



Pearson

# Mark Scheme (Results)

## January 2018

Pearson Edexcel International Advanced  
Level In Chemistry (WCH05) Paper 01  
General Principles of Chemistry II –  
Transition Metals and Organic Nitrogen  
Chemistry

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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.

## Section A (multiple choice)

Question Number	Correct Answer	Mark
<b>1</b>	<p><b>The only correct answer is D</b></p> <p><i>A is not correct because the electrode is wrong and <math>Mn^{2+}</math> ions are missing from the solution</i></p> <p><i>B is not correct because the electrode is wrong</i></p> <p><i>C is not correct because <math>Mn^{2+}</math> ions are missing from the solution</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>2</b>	<p><b>The only correct answer is C</b></p> <p><i>A is not correct because the oxidation number of Cr is + 3 and Mn is + 2</i></p> <p><i>B is not correct because the oxidation number of Cr is + 6 and Ti is + 3</i></p> <p><i>D is not correct because the oxidation number of Cr is + 6 and Mn is + 7</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>3</b>	<p><b>The only correct answer is A</b></p> <p><i>B is not correct because the oxidation number should be <math>+3 - 2 = +1</math></i></p> <p><i>C is not correct because the oxidation number should be <math>+3 - 2 = +1</math></i></p> <p><i>D is not correct because the oxidation number should be <math>+3 - 2 = +1</math></i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>4(a)</b>	<p><b>The only correct answer is A</b></p> <p><i>B is not correct because the complex is linear</i></p> <p><i>C is not correct because the complex is square planar</i></p> <p><i>D is not correct because the complex is octahedral</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>4(b)</b>	<p><b>The only correct answer is B</b></p> <p><i>A is not correct because the oxidation number of the metal is +3</i></p> <p><i>C is not correct because the oxidation number of the metal is +2</i></p> <p><i>D is not correct because the oxidation number of the metal is +4</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>5(a)</b>	<p><b>The only correct answer is C</b></p> <p><i>A is not correct because it is not -4/2</i></p> <p><i>B is not correct because it is not -4/2</i></p> <p><i>D is not correct because it is not -4/2</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>5(b)</b>	<p><b>The only correct answer is C</b></p> <p><i>A is not correct because incorrect number of Z ligands</i></p> <p><i>B is not correct because incorrect number of Z ligands and incorrect charge</i></p> <p><i>D is not correct because incorrect charge</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>6(a)</b>	<p><b>The only correct answer is A</b></p> <p><i>B is not correct because although copper(I) oxide is reddish brown, it is an incorrect product</i></p> <p><i>C is not correct because copper(II) oxide is black not brown and it is an incorrect product</i></p> <p><i>D is not correct because zinc sulfate is white not brown</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>6(b)</b>	<p><b>The only correct answer is B</b></p> <p><i>A is not correct because it is not a white solid</i></p> <p><i>C is not correct because it is not a white solid</i></p> <p><i>D is not correct because it is soluble</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>7</b>	<p><b>The only correct answer is B</b></p> <p><i>A is not correct because it is not an addition reaction</i></p> <p><i>C is not correct because not it is not a nucleophilic or addition reaction</i></p> <p><i>D is not correct because it is not a nucleophilic reaction</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>8(a)</b>	<p><b>The only correct answer is D</b></p> <p><i>A is not correct because this is the wrong product</i></p> <p><i>B is not correct because this is the wrong product</i></p> <p><i>C is not correct because this is the wrong product</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>8(b)</b>	<p><b>The only correct answer is C</b></p> <p><i>A is not correct because it is electrophilic not nucleophilic</i></p> <p><i>B is not correct because electromeric effect outweighs inductive effect</i></p> <p><i>D is not correct because it is a nucleophile not an electrophile</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>9(a)</b>	<p><b>The only correct answer is A</b></p> <p><i>B is not correct because the locants are incorrect</i></p> <p><i>C is not correct because there are no locants for the amine groups</i></p> <p><i>D is not correct because there are no locants for the amine groups</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>9(b)</b>	<p><b>The only correct answer is D</b></p> <p><i>A is not correct because there is no carbonyl group</i></p> <p><i>B is not correct because there is no carbonyl group</i></p> <p><i>C is not correct because the amide groups are incorrect</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>10(a)</b>	<p><b>The only correct answer is C</b></p> <p><i>A is not correct because it is not an acid</i></p> <p><i>B is not correct because it is not an acid</i></p> <p><i>D is not correct because it is optically active</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>10(b)</b>	<p><b>The only correct answer is A</b></p> <p><i>B is not correct because Q forms phenol</i></p> <p><i>C is not correct because R does not form sodium benzoate</i></p> <p><i>D is not correct because S does not form sodium benzoate</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>11(a)</b>	<p><b>The only correct answer is B</b></p> <p><i>A is not correct because it is a primary alcohol and should be a secondary alcohol</i></p> <p><i>C is not correct because it is a primary alcohol and should be a secondary alcohol</i></p> <p><i>D is not correct because it is a tertiary alcohol and should be a secondary alcohol</i></p>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>11(b)</b>	<b>The only correct answer is B</b> <i>A is not correct because there would be no loss of carbon atom</i> <i>C is not correct because there would be no loss of carbon atom</i> <i>D is not correct because there would be no loss of carbon atom</i>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>11(c)</b>	<b>The only correct answer is D</b> <i>A is not correct because this does not react with propanoic acid to give propanoyl chloride</i> <i>B is not correct because this does not react with propanoic acid to give propanoyl chloride</i> <i>C is not correct because this does not react with propanoic acid to give propanoyl chloride</i>	<b>(1)</b>

Question Number	Correct Answer	Mark
<b>11(d)</b>	<b>The only correct answer is B</b> <i>A is not correct because it is not branched</i> <i>C is not correct because it is not an amine</i> <i>D is not correct because it is not an amine</i>	<b>(1)</b>

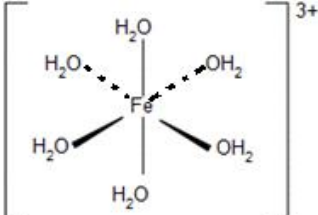


## Section B

Question Number	Acceptable Answers	Reject	Mark
<b>12(a)(i)</b>	$(Al^{3+} 1s^2)2s^22p^6$ (1) $(Fe^{3+} 1s^2)2s^22p^63s^23p^63d^5$ (1)  ALLOW $2p_x^22p_y^22p_z^2 / 3p_x^23p_y^23p_z^2$  ALLOW $4s^0$ included in $Fe^{3+}$ / any other orbitals with 0 electrons  IGNORE $1s^2$ written again		<b>(2)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>12(a)(ii)</b>	The increase in ionisation energy is balanced by an increase in hydration/lattice enthalpy  ALLOW There is (only) a gradual/ small increase in (successive) ionisation energies for iron OR Iron has (several removable) d electrons of similar energies OR The 4s / 3d electrons / orbitals have similar energies (for iron) OR The energy difference / gap between 4s and 3d is small (for iron) OR The ionisation energies are similar (for iron)  IGNORE References to stability of half-full d-subshell / References to 3p electrons	Just 'iron is a transition element'	<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>*12(b)</b>	<p><b>First mark - splitting</b>            (3)d orbitals / (3)d subshell are/is split (in energy by the ligands)</p> <p>ALLOW            "d orbital splitting" (1)</p> <p>IGNORE            Just 'there is an energy difference between the (3) d orbitals'</p> <p><b>Second mark - absorption</b>            Electrons / photons absorb energy</p> <p>ALLOW            Electrons absorb (visible) light            Frequencies / wavelengths (of visible light) are absorbed (1)</p> <p><b>Third mark - promotion</b>            Electrons are promoted (from lower to higher energy d orbital(s) / levels)            OR            Electrons move (from lower) to higher energy (d) orbital(s) / levels</p> <p>ALLOW            d-d transitions occur /            Electrons are excited to higher energy (d) orbital(s) / levels (1)</p> <p><b>Fourth mark - colour</b>            Reflected / transmitted / remaining light is coloured / is in the visible region</p> <p>ALLOW            Complementary colour seen            (The frequency of) reflected / transmitted / remaining light is seen (1)</p> <p>IGNORE            Reference to electrons relaxing / dropping to the ground state / any reference to aluminium</p>	<p>d orbital 'singular' is split</p> <p>d shell is split</p> <p>Penalise omission of (3)d only in First mark</p> <p>Light emitted</p>	<b>(4)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>12(c)(i)</b>	 <p><b>3D octahedral shape</b> Recognisable 3D octahedral shape</p> <p>ALLOW Wedges/dots instead of dashed lines going into the page or other recognisable representations (1)</p> <p><b>Note</b> The word 'octahedral' does not rescue a poor diagram</p> <p><b>Oxygen atoms</b> <b>6 oxygen</b> atoms joined to Fe (with or without lone pairs)</p> <p>ALLOW O<sub>2</sub>H Oxygens to Fe joined by single bonds / arrows for this mark (1)</p> <p>IGNORE Omission of brackets and charge Incorrect charge Name of shape, even if incorrect</p>	Negative charge on O	<b>(2)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>12(c)(ii)</b>	<p>Any 2 points from 3</p> <p><b>First point</b>  <math>\text{Fe}^{3+}</math> is (small and) highly charged/ <math>\text{Fe}^{3+}</math> has a high charge density (1)</p> <p><b>Second point</b>  <math>\text{Fe}^{3+}</math> polarises / weakens / distorts the O–H bond  OR  <math>\text{Fe}^{3+}</math> attracts the electrons / electron cloud / electron density in the OH bond</p> <p>ALLOW  <math>\text{Fe}^{3+}</math> polarises / distorts the water molecule (1)</p> <p><b>Third point</b>  (Solvent) water acts as a base  OR  (Solvent) water removes/ accepts a proton  OR  Water ligands donate a proton to (solvent) water</p> <p>ALLOW  <math>[\text{Fe}(\text{H}_2\text{O})_6]^{3+}</math> / the complex (ion) / water <b>ligand</b> acts as an acid (1)</p> <p>IGNORE  Just 'deprotonation' / just 'acid-base reaction' / alkali instead of base/ the complex is a proton donor</p>	<p>Water <b>ligands</b> act as a base</p> <p>Disproportionation</p>	<b>(2)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>12(d)</b>	<p><b>First mark – electron deficient</b> (The aluminium atom in) <math>\text{AlCl}_3</math> has an empty (p) orbital (in the outer shell) / is electron deficient / has 6 electrons (in the outer shell)</p> <p>ALLOW 6 electrons shown around Al on a diagram (1)</p> <p>IGNORE Just '<math>\text{AlCl}_3</math> has an incomplete (p) subshell'</p> <p><b>Second mark - bond</b> It can accept a pair of / two electrons (from chlorine) OR Chlorine donates a pair of / 2 electrons (to <math>\text{AlCl}_3</math>) OR It form a dative (covalent) bond (with chlorine)</p> <p>ALLOW Mention of chloride ion (1)</p> <p>IGNORE diagram</p>	<p>Reference to 3d / 3s orbitals</p> <p>Reference to aluminium <b>ion</b></p> <p>Reference to 'an electron'</p> <p>Chlorine molecule / <math>\text{Cl}_2</math></p>	<b>(2)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>12(e)(i)</b>	<p>Ligand exchange (reaction) OR Ligand substitution (reaction) OR Ligand replacement (reaction)</p> <p>Both words needed for the mark</p>	<p>Ligand change Ligand reaction Oxidation Reduction Redox</p>	<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>12(e)(ii)</b>	<p><b>Dot-and-cross diagram</b></p> <p>OR</p> <p>ALLOW Any symbols for electrons Bonds shown with 2 electrons on each e.g. <math>\times</math> (1)</p> <p>IGNORE Missing brackets and charge</p> <p><b>Structure and charge</b></p> $^{\ominus}\text{S}-\text{C}\equiv\text{N}$ <p>OR</p> $\text{S}=\text{C}=\text{N}^{\ominus}$ <p>Bonds correct <b>and</b> negative charge shown or stated on correct atom</p> <p>ALLOW This mark if bonds also shown in dot-and-cross diagram and negative charge on correct atom (1)</p>		<b>(2)</b>

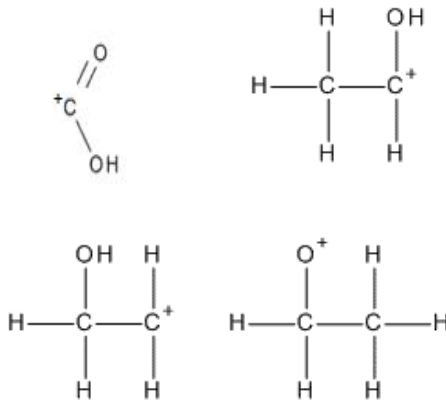
Question Number	Acceptable Answers	Reject	Mark
<b>12(e)(iii)</b>	<p>Dative covalent bond / bond from lone pair (of electrons) on sulfur/S <b>and</b> from nitrogen/N (to an empty orbital in <math>\text{Fe}^{3+}</math>)</p> <p>IGNORE Ionic bond</p>		<b>(1)</b>

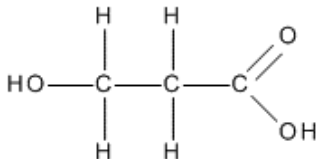
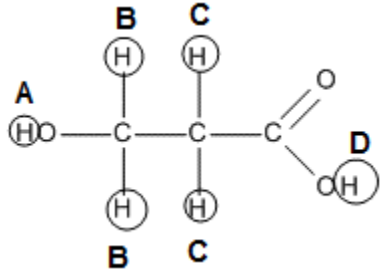
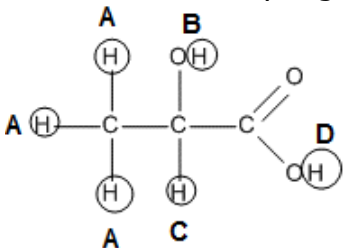
Question Number	Acceptable Answers	Reject	Mark
<b>12(f)</b>	<p><b>Ionic equation with hydrochloric acid</b>  <math>\text{Al(OH)}_3 + 3\text{H}^+ \rightarrow \text{Al}^{3+} + 3\text{H}_2\text{O}</math></p> <p>ALLOW  <math>\text{Al(OH)}_3(\text{H}_2\text{O})_3 + 3\text{H}^+ \rightarrow \text{Al}^{3+} + 6\text{H}_2\text{O}</math>  <math>\text{Al(OH)}_3(\text{H}_2\text{O})_3 + 3\text{H}^+ \rightarrow [\text{Al}(\text{H}_2\text{O})_6]^{3+}</math>  <math>\text{Al(OH)}_3 + 3\text{H}^+ + 3\text{H}_2\text{O} \rightarrow [\text{Al}(\text{H}_2\text{O})_6]^{3+}</math> (1)</p> <p>IGNORE  <math>\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}</math></p> <p><b>Ionic equation with sodium hydroxide</b>  <math>\text{Al(OH)}_3 + \text{OH}^- \rightarrow \text{AlO}_2^- + 2\text{H}_2\text{O}</math>  OR  <math>\text{Al(OH)}_3 + \text{OH}^- \rightarrow [\text{Al(OH)}_4]^-</math></p> <p>ALLOW  <math>\text{Al(OH)}_3(\text{H}_2\text{O})_3 + \text{OH}^- \rightarrow [\text{Al(OH)}_4]^- + 3\text{H}_2\text{O}</math>  <math>\text{Al(OH)}_3(\text{H}_2\text{O})_3 + \text{OH}^- \rightarrow [\text{Al(OH)}_4(\text{H}_2\text{O})_2]^- + \text{H}_2\text{O}</math>  <math>\text{Al(OH)}_3 + 2\text{OH}^- \rightarrow [\text{Al(OH)}_5]^{2-}</math>  <math>\text{Al(OH)}_3(\text{H}_2\text{O})_3 + 2\text{OH}^- \rightarrow [\text{Al(OH)}_5]^{2-} + 3\text{H}_2\text{O}</math>  <math>\text{Al(OH)}_3 + 3\text{OH}^- \rightarrow [\text{Al(OH)}_6]^{3-}</math>  <math>\text{Al(OH)}_3(\text{H}_2\text{O})_3 + 3\text{OH}^- \rightarrow [\text{Al(OH)}_6]^{3-} + 3\text{H}_2\text{O}</math> (1)</p> <p>If no other mark awarded, ALLOW 1 mark for two non-ionic / partially ionic equations e.g.  <math>\text{Al(OH)}_3 + 3\text{HCl} \rightarrow \text{AlCl}_3 + 3\text{H}_2\text{O}</math>  <b>and</b>  <math>\text{Al(OH)}_3 + \text{NaOH} \rightarrow \text{NaAl(OH)}_4</math></p> <p>IGNORE  State symbols, even if incorrect / missing square brackets</p>		<b>(2)</b>

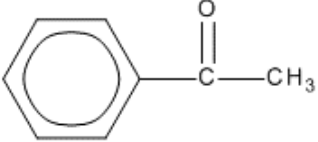
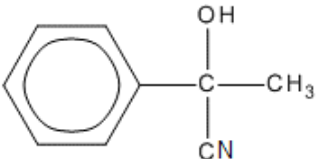
**(Total for Question 12 = 19 marks)**

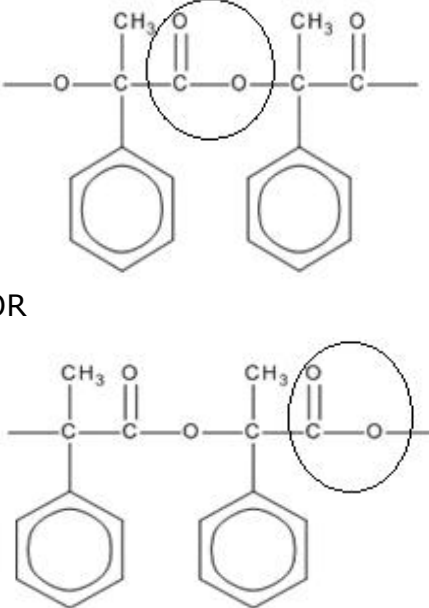
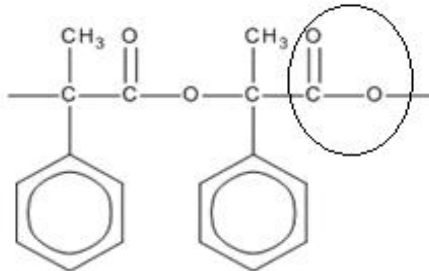
Question Number	Acceptable Answers	Reject	Mark
<b>13(a)(i)*</b>	<p>The methods below illustrate the allocation of marks. However, the marks may be scored by any correct method</p> <p>Correct molecular formulae with some working involving C/CO<sub>2</sub>, H/H<sub>2</sub>O and either O or use of A<sub>r</sub>s of C and H / COOH scores full marks</p> <p>Correct molecular formula with no working scores (1)</p> <p><b>Method 1</b>  mol CO<sub>2</sub> = 3.30/44 = 0.075 (= mol C) (1)</p> <p>mol H<sub>2</sub>O = 1.35/18 = 0.075 (1)</p> <p><b>and</b>  mol H = 2 x mol H<sub>2</sub>O = 0.150 or ratio C : H = 1 : 2 (1)</p> <p>mass O = 2.25 – ((12 x 0.075) + (1 x 0.150)) = 1.2 (g) (1)</p> <p>mol O = 1.2/16 = 0.075 (1)</p> <p><b>Method 2</b>  mass C = 3.30 x 12/44 = 0.90 (g) and mol C = 0.90/12 = 0.075 (1)</p> <p>mass H = 1.35 x 2/18 = 0.15 (g) and mol H = 0.15/1 = 0.15 (1)</p> <p>mass O = 2.25 – (0.90 + 0.15) = 1.2 (g) (1)</p> <p>mol O = 1.2/16 = 0.075 (1)</p> <p><b>Empirical and molecular formulae from Methods 1 and 2</b>  Empirical formula = CH<sub>2</sub>O (1)</p> <p>Relative empirical formula mass CH<sub>2</sub>O  = 12 + (2 x 1) + 16 = 30</p> <p>So, molecular formula is C<sub>3</sub>H<sub>6</sub>O<sub>3</sub> (1)</p> <p>TE on incorrect moles but the ratio must be a whole number</p> <p><b>Method 3</b>  mol T = 2.25/90 = 0.025 (1)</p> <p>mol CO<sub>2</sub> = 3.30/44 = 0.075 (= mol C) (1)</p> <p>mol ratio T : C / CO<sub>2</sub> = 1 : 3 (1)</p> <p>mol H<sub>2</sub>O = 1.35/18 = 0.075</p> <p><b>and</b>  mol H = 2 x mol H<sub>2</sub>O = 0.150 or mol ratio C : H = 1 : 2 / 3 : 6 (1)</p> <p>90 - (36 + 6) = 48 and mol O = 48/16 = 3 (1)</p> <p>So, molecular formula is C<sub>3</sub>H<sub>6</sub>O<sub>3</sub> (1)</p>		<b>(6)</b>



Question Number	Acceptable Answers	Reject	Mark
<b>13(a)(ii)</b>	<p>Any two of (1 mark for each structure)</p>  <p>ALLOW Structural formula i.e COOH<sup>+</sup>, CH<sub>3</sub>CHOH<sup>+</sup>, CH<sub>2</sub>OHCH<sub>2</sub><sup>+</sup>, CH<sub>3</sub>CH<sub>2</sub>O<sup>+</sup></p> <p>ALLOW Structures in brackets with positive charge outside bracket</p> <p>IGNORE Position of positive charge C<sub>2</sub>H<sub>5</sub>O<sup>+</sup> Connectivity of the OH group</p>	<p>Extra bonds once only e.g. –COOH<sup>+</sup></p> <p>Negative charge or omission of charge once only</p> <p>HCO<sub>2</sub><sup>+</sup></p>	<b>(2)</b>

Question Number	Acceptable Answers	Reject	Mark
13(a)(iii)	<p><b>Structure</b> of compound <b>T</b>:</p>  <p style="text-align: right;">(1)</p> <p>IGNORE Connectivity of the OH group</p> <p><b>Explanation:</b> <b>Use of peak ratio</b> Use of peak ratio e.g. protons A and D are ratio 1 : 1 (as they are single protons) and protons B and C are ratio 2 : 2 (as there are two protons in each environment)</p> <p>ALLOW Ratio of protons /hydrogens is 1 : 2 : 2 : 1 (1)</p> <p><b>Proton environments identified</b> 4 proton environments clearly identified by symbols or words e.g.</p>  <p style="text-align: right;">(1)</p> <p><b>Note</b> If compound <b>T</b> is identified as lactic acid, (1) mark awarded for identification of four proton environments only e.g.</p>  <p>No TE on any other structure</p>		<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13(b)(i)*</b>	<p><b>Reaction 1</b>            Reagents: CH<sub>3</sub>COCl/ ethanoyl chloride  <b>and</b> AlCl<sub>3</sub> / aluminium chloride / FeCl<sub>3</sub> / iron(III) chloride (1)</p> <p>Intermediate: stand alone or TE on acyl chloride used</p>  (1) <p><b>Reaction 2</b>            Reagents: conditional on a carbonyl compound            HCN / hydrogen cyanide  <b>and</b> KCN / potassium cyanide            OR            KCN / potassium cyanide  <b>and</b> acid / H<sub>2</sub>SO<sub>4</sub> / sulfuric acid / H<sup>+</sup> ions / hydrogen ions            OR            KCN / potassium cyanide  <b>and</b> pH 8-10 /alkali</p> <p>ALLOW            HCN / hydrogen cyanide  <b>and</b> alkali / NaOH / sodium hydroxide / OH<sup>-</sup> / hydroxide ions</p> <p>ALLOW            Sodium for potassium and vice versa (1)</p> <p>Intermediate: stand alone</p>  (1) <p><b>Reaction 3</b>            Reagents: conditional on reaction with a CN group            H<sup>+</sup> / hydrogen ions / (dilute) acid / name or formula of a strong acid</p> <p>ALLOW            OH<sup>-</sup> / hydroxide ions / alkali / name or formula of an alkali  <b>and</b>            followed by / then acidification / H<sup>+</sup> / hydrogen ions / (dilute) acid / name or formula of a strong acid (1)</p> <p>IGNORE            Concentration of acid or alkali</p>	<p>Just 'CN<sup>-</sup> in alkali'</p> <p>Additional reagent(s)            e.g. KMnO<sub>4</sub></p> <p>Acid and alkali added together</p>	<b>(5)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13(b)(ii)</b>	 <p>OR</p>  <p><b>First mark</b> One correct ester linkage (as circled above) (1)</p> <p><b>Second mark</b> Conditional on one (or more) ester linkage Rest of structure correct with 2 repeat units and extension bonds</p> <p>ALLOW C<sub>6</sub>H<sub>5</sub> for benzene ring (1)</p> <p>IGNORE Brackets and n / bond lengths and bond angles</p>	<p>Os at both ends or no O at either end loses second mark only</p>	<b>(2)</b>

**(Total for Question 13 = 18 marks)**

Question Number	Acceptable Answers	Reject	Mark
<b>14(a)(i)</b>	$V^{2+} + 2H_2O \rightarrow VO_2^+ + 4H^+ + 3e^{-}$  ALLOW Multiples Reversible arrow, provided equation written in the direction shown $V^{2+} + 2H_2O - 3e^{-} \rightarrow VO_2^+ + 4H^+$  IGNORE State symbols even if incorrect		<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14(a)(ii)</b>	<p><b>First mark – reducing agent</b>  Reducing agent: <math>\text{Fe}^{2+}(\text{aq})</math> / iron(II) (ions)  This can be shown in an equation (1)</p> <p>Justification:  <b>Second mark – V(V) to V(IV)</b>  <math>\text{Fe}^{2+}/\text{Fe}^{3+}</math> electrode potential / SEP / <math>E^\ominus</math> value is less positive / lower than the <math>\text{VO}_2^+/\text{VO}^{2+}</math> value / <math>(+)0.77 &lt; (+)1.00</math> (so V(V) is reduced to V(IV))</p> <p>OR  <math>\text{VO}_2^+/\text{VO}^{2+}</math> electrode potential / SEP / <math>E^\ominus</math> value is more positive / greater / higher than the <math>\text{Fe}^{2+}/\text{Fe}^{3+}</math> value / <math>(+)1.00 &gt; (+)0.77</math> (so V(V) is reduced to V(IV))</p> <p>OR  <math>E^\ominus_{\text{cell}}</math> for the reaction between <math>\text{VO}_2^+</math> and <math>\text{Fe}^{2+}</math> is positive / <math>(+)0.23 \text{ V}</math> / <math>&gt;0</math> (so V(V) is reduced to V(IV))</p> <p>ALLOW  Any of the above 3 explanations if <math>\text{SO}_2</math>, Zn, <math>\text{V}^{3+}</math> or <math>\text{V}^{2+}</math> chosen as reducing agent e.g. <math>E^\ominus</math> for <math>\text{SO}_2/\text{SO}_4^{2-} = (+)0.83</math> or <math>E^\ominus</math> for <math>\text{Zn}/\text{Zn}^{2+} = (+)1.76</math> or <math>E^\ominus</math> for <math>\text{V}^{3+}/\text{VO}^{2+} = (+)0.66</math> or <math>E^\ominus</math> for <math>\text{V}^{2+}/\text{V}^{3+} = (+)1.26</math> (so V(V) is reduced to V(IV)) (1)</p> <p><b>Third mark – V(IV) to V(III)</b>  <math>\text{Fe}^{2+}/\text{Fe}^{3+}</math> electrode potential / SEP / <math>E^\ominus</math> value is more positive / greater / higher than the <math>\text{VO}^{2+}/\text{V}^{3+}</math> value / <math>(+)0.77 &gt; (+)0.34</math> (so V(IV) is not reduced to V(III))</p> <p>OR  <math>\text{VO}^{2+}/\text{V}^{3+}</math> electrode potential / SEP / <math>E^\ominus</math> value is less positive / lower than the <math>\text{Fe}^{2+}/\text{Fe}^{3+}</math> value / <math>(+)0.34 &lt; (+)0.77</math> (so V(IV) is not reduced to V(III))</p> <p>OR  <math>E^\ominus_{\text{cell}}</math> for the reaction between <math>\text{VO}^{2+}</math> and <math>\text{Fe}^{2+}</math> is negative / <math>-0.43 \text{ V}</math> / <math>&lt;0</math> (so V(IV) is not reduced to V(III)) (1)</p>	<p>Incorrect value</p> <p>Incorrect value</p> <p>Incorrect value</p>	<b>(3)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14(a)(iii)</b>	<p><b>First mark - equation</b>  <math>2V^{3+} + H_2O \rightarrow V^{2+} + VO^{2+} + 2H^+</math></p> <p>ALLOW  Multiples  Reversible arrow, provided reaction is written in the direction shown (1)</p> <p>IGNORE  State symbols even if incorrect  Cancelled / crossed out electrons</p> <p><b>Second mark - <math>E^{\circ}_{cell}</math> value</b>  <math>E^{\circ}_{cell} = -0.26 - 0.34 = -0.6(0)</math> (V)</p> <p>NO TE on equation written in reverse (1)</p> <p><b>Third mark - feasibility</b>  <math>E^{\circ}_{cell}</math> is negative / <math>&lt;0</math>  <b>and</b>  so the disproportionation is not feasible / <math>V^{2+}</math> and <math>VO^{2+}</math> will react to form <math>V^{3+}</math></p> <p>ALLOW this mark even if an incorrect negative value is calculated for <math>E^{\circ}_{cell}</math></p> <p>TE on a positive value for <math>E^{\circ}_{cell}</math> e.g. <math>E^{\circ}_{cell}</math> is positive / <math>&gt;</math> <b>and</b> so the disproportionation is feasible (1)</p>	Equation with uncancelled electrons	<b>(3)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14(b)(i)</b>	<p>Correct answer, with or without working scores both marks</p> <p><b>First mark – mol I<sub>2</sub></b>  Mol S<sub>2</sub>O<sub>3</sub><sup>2-</sup> used = 24.20 x 0.100/1000  = 0.00242 / 2.42 x 10<sup>-3</sup></p> <p><b>and</b>  Mol I<sub>2</sub> = 0.00242/2 = 0.00121 / 1.21 x 10<sup>-3</sup> (1)</p> <p><b>Second mark – conc Br<sub>2</sub></b>  (Mol Br<sub>2</sub> = mol I<sub>2</sub> = 0.00121)  Conc Br<sub>2</sub> = 0.00121 x 1000/25.0 = 0.0484 (mol dm<sup>-3</sup>) (1)</p> <p>TE on mol S<sub>2</sub>O<sub>3</sub><sup>2-</sup> and mol I<sub>2</sub></p> <p>IGNORE SF except 1SF</p>		<b>(2)</b>

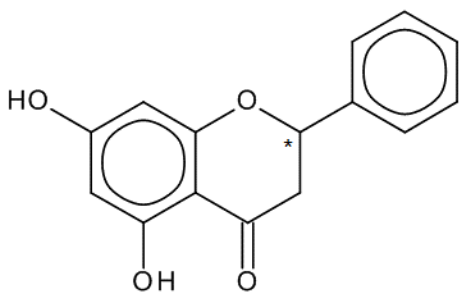


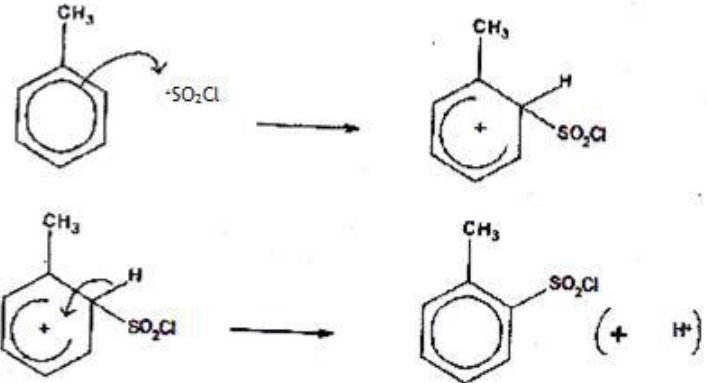
Question Number	Acceptable Answers	Reject	Mark
<b>14(b)(ii)</b>	<p>Allow correct expressions if intermediate values not evaluated</p> <p><b>First mark – original mol Br<sub>2</sub></b>  Original mol Br<sub>2</sub> = 100.0 x 0.0484/1000  = 0.00484 / 4.84 x 10<sup>-3</sup> (1)  TE on conc Br<sub>2</sub> in (i)</p> <p><b>Second mark – mol I<sub>2</sub></b>  Mol S<sub>2</sub>O<sub>3</sub><sup>2-</sup> used = 16.80 x 0.100/1000  = 0.00168 / 1.68 x 10<sup>-3</sup></p> <p><b>and</b>  Mol I<sub>2</sub> = 0.00168/2 = 0.00084 / 8.4 x 10<sup>-4</sup> (1)</p> <p><b>Third mark – mol Br<sub>2</sub> reacted</b>  (mol Br<sub>2</sub> in excess = mol I<sub>2</sub> = 0.00084)  Mol Br<sub>2</sub> reacted with S<sub>2</sub>O<sub>3</sub><sup>2-</sup>  = 0.00484 – 0.00084  = 0.00400 / 4.00 x 10<sup>-3</sup> (1)  TE on original mol Br<sub>2</sub> and mol I<sub>2</sub>/ Br<sub>2</sub> in excess</p> <p><b>Fourth mark – mol ratio</b>  Mole ratio S<sub>2</sub>O<sub>3</sub><sup>2-</sup> : Br<sub>2</sub>  = 0.00100 : 0.00400  = 1 : 4 (1)  TE on mol S<sub>2</sub>O<sub>3</sub><sup>2-</sup> and mol Br<sub>2</sub> reacted</p> <p><b>Fifth mark – equation – stand alone</b>  S<sub>2</sub>O<sub>3</sub><sup>2-</sup> + 4Br<sub>2</sub> + 5H<sub>2</sub>O → 2SO<sub>4</sub><sup>2-</sup> + 10H<sup>+</sup> + 8Br<sup>-</sup></p> <p>ALLOW  8HBr + 2Br<sup>-</sup> on RHS (1)  No TE on incorrect mol ratio</p> <p>IGNORE  State symbols even if incorrect</p>		<b>(5)</b>

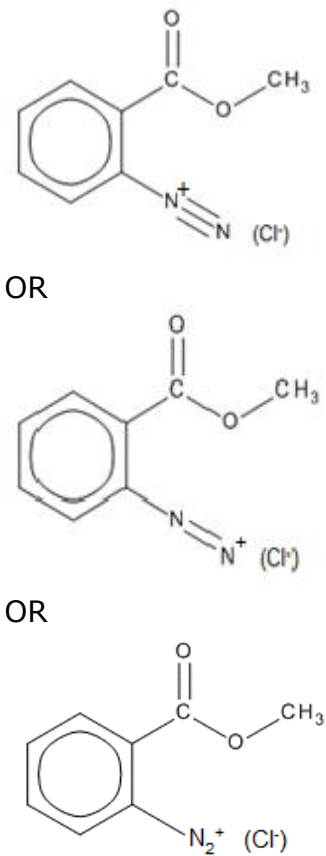
**(Total for Question 14 = 14 marks)**

## Section C

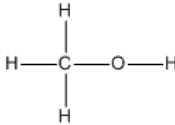
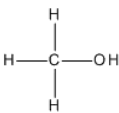
Question Number	Acceptable Answers	Reject	Mark
<b>15(a)(i)</b>	$C_{15}H_{12}O_4$  ALLOW symbols in any order, i.e. $C_{15}O_4H_{12}$ , $H_{12}O_4C_{15}$ , $H_{12}C_{15}O_4$ , $O_4H_{12}C_{15}$ , $O_4C_{15}H_{12}$  IGNORE Any other formulae as working	Numbers written as superscripts e.g. $C^{15}H^{12}O^4$	<b>(1)</b>

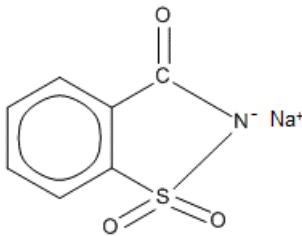
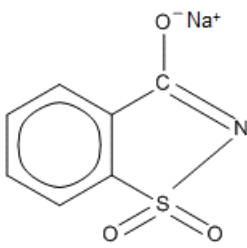
Question Number	Acceptable Answers	Reject	Mark
<b>15(a)(ii)</b>	  ALLOW Any way of identifying the chiral carbon, including a circle, provided that it does not include any other carbon atoms	Any additional carbon atoms indicated	<b>(1)</b>

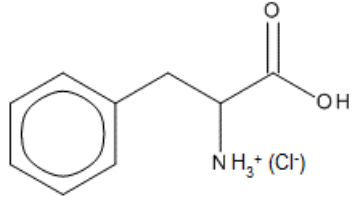
Question Number	Acceptable Answers	Reject	Mark
<p><b>15(b)</b></p>	 <p><b>First mark – first curly arrow</b> Curly arrow from on or within the circle to the S of <math>^+\text{SO}_2\text{Cl}</math></p> <p>ALLOW Curly arrow from anywhere within the hexagon</p> <p>ALLOW Curly arrow to any part of the <math>^+\text{SO}_2\text{Cl}</math> ion, including the + charge (1)</p> <p><b>Second mark - intermediate</b> Intermediate structure including charge with horseshoe covering at least 3 carbon atoms <b>and</b> facing the tetrahedral carbon atom <b>and</b> some part of the positive charge must be within the horseshoe (1)</p> <p><b>Note</b> Do not award this mark If benzene used instead of methylbenzene or if final product is not the 2-isomer</p> <p><b>Third mark – second curly arrow</b> Curly arrow from C-H bond to anywhere in the hexagon, reforming the delocalised structure (1)</p> <p>IGNORE Missing <math>\text{H}^+</math> Involvement of any other ion / molecule in removal of <math>\text{H}^+</math></p> <p>Correct Kekule structures score full marks</p>	<p>Curly arrow on or outside the hexagon / incorrect electrophile / missing +</p> <p>Dotted bonds to H and <math>\text{SO}_2\text{Cl}</math> unless part of a 3D structure</p>	<p><b>(3)</b></p>

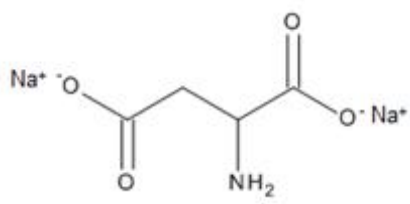
Question Number	Acceptable Answers	Reject	Mark
<b>15(c)(i)</b>	 <p>OR</p> <p>OR</p> <p>IGNORE Missing Cl<sup>-</sup> on the structures shown above</p>	<p>+ on wrong nitrogen atom</p> <p>Covalent bond to Cl</p>	<b>(1)</b>

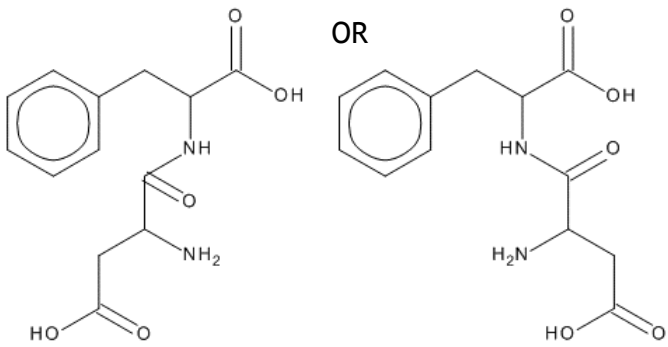
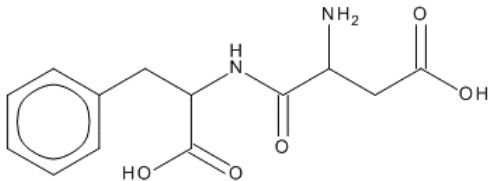
Question Number	Acceptable Answers	Reject	Mark
<b>15(c)(ii)</b>	<p>(alcoholic / ethanolic) ammonia / NH<sub>3</sub></p> <p>ALLOW Aqueous ammonia / NH<sub>3</sub>(aq)</p> <p>IGNORE Concentration / heat</p>		<b>(1)</b>

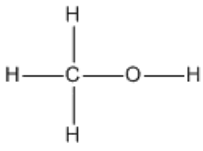
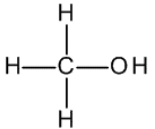
Question Number	Acceptable Answers	Reject	Mark
<b>15(c)(iii)</b>	$\text{CH}_3\text{OH}$ OR  OR   ALLOW $\text{CH}_4\text{O}$	$\text{CH}_3\text{OH}^+$  $\text{CH}_4\text{O}^+$	<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>15(c)(iv)</b>	 OR  Both charges needed ALLOW Correct structure in brackets with charge outside and $\text{Na}^+$	Bond between N and Na or between O and Na  Partial charges	<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>15(d)(i)</b>	 <p>ALLOW displayed, structural or skeletal formula or any combination of these</p> <p>ALLOW -NH<sub>3</sub>Cl as side group</p> <p>IGNORE Missing Cl<sup>-</sup> ions</p>	Bond between N and Cl	<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>15(d)(ii)</b>	 <p>ALLOW No charges, provided there is no bond between O and Na</p> <p>ALLOW Displayed, structural or skeletal formula or any combination of these e.g. COONaCH<sub>2</sub>CH(NH<sub>2</sub>)COONa</p> <p>IGNORE Missing Na<sup>+</sup> ions</p>	Partial charges δ <sup>+</sup> / δ <sup>-</sup>	<b>(1)</b>

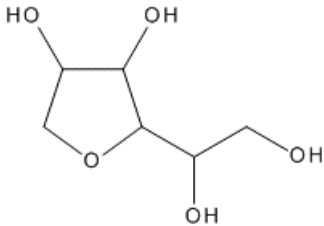
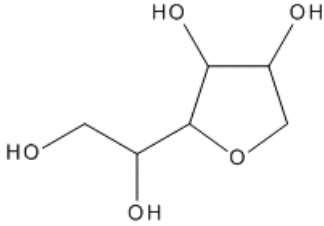
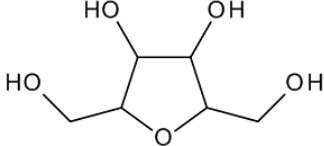
Question Number	Acceptable Answers	Mark
<b>15(d)(iii)</b>	 <p>OR</p>  <p>OR</p> <p>Any one amide/peptide <b>link</b> shown e.g. <math>\begin{array}{c} \text{O} \\ \parallel \\ \text{---C---N---} \end{array}</math> /-CONH-</p> <p>Do not award this mark if other functional groups are joined directly to the amide (1)</p> <p>Rest of structure correct</p> <p>ALLOW Displayed or structural formula or any combination of these (1)</p> <p>IGNORE Bond angles and bond lengths</p>	<b>(2)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>15(d)(iv)</b>	<p>Methanol OR Any unambiguous formula e.g. CH<sub>3</sub>OH /</p>  <p>/</p>  <p>If name and formula are given, both must be correct</p>	CH <sub>4</sub> O	<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>15(e)(i)</b>	LiAlH <sub>4</sub> / lithium tetrahydridoaluminate / lithium aluminium hydride (in dry ether)  OR  NaBH <sub>4</sub> / sodium tetrahydridoborate / sodium borohydride (in aqueous / alcohol solution)  IGNORE Lithal / heat	LiAlH <sub>4</sub> in water / aqueous solution  Just '[H] / H <sup>-</sup> '	<b>(1)</b>



Question Number	Acceptable Answers			Reject	Mark
<b>15(e)(ii)</b>	Reagent	Glucose	Sorbitol	Observations not linked to a reagent  Potassium dichromate(VI)	<b>(3)</b>
	Fehling's / Benedict's (solution and heat/boil)	Red / red-brown /brown / orange <b>and</b> precipitate	Stays blue / no change / no ppt		
	Tollens' (reagent) / ammoniacal silver nitrate (and warm)	Silver mirror or grey /black /silver <b>and</b> precipitate	No change / no ppt		
	Brady's (reagent) / 2,4-dinitro-phenyl-hydrazine / 2,4-DNP(H)	Orange / yellow / red <b>and</b> precipitate	Stays orange /no change / no ppt		
	Reagent	(1)			
	Matching observation for glucose	(1)			
	Matching observation for sorbitol	(1)			
	ALLOW Correct formulae				
	ALLOW No reaction / no observation / nothing happens for sorbitol				
	IGNORE Sodium hydroxide in Tollens' reagent				
	No TE on incorrect reagents				

Question Number	Acceptable Answers	Reject	Mark
<b>15(e)(iii)</b>	 <p>OR</p>  <p>OR</p>  <p>ALLOW Structural or displayed formulae or any combination of these</p> <p>IGNORE Bond angles and bond lengths OH connectivity</p>		<b>(1)</b>

**(Total for Section C = 19 marks)**  
**TOTAL FOR PAPER = 90 MARKS**