



# Mark Scheme (Results)

Summer 2014

IAL Chemistry (WCH01/01)

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Summer 2014

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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	Mark
<b>1</b>	C	<b>1</b>

Question Number	Correct Answer	Mark
<b>2</b>	D	<b>1</b>

Question Number	Correct Answer	Mark
<b>3</b>	B	<b>1</b>

Question Number	Correct Answer	Mark
<b>4</b>	C	<b>1</b>

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

Question Number	Correct Answer	Mark
<b>6</b>	C	<b>1</b>

Question Number	Correct Answer	Mark
<b>7</b>	B	<b>1</b>

Question Number	Correct Answer	Mark
<b>8</b>	C	<b>1</b>

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

Question Number	Correct Answer	Mark
<b>10</b>	C	<b>1</b>

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

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

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

Question Number	Correct Answer	Mark
<b>14</b>	C	<b>1</b>

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

Question Number	Correct Answer	Mark
<b>16</b>	A	<b>1</b>

Question Number	Correct Answer	Mark
<b>17</b>	B	<b>1</b>

Question Number	Correct Answer	Mark
<b>18</b>	D	<b>1</b>

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

Question Number	Correct Answer	Mark
<b>20</b>	D	<b>1</b>

**SECTION A = 20 marks**

**Section B**



Question Number	Acceptable Answers	Reject	Mark
<b>21 (a)(i)</b>	<p>Penalise use of chlorine once only in Q21(a)(i), (ii) and (iii) IGNORE lone pairs of electrons, even if incorrect in Q21(a)(i), (ii) and (iii)</p> <p>ALLOW one slip in the formula of the element if it is correctly given elsewhere in the answer e.g B for Br</p> <p><math>\text{Br}_2 \rightarrow \text{Br}\cdot + \text{Br}\cdot /</math> <math>\text{Br}_2 \rightarrow 2\text{Br}\cdot</math></p> <p>Ignore position of dot Ignore state symbols and curly arrows even if incorrect</p>	Br	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>21 (a)(ii)</b>	<p><math>\text{Br}_2 \rightarrow \text{Br}^+ + \text{Br}^-</math></p> <p>Ignore state symbols and curly arrows even if incorrect</p>	$\delta^+ / \delta^-$ for the + or -	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>21 (a)(iii)</b>	<p>(free radical) <math>\text{Br}\cdot</math></p> <p>NOTE:</p> <p>No TE, except <math>\text{Cl}\cdot</math></p> <p style="text-align: right;"><b>(1)</b></p> <p>Penalise omission of the dot only once in (a)(i) and (a)(iii)</p> <p>(electrophile) <math>\text{Br}^+</math></p> <p>NOTE:</p> <p>No TE, except <math>\text{Cl}^+</math></p> <p style="text-align: right;"><b>(1)</b></p>	Br	<b>2</b>



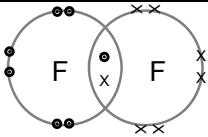
Question Number	Acceptable Answers	Reject	Mark
<b>21 (b)(i)</b>	$  \begin{array}{cccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\  &   &   &   &   &   &   \\  \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} - \text{H} \\  &   &   &   &   &   &   \\  & \text{Br} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H}  \end{array}  $ <p style="text-align: right;"><b>(1)</b></p> $  \begin{array}{cccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\  &   &   &   &   &   &   \\  \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} - \text{H} \\  &   &   &   &   &   &   \\  & \text{H} & \text{Br} & \text{H} & \text{H} & \text{H} & \text{H}  \end{array}  $ <p style="text-align: right;"><b>(1)</b></p> $  \begin{array}{cccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\  &   &   &   &   &   &   \\  \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} - \text{H} \\  &   &   &   &   &   &   \\  & \text{H} & \text{H} & \text{Br} & \text{H} & \text{H} & \text{H}  \end{array}  $ <p style="text-align: right;"><b>(1)</b></p> <p>Isomers can be in any order</p> <p>ALLOW skeletal or structural formulae</p>	Any branched-chain isomers	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>21 (b)(ii)</b>	<p>Corrosive / toxic / poisonous</p> <p>Allow correct symbols for corrosive or toxic / poisonous</p> <div style="display: flex; justify-content: space-around;">   </div> <p>IGNORE harmful / dangerous / irritant / acidic / volatile / any references to state of HBr</p> <p>IGNORE Any precautions taken, EXCEPT those related to flammability</p>	Flammable / 'naked flames'	<b>1</b>

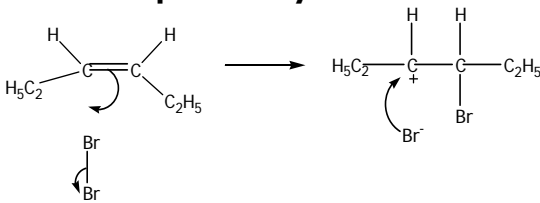
Question Number	Acceptable Answers	Reject	Mark
<b>21</b> <b>(b)(iii)</b>	<p><b>First mark</b> Calculation of the C<sub>6</sub>H<sub>13</sub>Br M<sub>r</sub> value and the total of the product Mr</p> <p>EXPECTED 164.9 <b>AND</b> 245.8</p> <p>ALLOW 165 <b>AND</b> 246</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Second mark</b></p> <p>EXPECTED</p> $\frac{164.9}{245.8} \text{ (x 100\%)}$ $= 67.08706265(\%)$ <p><b>= 67.1(%) to 3 s.f.</b></p> <p>ALLOW</p> $\frac{165}{246} \text{ (x 100\%)}$ $= 67.07317073 (\%)$ <p><b>= 67.1(%) to 3 s.f.</b></p> <p>ALLOW TE from any incorrect M<sub>r</sub> value(s) provided answer is not greater than 100%</p> <p style="text-align: right;"><b>(1)</b></p> <p>Answer <b>MUST</b> be rounded correctly to 3 s.f. for the second mark</p> <p>Correct answer with no working</p> <p style="text-align: right;"><b>(2)</b></p>		<b>2</b>

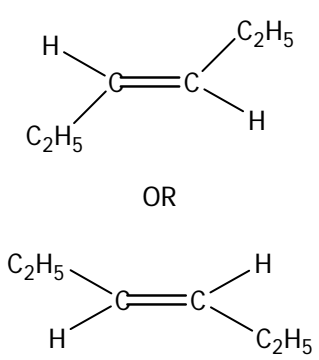
Question Number	Acceptable Answers	Reject	Mark
<b>21 (c)(i)</b>	CH <sub>4</sub> + F <sub>2</sub> → CH <sub>3</sub> F + HF IGNORE state symbols, even if incorrect	Cl <sub>2</sub> "Fl" if used more than once	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>21 (c)(ii)</b>	<p>NOTE Allow reverse argument throughout</p> <p><b>1<sup>st</sup> Mark</b></p> <p>Fluorine / F (atom is) <b>smaller</b> (than a Cl atom) <b>(1)</b></p> <p><b>2<sup>nd</sup> Mark</b></p> <p>Any ONE of:-</p> <p>(so expect) F—F <b>bond</b> to be shorter (than the Cl—Cl bond)</p> <p>OR F—F <b>bonding</b> electrons / <b>bond</b> pair / / <b>shared</b> pair closer to (both) nuclei</p> <p>OR (so) attraction between nuclei and <b>bonding</b> electrons / <b>bond</b> pair / <b>shared</b> pair expected to be stronger <b>(1)</b></p> <p>IGNORE Any references to the strengths of the F-F and/or Cl-Cl bonds</p> <p>Any references to the 'repulsion between nuclei'</p> <p>Any references to 'shielding' / 'Charge density' / 'Electronegativity' / outer electrons</p>	<p>F<sub>2</sub> / 'fluorine <b>molecule</b>'</p> <p>Mention of 'Intermolecular forces' (no <b>2<sup>nd</sup></b> mark)</p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>21</b> <b>(c)(iii)</b>	 <p>Shared pair of electrons shown <b>(1)</b></p> <p>The remaining six electrons on each F atom <b>(1)</b></p> <p>NOTE Can be dots or crosses – only total number of electrons matters</p> <p>Circles not required</p> <p>IGNORE Two inner-shell electrons</p> <p>ALLOW 'FI' or F symbol missing</p>		<b>2</b>
Question Number	Acceptable Answers	Reject	Mark
<b>21</b> <b>(c)(iv)</b>	<p>'<b>Repulsion</b> between electrons' scores (1)</p> <p>BUT</p> <p>'<b>Repulsion</b> between lone pairs (of electrons)' scores (2)</p> <p>ALLOW 'Non-bonding electrons' for lone pairs</p>	Just repulsion between bonding / shared electrons	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>21 (c)(v)</b>	UV (light) / (sun) light / heat / energy required to break Cl—Cl bond  OR UV (light) / (sun) light / heat / energy required to form Cl•  OR F—F requires less energy to break OR F—F requires less energy to form F•  IGNORE <b>Just</b> F <sub>2</sub> more reactive (than Cl <sub>2</sub> )  <b>Just</b> F—F bond is weaker (than Cl—Cl)  <b>Just</b> F—F bond energy is lower (than Cl—Cl)		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<p><b>21 (d)</b></p>	<p><b>Mark independently</b></p>  <p><b>First mark:</b></p> <p>For <b>both arrows</b> in initial step</p> <p>Allow upper arrow as in diagram or directly to Br atom</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Second mark:</b></p> <p>Carbocation intermediate</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Third mark:</b></p> <p>Arrow from anywhere on the bromide ion to the C or to the + sign on the intermediate</p> <p style="text-align: right;"><b>(1)</b></p> <p>Lone pair(s) on Br<sup>-</sup> not required</p>	<p><b>Half-arrow(s)</b></p> <p><b>Incorrect polarities</b></p> <p><b>Full-charges on Br<sub>2</sub></b></p> <p><b>Half-arrow(s)</b></p> <p><b>δ<sup>-</sup> instead of the full - sign on the Br<sup>-</sup></b></p>	<p style="text-align: center;"><b>3</b></p>

Question Number	Acceptable Answers	Reject	Mark
<b>21(e)(i)</b>	 <p>Diagram <b>clearly shows</b> that H atoms are diagonal to each other in the <i>E</i>-isomer/correct relative positions of hydrogen atoms and ethyl groups</p> <p>ALLOW Skeletal or displayed formula</p>		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>21(e)(ii)</b>	<p>EITHER</p> <p><b>Rotation</b> around C—C bond (in product molecule)</p> <p>OR</p> <p>Double bond is broken so <b>rotation</b> (is now possible)</p> <p>ALLOW</p> <p>Same carbocation / intermediate formed (so product is the same)</p> <p>IGNORE</p> <p>Comments about optical isomerism</p>		<b>1</b>

**(Total for Question 21 = 23 marks)**

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)</b>	<p>(The energy / enthalpy change / released that accompanies the formation of)</p> <p><b>one mole</b> of a(n ionic) compound <b>(1)</b></p> <p>ALLOW as alternative for compound: lattice / crystal / substance / solid / product / salt</p> <p>from (its) <b>gaseous ions</b> <b>(1)</b></p> <p>IGNORE References to 'standard conditions' or any incorrect standard conditions</p> <p><b>ALTERNATIVE RESPONSE</b> If no mark(s) already awarded from above, can answer by giving:-</p> <p>energy change <b>per mole</b> / enthalpy change <b>per mole</b> <b>(1)</b></p> <p><math>\text{Li}^+(\text{g}) + \text{F}^-(\text{g}) \rightarrow \text{LiF}(\text{s})</math> <b>(1)</b></p> <p><b>NOTE</b> If lattice energy of dissociation is given (e.g. "energy required to break down 1 mol of an ionic lattice into its gaseous ions") max (1) for the 2nd scoring point 'gaseous ions'</p>	<p>'energy required' / 'energy needed' / 'energy it takes'</p> <p>'from <b>one mole of gaseous ions</b>' (no 2nd mark)</p> <p>Just 'from gaseous <b>elements</b>' (no 2nd mark)</p>	<b>2</b>



Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	<div style="text-align: center;"> </div> <p>IGNORE missing electrons / e<sup>-</sup></p> <p><b>First mark (Box 1):</b></p> <p><b>Li(s) + 1/2F<sub>2</sub>(g)</b> (1)</p> <p><b>Second mark (Box 4):</b></p> <p><b>Li<sup>+</sup>(g) + F(g) (+e<sup>-</sup>)</b> (1)</p> <p><b>Third and Fourth marks (if box 1 is correct):</b></p> <p>'Box 2' as above i.e. Li(g) + 1/2F<sub>2</sub>(g) as above (1)</p> <p>'Box 3' as above i.e. Li<sup>+</sup>(g) + 1/2F<sub>2</sub>(g) (+ e<sup>-</sup>) as above (1)</p> <p>OR</p> <p>'Box 2' Li(s) + F (g) (1)</p> <p>'Box 3' Li(g) + F(g) (1)</p> <p>OR</p> <p>'Box 2' Li(g) + 1/2F<sub>2</sub>(g) (1)</p> <p>'Box 3' Li(g) + F(g) (1)</p>		<b>4</b>

	Penalise use of 'Fl' instead of 'F' once only  If Box 1 is INCORRECT max (2) for correct transitions e.g if use F(g) or F <sub>2</sub> (g) instead of ½F <sub>2</sub> (g), then 2 marks available for two correct transitions involving lithium.		
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Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(ii)</b>	<p><b>FIRST, CHECK THE FINAL ANSWER</b>  <b>IF answer = -1046 (kJ mol<sup>-1</sup>)</b>  <b>then</b>  <b>award (2) marks, with or without</b>  <b>working</b></p> <p>Otherwise look for</p> $-616 = (+159) + (+520) + (+79) + (-328) + \Delta H_{LE}$ <p><b>OR</b></p> $\Delta H_{LE} = -616 - [(+159) + (+520) + (+79) + (-328)]$ <p style="text-align: right;"><b>(1)</b></p> $= -616 - 430$ $= -1046 \text{ (kJ mol}^{-1}\text{)}$ <p style="text-align: right;"><b>(1)</b></p> <p>NOTE  <b>ALLOW for 1 mark:</b></p> <p>(+)1046 (wrong sign)          -186 (+430 instead of -430)          (+)186 (+616 instead of -616)          -1006.5 (+79 halved to +39.5)          -1702 (wrong sign for 328)</p>		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
*22(c)(i)	<p>ALLOW reverse argument where appropriate (NaF more negative than NaCl because)</p> <p><b>First mark</b></p> <p>F<sup>-</sup> smaller (than Cl<sup>-</sup>)</p> <p>ALLOW 'fluorine <b>ion</b> is smaller (than a chlorine <b>ion</b>)</p> <p>OR</p> <p>F<sup>-</sup> larger <b>charge density</b> (than Cl<sup>-</sup>)</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Second mark:</b></p> <p>F<sup>-</sup> (forms) stronger (electrostatic) <b>attractions</b> (than Cl<sup>-</sup>)</p> <p>IGNORE just 'stronger (ionic) bonds'</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Penalise ONCE ONLY in (c)(i) and (c)(ii)</b> the use of the word 'atom(s)' or 'molecule(s)'/ use of <b>just formulae</b> such as 'Mg', 'Na', 'F', 'F<sub>2</sub>', 'Cl', 'Cl<sub>2</sub>', etc.</p> <p>OR</p> <p><b>Penalise ONCE ONLY in (c)(i) and (c)(ii)</b> the use of <b>words</b> such as <b>just</b> 'magnesium' (instead of magnesium ions/Mg<sup>2+</sup>) and/or <b>just</b> 'fluorine' (instead of fluoride ions/F<sup>-</sup>) /and or <b>just</b> 'chlorine' (instead of chloride ions/Cl<sup>-</sup>)</p> <p>IGNORE</p> <p>Any comments about polarization of the anion (by the cation) / covalent character</p>	<p>"<b>NaF</b> is smaller than <b>NaCl</b>"</p> <p>F<sup>-</sup> has a smaller <b>atomic</b> radius than Cl<sup>-</sup></p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>*22(c)(ii)</b>	<p>ALLOW reverse argument where appropriate (NaF less negative than <math>\text{MgF}_2</math> because)</p> <p><b>First mark - size:</b></p> <p><math>\text{Mg}^{2+}</math> smaller (than <math>\text{Na}^+</math>)</p> <p>OR</p> <p>'Magnesium ion' is smaller (than <math>\text{Na}^+</math>)</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Second mark - charge:</b></p> <p><math>\text{Mg}^{2+}</math> has a greater charge (density) (than <math>\text{Na}^+</math>)</p> <p>OR</p> <p>'Magnesium ion' has a greater charge (density) (than <math>\text{Na}^+</math>)</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>[NOTE:</b> It follows that the statement that "<math>\text{Mg}^{2+}</math> ions are smaller than <math>\text{Na}^+</math> ions" would score BOTH marks]</p> <p>IGNORE Any comments about polarization of the anion (by the cation) / covalent character</p>	<p>"<b><math>\text{MgF}_2</math></b> is smaller than <b><math>\text{NaF}</math></b>"</p> <p><math>\text{Mg}^{2+}</math> has a smaller <b>atomic</b> radius than <math>\text{Na}^+</math></p>	<b>2</b>

**(Total for Question 22 = 12 marks)**

Question Number	Acceptable Answers	Reject	Mark
<b>23(a)</b>	<p>(Enthalpy/energy change when) <b>one mole</b> of a compound / <b>one mole</b> of a substance</p> <p>IGNORE Statements such as "energy released" or "energy required" here <b>(1)</b></p> <p>is formed from its elements (in their standard states, under standard conditions) <b>(1)</b></p> <p>(Standard temperature is) 298 K / 25°C</p> <p>ALLOW '°K'</p> <p>IGNORE References to room temperature</p> <p>(Standard pressure is) 1 atm / 101 kPa / 100 kPa <b>(1)</b></p>	'is formed from its <b>gaseous</b> elements'	<b>3</b>

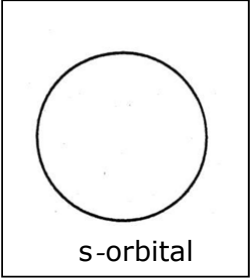
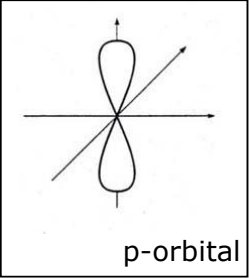
Question Number	Acceptable Answers	Reject	Mark
<b>23(b)</b>	<p><math>6\text{C}(\text{s, graphite}) + 7\text{H}_2(\text{g}) \rightarrow \text{C}_6\text{H}_{14}(\text{l})</math></p> <p><b>ALLOW</b> 6C(s) / 6C(graphite)</p> <p>Species <b>and</b> balancing correct <b>(1)</b></p> <p>State symbols correct <b>(1)</b></p> <p>State symbols mark is dependent on correct species but allow this mark if 14H used instead of 7H<sub>2</sub></p> <p><b>NOTE</b> <math>\text{C}_6\text{H}_{14}(\text{l}) \rightarrow 6\text{C}(\text{s, graphite}) + 7\text{H}_2(\text{g})</math> scores <b>(1)</b></p>		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>23(c)</b>	<div style="text-align: center;"> <math display="block">\boxed{\text{C(s)} + 2\text{H}_2\text{(g)}} \rightarrow \boxed{\text{CH}_4\text{(g)}}</math> <math display="block">\swarrow \quad \nwarrow</math> <math display="block">(+2\text{O}_2\text{(g)}) \quad (+2\text{O}_2\text{(g)})</math> <math display="block">\boxed{\text{CO}_2\text{(g)} + 2\text{H}_2\text{O(l)}}</math> </div> <p><b>First mark:</b> Both arrows point downwards <b>(1)</b></p> <p><b>Second mark:</b> <math>\text{CO}_2\text{(g)} + 2\text{H}_2\text{O(l)}</math> <b>(1)</b></p> <p><b>Third mark:</b> <math>((1 \times -394) + (2 \times -286) - (1 \times -890) =)</math> <b>-76</b> (kJ mol<sup>-1</sup>) No TE from cycle arrows <b>(1)</b></p>	<p><math>2\text{H}_2\text{O(g)}</math></p> <p>If incorrect units with a final answer, no 3<sup>rd</sup> mark</p>	<b>3</b>

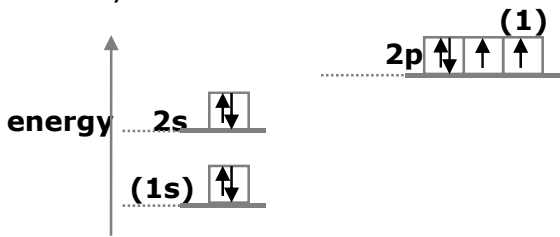
Question Number	Acceptable Answers	Reject	Mark
<b>23(d)(i)</b>	$(+1652 \div 4 =) (+)413$ (kJ mol <sup>-1</sup> )	-413	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>23(d)(ii)</b>	<p><b>First mark:</b> <math>(+2825 - 6 \times \text{answer to (d)(i)})</math> ALLOW TE only from a <b>positive</b> value given as answer to (d)(i) <b>(1)</b></p> <p><b>Second mark:</b> <math>= (+)347</math> (kJ mol<sup>-1</sup>) <b>(1)</b></p> <p>Second mark is CQ on first mark</p> <p>Correct answer with or without working scores <b>(2)</b></p> <p><b>NOTE</b> <math>-347</math> (kJ mol<sup>-1</sup>) <b>scores (1)</b></p>		<b>2</b>

**(Total for Question 23 = 11 marks)**

Question Number	Acceptable Answers	Reject	Mark
<b>24(a)</b>	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>s-orbital</p> </div> <div style="text-align: center;">  <p>p-orbital</p> </div> </div> <p><b>(s-orbital)</b></p> <p>Circle drawn</p> <p>ALLOW Concentric circles drawn <span style="float: right;"><b>(1)</b></span></p> <p><b>(p-orbital)</b></p> <p>Figure of '8' / 'dumb-bell' drawn</p> <p>NOTE: p-orbital can be drawn along any axis (axis does not have to be shown) <span style="float: right;"><b>(1)</b></span></p> <p>ALLOW If one, two or three p-orbitals of correct shapes are shown</p> <p>If <b>overlapping</b> orbitals are shown of correct shape in both cases, award <b>(1)</b> mark</p>		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark												
<b>24(b)</b>	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">(region)</th> <th style="text-align: left;">(no. of electrons)</th> <th></th> </tr> </thead> <tbody> <tr> <td>(a d-orbital)</td> <td style="text-align: center;"><b>2</b></td> <td style="text-align: right;"><b>(1)</b></td> </tr> <tr> <td>(a p sub-shell)</td> <td style="text-align: center;"><b>6</b></td> <td style="text-align: right;"><b>(1)</b></td> </tr> <tr> <td>(the third shell)</td> <td style="text-align: center;"><b>18</b></td> <td style="text-align: right;"><b>(1)</b></td> </tr> </tbody> </table>	(region)	(no. of electrons)		(a d-orbital)	<b>2</b>	<b>(1)</b>	(a p sub-shell)	<b>6</b>	<b>(1)</b>	(the third shell)	<b>18</b>	<b>(1)</b>		<b>3</b>
(region)	(no. of electrons)														
(a d-orbital)	<b>2</b>	<b>(1)</b>													
(a p sub-shell)	<b>6</b>	<b>(1)</b>													
(the third shell)	<b>18</b>	<b>(1)</b>													

Question Number	Acceptable Answers	Reject	Mark
<p><b>24(c)</b></p>	<p><b>First mark: BOTH</b> 2s and 2p labelled</p> <p>ALLOW 2s<sup>2</sup> and 2p<sup>4</sup></p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Second mark: ALL</b> eight e<sup>-</sup> shown correctly</p> <div style="text-align: right; margin-right: 20px;"><b>(1)</b></div>  <p>ALLOW Half-arrows or full arrows for each electron</p> <p>Paired arrows in any one of the 2p orbitals</p> <p>NOTE Single arrows must be orientated in same direction</p> <p>Paired arrows must have opposite spins</p>	<p>2p<sup>6</sup></p>	<p><b>2</b></p>



Question Number	Acceptable Answers	Reject	Mark
<b>24(d)(i)</b>	<p><b>First mark:</b></p> <p>Makes mention of energy/enthalpy/(heat) energy/heat (change/required)</p> <p>AND</p> <p>to remove an electron</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Second mark:</b></p> <p>one mole/1 mol</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Third mark:</b></p> <p>Makes mention of <b>gaseous atom(s)</b></p> <p style="text-align: right;"><b>(1)</b></p> <p><b>ALTERNATIVE ANSWER</b></p> <p>Energy change per mole / <math>\text{kJ mol}^{-1}</math> for</p> <p style="text-align: right;"><b>(1)</b></p> <p><math>X(\text{g}) \rightarrow X^+(\text{g}) + e^{(-)}</math></p> <p style="text-align: right;"><b>(2)</b></p> <p>One mark for species One mark for correct state symbols</p> <p>Mark independently</p> <p>IGNORE any references to standard conditions</p>	<p>"Energy <b>given out...</b>" for first mark</p> <p><b>Just</b> 'gaseous element'/ 'gaseous substance'</p>	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>24(d)(ii)</b>	$O^{2+}(g) - e^{-} \rightarrow O^{3+}(g)$ OR $O^{2+}(g) \rightarrow O^{3+}(g) + e^{-}$ All species and balancing correct <b>(1)</b> State symbols correct <b>(1)</b> 2 <sup>nd</sup> mark is dependent on 1 <sup>st</sup> mark ALLOW 'e' for 'e <sup>-</sup> ' IGNORE (g) on the e <sup>-</sup>	Reverse equation scores <b>(0)</b> overall	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>24(d)(iii)</b>	<p><b>First mark:</b></p> <p><b>Big</b> 'jump' / <b>large</b> increase <b>(1)</b></p> <p><b>Second mark:</b></p> <p>between <b>6th</b> and <b>7th</b> (IE)</p> <p>OR</p> <p>after the <b>6<sup>th</sup></b></p> <p>OR</p> <p>to the <b>7<sup>th</sup></b></p> <p>OR</p> <p>from 13327 to 71337</p> <p>OR</p> <p>of 58010</p> <p><b>IGNORE</b></p> <p>Additional jump identified between <b>4th</b> and <b>5th</b> (IE) if justified in terms of a change of <b>sub-shell</b></p> <p>OR</p> <p>Additional jump identified between <b>4th</b> and <b>5th</b> (IE) if justified in terms of NOT being a change of shell <b>(1)</b></p>	Any other ionization jumps mentioned	<b>2</b>

**(Total for Question 24 = 14 marks)**

**SECTION B = 60 marks**

**TOTAL FOR PAPER = 80 marks**

