

Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH01/01)

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:
  - i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  - ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  - iii) organise information clearly and coherently, using specialist vocabulary when appropriate

**Section A (multiple choice)**

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

| Question Number | Correct Answer | Mark     |
|-----------------|----------------|----------|
| <b>2</b>        | B              | <b>1</b> |

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

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

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

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

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

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

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

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

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

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

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

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

| Question Number | Correct Answer | Mark     |
|-----------------|----------------|----------|
| <b>15</b>       | B              | <b>1</b> |

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

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

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

| Question Number | Correct Answer | Mark     |
|-----------------|----------------|----------|
| <b>19</b>       | A              | <b>1</b> |

| Question Number | Correct Answer | Mark     |
|-----------------|----------------|----------|
| <b>20</b>       | A              | <b>1</b> |

**TOTAL FOR SECTION A = 20 MARKS**

## Section B

| Question Number | Acceptable Answers                                                                        | Reject | Mark     |
|-----------------|-------------------------------------------------------------------------------------------|--------|----------|
| <b>21(a)(i)</b> | Alkane(s)<br><b>IGNORE</b><br>Any references to 'branched' / 'aliphatic' / 'hydrocarbons' |        | <b>1</b> |

| Question Number  | Acceptable Answers                                                               | Reject | Mark     |
|------------------|----------------------------------------------------------------------------------|--------|----------|
| <b>21(a)(ii)</b> | 2,3- <b>di</b> methyloctane<br><b>IGNORE</b><br>Incorrect or missing punctuation |        | <b>1</b> |

| Question Number   | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Reject                        | Mark     |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|----------|
| <b>21(a)(iii)</b> | <p><b>1st mark:</b><br/>(Isomers) <b>A and C</b> <b>(1)</b></p> <p><b>NOTE</b><br/>If no isomers or isomers other than A &amp; C have been chosen, then award one mark max providing both 2<sup>nd</sup> and 3<sup>rd</sup> marking points are evident.</p> <p><b>2nd mark:</b><br/>(They/A and C) have the same <b>molecular formula</b> / C<sub>10</sub>H<sub>22</sub> / same number of C and H (atoms) <b>(1)</b></p> <p><b>3rd mark:</b><br/>(They/A and C) have different structural formulae/displayed formulae / skeletal formulae / different structures/different arrangement of atoms<br/><b>IGNORE</b><br/>Any references to 'in space' / 'spatial'<br/>Any references to names<br/>Any references to general formulae <b>(1)</b></p> | 'Different chemical formulae' | <b>3</b> |

| Question Number  | Acceptable Answers                                                               | Reject | Mark     |
|------------------|----------------------------------------------------------------------------------|--------|----------|
| <b>21(a)(iv)</b> | $C_{12}H_{24}$<br><b>1st mark:</b> $C_{12}$ (1)<br><b>2nd mark:</b> $H_{24}$ (1) |        | <b>2</b> |

| Question Number | Acceptable Answers                                                                                       | Reject | Mark     |
|-----------------|----------------------------------------------------------------------------------------------------------|--------|----------|
| <b>21(b)(i)</b> | <b>A</b><br>OR<br><b>B</b><br><br><b>ALLOW</b> lower case letters<br><b>IGNORE</b> any names or formulae |        | <b>1</b> |

| Question Number  | Acceptable Answers                                                                                   | Reject | Mark     |
|------------------|------------------------------------------------------------------------------------------------------|--------|----------|
| <b>21(b)(ii)</b> | <b>C</b><br>OR<br><b>D</b><br><b>ALLOW</b> lower case letters<br><b>IGNORE</b> any names or formulae |        | <b>1</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Reject | Mark     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>21(c)</b>    | <p>Any <b>one</b> of:</p> <p>(It improves engine performance by)</p> <p>Promoting efficient combustion<br/>OR<br/>Allowing smoother burning<br/>OR<br/>Increasing octane number<br/>OR<br/>Reduces knocking / prevents knocking<br/>OR<br/>Pre-ignition being less likely<br/>OR<br/>Being (more) efficient (fuels)<br/>OR<br/>Better burning / fuels easier to burn<br/>OR<br/>Combusting more easily<br/>OR<br/>Improving combustion / complete combustion<br/>OR<br/>Burns more cleanly<br/>OR<br/>More miles per gallon<br/><b>IGNORE</b> any references to energy density / boiling temperature / volatility</p> |        | <b>1</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reject | Mark     |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>21(d)</b>    | <p>[FIRST, check the answer on the answer line<br/>IF answer = 48000 (kJ kg<sup>-1</sup>) award <b>(3)</b> marks]</p> <p><b>1<sup>st</sup> two marks</b></p> <p><math>\frac{1000}{170}</math> <b>(1)</b>      x 8086      <b>(1)</b></p> <p><b>OR</b></p> <p><math>\frac{8086}{170}</math> <b>(1)</b>      x 1000      <b>(1)</b></p> <p>NOTE: second mark in both cases dependent on first mark unless one minor transcription error in first mark e.g. use of 110 rather than 170</p> <p><b>3<sup>rd</sup> mark</b><br/>         = 47564.70588<br/>         = 48000      <b>(1)</b></p> <p>Answer must be to 2 sf<br/> <b>Ignore signs and / or incorrect units at any stage</b></p> <p>48 scores <b>(2)</b><br/>         47.56 scores <b>(1)</b><br/>         1374.6 scores <b>(0)</b> even if rounded to 2SF</p> |        | <b>3</b> |

**(Total for Question 21 = 13 marks)**

| Question Number | Acceptable Answers                                          | Reject | Mark     |
|-----------------|-------------------------------------------------------------|--------|----------|
| <b>22(a)(i)</b> | $\Delta H_2$<br><b>ALLOW</b> $\Delta H_2 = \dots\dots\dots$ |        | <b>1</b> |

| Question Number  | Acceptable Answers                                          | Reject                 | Mark     |
|------------------|-------------------------------------------------------------|------------------------|----------|
| <b>22(a)(ii)</b> | $\Delta H_5$<br><b>ALLOW</b> $\Delta H_5 = \dots\dots\dots$ | $\frac{\Delta H_5}{2}$ | <b>1</b> |

| Question Number   | Acceptable Answers                                                                       | Reject       | Mark     |
|-------------------|------------------------------------------------------------------------------------------|--------------|----------|
| <b>22(a)(iii)</b> | $\frac{\Delta H_6}{2}$<br>OR $\Delta H_6 / 2$ OR $\Delta H_6 \div 2$ OR $0.5 \Delta H_6$ | $\Delta H_6$ | <b>1</b> |

| Question Number  | Acceptable Answers                                          | Reject       | Mark     |
|------------------|-------------------------------------------------------------|--------------|----------|
| <b>22(a)(iv)</b> | $\Delta H_1$<br><b>ALLOW</b> $\Delta H_1 = \dots\dots\dots$ | $\Delta H_7$ | <b>1</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Reject                                                                                                                                                   | Mark     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>22(b)(i)</b> | <p>(The energy change / enthalpy change that accompanies / energy released / enthalpy released) the formation of <b>one mole</b> of a(n ionic) compound<br/>(1)</p> <p>ALLOW as alternative for compound: lattice / crystal / substance / solid / product</p> <p>from its <b>gaseous ions</b><br/>(1)</p> <p><i>NOTE</i><br/>'one mole of gaseous ions' scores max <b>(1)</b><br/>(ie 2nd mark only available)</p> <p><i>IGNORE</i><br/>References to 'constituent elements'<br/>References to 'standard conditions'</p> <p><b>ALTERNATIVE RESPONSE</b><br/>If no mark(s) already awarded from above, can answer by giving:-</p> <p>energy change / enthalpy change <b>per mole</b><br/>(1)</p> <p><math>\text{Sr}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g}) \rightarrow \text{SrCl}_2(\text{s})</math><br/><b>ALLOW</b><br/>Any correct 'generic' equation with state symbols included<br/>(1)</p> | <p>'Energy / enthalpy <b>required</b>' / 'used'</p> <p>'molecule' <b>no 1<sup>st</sup> mark</b></p> <p>'gaseous atoms' <b>no 2<sup>nd</sup> mark</b></p> | <b>2</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Reject | Mark     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>22(b)(ii)</b> | <p>[FIRST, check the answer on the answer line<br/> IF answer = <b>−2153</b> (kJ mol<sup>−1</sup>) then award <b>(2)</b> marks, with or without working]</p> <p><b>1st Mark:</b><br/> <math>\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6 + \Delta H_7</math><br/> OR<br/> <math>\Delta H_7 = \Delta H_1 - [\Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6]</math><br/> OR<br/> <math>\Delta H_7 = -829 - [164 + 550 + 1064 + (122 \times 2) + (2 \times -349)]</math><br/> <b>(1)</b></p> <p><b>2nd Mark:</b><br/> <math>\Delta H_7 = -2153</math> (kJ mol<sup>−1</sup>) <b>(1)</b></p> <p><b>NOTE:</b><br/> <b>The following answers score (1) mark with or without working</b><br/> +2153 (kJ mol<sup>−1</sup>)<br/> −2031 (kJ mol<sup>−1</sup>)<br/> −2502 (kJ mol<sup>−1</sup>)<br/> −2380 (kJ mol<sup>−1</sup>)</p> <p><b>NO OTHER TEs are allowed on an incorrect expression involving <math>\Delta H_7</math></b></p> |        | <b>2</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reject                                                                                                                                                        | Mark     |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>22*(c)</b>   | <p>(Lattice energy of <math>\text{MgF}_2</math> more exothermic than that of <math>\text{NaF}</math> because)</p> <p><b>1st mark:</b><br/> <math>\text{Mg}^{2+}</math> is smaller (than <math>\text{Na}^+</math>)</p> <p><b>ALLOW</b><br/> "Magnesium / Mg is smaller (than sodium / Na)"<br/> <b>(1)</b></p> <p><b>2nd mark:</b></p> <p><math>\text{Mg}^{2+}</math> higher charge / higher charge density (than <math>\text{Na}^+</math>)</p> <p><b>ALLOW</b><br/> Any reference to <math>\text{Mg}^{2+}</math> <b>and</b> <math>\text{Na}^+</math> in answer for the 2<sup>nd</sup> mark, unless nuclear charge mentioned<br/> <b>(1)</b></p> <p><b>3rd mark:</b><br/> (So electrostatic forces of) <b>attraction</b> between <b>ions</b> stronger in <math>\text{MgF}_2</math> (than in <math>\text{NaF}</math>)</p> <p><b>ALLOW</b><br/> Stronger ionic bonds in <math>\text{MgF}_2</math> / stronger ionic bonding in <math>\text{MgF}_2</math><br/> <b>(1)</b></p> <p>OR reverse arguments</p> | <p><b>No 1<sup>st</sup> mark</b> if only mention Mg <b>atom</b> or <b>atomic</b> radius</p> <p>"<math>\text{Mg}^{2+}</math> higher <b>nuclear</b> charge"</p> | <b>3</b> |

**(Total for Question 22 = 11 marks)**

| Question Number | Acceptable Answers                                 | Reject | Mark     |
|-----------------|----------------------------------------------------|--------|----------|
| <b>23(a)</b>    | $C_nH_{2n}$<br><br>ALLOW<br>Letters other than $n$ |        | <b>1</b> |

**ALLOW:** (partially) displayed or skeletal formulae throughout

**Q23(b)**

**IGNORE:** additional incorrect non-organic products

| Question Number | Acceptable Answers | Reject   | Mark     |
|-----------------|--------------------|----------|----------|
| <b>23(b)(i)</b> | $CH_3CH_3$         | $C_2H_6$ | <b>1</b> |

| Question Number  | Acceptable Answers              | Reject       | Mark     |
|------------------|---------------------------------|--------------|----------|
| <b>23(b)(ii)</b> | $ClCH_2CH_2Cl$ / $CH_2ClCH_2Cl$ | $C_2H_4Cl_2$ | <b>1</b> |

**ONLY PENALISE ONCE ONLY in (b)(iii) & (b)(iv) THE CONNECTIVITY BETWEEN C and OH if CLEARLY a C to H covalent bond has been drawn**

| Question Number   | Acceptable Answers              | Reject                                            | Mark     |
|-------------------|---------------------------------|---------------------------------------------------|----------|
| <b>23(b)(iii)</b> | $HOCH_2CH_2OH$ / $CH_2OHCH_2OH$ | $C_2H_6O_2$ /<br><b><math>OHCH_2CH_2OH</math></b> | <b>1</b> |

| Question Number  | Acceptable Answers              | Reject                                            | Mark     |
|------------------|---------------------------------|---------------------------------------------------|----------|
| <b>23(b)(iv)</b> | $HOCH_2CH_2Br$ / $CH_2OHCH_2Br$ | $BrCH_2CH_2Br$ /<br>$C_2H_5OBr$ /<br>$C_2H_4Br_2$ | <b>1</b> |

**PENALISE USE OF Br instead of Cl once only in parts (c)(i) & (c)(ii)**  
**PENALISE missing H atoms from displayed formulae once only in parts (c)(i) & (c)(ii)**

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Reject | Mark     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>23(c)(i)</b> | <div style="text-align: center;"> <math display="block">  \begin{array}{ccccc}  &amp; \text{H} &amp; &amp; \text{Cl} &amp; &amp; \text{H} \\  &amp;   &amp; &amp;   &amp; &amp;   \\  \text{H} &amp; - \text{C} &amp; - &amp; \text{C} &amp; - &amp; \text{C} &amp; - \text{H} \\  &amp;   &amp; &amp;   &amp; &amp;   \\  &amp; \text{H} &amp; &amp; \text{H} &amp; &amp; \text{H}  \end{array}  </math> <p>(Major product) <span style="float: right;"><b>(1)</b></span></p> <br/> <math display="block">  \begin{array}{ccccc}  &amp; \text{H} &amp; &amp; \text{H} &amp; &amp; \text{H} \\  &amp;   &amp; &amp;   &amp; &amp;   \\  \text{H} &amp; - \text{C} &amp; - &amp; \text{C} &amp; - &amp; \text{C} &amp; - \text{Cl} \\  &amp;   &amp; &amp;   &amp; &amp;   \\  &amp; \text{H} &amp; &amp; \text{H} &amp; &amp; \text{H}  \end{array}  </math> <p>(Minor product) <span style="float: right;"><b>(1)</b></span></p> <p>Both DISPLAYED structures, with all bonds and atoms shown but in the wrong boxes scores <b>(1)</b></p> <p><b>PENALISE</b><br/> <math>\text{CH}_3</math> not fully displayed <b>ONCE</b> only<br/> <b>So</b><br/> <math>\text{CH}_3\text{CH}(\text{Cl})\text{CH}_3</math> and <math>\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}</math><br/> scores <b>(1)</b></p> </div> |        | <b>2</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reject                                                                                                                                                                                                    | Mark     |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>23(c)(ii)</b> | <div> <p style="text-align: center;">both arrows (1)</p> <p style="text-align: center;">carbocation (1)</p> </div> <div> <p style="text-align: center;">attack of chloride ion (1)</p> </div> <p><b>1st mark:</b><br/> Curly arrow from C=C to H (in H—Cl) <b>AND</b> curly arrow from bond in H—Cl to the Cl (dipole not reqd)<br/> Curly arrows must start from the bonds <b>NOT</b> the atoms <span style="float: right;"><b>(1)</b></span></p> <p><b>2nd mark:</b><br/> Structure of correct secondary carbocation <span style="float: right;"><b>(1)</b></span></p> <p><b>3rd mark:</b><br/> Curly arrow from anywhere on the chloride ion (including the minus sign) towards the C+ on the carbocation <span style="float: right;"><b>(1)</b></span></p> <p><b>NOTE:</b> The chloride ion must have a full negative charge, but the lone pair of electrons on the Cl<sup>-</sup> need not be shown</p> <p><b>ALLOW:</b> TE on major product given in (c)(i)</p> <p>Skeletal formulae can be used<br/> <b>Mark the three points independently</b></p> | <p><b>Full + and - charges on HCl</b></p> <p><b>Incorrect polarity on HCl</b></p> <p><b>Extra / spare bond dangling from the C+ carbon</b></p> <p><b>δ- on chloride ion instead of Cl<sup>-</sup></b></p> | <b>3</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Reject | Mark     |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>23(d)(i)</b> | <div> <math display="block">n\text{C}_3\text{H}_6 \rightarrow \begin{array}{c} \text{H} \\   \\ \text{H}-\text{C} \diagup \text{H} \\   \quad   \\ \text{---} \left[ \text{C} \quad \text{C} \right]_n \\   \quad   \\ \text{H} \quad \text{H} \end{array}</math> </div> <p>TWO 'n' in the equation and a correct formula (molecular or structural) for propene on the left-hand side of the equation <b>(1)</b></p> <p><b>One</b> correct repeating unit, with the methyl branch shown <b>(1)</b></p> <p><b>ALLOW</b></p> <p>CH<sub>3</sub> fully displayed or just as CH<sub>3</sub></p> <p><b>BOTH</b> continuation bonds (with or without bracket shown) <b>(1)</b></p> <p>If C=C bond left in polymer on right-hand side, then max (1)</p> <p><b>Mark the three points independently</b></p> |        | <b>3</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Reject | Mark     |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>23(d)(ii)</b> | <p>Non-biodegradable</p> <p>IGNORE<br/>References to toxicity of poly(propene) / flammability</p> <p>IGNORE<br/>Litter / pollution / waste of resources / costs</p> <p><b>ALLOW</b><br/>People are reluctant to recycle<br/>OR<br/>Harmful to marine life / harmful to wildlife<br/>OR<br/>References to 'landfill'<br/>OR<br/>References to 'incineration' producing toxic fumes/toxic gases / CO<sub>2</sub> / Greenhouse gases<br/>OR<br/>References to use of <b>energy/fuel</b> used in transport (of waste)<br/>OR<br/>It takes a long time to degrade</p> |        | <b>1</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                            | Reject | Mark     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>23(e)(i)</b> | <p>Both arrows in the correct direction</p> <p><b>AND</b><br/>3CO<sub>2</sub> <b>and</b> 3H<sub>2</sub>O in lowest box</p> <p>IGNORE state symbols, even if incorrect<br/>IGNORE extra O<sub>2</sub> molecules in box or alongside arrows</p> |        | <b>1</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Reject | Mark     |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>23(e)(ii)</b> | <p><b>1<sup>st</sup> mark</b><br/> <math>(-394 \times 3) + (-286 \times 3)</math></p> <p>OR</p> <p><math>= -2040 \text{ (kJ mol}^{-1}\text{)}</math> <b>(1)</b></p> <p><b>2nd mark:</b><br/> <math>\Delta H_f = -2040 - (-2058)</math><br/> <math>= (+)18 \text{ (kJ mol}^{-1}\text{)}</math> <b>(1)</b></p> <p><b>NOTE:</b><br/> <b>The following answers score (1) mark</b><br/> <b>with or without working</b><br/> <math>-18 \text{ (kJ mol}^{-1}\text{)}</math><br/> <math>(+)1378 \text{ (kJ mol}^{-1}\text{)}</math><br/> <math>(+)806 \text{ (kJ mol}^{-1}\text{)}</math><br/> <math>(+)590 \text{ (kJ mol}^{-1}\text{)}</math><br/> <math>-4098 \text{ (kJ mol}^{-1}\text{)}</math></p> <p>IGNORE units even if incorrect</p> |        | <b>2</b> |

**(Total for Question 23 = 17 marks)**

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                               | Reject                                                                                                                         | Mark     |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>24(a)</b>    | $\text{F(g)} \rightarrow \text{F}^+(\text{g}) + \text{e}^{(-)}$ <p>OR</p> $\text{F(g)} - \text{e}^{(-)} \rightarrow \text{F}^+(\text{g})$ <p>Species <b>(1)</b></p> <p>State symbols<br/>IGNORE<br/>Any state symbols on electrons <b>(1)</b></p> <p>2nd mark is dependent on the first<br/><b>NOTE:</b></p> $\text{F(g)} + \text{e}^{(-)} \rightarrow \text{F}^+(\text{g}) + 2\text{e}^{(-)}$ <p>Use of 'Fl' <b>max (1)</b></p> | <p>Electron affinity equation (0) overall</p> <p>Equations with <math>\text{F}_2(\text{g})</math> score <b>(0)</b> overall</p> | <b>2</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Reject                                                          | Mark     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|----------|
| <b>24*(b)</b>   | <p><b>1st mark:</b><br/>Number of protons increases / increasing nuclear charge / increasing effective nuclear charge</p> <p><b>IGNORE</b><br/>Just 'the atomic number increases' <b>(1)</b></p> <p><b>2nd mark:</b><br/>Same shielding / same number of (occupied) shells / electron removed from the same shell / atomic radius decreases <b>(1)</b></p> <p><b>3rd mark:</b><br/>Greater (electrostatic) attraction between nucleus / protons and (outermost) electron <b>(1)</b></p> | <p>'Shielding increases' <b>(0)</b> for 2<sup>nd</sup> mark</p> | <b>3</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Reject                                         | Mark     |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|----------|
| <b>24(c)*(i)</b> | <p>For aluminium</p> <p><b>1st mark:</b><br/>(Electron lost from) (3)<b>p</b>-subshell / (3)<b>p</b>-orbital<br/>ALLOW<br/>Correct electron configuration for Al: <math>1s^2 2s^2 2p^6 3s^2 3p^1</math> or <math>[\text{Ne}] 3s^2 3p^1</math> or drawn as electrons-in-boxes<br/><b>(1)</b></p> <p><b>NOTE</b><br/>First mark must refer to aluminium</p> <p><b>2nd mark:</b><br/>at higher energy / further from the nucleus / (more) shielded (by 3s)<br/><br/>OR<br/><br/>Magnesium electron is at lower energy / closer to the nucleus / less shielded<br/><b>(1)</b></p> <p><b>IGNORE</b><br/>References to stability of <math>3s^2</math> or full s-orbitals / full s sub-shell in Mg</p> | Mention of <b>2p</b> , no 1 <sup>st</sup> mark | <b>2</b> |

| Question Number   | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Reject | Mark     |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>24(c)*(ii)</b> | <p>For sulfur</p> <p><b>1st mark:</b><br/>(Electron lost from a) pair of electrons / an orbital with electrons (spin-) paired / a full (p) orbital</p> <p><b>ALLOW</b><br/>Mention of <math>(3)p^4</math><br/>OR<br/>Correct electron configuration for S: <math>1s^2 2s^2 2p^6 3s^2 3p^4</math> or <math>[\text{Ne}]3s^2 3p^4</math> or drawn as electrons-in-boxes<br/><b>(1)</b></p> <p><b>2nd mark:</b><br/>(increase in) <b>repulsion</b> (allows <math>e^-</math> to be removed more easily)<br/><b>(1)</b></p> <p>If no correct reference to Sulfur, then allow one mark for P (atom) has half-filled p sub-shell / <math>p^3</math> (arrangement) is stable.</p> |        | <b>2</b> |

| Question Number | Acceptable Answers                                                                                               | Reject | Mark     |
|-----------------|------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>24(d)(i)</b> | (Al)    (Si)    (P)    (S)<br>high   high   low   low<br><br>Four correct <b>(2)</b><br>Three correct <b>(1)</b> |        | <b>2</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                             | Reject | Mark     |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>24(d)(ii)</b> | (Na)            (Al)    (Si)    (P)            (S)<br>giant (giant) giant giant molecular molecular<br><br>ALLOW 'giant molecular' for Si<br>ALLOW 'simple molecular' for P and/or S<br><br>Five correct <b>(2)</b><br>Four correct <b>(1)</b> |        | <b>2</b> |

| Question Number   | Acceptable Answers                                                                                                                                                                       | Reject | Mark     |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>24(d)(iii)</b> | (Na)            (Al)    (Si)    (P)    (S)<br>high (high)   high <b>X</b> low   low<br><br>All four must be correct<br><br><b>IGNORE</b><br>Any word written over <b>X</b> in the Si box |        | <b>1</b> |

| Question Number | Acceptable Answers                      | Reject | Mark     |
|-----------------|-----------------------------------------|--------|----------|
| <b>24(e)(i)</b> | ( $\frac{2.76}{23.0}$ ) = 0.12(0) (mol) |        | <b>1</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Reject | Mark     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>24(e)(ii)</b> | <p>Moles H<sub>2</sub> = <math>\frac{1}{2}</math> x mol Na <b>(1)</b></p> <p>Volume H<sub>2</sub> = 0.06(0) x 24<br/>= 1.44 (dm<sup>3</sup>) <b>(1)</b></p> <p>ALLOW<br/>ECF from moles of Na in (e)(i)</p> <p>ALLOW</p> <p>Both marks if answer given 1440 <b>cm<sup>3</sup></b></p> <p>Correct answer, no working scores <b>(2)</b></p> <p><b>NOTE:</b><br/><b>The following answers score (1) mark</b><br/><b>with or without working</b><br/>2.88 (dm<sup>3</sup>) / 2880 <b>cm<sup>3</sup></b><br/>5.76 (dm<sup>3</sup>) / 5760 <b>cm<sup>3</sup></b></p> <p>However, check as 2.88 could score 2 as a TE of 0.24 mol from (e)(i)</p> <p>IGNORE<br/>SF except 1 SF</p> |        | <b>2</b> |

| Question Number   | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Reject                                                                                                    | Mark     |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|----------|
| <b>24(e)(iii)</b> | <p><b>1st mark:</b><br/>Moles NaOH = moles of Na <b>(1)</b></p> <p>Can be implied by use of value from (e)(i)</p> <p><b>2nd mark:</b><br/>( <math>\frac{0.12}{0.500}</math> ) = 0.24(0) (mol dm<sup>-3</sup>) <b>(1)</b></p> <p>ALLOW<br/>TE from moles of Na in (e)(i)<br/>Correct answer, no working scores <b>(2)</b><br/>IGNORE<br/>SF except 1 SF</p> <p>NOTE: TE from first mark to second mark only if answer from (e)(i) has been used in some way e.g. answer to (e)(i) × 2 would not score mark 1, but could then be used to score mark 2 as a TE</p> | <p>No 2<sup>nd</sup> mark if give wrong units, e.g<br/>"mol/dm<sup>-3</sup>"<br/>"dm<sup>3</sup>/mol"</p> | <b>2</b> |

(Total for Question 24 = 19 marks)

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**TOTAL FOR SECTION B = 60 MARKS**

**TOTAL FOR PAPER = 80 MARKS**

