



# Mark Scheme (Provisional)

Summer 2021

Pearson Edexcel International Advanced  
Subsidiary Level  
In Chemistry (WCH11)  
Paper 01: Structure, Bonding and Introduction to  
Organic Chemistry

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

## 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	Answer	Mark
1	<p><b>The only correct answer is D</b> ( Y and Z)</p> <p><i>A is incorrect because W and X both have the same number of neutrons</i></p> <p><i>B is incorrect because W and Y have different numbers of protons so are different elements</i></p> <p><i>C is incorrect because X and Y have different numbers of protons so are different elements</i></p>	1

Question number	Answer	Mark
2	<p><b>The only correct answer is C</b> (4)</p> <p><i>A is incorrect because the <math>\text{ICl}_3^+</math> ion can have <math>3 \times {}^{35}\text{Cl}</math>, <math>2 \times {}^{35}\text{Cl} + 1 \times {}^{37}\text{Cl}</math>, <math>1 \times {}^{35}\text{Cl} + 2 \times {}^{37}\text{Cl}</math> or <math>3 \times {}^{37}\text{Cl}</math></i></p> <p><i>B is incorrect because the <math>\text{ICl}_3^+</math> ion can have <math>3 \times {}^{35}\text{Cl}</math>, <math>2 \times {}^{35}\text{Cl} + 1 \times {}^{37}\text{Cl}</math>, <math>1 \times {}^{35}\text{Cl} + 2 \times {}^{37}\text{Cl}</math> or <math>3 \times {}^{37}\text{Cl}</math></i></p> <p><i>D is incorrect because the <math>\text{ICl}_3^+</math> ion can have <math>3 \times {}^{35}\text{Cl}</math>, <math>2 \times {}^{35}\text{Cl} + 1 \times {}^{37}\text{Cl}</math>, <math>1 \times {}^{35}\text{Cl} + 2 \times {}^{37}\text{Cl}</math> or <math>3 \times {}^{37}\text{Cl}</math></i></p>	1

Question number	Answer	Mark
3	<p><b>The only correct answer is C</b> (192.5)</p> <p><i>A is incorrect because this is the relative atomic mass with the abundances reversed</i></p> <p><i>B is incorrect because this would be the relative atomic mass if there were equal amounts of the two isotopes</i></p> <p><i>D is incorrect because this is the relative atomic mass of the most abundant isotope</i></p>	1

Question number	Answer	Mark
4	<p><b>The only correct answer is B</b> (<math>\text{Mg}^+(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + \text{e}^-</math>)</p> <p><i>A is incorrect because this represents the first and second ionisations</i></p> <p><i>C is incorrect because this represents the first and second ionisations and the state symbols are incorrect</i></p> <p><i>D is incorrect because the state symbols are incorrect</i></p>	1

Question number	Answer	Mark
5	<p><b>The only correct answer is B</b> (3 quantum shells and 5 electrons in the outer shell)</p> <p><i>A is incorrect because the outer five electrons require the least amount of energy to remove</i></p> <p><i>C is incorrect because there are two large jumps between the 3 quantum shells and the outer five electrons require the least amount of energy to remove</i></p> <p><i>D is incorrect because there are two large jumps between the 3 quantum shells</i></p>	1

Question number	Answer	Mark
6	<p><b>The only correct answer is B</b> (<math>\text{Cl}^-</math>)</p> <p><i>A is incorrect because <math>\text{Al}^{3+}</math> has electronic configuration <math>1s^2 2s^2 2p^6</math></i></p> <p><i>C is incorrect because <math>\text{N}^{3-}</math> has electronic configuration <math>1s^2 2s^2 2p^6</math></i></p> <p><i>D is incorrect because <math>\text{Na}^+</math> has electronic configuration <math>1s^2 2s^2 2p^6</math></i></p>	1

Question number	Answer	Mark
7	<p><b>The only correct answer is D</b> (286)</p> <p><i>A is incorrect because this is the relative formula mass of anhydrous sodium carbonate, Na<sub>2</sub>CO<sub>3</sub></i></p> <p><i>B is incorrect because this is the relative formula mass of Na<sub>2</sub>CO<sub>3</sub> + (20 x 1) + 16</i></p> <p><i>C is incorrect because this is the relative formula mass of NaCO<sub>3</sub>.10H<sub>2</sub>O</i></p>	1

Question number	Answer	Mark
8	<p><b>The only correct answer is C</b> (O<sup>2-</sup>)</p> <p><i>A is incorrect because Na<sup>+</sup> has more protons than oxygen and nitrogen but a lower charge than magnesium</i></p> <p><i>B is incorrect because Mg<sup>2+</sup> is the smallest as it has the most protons and a higher charge than sodium</i></p> <p><i>D is incorrect because F<sup>-</sup> has one more proton than oxygen and one less electron added to the atom</i></p>	1

Question number	Answer	Mark
9	<p><b>The only correct answer is D</b> (I<sup>-</sup>)</p> <p><i>A is incorrect because cations cause polarisation of anions and are not polarised themselves</i></p> <p><i>B is incorrect because cations cause polarisation of anions and are not polarised themselves</i></p> <p><i>C is incorrect because a chloride ion is smaller than an iodide ion and large anions are more easily polarised than small anions</i></p>	1

Question number	Answer	Mark
10	<p><b>The only correct answer is A</b> (diamond)</p> <p><i>B is incorrect because ice consists of H<sub>2</sub>O molecules</i></p> <p><i>C is incorrect because poly(ethene) consists of long chain molecules</i></p> <p><i>D is incorrect because sodium chloride consists of a giant lattice of ions</i></p>	1

Question number	Answer	Mark
11	<p><b>The only correct answer is A</b> (H<sub>2</sub>O)</p> <p><i>B is incorrect because the greatest electronegativity difference is between hydrogen and oxygen</i></p> <p><i>C is incorrect because the greatest electronegativity difference is between hydrogen and oxygen</i></p> <p><i>D is incorrect because the greatest electronegativity difference is between hydrogen and oxygen</i></p>	1

Question number	Answer	Mark
12	<p><b>The only correct answer is B</b> (C<sub>2</sub>F<sub>4</sub>)</p> <p><i>A is incorrect because CF<sub>4</sub> is tetrahedral</i></p> <p><i>C is incorrect because PF<sub>5</sub> is trigonal bipyramidal</i></p> <p><i>D is incorrect because SF<sub>6</sub> is octahedral</i></p>	1



Question number	Answer	Mark
13	<p><b>The only correct answer is B</b> (<math>C_7H_{14}</math>)</p> <p><i>A is incorrect because this would be correct if ethane was formed instead of ethene</i></p> <p><i>C is incorrect because this would be correct if only one molecule of E was produced and ethane was formed instead of ethene</i></p> <p><i>D is incorrect because this would be correct if only one molecule of E was produced</i></p>	1

Question number	Answer	Mark
14	<p><b>The only correct answer is C</b> (4,5-dimethylhex-1-ene)</p> <p><i>A is incorrect because the longest chain has 6 carbon atoms</i></p> <p><i>B is incorrect because the double bond starts at the first carbon atom</i></p> <p><i>D is incorrect because the longest chain has 6 carbon atoms</i></p>	1

Question number	Answer	Mark
15	<p><b>The only correct answer is A</b> (5.25 g)</p> <p><i>B is incorrect because this is 51.2% of 12.5 g</i></p> <p><i>C is incorrect because the <math>M_r</math>s have been reversed</i></p> <p><i>D is incorrect because this is the mass produced if the yield was 100%</i></p>	1

Question number	Answer	Mark
16	<p><b>The only correct answer is C</b> (11.0 g of carbon dioxide)</p> <p><i>A is incorrect because 6.0 dm<sup>3</sup> is occupied by 0.25 mol of gas and 2.0 g is 0.5 mol of helium</i></p> <p><i>B is incorrect because 6.0 dm<sup>3</sup> is occupied by 0.25 mol of gas and 4.0 g is 0.125 mol of oxygen gas, O<sub>2</sub></i></p> <p><i>D is incorrect because 6.0 dm<sup>3</sup> is occupied by 0.25 mol of gas and 14.0 g is 0.5 mol of nitrogen gas, N<sub>2</sub></i></p>	1

Question number	Answer	Mark
17	<p><b>The only correct answer is D</b> (Pb<sub>3</sub>O<sub>4</sub>)</p> <p><i>A is incorrect because PbO contains 92.8% by mass of lead</i></p> <p><i>B is incorrect because PbO<sub>2</sub> contains 86.6% by mass of lead</i></p> <p><i>C is incorrect because Pb<sub>2</sub>O<sub>3</sub> contains 89.6% by mass of lead</i></p>	1

Question number	Answer	Mark
18	<p><b>The only correct answer is B</b> (400 cm<sup>3</sup>)</p> <p><i>A is incorrect because this is the volume of carbon dioxide produced and there is 100 cm<sup>3</sup> of oxygen left</i></p> <p><i>C is incorrect because this is the volume of carbon dioxide and water produced if water was a gas</i></p> <p><i>D is incorrect because this is the volume of carbon dioxide and water produced if water was a gas plus 100 cm<sup>3</sup> of oxygen that remains</i></p>	1

Question number	Answer	Mark
19	<p><b>The only correct answer is C</b> (500 cm<sup>3</sup> of 1.0 mol dm<sup>-3</sup> NaCl)</p> <p><i>A is incorrect because this contains <math>0.2 \times 1.5 \times 3 = 0.9</math> mol of ions but C contains <math>0.5 \times 1.0 \times 2 = 1.0</math> mol of ions</i></p> <p><i>B is incorrect because this contains <math>0.4 \times 0.8 \times 2 = 0.64</math> mol of ions but C contains 1.0 mol of ions</i></p> <p><i>D is incorrect because this contains <math>1.0 \times 0.25 \times 3 = 0.75</math> mol of ions but C contains 1.0 mol of ions</i></p>	1

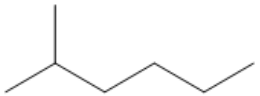
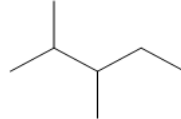

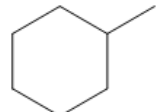
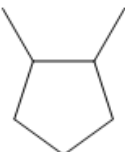
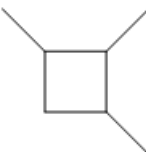

Question number	Answer	Mark
20	<p><b>The only correct answer is A</b> (<math>2 \times 10^{10}</math>)</p> <p><i>B is incorrect because the mass of gold has not been converted into moles</i></p> <p><i>C is incorrect because kg has not been converted into g</i></p> <p><i>D is incorrect because the mass of gold has not been converted into moles and kg has not been converted into g</i></p>	1

**Total for Section A = 20 marks**

**Section B**

<b>Question number</b>	<b>Answer</b>	<b>Additional guidance</b>	<b>Mark</b>
21(a)(i)	<ul style="list-style-type: none"><li>limited supply of oxygen / air</li></ul>	Accept not enough oxygen / air Allow lack of oxygen / air Ignore excess fuel / burning in an enclosed space Do not award no oxygen / air	<b>1</b>

<b>Question number</b>	<b>Answer</b>	<b>Additional guidance</b>	<b>Mark</b>
21(a)(ii)	<ul style="list-style-type: none"><li>equation</li></ul>	Examples of equation: $2\text{C}_7\text{H}_{16} + 15\text{O}_2 \rightarrow 14\text{CO} + 16\text{H}_2\text{O}$ $\text{C}_7\text{H}_{16} + 7\frac{1}{2}\text{O}_2 \rightarrow 7\text{CO} + 8\text{H}_2\text{O}$ Allow multiples Ignore state symbols even if incorrect	<b>1</b>

Question number	Answer	Additional guidance	Mark
21(b)(i)	<ul style="list-style-type: none"> <li data-bbox="324 331 1064 367">• branched-chain alkane (1)</li>   <li data-bbox="324 555 1064 590">• cycloalkane (1)</li> </ul>	<p data-bbox="1131 292 1534 327">Examples of skeletal formulae:</p> <div style="display: flex; justify-content: space-around; align-items: center;">   </div> <p data-bbox="1131 494 1825 529">Allow any branched-chain alkane with 7 carbon atoms</p> <div style="display: flex; flex-wrap: wrap; justify-content: space-around; align-items: center;">   </div> <div style="display: flex; flex-wrap: wrap; justify-content: space-around; align-items: center; margin-top: 10px;">    </div> <p data-bbox="1131 917 1937 981">Allow any ring with three or more carbon atoms and additional carbons to give a total of 7 carbon atoms</p> <p data-bbox="1131 1029 1892 1125">Allow (1) for a correct branched-chain alkane <b>and</b> a cyclic alkane with 7 carbon atoms using structural or displayed formulae</p> <p data-bbox="1131 1173 1803 1204">Ignore molecular formulae / names even if incorrect</p> <p data-bbox="1131 1228 1937 1332">If no other mark is awarded, allow (1) for correct skeletal formulae of a branched-chain alkane <b>and</b> a cycloalkane that do not have 7 carbon atoms</p>	2

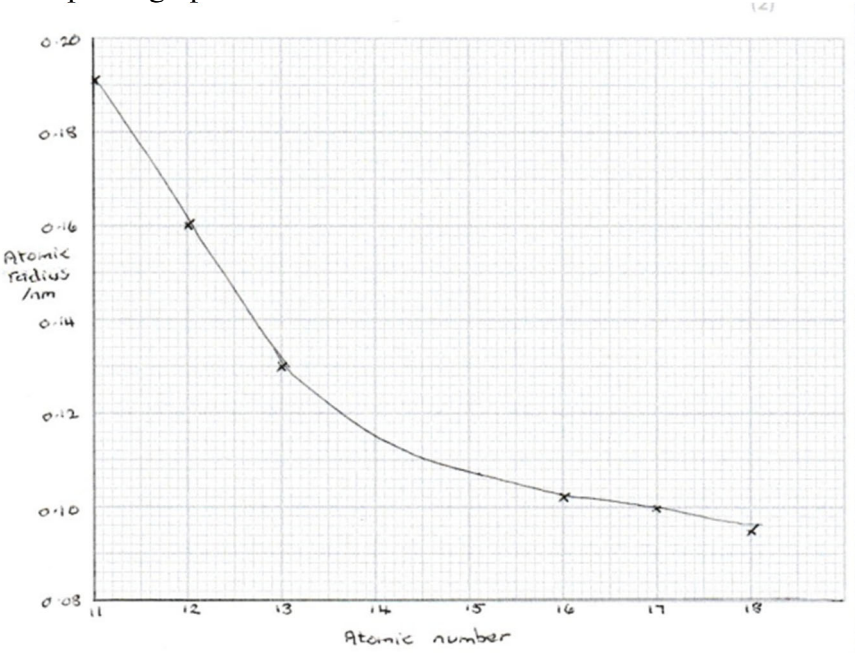
Question number	Answer	Additional guidance	Mark
21(b)(ii)	<ul style="list-style-type: none"> <li>equation</li> </ul>	<p>Example of equation:  <math>C_7H_{16} \rightarrow C_7H_{14} + H_2</math></p> <p>Allow multiples</p> <p>Ignore structural / displayed / skeletal formulae            Ignore state symbols even if incorrect</p> <p>Do not award equations for cracking into more than one hydrocarbon</p>	1

Question number	Answer	Additional guidance	Mark
21(b)(iii)	<p>An answer that makes reference to the following point:</p> <ul style="list-style-type: none"> <li>burns more efficiently / smoothly</li> </ul> <p>or</p> <ul style="list-style-type: none"> <li>prevents pre-ignition / knocking / pinking</li> </ul>	<p>Allow the octane number would increase            Allow research octane number (RON) increases</p> <p>Ignore increases efficiency of the engine / just 'more efficient' / burns more easily / burns better / increase in volatility</p>	1

Question number	Answer	Additional guidance	Mark
21(c)(i)	<ul style="list-style-type: none"> <li>(free) radical (1)</li> <li>substitution (1)</li> </ul>	<p>Allow the words in either order</p> <p>Ignore homolytic /photochemical            Do not award heterolytic / nucleophilic / electrophilic</p> <p>Do not award other types of reaction e.g. addition</p>	2

Question number	Answer	Additional guidance	Mark
21(c)(ii)	<ul style="list-style-type: none"> <li>• initiation (step)</li> <li>• equation for initiation step</li>   <li>• propagation (step(s))</li> <li>• one equation for a propagation step</li> <li>• another equation for a propagation step</li>   <li>• termination (step)</li> <li>• equation for termination step</li> </ul>	<p>Allow structural / displayed formulae            Penalise missing • once only            Ignore full curly arrows and curly half-arrows even if incorrect            Ignore reference to any conditions e.g. uv / heat</p> <p>(1) Allow initiating (step)</p> <p>(1) <math>\text{Cl}_2 \rightarrow 2\text{Cl}\cdot</math> / <math>\text{Cl}_2 \rightarrow \text{Cl}\cdot + \text{Cl}\cdot</math> / <math>\frac{1}{2}\text{Cl}_2 \rightarrow \text{Cl}\cdot</math>            or Cl-Cl for <math>\text{Cl}_2</math></p> <p>(1) Allow propagating (step(s))</p> <p>(1) <math>\text{C}_7\text{H}_{16} + \text{Cl}\cdot \rightarrow \text{C}_7\text{H}_{15}\cdot + \text{HCl}</math></p> <p>(1) <math>\text{C}_7\text{H}_{15}\cdot + \text{Cl}_2 \rightarrow \text{C}_7\text{H}_{15}\text{Cl} + \text{Cl}\cdot</math></p> <p>Allow propagation steps in either order</p> <p>(1) Allow terminating (step)</p> <p>(1) <math>2\text{C}_7\text{H}_{15}\cdot \rightarrow \text{C}_{14}\text{H}_{30}</math> / <math>\text{C}_7\text{H}_{15}\cdot + \text{C}_7\text{H}_{15}\cdot \rightarrow \text{C}_{14}\text{H}_{30}</math></p> <p>Ignore additional termination steps - <math>\text{Cl}\cdot + \text{Cl}\cdot \rightarrow \text{Cl}_2</math> / <math>\text{C}_7\text{H}_{15}\cdot + \text{Cl}\cdot \rightarrow \text{C}_7\text{H}_{15}\text{Cl}</math></p> <p>Do not award any other termination steps</p>	7

(Total for Question 21 = 15 marks)

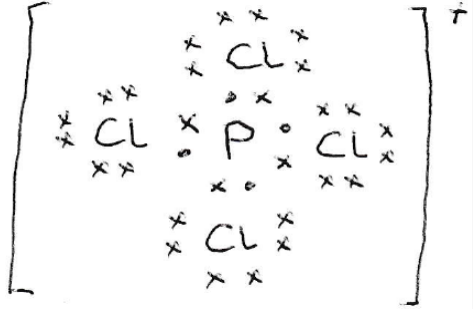
Question number	Answer	Additional guidance	Mark
22(a)(i)	<ul style="list-style-type: none"> <li data-bbox="383 906 1021 975">• axes correct and labelled with atomic radius /nm and atomic number (1)</li> <li data-bbox="383 1043 1021 1078">• points plotted correctly (1)</li> </ul>	<p data-bbox="1043 217 1285 248">Example of graph:</p>  <p data-bbox="1043 906 1756 941">Allow y axis with 191 etc and label as pm or <math>\times 10^{-3}</math> nm</p> <p data-bbox="1043 944 1368 979">Ignore symbols on x axis</p> <p data-bbox="1043 983 1585 1018">Do not award M1 if x axis scale starts at 0</p> <p data-bbox="1043 1053 1899 1123">(1) The points for Si / atomic number 14 and P / atomic number 15 do not need to be marked</p> <p data-bbox="1043 1168 1568 1203">Accept graph with or without line drawn</p> <p data-bbox="1043 1238 1182 1273"><b>Comment</b></p> <p data-bbox="1043 1276 1899 1311">If atomic radius is plotted on the x axis, allow (1) for correct graph</p>	2



Question number	Answer	Additional guidance	Mark
22(a)(ii)	<ul style="list-style-type: none"> <li>value in allowed range</li> </ul>	Allow 0.112 to 0.118 (nm) Allow value written in table  Ignore any value given for phosphorus	1

Question number	Answer	Additional guidance	Mark
22(a)(iii)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>(as the atomic number increases / across the period) the nuclear charge increases / the number of protons (in the nucleus) increases (1)</li> </ul> <p><b>Any two from:</b></p> <ul style="list-style-type: none"> <li>this is only partially offset by the increased electron (-electron) repulsion as the number of electrons in the (outer) shell increases (1)</li> <li>the electrons are all the same (quantum) shell / experience similar shielding (1)</li> <li>so there is an increase in attractive force between the nucleus and (outer) electrons (1)</li> </ul>	Allow effective nuclear charge increases      Allow the same amount of shielding Allow same number of (occupied quantum) shells Do not award electrons in the same subshell / orbital	3

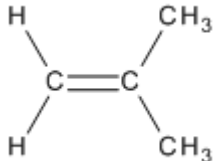
Question number	Answer	Additional guidance	Mark																				
22(b)	<ul style="list-style-type: none"> <li>• giant for structure of sodium chloride (1)</li> <li>• metallic bonding for sodium (1)</li> <li>• ionic bonding for sodium chloride (1)</li> <li>• intermolecular (forces) for chlorine (1)</li> <li>• Na<sup>+</sup> <b>and</b> electrons / cations <b>and</b> electrons (particles in sodium) (1)</li> <li>• Na<sup>+</sup> <b>and</b> Cl<sup>-</sup> /cations <b>and</b> anions (particles in sodium chloride) (1)</li> </ul>	<p>Allow giant ionic / (giant) lattice</p> <p>Ignore metal</p> <p>Ignore ion(s) Ignore electrostatic attractions in M2 and M3</p> <p>Accept London / dispersion (forces) Allow van der Waals' (forces) Ignore weak (forces)</p> <p>Allow positive ions <b>and</b> electrons Allow sodium atoms / ions <b>and</b> electrons</p> <p>Allow positive (sodium) ion and negative (chloride / chlorine) ion Ignore just sodium ions and chloride ions Penalise incorrect charge on an ion once only e.g. Na<sup>2+</sup></p>	6																				
<p><u>Example of table:</u></p> <table border="1" data-bbox="712 930 1601 1369" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Substance</th> <th>Sodium</th> <th>Sodium chloride</th> <th>Chlorine</th> </tr> </thead> <tbody> <tr> <td>Melting temperature /°C</td> <td>(98)</td> <td>(801)</td> <td>(-101)</td> </tr> <tr> <td>Type of structure</td> <td>(giant)</td> <td>giant</td> <td>(simple molecular)</td> </tr> <tr> <td>Type of bond or force broken on melting</td> <td>metallic</td> <td>ionic</td> <td>intermolecular forces</td> </tr> <tr> <td>Particles involved</td> <td>Na<sup>+</sup> <b>and</b> electrons / cations <b>and</b> electrons</td> <td>Na<sup>+</sup> <b>and</b> Cl<sup>-</sup> /cations <b>and</b> anions</td> <td>(chlorine molecules)</td> </tr> </tbody> </table>				Substance	Sodium	Sodium chloride	Chlorine	Melting temperature /°C	(98)	(801)	(-101)	Type of structure	(giant)	giant	(simple molecular)	Type of bond or force broken on melting	metallic	ionic	intermolecular forces	Particles involved	Na <sup>+</sup> <b>and</b> electrons / cations <b>and</b> electrons	Na <sup>+</sup> <b>and</b> Cl <sup>-</sup> /cations <b>and</b> anions	(chlorine molecules)
Substance	Sodium	Sodium chloride	Chlorine																				
Melting temperature /°C	(98)	(801)	(-101)																				
Type of structure	(giant)	giant	(simple molecular)																				
Type of bond or force broken on melting	metallic	ionic	intermolecular forces																				
Particles involved	Na <sup>+</sup> <b>and</b> electrons / cations <b>and</b> electrons	Na <sup>+</sup> <b>and</b> Cl <sup>-</sup> /cations <b>and</b> anions	(chlorine molecules)																				

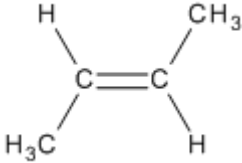
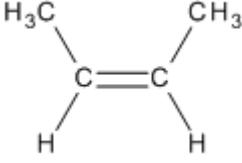
Question number	Answer	Additional guidance	Mark
22(c)(i)	<ul style="list-style-type: none"> <li>correct dot-and-cross diagram</li> </ul>	<p>Example of dot-and-cross diagram:</p>  <p>Allow any combination of dots and crosses, including all dots or all crosses</p> <p>Allow overlapping circles</p> <p>Allow electrons in bonds along the axis of the bond</p> <p>Ignore missing bracket and charge</p> <p>Ignore lines representing covalent bonds e.g. <math>\frac{x}{\cdot}</math></p>	1

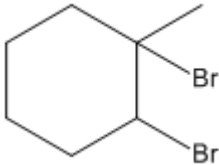
Question number	Answer	Additional guidance	Mark
22(c)(ii)	<ul style="list-style-type: none"> <li data-bbox="383 236 1223 268">• Shape – tetrahedral (1)</li>   <li data-bbox="383 363 1223 435">• Justification – (four) bonding pairs /pairs of electrons (around P) (1)</li>   <li data-bbox="383 619 1223 651">• (electron pairs) arranged to minimise repulsion (1)</li> </ul>	<p data-bbox="1256 236 1585 316">Stand alone No TE on (c)(i) for shape</p> <p data-bbox="1256 379 1912 547">Allow the number of electron pairs shown in (c)(i) Allow regions of electron density for electron pairs Ignore reference to lone pair-lone pair / lone pair-bond pair repulsion</p> <p data-bbox="1256 595 1845 659">Allow (electron pairs) arranged for maximum separation / as far apart as possible</p> <p data-bbox="1256 707 1697 738">Ignore electron pairs repel equally</p> <p data-bbox="1256 778 1928 842">Penalise use of bonds for electron pairs once only in M2 and M3</p>	<b>3</b>

**(Total for Question 22 = 16 marks)**

Question number	Answer	Additional guidance	Mark
23(a)	<ul style="list-style-type: none"> <li>(alkene is) C<sub>8</sub>H<sub>16</sub></li> </ul>	Allow H <sub>16</sub> C <sub>8</sub> Allow large numbers e.g. C8H16 Do not award C <sup>8</sup> H <sup>16</sup>	1

Question number	Answer	Additional guidance	Mark
23(b)(i)	<ul style="list-style-type: none"> <li>structure of C<sub>4</sub>H<sub>8</sub> branched alkene</li> </ul>	Example of structure:  Allow any unambiguous structure e.g. structural or displayed formula or any combination of these / skeletal formula  Ignore name even if incorrect	1

Question number	Answer	Additional guidance	Mark
23(b)(ii)	<ul style="list-style-type: none"> <li>• structure of one geometric isomer <b>and</b> name (1)</li>   <li>• structure of the other geometric isomer <b>and</b> name (1)</li> </ul>	<p>Examples of structures and names:</p>  <p><b>and</b> <i>trans</i>-but-2-ene / <i>E</i>-but-2-ene</p>  <p><b>and</b> <i>cis</i>-but-2-ene / <i>Z</i>-but-2-ene</p> <p>Allow isomers in either order</p> <p>Allow 2-butene for but-2-ene</p> <p>Allow any unambiguous structures e.g. displayed formulae or skeletal formulae</p> <p>Ignore missing hyphens</p> <p>If no other mark is scored, allow (1) for two correct structures <b>or</b> two correct names</p>	2

Question number	Answer	Additional guidance	Mark
23(c)(i)	<ul style="list-style-type: none"> <li>skeletal formula of product</li> </ul>	Example of skeletal formula:  Ignore structural / displayed formula	1

Question number	Answer	Additional guidance	Mark
23(c)(ii)	An answer that makes reference to one of the following pairs:  <b>Either</b>  <ul style="list-style-type: none"> <li>steam / H<sub>2</sub>O(g) (1)</li> <li>phosphoric(V) acid (catalyst) / H<sub>3</sub>PO<sub>4</sub> (1)</li> </ul> <b>Or</b>  <ul style="list-style-type: none"> <li>(concentrated) sulfuric acid / H<sub>2</sub>SO<sub>4</sub> (1)</li> <li><b>followed by</b> water / H<sub>2</sub>O (1)</li> </ul>	Allow reagent and condition written on either dotted line for the steam and phosphoric acid answer  Allow water / H <sub>2</sub> O <b>and</b> heat / any temperature above 100°C Ignore pressure  If oxidation number is given, it must be correct Allow just 'acid catalyst' Ignore hydrochloric acid / just 'H <sup>+</sup> '  Ignore specified temperature / heat / reflux  Do not award H <sub>2</sub> O(g)	2

Question number	Answer	Additional guidance	Mark
23(d)	<ul style="list-style-type: none"> <li>curly arrow from C=C bond to / towards <math>I^{\delta+}</math> <b>and</b> curly arrow from I-Cl bond to, or just beyond Cl (1)</li> <li>intermediate (1)</li> <li>lone pair on <math>Cl^-</math> <b>and</b> curly arrow from lone pair to carbon with positive charge (1)</li> <li>structure of major product (1)</li> </ul>	<p>Example of mechanism:</p> <p>Do not award <math>\delta+</math> charge on intermediate</p> <p>Do not award <math>\delta-</math> charge on chloride ion</p> <p>Allow curly arrow from lone pair to positive charge</p> <p><b>Note</b> Mechanism for the formation of the minor product can score M1, M3 and M4</p>	4

Question number	Answer	Additional guidance	Mark
23(e)	<ul style="list-style-type: none"> <li>pent-2-ene</li> </ul>	<p>Allow 2-pentene Ignore <i>E</i> / <i>Z</i> / <i>cis</i> / <i>trans</i> Do not award just 'pentene'</p>	1



Question number	Answer	Additional guidance	Mark
23(f)	<ul style="list-style-type: none"> <li data-bbox="383 252 786 284">• conversion of volume to m<sup>3</sup></li> <li data-bbox="383 331 891 363">• rearrangement of ideal gas equation</li>   <li data-bbox="383 635 685 667">• evaluation to give n</li>   <li data-bbox="383 746 913 778">• deduction of number of double bonds</li> </ul>	<p data-bbox="1272 217 1585 248">Example of calculation:</p> <p data-bbox="1272 248 1832 320">volume of H<sub>2</sub> = <math>\frac{600}{1 \times 10^6} = 6 \times 10^{-4} / 0.0006 \text{ m}^3</math></p> <p data-bbox="1272 328 1368 392"><math>n = \frac{pV}{RT}</math></p> <p data-bbox="1272 400 1305 432"><b>or</b></p> <p data-bbox="1272 432 1592 504"><math>n = \frac{1.24 \times 10^5 \times 6 \times 10^{-4}}{8.31 \times 298}</math></p> <p data-bbox="1272 552 1462 584">TE on volume</p> <p data-bbox="1272 624 1720 687"><math>n = 0.03004 / 0.0300 / 0.030 / 0.03</math> TE on volume</p> <p data-bbox="1272 735 1738 799">ratio alkene : H<sub>2</sub> = 0.01 : 0.03 / 1 : 3 <b>and</b> so there are 3 double bonds</p> <p data-bbox="1272 847 1462 879">TE on volume</p> <p data-bbox="1272 919 1794 951">Final answer with no working scores (1)</p> <p data-bbox="1272 991 1592 1023">Ignore SF including 1SF</p>	4

(Total for Question 23 = 16 marks)

Question number	Answer	Additional guidance	Mark						
24(a)	<ul style="list-style-type: none"> <li>all three numbers correct</li> </ul>	Example of table: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Number of protons</th> <th>Number of neutrons</th> <th>Number of electrons</th> </tr> </thead> <tbody> <tr> <td>26</td> <td>30</td> <td>24</td> </tr> </tbody> </table>	Number of protons	Number of neutrons	Number of electrons	26	30	24	1
Number of protons	Number of neutrons	Number of electrons							
26	30	24							

Question number	Answer	Additional guidance	Mark
24(b)	<ul style="list-style-type: none"> <li>expression to calculate relative atomic mass</li> <li>correct answer to 3SF</li> </ul>	Example of calculation: $\frac{(54 \times 5.84) + (56 \times 91.68) + (57 \times 2.17) + (58 \times 0.31)}{100}$ Relative atomic mass (= 55.911) = 55.9 TE on incorrect numbers in correct expression  Ignore units of $\text{g mol}^{-1}$ or $\text{g mol}^{-}$ Do not award other incorrect units e.g. g or %  Correct answer with some working scores (2)	2

Question number	Answer	Additional guidance	Mark
24(c)	<ul style="list-style-type: none"> <li data-bbox="383 292 613 323">• ionic equation</li>   <li data-bbox="383 443 645 475">• all state symbols</li> </ul>	<p data-bbox="1227 217 1509 248">Example of equation:</p> <p data-bbox="1227 288 1715 320"><b>(1)</b> <math>\text{Mg(s)} + \text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe(s)} + \text{Mg}^{2+}(\text{aq})</math></p> <p data-bbox="1227 363 1440 395">Allow multiples</p> <p data-bbox="1227 435 1816 467"><b>(1)</b> State symbols conditional on correct equation</p> <p data-bbox="1227 491 1921 555">Allow state symbols if equation includes correct metals combined with ions with incorrect charges e.g.</p> <p data-bbox="1227 579 1778 611"><math>3\text{Mg(s)} + 2\text{Fe}^{3+}(\text{aq}) \rightarrow 2\text{Fe(s)} + 3\text{Mg}^{2+}(\text{aq})</math></p> <p data-bbox="1227 619 1267 651">Or</p> <p data-bbox="1227 675 1738 707"><math>2\text{Mg(s)} + \text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe(s)} + 2\text{Mg}^{+}(\text{aq})</math></p> <p data-bbox="1227 746 1910 778">Allow state symbols for balanced non-ionic equation</p> <p data-bbox="1227 786 1771 818"><math>\text{Mg(s)} + \text{FeSO}_4 \rightarrow \text{Fe(s)} + \text{MgSO}_4(\text{aq})</math></p> <p data-bbox="1227 826 1384 858">or multiples</p>	2

Question number	Answer	Additional guidance	Mark																														
24(d)	<ul style="list-style-type: none"> <li>• calculation of mass of oxygen <b>and</b> working to find mol</li> <li>• calculation of mol of Fe, S and O</li> <li>• calculation of simplest whole number ratio <b>and</b> deduction of empirical formula</li> </ul>	<p>Example of calculation: mass of oxygen = 25.00 – 6.98 – 6.03 = 11.99 (g)</p> <table style="margin-left: 40px;"> <tr> <td></td> <td>Fe</td> <td>:</td> <td>S</td> <td>:</td> <td>O</td> </tr> <tr> <td>mol</td> <td><u>6.98</u></td> <td>:</td> <td><u>6.03</u></td> <td>:</td> <td><u>11.99</u></td> </tr> <tr> <td></td> <td>55.8</td> <td></td> <td>32.1</td> <td></td> <td>16.0</td> </tr> </table> <p>= 0.12509 : 0.18785 : 0.74938 Ignore SF except 1 SF in M2</p> <table style="margin-left: 40px;"> <tr> <td>ratio</td> <td>1</td> <td>:</td> <td>1.5</td> <td>:</td> <td>6</td> </tr> <tr> <td>=</td> <td>2</td> <td>:</td> <td>3</td> <td>:</td> <td>12</td> </tr> </table> <p><b>and</b> (1) empirical formula is Fe<sub>2</sub>S<sub>3</sub>O<sub>12</sub> TE on mol Fe, S and O</p> <p>Allow symbols in any order</p> <p>Correct empirical formula with no working scores (3)</p> <p>Penalise incorrect rounding / truncation of numbers once only in M2 e.g. 0.12 / 0.18 / 0.74</p> <p><b>Note</b> Allow (3) for correct working with Fe<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> but Fe<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> with no working scores (0)</p>		Fe	:	S	:	O	mol	<u>6.98</u>	:	<u>6.03</u>	:	<u>11.99</u>		55.8		32.1		16.0	ratio	1	:	1.5	:	6	=	2	:	3	:	12	<b>3</b>
	Fe	:	S	:	O																												
mol	<u>6.98</u>	:	<u>6.03</u>	:	<u>11.99</u>																												
	55.8		32.1		16.0																												
ratio	1	:	1.5	:	6																												
=	2	:	3	:	12																												

Question number	Answer	Additional guidance	Mark
24(e)	<ul style="list-style-type: none"> <li>• calculation of mol of iron(III) oxide</li>   <li>• calculation of mol of sulfur dioxide <b>and</b> mol of sulfur trioxide</li>   <li>• calculation of mass <b>and</b> mol of H<sub>2</sub>O</li>   <li>• calculation of value of x</li>   <li>• balanced equation</li> </ul>	<p>(1) Example of calculation:  <math display="block">\text{mol Fe}_2\text{O}_3 = \frac{2.00}{159.6} = 0.012531 / 1.2531 \times 10^{-2}</math></p> <p>(1) <b>and</b>  <math display="block">\text{mol SO}_2 = \frac{0.80}{64.1} = 0.0124805 / 1.24805 \times 10^{-2}</math></p> <p>(1) <b>and</b>  <math display="block">\text{mol SO}_3 = \frac{1.00}{80.1} = 0.012484 / 1.2484 \times 10^{-2}</math></p> <p>(1) mass of H<sub>2</sub>O = 6.95 – (2.00 + 0.80 + 1.00)  = 3.15 (g)</p> <p><b>and</b>  <math display="block">\text{mol of H}_2\text{O} = \frac{3.15}{18} = 0.175 \text{ (mol)}</math></p> <p>(1) Ratio SO<sub>2</sub> : SO<sub>3</sub> : H<sub>2</sub>O = 1 : 1 : 14  There must be 2FeSO<sub>4</sub> to produce SO<sub>2</sub> and SO<sub>3</sub>  So x = 7  TE on M1, M2, and M3  This mark may be awarded in M5</p> <p>(1) Example of equation:  <math display="block">2\text{FeSO}_4 \cdot 7\text{H}_2\text{O} \rightarrow \text{Fe}_2\text{O}_3 + \text{SO}_2 + \text{SO}_3 + 14\text{H}_2\text{O}</math>  Stand alone mark</p> <p>Allow multiples  Allow fractions for numbers of moles  TE on value of x in M4 provided equation is balanced  Ignore state symbols even if incorrect  See next page for alternative methods  Alternative methods for M3 and M4:</p>	5

		<p><b>Method 1</b>  mol FeSO<sub>4</sub> = 2 x 1.2531 x 10<sup>-2</sup> = 0.025062 (1)  <i>M<sub>r</sub></i> of hydrate = 6.95 / 0.025062 = 277.305  <b>and</b>  mass of water = 265.34 – 151.9 = 125.405 (g)  <b>and</b>  mol water = 125.405/18 = 6.9669 = 7 (1)</p> <p><b>Method 2</b>  mass of water = 6.95 – (2.00 + 0.80 + 1.00) = 3.15 (g)  <b>and</b>  mass of FeSO<sub>4</sub> = 3.8(0) (g) (1)</p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td style="text-align: center;">FeSO<sub>4</sub></td> <td style="text-align: center;">H<sub>2</sub>O</td> </tr> <tr> <td style="text-align: right;">mol FeSO<sub>4</sub> and water</td> <td style="text-align: center;"><u>3.80</u></td> <td style="text-align: center;"><u>3.15</u></td> </tr> <tr> <td></td> <td style="text-align: center;">151.9</td> <td style="text-align: center;">18</td> </tr> <tr> <td></td> <td style="text-align: center;">= 0.025</td> <td style="text-align: center;">0.175</td> </tr> <tr> <td style="text-align: right;">simplest ratio</td> <td style="text-align: center;">1</td> <td style="text-align: center;">7 (1)</td> </tr> </table>		FeSO <sub>4</sub>	H <sub>2</sub> O	mol FeSO <sub>4</sub> and water	<u>3.80</u>	<u>3.15</u>		151.9	18		= 0.025	0.175	simplest ratio	1	7 (1)	
	FeSO <sub>4</sub>	H <sub>2</sub> O																
mol FeSO <sub>4</sub> and water	<u>3.80</u>	<u>3.15</u>																
	151.9	18																
	= 0.025	0.175																
simplest ratio	1	7 (1)																

**(Total for Question 24 = 13 marks)**

