts ALLOW 4s before 3d</p> <p>Penalise omission of $3s^2 3p^6$ once only if rest is correct</p>		2

Question Number	Acceptable Answers	Reject	Mark
21a*(ii)	<p>First electron removed is from 4s (in both atoms) (1)</p> <p>Second electron in Cu (is harder to remove so it is) EITHER closer to nucleus/in inner shell OR less shielded (1)</p> <p>IGNORE Comments about second electron being in full shell/ in a 3d shell/in a 3d orbital Reference to $3d^{10}$ stability</p>		2

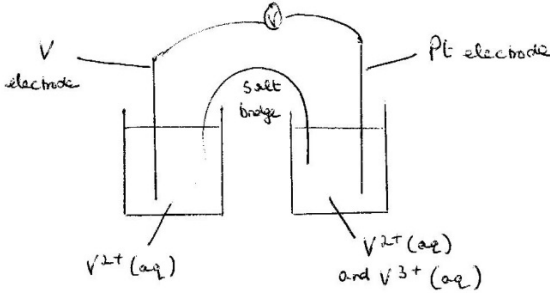
Question Number	Acceptable Answers	Reject	Mark
21a(iii)	<p>(attraction on (3d) electrons increases due to) number of protons increasing / nuclear charge increasing</p> <p>IGNORE The charge density of the 2^+ ions increases Effective nuclear charge</p>		1

Question Number	Acceptable Answers	Reject	Mark
21b(i)	$2\text{Cu}^+(\text{aq}) \rightarrow \text{Cu}(\text{s}) + \text{Cu}^{2+}(\text{aq})$ IGNORE Eqm sign for \rightarrow	Reverse equation Any equation involving electrons	1

Question Number	Acceptable Answers	Reject	Mark
21b(ii)	Both white ALLOW (both) Colourless (1) COMMENT Ignore states eg solution/precipitate As have $3d^{10}$ / have a full 3d sub-shell / ALL 3d orbitals are full (1) IGNORE Does not have partially filled d orbitals They do not absorb light No d-d transitions occur		2

Question Number	Acceptable Answers	Reject	Mark
21c	(Zinc) does not form a (stable) ion with incompletely/partially filled d orbitals ALLOW d sub-shell for d orbitals The only (stable) ion formed by zinc has full d sub-shell It does not form a (stable) oxidation state with incompletely/partially filled d orbitals	Element has full d shells.	1

Total for Question 21 = 9 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	 <p>Beaker with V electrode in solution containing $V^{2+}(aq)$ AND beaker containing $V^{2+}(aq)$ and $V^{3+}(aq)$ with Pt electrode</p> <p>N.B. Both solution levels must be shown (1)</p> <p>Labelled salt bridge AND connections to voltmeter ALLOW Suitable name or formula of salt for label</p> <p>ALLOW Salts eg NaCl in salt bridge (1)</p> <p>Ion concentrations = 1 mol dm^{-3} ALLOW M for mol dm^{-3} Concentrations given in one beaker only (1)</p> <p>Beaker positions may be reversed</p> <p>Ignore references to temperature and pressure</p>	<p>Salt bridge neither dipping into nor touching solution unless penalised in MP1</p> <p>Salt bridge containing an alkali/acid</p> <p>1 mole of V^{2+} and 1 mole of V^{3+}</p>	3

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	<p>First mark $2V^{3+} + V \rightarrow 3V^{2+}$ Balanced equation, either direction ALLOW Eqm sign for \rightarrow</p> <p>IGNORE State symbol even if incorrect (1)</p> <p>Second mark Correct direction ALLOW If balancing is incorrect or e^- included in equation (1)</p>	e^- included	2

Question Number	Acceptable Answers	Reject	Mark						
22b(i)	<table border="1"> <tr> <td>($[VO^{2+}(aq) + 2H^+(aq)]$, $[V^{3+}(aq) + H_2O(l)]$ Pt)</td> <td>+0.34</td> </tr> <tr> <td>($[VO_2^+(aq) + 2H^+(aq)]$, $[VO^{2+}(aq) + H_2O(l)]$ Pt)</td> <td>+1.00</td> </tr> <tr> <td>Sign and value needed</td> <td></td> </tr> </table>	($[VO^{2+}(aq) + 2H^+(aq)]$, $[V^{3+}(aq) + H_2O(l)]$ Pt)	+0.34	($[VO_2^+(aq) + 2H^+(aq)]$, $[VO^{2+}(aq) + H_2O(l)]$ Pt)	+1.00	Sign and value needed			1
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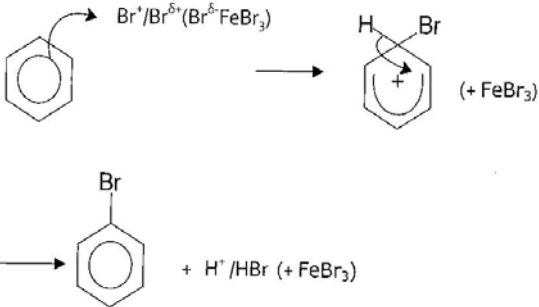
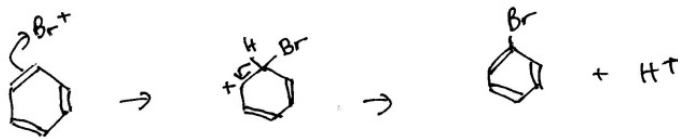
Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	<p>A: (+)0.32 (V) (1)</p> <p>VO²⁺ (may be shown as a product in an overall equation) (1)</p> <p>EITHER Bubbles / effervescence (of colourless gas) OR Colour changes (from yellow) to blue</p> <p>TE on negative E_{cell} for 'stays yellow'</p> <p>ALLOW (from yellow) to green if justified by partial reduction (1)</p> <p>B: -0.2(0) (V) (1) no change / stays blue (1) If B=+0.2 or other positive value allow colour change from blue to green or brown.</p> <p>EITHER Consistent use of rule that reaction occurs when E_{cell} is positive OR Consistent use of rule that no reaction occurs when E_{cell} negative ALLOW If implied but not stated specifically (1)</p>	Violet Stays violet	6

Question Number	Acceptable Answers	Reject	Mark
22c(i)	<p>V²⁺ + 2H₂O → VO₂⁺ + 4H⁺ + 3e⁻ OR Ox number of V increases by 3, ox number of Mn decreases by 5</p> <p>ALLOW Balanced full equation 5V²⁺ + 3MnO₄⁻ + 4H⁺ → 5VO₂⁺ + 3Mn²⁺ + 2H₂O</p>	Reverse equation unless used to deduce final correct equation.	1

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	(35.50 × 0.0200/1000) = 7.1(0) × 10 ⁻⁴ / 0.00071		1

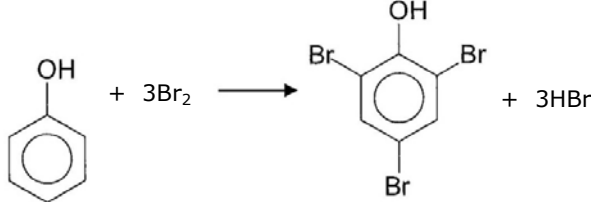
Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	<p>In final answer 92.2 scores 3 marks 33.2 scores 2 marks (ratio inverted) 55.3 scores 2 marks (ratio 1:1)</p> <p>METHOD 1 Mol V²⁺ reacting = $7.10 \times 10^{-4} \times 5/3$ = 1.18333×10^{-3} = mol VO₂⁺ TE on answer to (c)(ii) (1)</p> <p>Mass NH₄VO₃ = $(1.183 \times 10^{-3} \times 116.9)$ = 0.1382927 g TE from $4.26 \times 10^{-3} = 0.497994$ (1)</p> <p>% purity = $(0.1382927 \times 100 / 0.150) =$ (92.19333) = 92.2% TE from 0.497994 = 33.2% (1)</p> <p>METHOD 2</p> <p>If 100% pure, moles of NH₄VO₃ = $0.150 / 116.9 = 1.283 \times 10^{-3}$ (1)</p> <p>Mol V²⁺ reacting = $7.10 \times 10^{-4} \times 5/3$ = 1.18333×10^{-3} = mol VO₂⁺ TE on answer to (c)(ii) (1)</p> <p>% purity = = $1.18333 \times 10^{-3} \times 100 / 1.283 \times 10^{-3}$ = 92.2% (1)</p> <p>ALLOW TE at each step provided that each number used is to at least 2sf</p>	<p>x 3/5 = 4.26×10^{-4}</p>	3

Total for Question 22 = 17 marks

Question Number	Acceptable Answers	Reject	Mark
23(c)	<p>First mark: $\text{FeBr}_3 + \text{Br}_2 \rightarrow \text{FeBr}_4^- + \text{Br}^+$ OR $\text{Br}-\text{Br} + \text{FeBr}_3 \rightarrow \text{Br}^{\delta+} \dots \text{Br}^{\delta-}\text{FeBr}_3$ (1) Ignore state symbols even if wrong</p> <p>Second, third and fourth marks: Either</p>  <p>Arrow from benzene ring electrons (from inside the hexagon) to Br⁺ / Br^{δ+} (..... Br^{δ-}FeBr₃) (1)</p> <p>Correctly drawn intermediate with delocalisation covering at least three carbon atoms, but not the carbon atom bonded to the bromine, with the positive charge shown inside the horseshoe</p> <p>The bonds to H and Br may be dotted (1)</p> <p>Arrow from / close to C-H bond to inside the hexagon and H⁺ / HBr as product (1)</p> <p>OR</p>  <p>Use of Kekulé structure for benzene and intermediate with arrow from C=C double bond to Br⁺ / Br^{δ+} (..... Br^{δ-}FeBr₃) (1)</p> <p>Correctly drawn intermediate with + charge on the C atom next to the C bonded to H and Br</p>	Gap in wrong place	4

	The bonds to H and Br may be dotted (1)		
	Arrow from / close to C-H bond to bond beside + charged C and H ⁺ / HBr as product (1)		
	Each marking point is independent		

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	Bromine goes colourless OR It/the mixture goes from brown to colourless ALLOW Red-brown/ Orange/ yellow/ combinations of these colours Bromine is decolorised (1) White precipitate/solid forms / Steamy fumes (1) IGNORE Antiseptic smell Gets hot	Goes clear Red to colourless Bromine is discoloured Effervescence	2

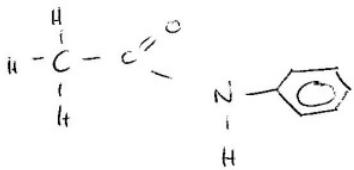
Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	 <p>Organic product with structure shown (1) Rest of equation correct ALLOW C₆H₅OH or Kekule for phenol (1) C₆H₅OH + 3Br₂ → C₆H₂Br₃OH + 3HBr Scores MP2 only Substitution of 1Br or 2Br in any position in balanced equation scores MP2 only.</p>		2

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	Concentrated nitric acid AND concentrated sulfuric acid ALLOW 'concentrated nitric and sulfuric acids' Concentrated HNO ₃ and concentrated H ₂ SO ₄	Extra reagents	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	To prevent multiple substitutions/ to stop di- or trinitrobenzene forming ALLOW To stop further substitution (of NO ₂)/ further nitration IGNORE further reaction	Further addition of nitro groups	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(iii)	Tin/ Sn AND concentrated HCl/ concentrated hydrochloric acid ALLOW Iron/Fe or Zn/Zinc for tin Conc for concentrated	Dilute HCl	1

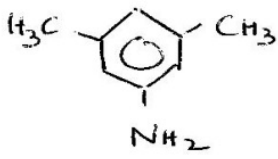
Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	C ₆ H ₅ NH ₃ ⁺ Cl ⁻ ALLOW C ₆ H ₅ NH ₃ Cl		1

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	 ALLOW C ₆ H ₅ for benzene Undisplayed CH ₃	Skeletal formula Structural formula	1

Question Number	Acceptable Answers	Reject	Mark
24(b)(iii)	<p>D (transition metal) complex ion ALLOW Transition metal complex / copper complex IGNORE Formulae of ions (1)</p> <p>F (azo) dye / azo compound / diazo compound ALLOW diazonium compound molecule for compound (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
24b(iv)	<p>Benzenediazonium chloride ALLOW Phenyldiazonium chloride</p>	<p>Benzadiazonium chloride Diazonium salt</p>	1

Question Number	Acceptable Answers	Reject	Mark
24b(v)	<p>HCl + NaNO₂ OR Hydrochloric acid + Sodium nitrite / nitrate(III) OR alternative cation to Na⁺</p> <p>IGNORE HNO₂ Concentration of HCl</p>	HCl + HNO ₂	1

Question Number	Acceptable Answers	Reject	Mark
24b(vi)	 <p>ALLOW any substitution positions $C_6H_3(CH_3)_2NH_2$ H- $C_6H_2(CH_3)_2NH_2$ Kekule structure</p>	$C_6H_2(CH_3)_2NH_2$	1

Total for Question 24 = 10 marks

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	$ \begin{array}{c} \text{H} \\ \\ ^+\text{H}_3\text{N} - \text{C} - \text{COO}^- \\ \\ \text{CH}_2\text{OH} \end{array} $ <p>OR $\text{HOCH}_2\text{CH}(\text{NH}_3^+)\text{CO}_2^-$</p> <p>ALLOW Charge on NH_3 shown on N atom</p>		1

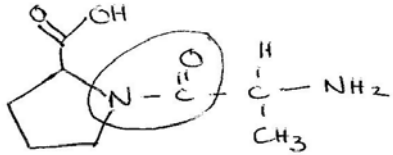
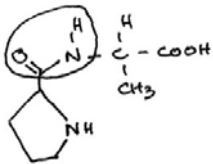
Question Number	Acceptable Answers	Reject	Mark
*25(a)(ii)	<p>EITHER</p> <p>At pH 5.68 both NH₂ groups on lysine will be NH₃⁺ / lysine has an overall positive charge while serine has no overall charge (1)</p> <p>So only lysine will move to negative terminal / in an electric field (1)</p> <p>OR</p> <p>lysine has a greater positive charge (than serine) (1)</p> <p>Lysine will move faster / further in an electric field (1)</p> <p>ALLOW They have different charges so will move different distances/ at different speeds 1 mark max</p> <p>IGNORE Answers based on molecular mass</p>		2

Question Number	Acceptable Answers	Reject	Mark
*25(b)	<p>COMMENT</p> <p>Ignore references to H bonds from amino and carboxyl groups and assume that "phenylalanine cannot form H bonds" refers to R group in the compound.</p> <p>Serine has an OH (alcoholic) group which can form H bonds with water (1)</p> <p>Benzene ring in phenylalanine is bulky / is large and non-polar / is hydrophobic / London forces between phenylalanine molecules are significant ALLOW van der Waals etc for London</p> <p>ALLOW If MP1 is not scored, 'phenylalanine cannot form H bonds with water' can score MP2 (1)</p>	VdW / id-id	2

Question Number	Acceptable Answers	Reject	Mark
25(c)	H, -H, H- ALLOW NH ₂ CH ₂ CO ₂ H / NH ₂ CH ₂ COOH $ \begin{array}{c} \text{H} \\ \\ \text{H}_2\text{N} - \text{C} - \text{C} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{OH} \end{array} \\ \\ \text{H} \end{array} $		1

Question Number	Acceptable Answers	Reject	Mark
25(d)(i)	(Measure) the amount of / angle of / degree of / extent of rotation (of plane of polarization/ plane polarized light) IGNORE direction they rotate the light	Just "polarimetry"	1

Question Number	Acceptable Answers	Reject	Mark
25(d)(ii)	(Leu has 1 chiral C but) Ile has 2 chiral C / 2 asymmetric C atoms OR The R group in Ile contains a chiral C (Leu has 2 optical isomers but Ile has 4 optical isomers) ALLOW Ile has (1) more chiral C (than leu) Chiral centres shown on formulae	Leu has no chiral C	1

Question Number	Acceptable Answers	Reject	Mark
25(e)	 <p>CON circled with N as part of ring (1) Fully correct structure (1)</p> <p>ALLOW -CH(CH₃)NH₂ shown skeletally</p> <p>OR Dipeptide using NH₂ from alanine and COOH from proline, with correct structure and CONH circled This scores max (1)</p> 	Just N-C circled	2

Question Number	Acceptable Answers	Reject	Mark
25(f)(i)	<p>CH₃CHO / CH₂CHOH</p> <p>ALLOW Displayed or semi-displayed formula C₂H₄O</p>	CH ₃ COH (unless with correct structure)	1

Question Number	Acceptable Answers	Reject	Mark
25(f)(ii)	C ₁₈ H ₉ NO ₄		1

Question Number	Acceptable Answers	Reject	Mark																																								
25(f)(iii)	<p>Several methods are possible. Amount of O should have been calculated and final answer should be consistent with masses/mols in calculation. There should be evidence of working at each stage for 4 marks</p> <p>MP1 2.614 g CO₂ contain 0.7129 g C 0.2673 g H₂O contain 0.0297 g H</p> <p>OR 2.614 g CO₂ contain 0.059409 mol CO₂ 0.2673 g H₂O contain 0.01485 mol H₂O (1)</p> <p>MP2 Mass O in Q = (1.00 – 0.7129– 0.0297 –0.04620) = 0.2112 g (1)</p> <table> <thead> <tr> <th></th> <th>%</th> <th>mol/100g</th> <th>ratio</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>71.29</td> <td>5.94</td> <td>18</td> </tr> <tr> <td>H</td> <td>2.97</td> <td>2.97</td> <td>9</td> </tr> <tr> <td>N</td> <td>4.62</td> <td>0.33</td> <td>1</td> </tr> <tr> <td>O</td> <td>21.12</td> <td>1.32</td> <td>4</td> </tr> </tbody> </table> <p>MP3 Number of moles of each element OR Number of mol in 100g Allow TE for incorrect mol of H – see calculation below (1)</p> <p>MP4 Ratio stated must follow from numbers in calculation (so empirical formula is consistent with the molecular formula of Q) (1)</p> <p>OR Calculation following error in H scores max (3) If mass H is wrongly calculated as 0.01485 g, then mass O will be 0.22605 (TE for MP2) (1)</p> <table> <thead> <tr> <th></th> <th>%</th> <th>mol/100g</th> <th>ratio</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>71.29</td> <td>5.94</td> <td>18</td> </tr> <tr> <td>H</td> <td>1.48</td> <td>1.48</td> <td>4.5</td> </tr> <tr> <td>N</td> <td>4.62</td> <td>0.33</td> <td>1</td> </tr> <tr> <td>O</td> <td>22.60</td> <td>1.41</td> <td>4.27</td> </tr> </tbody> </table>		%	mol/100g	ratio	C	71.29	5.94	18	H	2.97	2.97	9	N	4.62	0.33	1	O	21.12	1.32	4		%	mol/100g	ratio	C	71.29	5.94	18	H	1.48	1.48	4.5	N	4.62	0.33	1	O	22.60	1.41	4.27		4
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	Number of moles of each element (TE for MP3) (1) Ratio stated and empirical formula said not to be consistent (TE for MP4) (1)		
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Question Number	Acceptable Answers	Reject	Mark
25(f)(iv)	Mass of molecular ion in mass spectrum = 303 / any sensible fragment with mass eg 302 / 158 / 145 or smaller fragment (1) ALLOW Molecular ion based on formula in f(i) Number of peaks in nmr = 2 / 3 ALLOW 5 (1)	4	2

Total for Question 25 = 18 marks

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