

# Mark Scheme (Results)

January 2016

Pearson Edexcel International  
Advanced Level in Chemistry  
(WCH05) Paper 01 - General  
Principles of Chemistry II  
(including synoptic assessment)

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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

## Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.

( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

### Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

## Section A

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>1</b>        | <b>B</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>2(a)</b>     | <b>D</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>2(b)</b>     | <b>D</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>3</b>        | <b>C</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>4</b>        | <b>A</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>5</b>        | <b>C</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>6</b>        | <b>D</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>7</b>        | <b>C</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>8</b>        | <b>D</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>9</b>        | <b>D</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>10</b>       | <b>A</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>11</b>       | <b>B</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>12</b>       | <b>A</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>13</b>       | <b>A</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>14</b>       | <b>B</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>15(a)</b>    | <b>B</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>15(b)</b>    | <b>D</b>       |        | 1    |

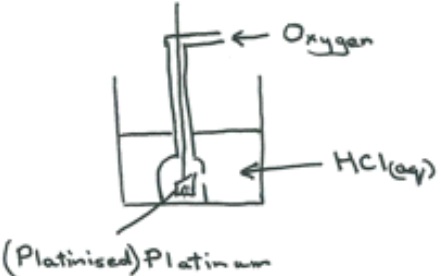
| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>16</b>       | <b>C</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>17</b>       | <b>C</b>       |        | 1    |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| <b>18</b>       | <b>B</b>       |        | 1    |

**TOTAL FOR SECTION A = 20 Marks**

## Section B

| Question Number | Correct Answer   | Reject        | Mark |
|-----------------|--|---------------|------|
| 19(a)           | <p>Mark independently</p>  <p>Glassware with oxygen <b>and</b> 1 atm pressure</p> <p>Tube carrying oxygen must be open at the bottom <b>but</b> not after the feed at the top (1)</p> <p>(Platinised) platinum/Pt (electrode) <b>and</b> 298 K/ 25°C (1)</p> <p>Hydrochloric acid/HCl(aq), <b>covering</b> some of the electrode <b>and</b> 1 mol dm<sup>-3</sup></p> <p>OR</p> <p>1 mol dm<sup>-3</sup> H<sup>+</sup> covering electrode (1)</p> <p>A fully correct hydrogen electrode <b>2max</b></p> | Sulfuric acid | 3    |

| Question Number | Correct Answer  | Reject  | Mark |
|-----------------|---|---|------|
| 19(b)           | <p>CH<sub>3</sub>OH + 1½O<sub>2</sub> → CO<sub>2</sub> + 2H<sub>2</sub>O</p> <p>OR</p> <p>multiples</p> | Uncancelled electrons, H <sup>+</sup> ions and H <sub>2</sub> O | 1    |

| Question Number | Correct Answer  | Reject     | Mark |
|-----------------|---|------------|------|
| 19(c)           | <p><math>E^{\ominus}_{\text{cell}} = +1.23 - 0.02</math></p> <p><math>= (+) 1.21 \text{ (V)}</math></p> | - 1.21 (V) | 1    |

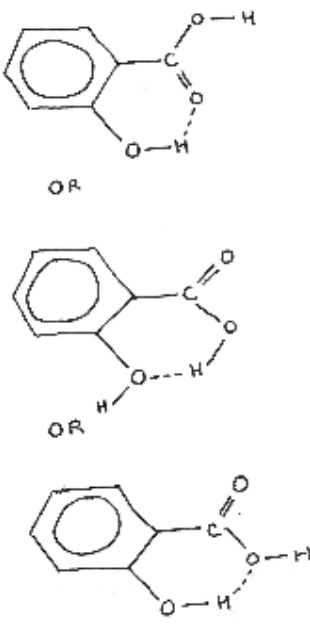
| Question Number | Correct Answer  | Reject | Mark |
|-----------------|---|--------|------|
| 19(d)           | <p><b>Additional Comment</b><br/>Note that the words advantage and disadvantage are not required</p> <p><b>(Advantages)</b></p> <p>Any one from:</p> <p>Easier to store/transport than hydrogen (as a liquid rather than a gas)</p> <p>OR</p> <p>Methanol can be produced from waste / methanol is renewable</p> <p>OR</p> <p>Energy per volume is greater (1)</p> <p>IGNORE</p> <p>Hydrogen is flammable/ explosive</p> <p><b>(Disadvantages)</b></p> <p>Any one from:</p> <p>Produces CO<sub>2</sub></p> <p>OR</p> <p>Low efficiency</p> <p>OR</p> <p>Limited power/energy (1)</p> <p>OR</p> <p>Lower emf/E value</p> <p>IGNORE</p> <p>Land used up in producing methanol instead for crops</p> |        | 2    |

(Total for Question 19 = 7 marks)

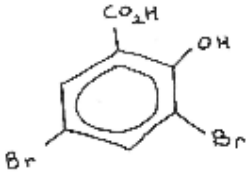


| Question Number | Correct Answer   | Reject | Mark |
|-----------------|--|--------|------|
| <b>20(a)</b>    | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub><br><br>IGNORE<br><br>Any other formulae eg C <sub>6</sub> H <sub>4</sub> OHCOOH |        | 1    |

| Question Number | Correct Answer  | Reject   | Mark |
|-----------------|---|--|------|
| <b>20(b)</b>    | NaCO <sub>3</sub> scores 0<br><br>$2\text{C}_6\text{H}_4\text{OHCOOH} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{C}_6\text{H}_4\text{OHCOO}^{(-)}\text{Na}^{(+)} + \text{CO}_2 + \text{H}_2\text{O}$ Entities <span style="float: right;"><b>(1)</b></span><br><br>Balancing correct entities/H <sub>2</sub> CO <sub>3</sub> /C <sub>7</sub> H <sub>6</sub> O <sub>3</sub><br><br>ALLOW<br><br>Incorrect hydrogens in organic formula on both sides <span style="float: right;"><b>(1)</b></span><br><br>ALLOW other correct formulae for 2-hydroxybenzoic acid<br><br>Fully correct ionic equation (2)<br><br>IGNORE<br><br>State symbols even if incorrect | H <sub>2</sub> CO <sub>3</sub> /<br>C <sub>7</sub> H <sub>6</sub> O <sub>3</sub> | 2    |

| Question Number | Correct Answer  | Reject | Mark |
|-----------------|---|--------|------|
| 20(c)(i)        |  <p data-bbox="519 462 560 493">OR</p> <p data-bbox="519 703 560 735">OR</p> <p data-bbox="454 1018 860 1050">Ignore bond angles around H</p> <p data-bbox="454 1081 560 1113">ALLOW</p> <p data-bbox="454 1144 901 1249">Two hydrogen bonds within one molecule between <b>phenol</b> and <b>carboxylate</b> groups</p> |        | 1    |

| Question Number  | Correct Answer  | Reject   | Mark |
|------------------|---|--|------|
| <b>20(c)(ii)</b> | <p><b>First mark</b></p> <p>4-hydroxybenzoic acid has a higher melting temperature with some attempt at justification which may not be correct (1)</p> <p><b>Second mark</b></p> <p>EITHER</p> <p>There are (more) hydrogen bonds between molecules</p> <p>OR</p> <p>chains of molecules held together by hydrogen bonds</p> <p>OR</p> <p>So more hydrogen bonds have to be broken</p> <p>OR</p> <p>More energy is needed to break the extra hydrogen bonds</p> <p>OR</p> <p>The intramolecular hydrogen bonds in 2-hydroxybenzoic acid do not need to be broken (1)</p> <p>Or reverse argument</p> | <p>Lower/same melting temperature loses first mark</p> | 2    |

| Question Number | Correct Answer   | Reject  | Mark |
|-----------------|--|---|------|
| 20(d)           | <p><b>Scroll down answer to check name first</b></p>  <p>OR COOH for carboxylic acid group (1)</p> <p>3,5-dibromo-2-hydroxybenzoic acid</p> <p>ALLOW</p> <p>2-hydroxy-3,5-dibromobenzoic acid (1)</p> <p>TE for name on their incorrect mono/di/tri/tetra substituted product for 1 max</p> | <p>Look out for substitution of the <b>phenol group or the carboxylic acid group</b><br/>0 out of 2</p> | 2    |

| Question Number | Correct Answer   | Reject             | Mark |
|-----------------|--|--------------------|------|
| 20(e)(i)        | <p>Methanol (1)</p> <p>(Concentrated) sulfuric acid</p> <p>ALLOW</p> <p>(concentrated) hydrochloric acid</p> <p>IGNORE</p> <p>Acidic conditions</p> <p><b>And</b></p> <p>Heat/reflux/warm/any temperature above 25°C</p> <p>Second mark dependent on an alcohol in MP1 (1)</p> | <p>Nitric acid</p> | 2    |

| Question Number                      | Correct Answer  | Reject | Mark |
|--------------------------------------|---|--------|------|
| <p><b>20</b><br/><b>(e) (ii)</b></p> | <p>Methyl 2-hydroxybenzoate molecules are held together by (strong) London/ dispersion forces</p> <p>IGNORE</p> <p>Dipole forces and hydrogen bonds <b>(1)</b></p> <p>Less / limited hydrogen bond <b>between</b> water and methyl 2-hydroxybenzoate (so sparingly soluble) <b>(1)</b></p> <p>The hydrogen bonding between water molecules is (very) strong <b>(1)</b></p> <p>Insufficient energy released to break hydrogen bonds in water/ London forces in methyl 2-hydroxybenzoate <b>(1)</b></p> <p>(Some of the) hydrogen bonds are internal in methyl 2-hydroxybenzoate <b>(1)</b></p> <p>The oxygens in methyl 2-hydroxybenzoate can form hydrogen bonds to the hydrogens of water molecules</p> <p>OR</p> <p>The hydrogen on the oxygen in methyl 2-hydroxybenzoate can form hydrogen bonds to the oxygens of water molecules <b>(1)</b></p> |        | 3    |

| Question Number                       | Correct Answer   | Reject               | Mark     |
|---------------------------------------|--|----------------------|----------|
| <p><b>20</b><br/><b>(e) (iii)</b></p> | <p>ALLOW</p> <p>Correct formulae for names</p> <p><b>First mark</b></p> <p>Sodium hydrogencarbonate (solution)</p> <p>ALLOW</p> <p>Sodium carbonate (solution)</p> <p>IGNORE water <b>(1)</b></p> <p><b>Second mark</b></p> <p>to neutralise/ remove remaining acids <b>(1)</b></p> <p>IGNORE references to saturated sodium chloride solution to reduce solubility of ester</p> <p><b>Third mark</b></p> <p>(Dried with) (anhydrous)</p> <p>sodium sulfate</p> <p>OR</p> <p>magnesium sulfate</p> <p>OR</p> <p>calcium sulfate</p> <p>OR</p> <p>calcium chloride <b>(1)</b></p> | <p>Anything else</p> | <p>3</p> |

| Question Number    | Correct Answer  | Reject                                       | Mark |
|--------------------|---|--|------|
| <b>20 (e) (iv)</b> | Distillation<br><br>OR<br><br>Distil off the ethyl ethanoate<br><br>ALLOW<br><br>Fractional distillation/redistillation | Steam distillation<br><br>Solvent extraction | 1    |

| Question Number  | Correct Answer   | Reject            | Mark |
|------------------|--|-------------------|------|
| <b>20(e) (v)</b> | <p><b>First marking point</b></p> <p>A is methyl 2-hydroxybenzoate</p> <p>OR</p> <p>B is 2-hydroxybenzoic acid</p> <p><b>and</b> a bond / wavenumber considered (eg O-H, C-O, C=O, C-H in CH<sub>3</sub>)</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Second marking point</b></p> <p>This is independent of the first mark</p> <p>Any one bond with wavenumber from:</p> <p>In spectrum B the carboxylic acid OH between 3300 and 2500 (cm<sup>-1</sup>)</p> <p>In spectrum A<br/>no broad peak between 3300 and 2500 (cm<sup>-1</sup>)</p> <p>In spectrum A, C-O (benzoate) between 1150-1100 (cm<sup>-1</sup>) and/or 1310-1250 (cm<sup>-1</sup>)</p> <p>In spectrum A alkyl C-H between 2962 – 2853 (cm<sup>-1</sup>)</p> <p style="text-align: right;"><b>(1)</b></p> <p>IGNORE</p> <p>In spectrum A phenol/OH peak between 3300 and 3100 (cm<sup>-1</sup>)</p> <p>OR</p> <p>C-H arene</p> | C=O in acid/ester | 2    |

| Question Number  | Correct Answer   | Reject | Mark |
|------------------|--|--------|------|
| <b>20(e)(vi)</b> | moles of 2-hydroxybenzoic acid =<br>$\frac{9.00}{138} = 0.0652$<br><b>and</b><br>moles of methyl 2-hydroxybenzoate<br>$= 0.6 \times 0.0652 = 0.0391 \quad (1)$<br>Mass of methyl 2-hydroxybenzoate<br>$= 0.0391 \times 152 = 5.948 \text{ (g)} \quad (1)$<br><br>Volume of methyl 2-hydroxybenzoate<br>$= 5.948/1.174 = 5.066 = 5.07 \text{ cm}^3$<br><br>Correct volume with no working<br>3 marks<br><br><b>ALLOW</b><br>Internal TE s eg<br><br>For 100% gives 9.91(3) g and 8.44(4) cm <sup>3</sup><br><br><b>(2)</b><br><br>IGNORE SF |        | 3    |

(Total for Question 20 = 22 marks)



| Question Number | Correct Answer   | Reject | Mark |
|-----------------|--|--------|------|
| <b>21(a)(i)</b> | $3d^5 4s^1$<br>$/4s^1 3d^5$<br><br>ALLOW<br><br>Complete configuration<br>$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$<br><br>ALLOW<br><br>Capitals and subscripts |        | 1    |

| Question Number  | Correct Answer  | Reject | Mark |
|------------------|---|--------|------|
| <b>21(a)(ii)</b> | It is $4s^1$ rather than $4s^2$<br>because with two of the reasons<br>below<br><br>$3d^5$ / half-filled 3d sub shell is<br>particularly stable <b>(1)</b><br><br>The paired electrons repel <b>(1)</b><br><br>All six electrons are in separate<br>orbitals (minimizing repulsion) <b>(1)</b><br><br>ALLOW<br><br>The energy required to promote/<br>transfer 4s to 3d is small<br>OR<br>The energy difference between 4s and<br>3d is small <b>(1)</b> |        | 2    |

| Question Number | Correct Answer  | Reject | Mark |
|-----------------|---|--------|------|
| <b>21(b)(i)</b> | $(E^\ominus \text{Zn}^{2+}(\text{aq})   \text{Zn}(\text{s}) = -0.76 \text{ V}$<br>$E^\ominus \text{Cr}^{3+}(\text{aq}), \text{Cr}^{2+}(\text{aq})   \text{Pt} = -0.41 \text{ V}$<br>$E^\ominus [\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 7\text{H}^+(\text{aq})],$<br>$[2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})]   \text{Pt} = +1.33 \text{ V}$<br><p>If no other mark is scored, data scores (1) however shown</p> <p>Calculation of <math>E^\ominus_{\text{cell}}</math> values:</p> $E^\ominus_{\text{cell}}$ for first step =<br>$1.33 - -0.76 = (+)2.09 \text{ (V)} \quad \mathbf{(1)}$<br>$E^\ominus_{\text{cell}}$ for second step =<br>$-0.41 - -0.76 = (+)0.35 \text{ (V)} \quad \mathbf{(1)}$<br><p>As (both) values are positive, (both) reactions are spontaneous/feasible <math>\mathbf{(1)}</math></p> <p>Third mark is independent</p> |        | 3    |

| Question Number  | Correct Answer  | Reject | Mark |
|------------------|---|--------|------|
| <b>21(b)(ii)</b> | <p><b>Orange to green to blue</b></p> <p>IGNORE qualifying words eg pale blue</p> |        | 1    |

| Question Number   | Correct Answer   | Reject | Mark |
|-------------------|--|--------|------|
| <b>21(b)(iii)</b> | <p>The small amount of hydrogen produced (does not present a serious risk)</p> <p>ALLOW</p> <p>"Less" for small amount<br/>Indication of ventilation</p> |        | 1    |

| Question Number | Correct Answer                   | Reject      | Mark |
|-----------------|----------------------------------|-------------|------|
| <b>21(c)(i)</b> | It is bridging/ bidentate ligand | Polydentate | 1    |

| Question Number  | Correct Answer                                    | Reject | Mark |
|------------------|---|--------|------|
| <b>21(c)(ii)</b> | Dative (covalent) (bonds)/<br>co-ordinate (bonds) |        | 1    |

| Question Number   | Correct Answer   | Reject                       | Mark |
|-------------------|--|------------------------------|------|
| <b>21(c)(iii)</b> | <p><b>Any two from:</b></p> <p>Chromium atoms/ ions are covalently bonded/bonded to each other</p> <p>OR</p> <p>Two (chromium) ions/ chromium atoms in the complex (1)</p> <p>Each ethanoate ligand forms bonds to two different atoms/ ions (1)</p> <p>Ethanoate ions are not normally bidentate ligands (1)</p> <p>ALLOW</p> <p>Contains both monodentate and bidentate ligands (1)</p> <p>Allow six ligands <b>and</b> complex not octahedral (1)</p> | Just "two different ligands" | 2    |

| Question Number  | Correct Answer   | Reject                 | Mark |
|------------------|--|------------------------|------|
| <b>21(c)(iv)</b> | <p>The energies of the d electron levels are split to different extents (by different ligands)</p> <p>ALLOW</p> <p>d-d (orbitals) splitting is different</p> <p>OR</p> <p>d-d transitions are different (1)</p> <p>So different energy/ frequency/ wavelength light absorbed (1)</p> | ... (just) transmitted | 2    |

| Question Number | Correct Answer  | Reject | Mark |
|-----------------|---|--------|------|
| <b>21(c)(v)</b> | <p>There are two peaks as two different hydrogen environments <b>(1)</b></p> <p>EITHER</p> <p>The areas due to hydrogen in water molecules compared to hydrogen in ethanoate ions is in the ratio 1 to 3/4 to 12</p> <p>OR</p> <p>As there are 4 hydrogen atoms in water and 12 hydrogen atoms in ethanoate ions <b>(1)</b></p> |        | 2    |

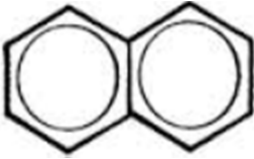
| Question Number | Correct Answer   | Reject | Mark |
|-----------------|--|--------|------|
| 21(d)           | <p><b>First mark</b><br/>Dilution factor:</p> <p>moles of chromium(II) ethanoate in 25.0 cm<sup>3</sup><br/> <math>= \frac{2.66 \times 10^{-3}}{10} = 2.66 \times 10^{-4}</math> (1)</p> <p><b>Second mark</b><br/>Ratio of manganate(VII) to chromium</p> <p>4 mol manganate(VII) react with 5 mol of chromium (II)</p> <p>OR</p> <p>8 mol manganate(VII) react with 5 mol of chromium(II) ethanoate (1)</p> <p><b>Third mark</b><br/>moles of manganate(VII) ion<br/> <math>= \frac{4 \times 5.32 \times 10^{-4}}{5}</math> OR <math>\frac{8 \times 2.66 \times 10^{-4}}{5}</math><br/> <math>= 4.256 \times 10^{-4}</math> (1)</p> <p><b>Fourth mark</b><br/>Volume of manganate(VII) solution<br/> <math>= \frac{4.256 \times 10^{-4} \times 1000}{0.00750}</math><br/> <math>= 56.75 \text{ cm}^3</math> (1)</p> <p>Correct answer no working (4)</p> <p>28.375 cm<sup>3</sup> gets (3)</p> <p><b>Fifth mark</b><br/>This is unsuitable/ inaccurate because it requires refilling the burette hence increasing burette error</p> <p>OR</p> <p>Better to use more concentrated potassium manganate(VII) OR less chromium ethanoate (1)</p> |        | 5    |

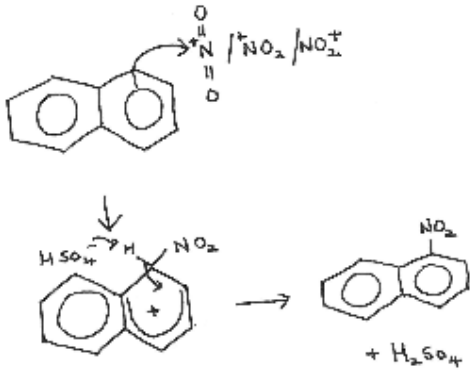
(Total for Question 21 = 21 marks)

TOTAL FOR SECTION B = 50 Marks

### Section C

| Question Number | Correct Answer                    | Reject                                       | Mark |
|-----------------|-----------------------------------|--|------|
| <b>22(a)</b>    | X-ray diffraction/crystallography | X-rays alone<br>X radiation<br><br>IR/UV/nmr | 1    |

| Question Number | Correct Answer  | Reject  | Mark |
|-----------------|---|---|------|
| <b>22(b)</b>    | <p>Mark independently</p> <p><b>First mark:</b></p>  <p>ALLOW<br/>Single ring and two double bonds</p> <p>Single ring around all atoms <b>(1)</b></p> <p><b>Second mark:</b><br/>EITHER<br/>electrons delocalised (around the ring(s))</p> <p>OR</p> <p>pi system around all (10) carbon atoms <b>(1)</b></p> <p><b>Third mark:</b><br/>EITHER<br/>overlap of p-orbitals</p> <p>OR</p> <p>p/ pi-/π/ 10 (ALLOW pie) electrons <b>(1)</b></p> <p>ALLOW</p> <p>six electrons if single ring and two double bonds shown</p> <p>Phthalic anhydride structure <b>2 max</b></p> | <p>Single ring and three double bonds</p> <p>delocalised orbitals</p> | 3    |

| Question Number | Correct Answer   | Reject | Mark |
|-----------------|--|--------|------|
| 22(c)           | <p><b>First mark</b><br/>Formation of nitronium ion (may combine equations) <b>(1)</b></p> $2\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow {}^+\text{NO}_2/\text{NO}_2^+ + \text{H}_3\text{O}^+ + 2\text{HSO}_4^-$ <p>OR</p> $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow {}^+\text{NO}_2/\text{NO}_2^+ + \text{H}_2\text{O} + \text{HSO}_4^-$ <p>OR</p> $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-$ <p><b>And</b></p> $\text{H}_2\text{NO}_3^+ \rightarrow \text{NO}_2^+ + \text{H}_2\text{O}$ <p><b>Charges are needed for first mark</b></p>  <p>TE on incorrect electrophile</p> <p>If benzene used instead of naphthalene <b>3 max</b><br/>Do not penalise the use of Phthalic anhydride</p> <p>Correct Kekulé structures score full marks</p> <p>ALLOW<br/>multiple nitrations</p> |        | 4    |

|   |  |
|---|--|
| <p><b>Second mark</b><br/>Curly arrow from on or within the circle to (positive) N</p> <p>ALLOW<br/>Curly arrow from anywhere within the hexagon</p> <p>Arrow to <b>any</b> 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<br/><b>(1)</b></p>   | <p>Curly arrow on or outside the hexagon</p> |
| <p><b>Third mark</b><br/>Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, <b>and</b> facing the tetrahedral carbon <b>and</b> with some part of the positive charge within the horseshoe.</p> <p>ALLOW dotted horseshoe<br/><b>(1)</b></p> <p>IGNORE</p> <p>displayed nitro group even if incorrect<br/>A single lapse of omitting internal circle or double bonds in 3<sup>rd</sup> or 4<sup>th</sup> mark</p> | <p>Partial bonds to H or Subs group</p>      |
| <p><b>Fourth mark</b><br/>If final product not 1, 4, 5 or 8 MP4 cannot be scored<br/>Curly arrow from C—H bond to anywhere in the ring reforming delocalised structure of a correct stable molecule.<br/><b>(1)</b></p> <p>IGNORE</p> <p>Absence of <math>\text{HSO}_4^-/\text{H}_2\text{SO}_4/\text{H}^+</math></p>  | <p><math>\text{H}_2</math> / H product</p>   |

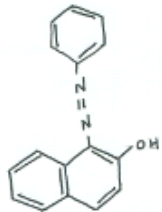


| Question Number | Correct Answer   | Reject | Mark |
|-----------------|--|--------|------|
| 22(d)           | <p><math>C_{10}H_8</math></p> <p>This mark can be awarded if the molar mass of naphthalene has been used as 128 even if the skeletal formula in the equation has been used (1)</p> <p><math>C_{10}H_8 + 12O_2 \rightarrow 10CO_2 + 4H_2O</math> (1)</p> <p>ALLOW<br/>The balanced equation with skeletal formula of naphthalene scores both marks</p> <p>Ignore state symbols even if incorrect</p> <p>Number of moles of naphthalene<br/>= <math>\frac{1.28}{128}</math> = 0.01(00)</p> <p>Volume of gas = <math>10 \times 0.01 \times 24.0</math><br/>= 2.4(0) dm<sup>3</sup> /2400 cm<sup>3</sup> (1)</p> <p>ALLOW<br/>TE on incorrect formula of naphthalene for max 2</p> |        | 3    |

| Question Number | Correct Answer   | Reject                                  | Mark |
|-----------------|--|---|------|
| 22(e)           | <p>Hydrogen /H<sub>2</sub> (1)</p> <p><b>Second mark is consequential on Hydrogen</b></p> <p>Heat/any specified temperature above 100°C</p> <p><b>And</b></p> <p>nickel/ Ni /platinum/ Pt/ palladium / Pd catalyst (1)</p> | H alone loses first mark but not second | 2    |

| Question Number | Correct Answer         | Reject | Mark |
|-----------------|------------------------|--------|------|
| <b>22(f)(i)</b> | Water/H <sub>2</sub> O |        | 1    |

| Question Number  | Correct Answer   | Reject | Mark |
|------------------|--|--------|------|
| <b>22(f)(ii)</b> | <p>(In strong acid) an oxygen (in the C–O/C=O/O–H bond) will protonate/gain H/H<sup>+</sup> <b>(1)</b></p> <p>(In alkali) a proton is lost from each/both phenol group(s)</p> <p>ALLOW</p> <p>(In alkali) a proton/hydrogen/ H/H<sup>+</sup> is lost from phenol group(s) <b>(1)</b></p> |        | 2    |

| Question Number | Correct Answer   | Reject              | Mark |
|-----------------|--|---------------------|------|
| <b>22(g)</b>    | <p>Phenylamine is added to a mixture of sodium nitrite/ sodium nitrate(III)/ <math>\text{NaNO}_2</math><br/> <b>and</b><br/> (dilute) hydrochloric acid/ <math>\text{HCl}</math>/<br/> sulfuric acid/ <math>\text{H}_2\text{SO}_4</math></p> <p>ALLOW</p> <p>nitrous acid/ <math>\text{HNO}_2</math> (1)</p> <p>at <math>5^\circ\text{C}</math>/between <math>0</math> and <math>10^\circ\text{C}</math>/<br/> at <math>10^\circ\text{C}</math>/ or less than <math>10^\circ\text{C}</math></p> <p>ALLOW</p> <p>ice bath</p> <p>ALLOW</p> <p>any temperature or range of<br/> temperatures within that range (1)</p> <p>(A mixture of 2-naphthol and)<br/> aqueous sodium hydroxide/alkali is<br/> added to produce a dye (1)</p>  <p>OR</p> <p>rings in hexagons</p> <p>ALLOW</p> <p><math>\text{C}_6\text{H}_5\text{N}_2</math> group at any carbon except<br/> fused carbons (1)</p> | Just sodium nitrate | 4    |

(Total for Question 22 = 20 marks)

TOTAL FOR PAPER = 90 Marks