



Mark Scheme (Results)

January 2016

Pearson Edexcel International
Advanced Level in Chemistry (WCH01)
Paper 01 – The Core Principles of
Chemistry.

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January 2016

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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 (multiple choice)

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 1 | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 2 | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 3 | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 4 | A | | 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 | C | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 8(a) | A | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 8(b) | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 9(a) | C | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 9(b) | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 9(c) | C | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 10 | C | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 11 | A | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 12 | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 13 | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 14 | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 15 | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 16 | A | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|----------|
| 17 | A | | 1 |

(Total for Section A = 20 marks)

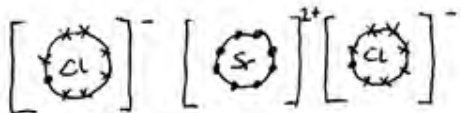
Section B

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---|----------|
| 18(a)(i) | <p>First mark Weighted mean mass</p> <p>ALLOW (Weighted) average (atomic) mass (1)</p> <p>Second mark (Mass) of atom(s) (of an element)</p> <p>ALLOW (Mass of all) the isotopes (of an element) (1)</p> <p>Third mark Divided by / compared with 1/12th the mass of (an atom of) ^{12}C / C-12 OR On a scale in which ^{12}C / C-12 = 12 (g) (1)</p> | <p>average weight</p> <p>atom of an isotope</p> <p>Mole(s) of atoms</p> | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|---|----------|
| 18(a)(ii) | <p>(Beam of) high energy electrons / accelerated electrons / electrons from electron gun / high speed electrons /</p> <p>ALLOW Electron beam OR Electrons bombard / hit / blast the (gaseous) atoms OR Electrons are fired at the (gaseous) atoms (1)</p> <p>Knock off / liberates an electron(s) / leads to loss/removal of electron(s) (from the gaseous atoms) (1)</p> <p>IGNORE References to ionising / forming (positive) ions / just an equation e.g. $\text{M}(\text{g}) \rightarrow \text{M}^+(\text{g}) + \text{e}$</p> | <p>Just 'electron gun' / 'electron(s)'</p> <p>highly charged electrons</p> <p>Just 'takes an electron(s)'</p> | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|---|--------|----------|
| 18(a)(iii) | <p>Correct answer with or without working scores both marks</p> $((84.0 \times 0.56) + (86.0 \times 9.86) + (87.0 \times 7.02) + (88.0 \times 82.56))/100 \quad \mathbf{(1)}$ $= 87.7 \text{ (must be to 3 SF)} \quad \mathbf{(1)}$ <p>NOTE 87.71/ 87.710/87.7102 score (1) with or without working</p> <p>IGNORE g or g mol⁻¹, but wrong units, eg %, lose the second mark</p> | | 2 |

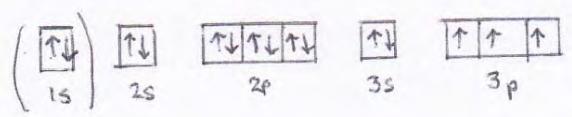
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|---|----------|
| 18(b) | <p>s (block)</p> <p>ALLOW S (block)</p> <p>IGNORE group 2 / period 5</p> | <p>Any number in front of the s e.g. 4s</p> <p>Any other group number / period number</p> | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|------------------------------------|----------|
| 18(c) |  <p>First mark</p> <p>Correct dot and cross diagrams with 2+ charge on Sr and – charge on Cl (1)</p> <p>ALLOW no electrons or 8 electrons on outer shell of Sr</p> <p>ALLOW dots or crosses for electrons</p> <p>ALLOW diagrams without square brackets</p> <p>Second mark</p> <p>Ratio of 1 strontium and 2 chloride (ions)</p> <p>ALLOW this shown as 2 in front of a chloride ion or subscript 2 after the ion (1)</p> <p>IGNORE any inner shell electrons</p> <p>ALLOW max 1 for incorrect symbol(s)</p> | <p>covalent bonding (0)</p> | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|-------------------------------------|----------|
| 18(d) | $\text{SrO(s)} + 2\text{HNO}_3(\text{aq}) \rightarrow \text{Sr}(\text{NO}_3)_2(\text{aq}) + \text{H}_2\text{O(l)}$ OR $\text{SrO(s)} + 2\text{H}^+(\text{aq}) \rightarrow \text{Sr}^{2+}(\text{aq}) + \text{H}_2\text{O(l)}$ Correct formulae and balancing ALLOW multiples (1) State symbols (1) If no other mark awarded, ALLOW Ionic equation given as $\text{O}^{2-}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O(l)}$ (1) | H ₂ scores (0) | 2 |

| Question Number | Acceptable Answers | Reject | Mark | | | | | | | | | | | | | | |
|-----------------|---|-------------|-------------|------------|---|--|---|-------------|-------------|-------------|------------|----------------|------|------|------|---|----------|
| 18(e) | SrC_2O_4 with or without working scores 3 marks <table style="margin-left: 40px;"> <tr> <td></td> <td style="text-align: center;">Sr</td> <td style="text-align: center;">C</td> <td style="text-align: center;">O</td> <td></td> </tr> <tr> <td style="text-align: right;">%</td> <td style="text-align: center;"><u>49.9</u></td> <td style="text-align: center;"><u>13.7</u></td> <td style="text-align: center;"><u>36.4</u></td> <td rowspan="2" style="vertical-align: middle;">(1)</td> </tr> <tr> <td style="text-align: right;">A_r</td> <td style="text-align: center;">87.6</td> <td style="text-align: center;">12.0</td> <td style="text-align: center;">16.0</td> </tr> </table> divide <u>0.57</u> <u>1.14</u> <u>2.28</u> by 0.57 0.57 0.57 smaller ratio 1 2(.004) 4/3.993 (1) empirical formula SrC_2O_4 (1) ALLOW symbols in any order ALLOW use of 87.7 instead of 87.6 ALLOW TE for MP2 and 3, if one slip in MP1 or MP2 | | Sr | C | O | | % | <u>49.9</u> | <u>13.7</u> | <u>36.4</u> | (1) | A _r | 87.6 | 12.0 | 16.0 | If all A _r /%, scores (0) overall If all %/atomic number, scores (0) overall Incorrect symbol(s) | 3 |
| | Sr | C | O | | | | | | | | | | | | | | |
| % | <u>49.9</u> | <u>13.7</u> | <u>36.4</u> | (1) | | | | | | | | | | | | | |
| A _r | 87.6 | 12.0 | 16.0 | | | | | | | | | | | | | | |

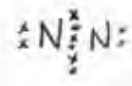
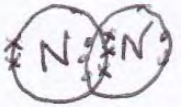
(Total for Question 18 = 15 marks)

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------|
| 19(a)(i) |  <p>Arrows correct</p> <p>ALLOW half-headed arrows/ 3p electrons all pointing downwards (1)</p> <p>Labels correct OR 2p_x, 2p_y, 2p_z and 3p_x, 3p_y, 3p_z (1)</p> <p>IGNORE numbers as superscripts</p> | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|-------------------|------|
| 19(a)(ii) | <p>Mark independently</p> <p>First mark (idea of paired electrons in S) In sulfur: spin-pairing has occurred (in the 3p orbital / sub-shell)/ there are paired electrons (in a 3p orbital / sub-shell)</p> <p>OR</p> <p>there are two electrons in the same (3p) orbital / there is a full (3p) orbital (1)</p> <p>Note – Just stating 3p⁴ does not get this mark</p> <p>Second mark (idea of repulsion) (Resultant increase in) repulsion (allows electron to be removed more easily) (1)</p> <p>Note – if no correct reference to sulfur</p> <p>ALLOW Phosphorus has a half-filled sub-shell which is (more) stable (1)</p> <p>IGNORE any reference to nuclear attraction / atomic radius / shielding</p> | Sub-shell / shell | 2 |

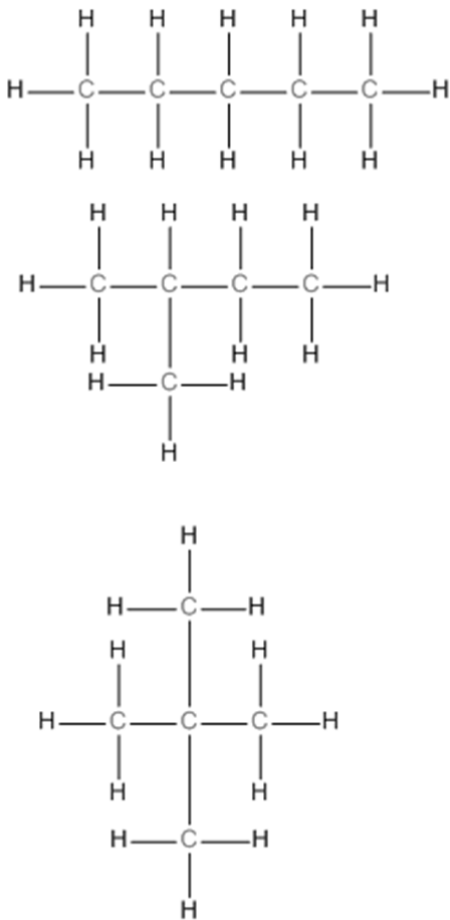
| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|---|--------------------------------------|----------|
| 19(a)(iii) | $\text{P}^{2+}(\text{g}) \rightarrow \text{P}^{3+}(\text{g}) + \text{e}^{(-)}$ <p>ALLOW $\text{P}^{2+}(\text{g}) - \text{e}^{(-)} \rightarrow \text{P}^{3+}(\text{g})$</p> <p>ALLOW +2/+3 for 2+/3+ or additional electrons provided the equation balances</p> <p>Correct symbols (1)</p> <p>Both (g) (1)</p> <p>Mark independently</p> <p>IGNORE state symbol on the electron / IE in equation</p> | Incorrect symbol for first mark only | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---|----------|
| 19(b)(i) | <p>Mark independently</p> <p>First mark (number of shells) N has fewer (electron) shells than P</p> <p>ALLOW The outer electron is in a shell closer to the nucleus in N OR In N the atomic radius/size is less (1)</p> <p>Second mark (shielding) (Outermost electron in N) has less shielding (1)</p> <p>Third mark (attraction) (Even though N has a lower nuclear charge/fewer protons) (there is a) greater (force of) attraction between the nucleus and the (outer) electron/ greater effective nuclear charge OR outer electron is held more strongly by the nucleus (1)</p> <p>IGNORE N has a greater charge density</p> <p>ALLOW Reverse argument for phosphorus / trend down the group</p> | <p>Mention of molecules Just 'lower atomic number' / 'N is smaller than P'</p> <p>Ionic radius</p> <p>N has a higher nuclear charge than P</p> | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--------|------|
| 19(b)(ii) |  <p>OR</p>  <p>ALLOW all dots, all crosses or any other symbol for the electrons</p> <p>First Mark Three pairs of electrons between the nitrogen atoms</p> <p>ALLOW Two or three of the 3 pairs of electrons circled to show sharing as part of triple bond (1)</p> <p>Second Mark Lone pair on each nitrogen atom</p> <p>ALLOW 2 unpaired electrons (1)</p> | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------|
| 19(c) | <p>Correct answer with or without working scores both marks</p> <p>Number of moles = $\frac{24.8}{31.0 \times 4}$ (1) = 0.2(00) (mol)</p> <p>Number of molecules of P₄ = $0.2 \times 6.02 \times 10^{23}$ = 1.204×10^{23} / 1.20×10^{23} / 1.2×10^{23} (1)</p> <p>TE on number of moles IGNORE SF except 1SF</p> | | 2 |

(Total for Question 19 = 13 marks)

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--|------|
| 20(a) |  <p>All 3 correct (2) Any 2 correct (1)</p> <p>ALLOW CH₃ groups</p> <p>If no other marks are scored, ALLOW 3 correct isomers as structural, skeletal or any other combination of formulae except molecular for (1) mark</p> <p>IGNORE bond angles and bond lengths</p> <p>IGNORE structural or skeletal formulae in addition to displayed formulae / names, even if incorrect</p> <p>If 4 or more isomers drawn, max 1</p> | <p>Missing H once only</p> <p>Only structural or skeletal formulae once only</p> | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--|----------|
| 20(b)(i) | (Free) radical (1) | Heterolytic /electrophilic /nucleophilic | 2 |
| | Substitution (1) | | |
| | IGNORE homolytic fission/ initiation / propagation /termination | | |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|---|----------|
| 20(b)(ii) | $C_5H_{12} + Cl\cdot \rightarrow C_5H_{11}\cdot + HCl$ (1) | Missing dots once only in (b)(ii) and (b)(iii) Additional incorrect equations once only Formation of $H\cdot$ scores (0) overall | 2 |
| | $C_5H_{11}\cdot + Cl_2 \rightarrow C_5H_{11}Cl + Cl\cdot$ (1) | | |
| | ALLOW equations in either order / displayed formulae / structural formulae | | |
| | NO TE on incorrect free radical IGNORE size and position of dot / any type of curly arrows | | |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|--|----------------------------------|----------|
| 20(b)(iii) | Any one from | Additional incorrect equation | 1 |
| | $Cl\cdot + Cl\cdot \rightarrow Cl_2$ | | |
| | $Cl\cdot + C_5H_{11}\cdot \rightarrow C_5H_{11}Cl$ | | |
| | $C_5H_{11}\cdot + C_5H_{11}\cdot \rightarrow C_{10}H_{22}$ | | |
| | IGNORE any type of curly arrows | | |


| Question Number | Acceptable Answers | Reject | Mark |
|------------------|---|---------------|----------|
| 20(c) (i) | <p>Correct answer with or without working scores the mark</p> $100.0 \times 4.18 \times 14.5 (= 6061 \text{ J})$ $= 6.061/6.06/6.1 \text{ (kJ)}$ <p>ALLOW 6061 J</p> <p>IGNORE sign (+/-) / kJ mol⁻¹</p> | 6 / 6061 (kJ) | 1 |

| Question Number | Acceptable Answers | Mark |
|-------------------|--|----------|
| 20(c) (ii) | <p>Correct answer with or without working scores the mark</p> $\text{number of moles} = \frac{0.144}{72} = 0.002 / 2 \times 10^{-3}$ <p>ALLOW correct working with no answer written</p> | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|--------------------|--|---|----------|
| 20(c) (iii) | <p>Correct answer with or without working scores both marks</p> <p>enthalpy change of combustion = <u>answer to (c)(i)</u> answer to (c)(ii)</p> $= -3030.5/-3031 \text{ kJ mol}^{-1}$ <p>Or</p> $-3030500/-3.0305 \times 10^6 / -3031000 / -3.031 \times 10^6$ <p>J mol⁻¹</p> <p>Correct number (1)</p> <p>Correct sign and units consistent with number (1)</p> <p>Mark independently</p> <p>ALLOW -3030/-3050 kJ mol⁻¹ and equivalent answers in J mol⁻¹ score both marks</p> <p>ALLOW units as kJ/mol or $\frac{\text{kJ}}{\text{mol}}$ or J/mol or $\frac{\text{J}}{\text{mol}}$</p> <p>IGNORE SF except 1SF</p> <p>ALLOW TE from (c)(i) and (c)(ii)</p> | Incorrect unit e.g. kJ/mol ⁻¹ or kJ mol ⁻ | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|---|--------|----------|
| 20(c) (iv) | <p>First mark Incomplete combustion</p> <p>ALLOW incomplete reaction (1)</p> <p>IGNORE not enough oxygen / not all the fuel has reacted</p> <p>Second mark Evaporation of the alkane / fuel / reactant / compound</p> <p>ALLOW alkane is volatile / heat capacity of/heat absorbed by container/apparatus was not included (1)</p> <p>IGNORE Heat loss to the surroundings / Not measured at standard conditions / Mention of heat capacity/density of water / Evaporation of water / Error in thermometer/balance / Alkane is impure</p> <p>If average bond enthalpies is mentioned, max (1)</p> | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|-------------------------|----------|
| 20(c) (v) | <p>The experimental errors are greater than the differences in the Data Book values</p> <p>OR</p> <p>The experimental value is much lower than all the Data Book values/ the Data Book values are all much more exothermic than the experimental value</p> <p>ALLOW The three Data Book values are (too) close together</p> <p>IGNORE Answer to (c)(iii)/ experimental value is very different to the Data Book values</p> | Average bond enthalpies | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|----------------------|----------|
| 20(d) | $\text{C}_5\text{H}_{12}(\text{l}) + 8\text{O}_2(\text{g}) \rightarrow 5\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$  $5\text{C}(\text{s, graphite}) + 6\text{H}_2(\text{g}) + 8\text{O}_2(\text{g})$ <p>Cycle 2 marks $5\text{C}(\text{s, graphite}) + 6\text{H}_2(\text{g}) + 8\text{O}_2(\text{g})$ OR $5\text{C}(\text{s}) + 6\text{H}_2(\text{g}) + 8\text{O}_2(\text{g})$</p> <p>Correct species, multiples and all state symbols needed (1)</p> <p>Both arrows upwards</p> <p>ALLOW two arrows from elements to products of combustion /downward arrows provided they are labelled with correct value or symbol (1)</p> <p>IGNORE additional curved arrows as part of working</p> <p>Calculation 2 marks Mark independently of arrows on cycle</p> <p>Correct answer with or without working scores both marks</p> $\Delta H_c = (5x-393.5) + (6x-285.8) - (-173.2) \quad (1)$ $= -3509.1/-3509 \text{ (kJ mol}^{-1}\text{)} \quad (1)$ <p>IGNORE kJ as unit</p> <p>ALLOW TE from incorrect multiple of C and H₂</p> | Other incorrect unit | 4 |

(Total for Question 20 = 18 marks)

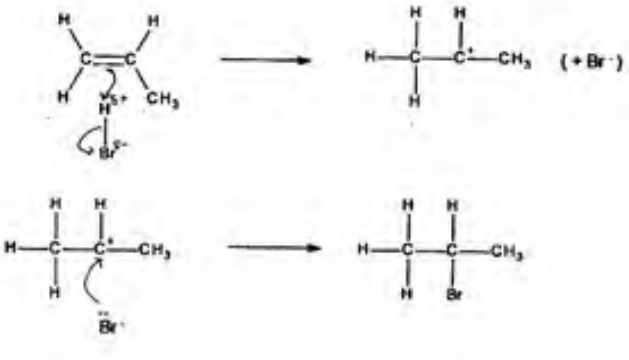
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------------------------------|----------|
| 21(a)(i) | C ₇ H ₁₄ ALLOW H ₁₄ C ₇ IGNORE any working/ names | C ⁷ H ¹⁴ | 1 |

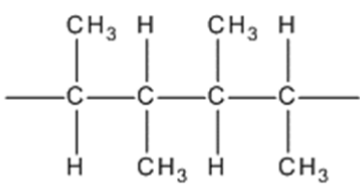
| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|---|----------|
| 21(a)(ii) | <p>First mark Restricted/barrier to rotation (around C=C/ pi bond)</p> <p>ALLOW no rotation (around C=C/ pi bond/ the double bond) (1)</p> <p>IGNORE Just 'groups/atoms attached to C=C are in fixed positions '</p> <p>Second mark (Two) different groups/atoms (with different priorities/masses) on both/each of the carbon atoms (of C=C) OR (Two) different groups on either side of C=C OR There are three different groups/atoms around the C=C bond</p> <p>ALLOW two clear diagrams/structures showing the two different groups in each isomer (1)</p> | <p>the molecule/ hydrocarbon cannot rotate</p> <p>compounds/ molecules/ branches for groups</p> <p>4 different groups/atoms</p> | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|---|----------|
| 21(b)(i) | bromine water/ aqueous bromine /Br ₂ (aq) | Just 'bromine/Br ₂ '/ Br ₂ (l)/ BrOH | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|---|--|----------|
| 21(b)(ii) | <p>propane-1,2-diol</p> <p>ALLOW propan-1,2-diol/ 1,2-propanediol/ 1,2-propandiol</p> <p>IGNORE missing/ additional hyphens in name</p> <p>OR</p> $ \begin{array}{ccccc} & \text{H} & & \text{H} & & \text{H} \\ & & & & & \\ \text{H} & -\text{C} & - & \text{C} & - & \text{C} & -\text{H} \\ & & & & & \\ & \text{OH} & & \text{OH} & & \text{H} \end{array} $ <p>ALLOW Structural formula, skeletal formula or a combination of these</p> <p>IGNORE Molecular formula/ $\text{C}_3\text{H}_8\text{O}_2$</p> | <p>1,2-dipropanol</p> <p>Correct name with incorrect formula or vice versa</p> <p>O-H-C... OH-C... OHC... ...C-H-O ... C-HO ...CHO</p> | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|---|--------|----------|
| 21(b)(iii) | <p>(From) purple/ pink (to) colourless</p> <p>Both colours correct for the mark</p> | | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------------|---|---|-----------------|
| <p>21(b)(iv)</p> |  <p>Correct dipole on HBr (1)</p> <p>Curly arrow from C=C to H of HBr and curly arrow from H-Br bond to Br (1)</p> <p>Correct intermediate with + charge (1)</p> <p>(At least one) lone pair on Br⁻ and curly arrow from Br⁻ to C⁺ (1)</p> <p>ALLOW curly arrow from anywhere on Br, including the - sign</p> <p>If mechanisms are given for 1-bromopropane and 2-bromopropane, ignore the mechanism for 1-bromopropane</p> <p>If final product is 1-bromopropane only, mechanism can score marks 1, 2 and 4</p> | <p>Clearly half-headed arrows once only</p> <p>Missing H on structures once only</p> <p>δ+</p> <p>Br^{δ-}</p> | <p>4</p> |

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|-----------------|--|--------|----------|
| 21(c) |  <p>ALLOW CH₃ groups above or below the chain</p> <p>ALLOW fully displayed formula</p> <p>IGNORE brackets and n/ 2</p> <p>IGNORE bond angles and bond lengths</p> <p>IGNORE working before final structure</p> | | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--|----------|
| 21(d)(i) | <p>Correct answer with no working scores the mark</p> $(\text{percentage atom economy}) = \frac{82.0}{100.0} \times 100$ $= 82(.0) (\%)$ | <p>82.4(%) (incorrect M_rs of 84 and 102 used)</p> <p>80 (1 SF)</p> | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|--|----------|
| 21(d)(ii) | <p>Correct answer with no working scores both marks</p> <p>First mark</p> <p>moles of cyclohexanol $= \frac{10.2}{100.0} = 0.102$</p> <p>ALLOW TE on incorrect M_r in (i) (1)</p> <p>Second mark EITHER moles of cyclohexene produced $= \frac{6.15}{82.0} = 0.075$</p> <p>% yield = $\frac{0.075}{0.102} \times 100$ = 73.529/ 73.53/ 73.5/ 74 (%) (1)</p> <p>ALLOW TE on incorrect mol of cyclohexanol and cyclohexene or incorrect M_r in (i)</p> <p>OR</p> <p>theoretical mass of cyclohexene = 0.102 x 82.0 = 8.364 g</p> <p>% yield = $\frac{6.15}{8.364} \times 100$ = 73.529/ 73.53/ 73.5/ 74 (%) (1)</p> <p>ALLOW TE on mol of cyclohexanol, mass of cyclohexene or incorrect M_r</p> <p>IGNORE SF except 1 SF</p> | <p>$\frac{6.15}{10.2} \times 100$ = 60.3% scores (0)</p> <p>70 for the second mark</p> | 2 |

(Total for Question 21 = 14 marks)

TOTAL FOR PAPER = 80 MARKS