



## Mark Scheme (Results)

January 2021

Pearson Edexcel International Advanced  
Subsidiary Level

In Chemistry (WCH11)

Paper 1: Structure, Bonding and Introduction to  
Organic Chemistry

## **Edexcel and BTEC Qualifications**

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at [www.edexcel.com](http://www.edexcel.com) or [www.btec.co.uk](http://www.btec.co.uk). Alternatively, you can get in touch with us using the details on our contact us page at [www.edexcel.com/contactus](http://www.edexcel.com/contactus).

## **Pearson: helping people progress, everywhere**

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: [www.pearson.com/uk](http://www.pearson.com/uk)

January 2021

Publications Code WCH11\_01\_2101\_MS

All the material in this publication is copyright

© Pearson Education Ltd 2021

## 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.

Section A

Question number	Answer	Mark
1	<p><b>The only correct answer is B</b> (<math>C_3H_8</math>)</p> <p><i>A is incorrect because the empirical formula is <math>CH_2</math></i></p> <p><i>C is incorrect because the empirical formula is <math>C_2H_5</math></i></p> <p><i>D is incorrect because the empirical formula is <math>CH_2</math></i></p>	1

Question number	Answer	Mark
2	<p><b>The only correct answer is C</b> (<math>BH_3</math>)</p> <p><i>A is incorrect because there are <math>1.51 \times 10^{23}</math> atoms</i></p> <p><i>B is incorrect because there are <math>4.52 \times 10^{23}</math> atoms</i></p> <p><i>D is incorrect because there are <math>7.53 \times 10^{23}</math> atoms</i></p>	1

Question number	Answer	Mark
3	<p><b>The only correct answer is A</b> (<math>0.1 \text{ g dm}^{-3} \text{ HCl}</math>)</p> <p><i>B is incorrect because HCl has a higher concentration of chloride ions</i></p> <p><i>C is incorrect because HCl has a higher concentration of chloride ions</i></p> <p><i>D is incorrect because HCl has a higher concentration of chloride ions</i></p>	1

Question number	Answer	Mark
4	<p><b>The only correct answer is D</b> (<math>\text{CaCO}_3 + 2\text{NaCl} \rightarrow \text{CaCl}_2 + \text{Na}_2\text{CO}_3</math>)</p> <p><b>A</b> is incorrect because there are no waste products</p> <p><b>B</b> is incorrect because <math>\text{H}_2</math> has a lower <math>M_r</math> than <math>\text{Na}_2\text{CO}_3</math></p> <p><b>C</b> is incorrect because the combined <math>M_r</math> of <math>\text{H}_2\text{O}</math> and <math>\text{CO}_2</math> is lower than <math>\text{Na}_2\text{CO}_3</math></p>	1

Question number	Answer	Mark
5	<p><b>The only correct answer is B</b> (<math>^{124}_{50}\text{Sn}</math>)</p> <p><b>A</b> is incorrect because <math>^{115}_{49}\text{In}</math> has 66 neutrons</p> <p><b>C</b> is incorrect because <math>^{123}_{51}\text{Sb}</math> has 72 neutrons</p> <p><b>D</b> is incorrect because <math>^{124}_{52}\text{Te}</math> has 72 neutrons</p>	1

Question number	Answer	Mark
6	<p><b>The only correct answer is B</b> (<math>1s^2 2s^2 2p^6 3s^2 3p^6</math>)</p> <p><b>A</b> is incorrect because this is the electronic configuration of an s-block element</p> <p><b>C</b> is incorrect because this could not be the electronic configuration of the ion of a p-block element</p> <p><b>D</b> is incorrect because this could not be the electronic configuration of the ion of a Period 3 element</p>	1

Question number	Answer	Mark
7	<p><b>The only correct answer is C</b> (carbon)</p> <p><i>A is incorrect because Al is in Period 3</i></p> <p><i>B is incorrect because the element with the highest melting temperature is in Group 4</i></p> <p><i>D is incorrect because Si is in Period 3</i></p>	1

Question number	Answer	Mark
8	<p><b>The only correct answer is C</b> (Hg(l))</p> <p><i>A is incorrect because simple molecules do not conduct electricity</i></p> <p><i>B is incorrect because simple molecules do not conduct electricity</i></p> <p><i>D is incorrect because ionic compounds do not conduct electricity as solids</i></p>	1

Question number	Answer	Mark
9	<p><b>The only correct answer is A</b> (<math>N^{3-}</math>)</p> <p><i>B is incorrect because <math>F^-</math> has more protons than <math>N^{3-}</math> so greater nuclear attraction on the outer electrons</i></p> <p><i>C is incorrect because <math>Na^+</math> has more protons than <math>N^{3-}</math> so greater nuclear attraction on the outer electrons</i></p> <p><i>D is incorrect because <math>Al^{3+}</math> has more protons than <math>N^{3-}</math> so greater nuclear attraction on the outer electrons</i></p>	1

Question number	Answer	Mark
10	<p><b>The only correct answer is D</b> (<math>\text{Ca}^{2+}</math>)</p> <p><i>A is incorrect because anions do not polarise cations</i></p> <p><i>B is incorrect because anions do not polarise cations</i></p> <p><i>C is incorrect because <math>\text{K}^+</math> has a smaller charge and a greater ionic radius</i></p>	1

Question number	Answer	Mark
11	<p><b>The only correct answer is A</b> (<math>\text{C}_{60}</math> fullerene)</p> <p><i>B is incorrect because the structure of diamond is formed by a giant lattice of carbon atoms</i></p> <p><i>C is incorrect because the structure of graphene is formed by a giant lattice of carbon atoms</i></p> <p><i>D is incorrect because the structure of graphite is formed by a giant lattice of carbon atoms</i></p>	1

Question number	Answer	Mark
12	<p><b>The only correct answer is A</b> (HF)</p> <p><i>B is incorrect because there is a relatively small difference in electronegativity between oxygen and fluorine</i></p> <p><i>C is incorrect because <math>\text{BF}_3</math> is a non-polar molecule</i></p> <p><i>D is incorrect because <math>\text{CF}_4</math> is a non-polar molecule</i></p>	1

Question number	Answer	Mark
13	<p><b>The only correct answer is B</b> (corrosive)</p> <p><i>A is incorrect because this is a precaution and not a hazard</i></p> <p><i>C is incorrect because this is a precaution and not a hazard</i></p> <p><i>D is incorrect because this is not the symbol for oxidising</i></p>	1

Question number	Answer	Mark
14	<p><b>The only correct answer is C</b> (3,4,6-trimethyloctane)</p> <p><i>A is incorrect because the longest chain of carbon atoms is not seven</i></p> <p><i>B is incorrect because the longest chain of carbon atoms is not seven</i></p> <p><i>D is incorrect because the sum of the locant numbers is not the lowest</i></p>	1

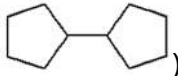
Question number	Answer	Mark
15	<p><b>The only correct answer is A</b> (burn to produce greenhouse gases)</p> <p><i>B is incorrect because they are not all carbon neutral</i></p> <p><i>C is incorrect because they are not all sustainable</i></p> <p><i>D is incorrect because they do not all biodegrade rapidly</i></p>	1



Question number	Answer	Mark
16(a)	<p><b>The only correct answer is D</b> (<math>C_5H_{10} + Br_2 \rightarrow C_5H_9Br + HBr</math>)</p> <p><i>A is incorrect because <math>C_5H_8</math> is the formula of cyclopentene and the reaction is not addition</i></p> <p><i>B is incorrect because the reaction is not addition and this product is not formed</i></p> <p><i>C is incorrect because these products are not formed</i></p>	1

Question number	Answer	Mark
16(b)	<p><b>The only correct answer is A</b> (only the initiation step involves homolytic bond fission)</p> <p><i>B is incorrect because not all of the bromine is converted to radicals in the initiation step</i></p> <p><i>C is incorrect because many more propagation than termination reactions occur</i></p> <p><i>D is incorrect because additional substitution products are likely to form</i></p>	1

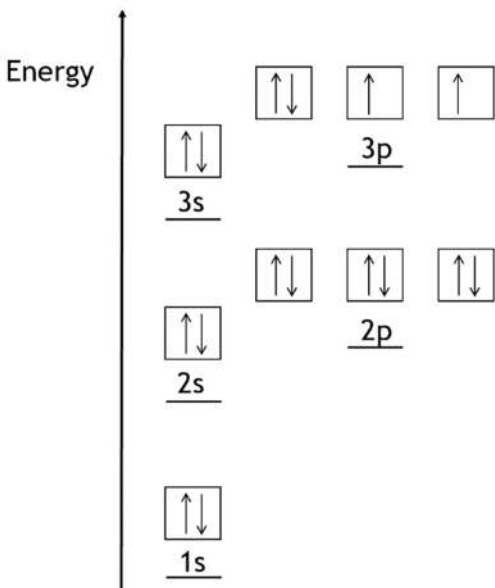
Question number	Answer	Mark
16(c)	<p><b>The only correct answer is D</b> (<math>H^\bullet</math>)</p> <p><i>A is incorrect because <math>C_5H_9^\bullet</math> radicals form in propagation reactions</i></p> <p><i>B is incorrect because <math>Br^\bullet</math> radicals form in propagation reactions</i></p> <p><i>C is incorrect because <math>C_5H_8Br^\bullet</math> radicals may form in secondary propagation reactions</i></p>	1

Question number	Answer	Mark
16(d)	<p>The only correct answer is C ()</p> <p><i>A is incorrect because the molecule does not contain 10 carbon atoms</i></p> <p><i>B is incorrect because the molecule does not contain 10 carbon atoms</i></p> <p><i>D is incorrect because the molecule does not contain 18 hydrogen atoms</i></p>	1

Question number	Answer	Mark
17	<p>The only correct answer is B (exporting polymer waste)</p> <p><i>A is incorrect because biodegradable polymers are broken down by microorganisms</i></p> <p><i>C is incorrect because this removes harmful pollution</i></p> <p><i>D is incorrect because this saves energy and conserves non-renewable resources</i></p>	1

**TOTAL FOR SECTION A = 20 MARKS**

**Section B**

Question Number	Answer	Additional guidance	Mark
18(a)	<p>A completed diagram showing:</p> <ul style="list-style-type: none"> <li>correctly labelled subshells (1)</li> <li>correctly filled boxes/orbitals (1)</li> </ul>	<p>Allow p subshell labelled as orbitals eg <math>2p_x</math>, <math>2p_y</math>, <math>2p_z</math>            Ignore specified number of electrons, even if incorrect eg <math>3p^5</math></p> <p>Allow paired 3p electrons in any 3p orbital            Allow unpaired 3p electrons as spin down            Allow half-headed arrows            Do not award vertical lines for arrows            Do not award paired electrons with parallel spin</p> <p><u>Example of completed diagram:</u></p>  <p>The diagram shows energy levels on the y-axis. From bottom to top: 1s (one box with two electrons), 2s (one box with two electrons), 2p (three boxes, each with two electrons), 3s (one box with two electrons), and 3p (three boxes: the first has two electrons, the second has one electron pointing up, and the third has one electron pointing up).</p>	2

Question Number	Answer	Additional guidance	Mark
18(b)	<ul style="list-style-type: none"><li>species and balancing</li><li>correct state symbols</li></ul>	<p>Example of equation: <math>S(g) \rightarrow S^+(g) + e^{(-)}</math> or <math>S(g) - e^{(-)} \rightarrow S^+(g)</math></p> <p>(1) Do not award multiples</p> <p><b>M2 dependent on S/S<sub>8</sub> on one side of equation and charged S<sup>+</sup>/S<sub>8</sub><sup>+</sup>/S<sup>-</sup>/S<sub>8</sub><sup>-</sup> on the other (does not need to be balanced)</b></p> <p>(1) Ignore (g) state symbol on electron</p> <p><math>S(g) + e^{(-)} \rightarrow S^+(g) + 2e^{(-)}</math> scores (1)</p>	2

Question Number	Answer	Additional guidance	Mark
18(c)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• outermost electrons in same subshell / (quantum) shell (1)</li>   <li>• Cl contains the greatest number of protons / more protons than S (1)</li>   <li>• repulsion between (paired) electrons in (3)p orbital in S (1)</li> </ul>	<p>Accept similar/same (electron) shielding            Allow same number of shells            Allow correct reference to full or partial electronic configurations for two/three elements            Do not award incorrect electronic configurations</p> <p>Accept Cl has the greatest nuclear charge            Ignore Cl has the greatest nuclear attraction            Ignore Cl has the greatest atomic number            Do not award just Cl has the greatest charge            Do not award S has the smallest nuclear charge            Allow Cl has the smallest atomic radius / smaller atomic radius than S            Do not award S had the greatest atomic radius            Do not award same/similar atomic radius            Do not award outer electron same/similar distance from nucleus            Do not award ionic/molecular radius</p> <p>There must be a mention of <b>p</b> (orbital)            Allow subshell for orbital            Do not award shell for orbital            Allow spin-spin repulsion in p orbital/subshell            Allow correct reference to stable half-full p subshell:            eg stable half-full p subshell in P            eg removing electron from S gives stable half-full p subshell            Do not award reference to bonding electrons</p>	3

Question Number	Answer	Additional guidance	Mark
18(d)(i)	<ul style="list-style-type: none"> <li>(atoms with the) same number of protons (1)</li> <li>(and) different number of neutrons (1)</li> </ul>	<p>Penalise use of species/particles/molecules for atoms once only</p> <p>Allow same atomic number Allow amount for number Ignore atoms of the same element Ignore electrons</p> <p>Ignore different mass number Do not award different number of electrons</p>	2

Question Number	Answer	Additional guidance	Mark
18(d)(ii)	<ul style="list-style-type: none"> <li>Expression for relative atomic mass (1)</li> <li>Calculation and answer to two decimal places (1)</li> </ul>	<p>Example of calculation:</p> $(A_r =) \frac{32 \times 94.88 + 33 \times 0.83 + 34 \times 4.27 + 36 \times 0.02}{100}$ <p>(<math>A_r =</math>) 32.09</p> <p>TE on transcription errors only (ie no TE on incorrect expression) Ignore units of amu / g / g mol<sup>-1</sup> Do not award any other unit</p> <p>32.09 scores (2) provided there is evidence of all four isotopes having been used in the calculation</p> <p>32.09 with no working scores (1) 32.10 with no working scores (0) 33.75 scores (0)</p>	2

Question Number	Answer	Additional guidance	Mark
18(e)(i)	<ul style="list-style-type: none"> <li><math>\frac{256}{32} = 8</math> (atoms)</li> </ul>	Allow working shown on mass spectrum Ignore calculations involving the Avogadro constant, even if incorrect Do not award just 8 (with no working)	1

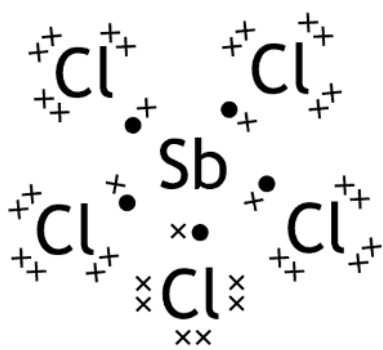
Question Number	Answer	Additional guidance	Mark
18(e)(ii)	An answer that makes reference to the following points: <ul style="list-style-type: none"> <li>(species containing) two sulfur atoms (1)</li> <li>(ion with) 1+ charge (1)</li> </ul>	Penalise isotopes other than $^{32}\text{S}$ once only  eg $\text{S}_2$ / $\text{S—S}$ Allow $\text{SS}$ / $\text{S,S}$ Ignore incorrect charge, including negative charge  <b>M2 dependent on an ion containing sulfur only</b>  $\text{S}_2^+$ / $[\text{S—S}]^+$ / $\text{SS}^+$ / $\text{S,S}^+$ scores (2)  $\text{S}_4^{2+}$ / $[\text{S}_2\text{—S}_2]^{2+}$ / $\text{S}_2\text{S}_2^{2+}$ / $\text{S}_2^+\text{S}_2^+$ / $\text{S}_2^+,\text{S}_2^+$ scores (1)	2

(Total for Question 18 = 14 marks)

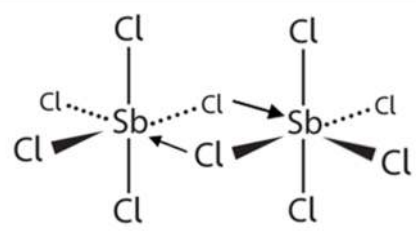
Question Number	Answer	Additional guidance	Mark								
19(a)	<p>A completed table showing:</p> <ul style="list-style-type: none"> <li>• correct number of bond pairs <b>and</b> lone pairs (1)</li> <li>• correct Cl–N–Cl bond angle (1)</li> <li>• correct name of shape (1)</li> </ul>	<p><b>Mark all points independently</b></p> <table border="1" data-bbox="1158 301 1986 799"> <tbody> <tr> <td data-bbox="1158 301 1608 379">Number of bond pairs around N atom</td> <td data-bbox="1608 301 1986 379"><u>3</u></td> </tr> <tr> <td data-bbox="1158 379 1608 459">Number of lone pairs around N atom</td> <td data-bbox="1608 379 1986 459"><u>1</u></td> </tr> <tr> <td data-bbox="1158 459 1608 596">Cl–N–Cl bond angle</td> <td data-bbox="1608 459 1986 596"><u>107<sup>(o)</sup></u> Allow 106<sup>(o)</sup> – 108<sup>(o)</sup></td> </tr> <tr> <td data-bbox="1158 596 1608 799">Name of shape of molecule</td> <td data-bbox="1608 596 1986 799">(Trigonal) <u>pyramidal</u> Allow pyramid Ignore tetrahedral Do not award bipyramidal</td> </tr> </tbody> </table>	Number of bond pairs around N atom	<u>3</u>	Number of lone pairs around N atom	<u>1</u>	Cl–N–Cl bond angle	<u>107<sup>(o)</sup></u> Allow 106 <sup>(o)</sup> – 108 <sup>(o)</sup>	Name of shape of molecule	(Trigonal) <u>pyramidal</u> Allow pyramid Ignore tetrahedral Do not award bipyramidal	<b>3</b>
Number of bond pairs around N atom	<u>3</u>										
Number of lone pairs around N atom	<u>1</u>										
Cl–N–Cl bond angle	<u>107<sup>(o)</sup></u> Allow 106 <sup>(o)</sup> – 108 <sup>(o)</sup>										
Name of shape of molecule	(Trigonal) <u>pyramidal</u> Allow pyramid Ignore tetrahedral Do not award bipyramidal										



Question Number	Answer	Additional guidance	Mark
19(b)(i)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li data-bbox="369 359 1281 395">• strong(er) (electrostatic) attraction between ions (in <math>\text{PCl}_5</math>) (1)</li> <li data-bbox="369 769 1281 805">• (than) weak intermolecular forces (in <math>\text{SbCl}_5</math>) (1)</li> </ul>	<p><b>Mark M1 and M2 independently</b> Ignore reference to solid/liquid</p> <p>Allow strong ionic bonds / strong ionic lattice Allow strong attraction between positive and negative charges Allow strong attraction between cations and anions / <math>\text{PCl}_4^+</math> and <math>\text{PCl}_6^-</math> Ignore just <math>\text{PCl}_5</math> is (giant) ionic Do not award reference to <math>\text{PCl}_5</math> molecules/ intermolecular forces Do not award reference to breaking of covalent bonds</p> <p>Accept just London/van der Waals/dispersion/ temporary-induced dipole/instantaneous-induced dipole forces Ignore just <math>\text{SbCl}_5</math> is (simple) molecular Do not award reference to breaking of covalent/ionic bonds</p> <p>Ionic bonding is stronger than intermolecular forces scores (2)</p>	2

Question Number	Answer	Additional guidance	Mark
19(b)(ii)	<p>Dot-and-cross diagram showing the following:</p> <ul style="list-style-type: none"> <li>• central Sb with five bond pairs and no lone pairs (1)</li> <li>• five Cl atoms each with one bond pair and three lone pairs (1)</li> </ul>	<p><b>Mark M1 and M2 independently</b></p> <p>Example of dot-and-cross diagram:</p>  <p>TE on M1 for three or four Cl atoms</p> <p>Allow any combination of crosses and dots</p> <p>Allow circles to indicate outer shells Ignore inner shells Ignore lines showing the covalent bonds</p>	2

Question Number	Answer	Additional guidance	Mark
19(c)(i)	<ul style="list-style-type: none"><li data-bbox="387 268 981 336">• suitable description of a dative covalent bond</li></ul>	<p data-bbox="1070 220 1704 252">For credit to be awarded, it must be clear that:</p> <ul data-bbox="1115 260 1794 384" style="list-style-type: none"><li data-bbox="1115 260 1711 292">i) a pair of / two electrons are involved</li><li data-bbox="1115 304 1704 336">ii) these electrons are shared/bonding</li><li data-bbox="1115 349 1794 381">iii) these electrons come from the same atom</li></ul> <p data-bbox="1070 440 1957 509">eg shared electrons in which both electrons come from the same atom</p> <p data-bbox="1070 560 1879 628">eg lone pair/full orbital from one atom overlaps with empty orbital of another</p> <p data-bbox="1070 679 1391 711">Allow element for atom</p> <p data-bbox="1070 719 1861 788">Allow just both electrons in the bond come from the same element</p> <p data-bbox="1070 799 1917 868">Allow one element donates/gives/shares both electrons to the bond</p> <p data-bbox="1070 879 1588 911">Allow one atom shares both electrons</p> <p data-bbox="1070 962 1957 1031">Do not award just one atom donates/gives both electrons (or any reference to ions being formed)</p> <p data-bbox="1070 1038 1682 1070">Do not award ion/molecule/species for atom</p>	<b>1</b>

Question Number	Answer	Additional guidance	Mark
19(c)(ii)	<ul style="list-style-type: none"> <li>two correct dative covalent bonds shown as arrows</li> </ul>	 <p>Ignore lone pairs shown on Cl Do not award dative bonds from any other Cl atoms</p>	1

Question Number	Answer	Additional guidance	Mark
19(d)	<p>An answer that makes reference to one of the following points:</p> <ul style="list-style-type: none"> <li>no 2d orbitals <b>or</b> (nitrogen) cannot expand its octet</li> <li><b>or</b></li> <li>(nitrogen is) too small (to bond to 5 atoms)</li> <li><b>or</b></li> <li>repulsion between electron <b>pairs</b> would be too great</li> </ul>	<p>Accept reverse arguments</p> <p>Allow no d orbitals as only two (quantum) shells Allow no d orbitals (accessible) Allow (nitrogen) cannot have more than eight electrons in its outer shell Ignore just cannot expand its outer/valence shell Ignore just nitrogen obeys the octet rule</p> <p>Ignore just (nitrogen has a) very small/smallest atomic radius Ignore Cl atoms too large Ignore nitrogen has fewest/only two shells</p> <p>Ignore just repulsion between electron pairs Ignore repulsion between Cl atoms Ignore not enough room for 5 electron pairs</p>	1

(Total for Question 19 = 10 marks)

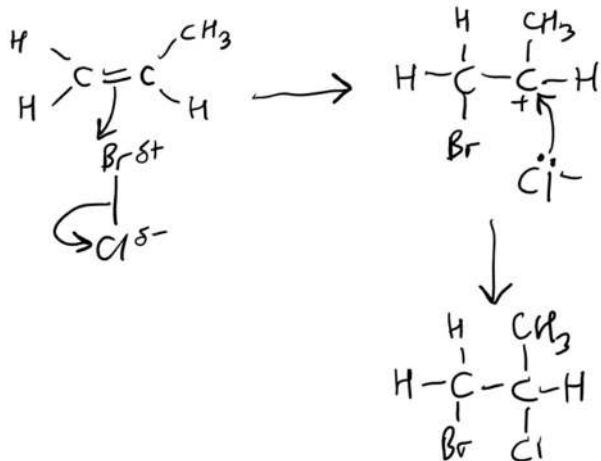
Question Number	Answer	Additional guidance	Mark
20(a)	<ul style="list-style-type: none"> <li>• balanced equation with <b>1 mol</b> C<sub>3</sub>H<sub>6</sub> and correct products (1)</li> <li>• state symbols (1)</li> </ul>	<p>Example of equation:</p> $\text{C}_3\text{H}_6(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{CO}(\text{g}) + \text{C}(\text{s}) + 3\text{H}_2\text{O}(\text{l})$ <p>Allow structural, displayed or skeletal formulae</p> <p>Allow H<sub>2</sub>O(g) Do not award H<sub>2</sub>O(aq)</p> <p>M2 dependent on correct species for the incomplete combustion of any C<sub>n</sub>H<sub>2n</sub> / C<sub>n</sub>H<sub>2n+2</sub> hydrocarbon forming CO<sub>2</sub>(g), CO(g), C(s) and H<sub>2</sub>O(l)/(g)</p> <p>If no other mark awarded, a correctly balanced equation, with correct state symbols, for the incomplete combustion of propene scores (1) eg C<sub>3</sub>H<sub>6</sub>(g) + 3O<sub>2</sub>(g) → 3CO(g) + 3H<sub>2</sub>O(l)/(g) eg 2C<sub>3</sub>H<sub>6</sub>(g) + 7O<sub>2</sub>(g) → 2CO<sub>2</sub>(g) + 4CO(g) + 6H<sub>2</sub>O(l)/(g)</p>	<b>2</b>

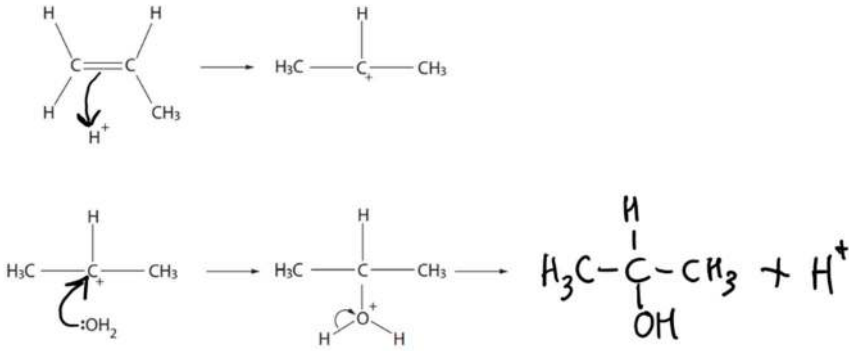
Question Number	Answer	Additional guidance	Mark
20(b)	<ul style="list-style-type: none"> <li data-bbox="371 453 1012 480">• both solutions decolourise / turn colourless</li>   <li data-bbox="371 544 976 715">• from purple with (potassium) manganate(VII)/<math>\text{KMnO}_4/\text{MnO}_4^-</math> <b>and</b> from orange with (aqueous) bromine/<math>\text{Br}_2</math></li> </ul>	<p data-bbox="1261 220 1957 411">Ignore any reference to breaking of the C=C bond / type of reaction Ignore any reference to layers / effervescence Ignore any reference to reaction products / formation of solids</p> <p data-bbox="1189 456 1709 496">(1) Ignore turn clear / change colour</p> <p data-bbox="1261 544 1854 616">Allow pink for purple or any combination of purple/pink</p> <p data-bbox="1189 663 1924 775">(1) Allow yellow or brown for orange or any combination of orange/yellow/brown Do not award any mention of red (eg red-brown)</p> <p data-bbox="1261 823 1854 1056">If neither M1 nor M2 awarded, either of the following scores (1): (potassium) manganate(VII)/<math>\text{KMnO}_4/\text{MnO}_4^-</math> decolourises from purple/pink or bromine decolourises from orange/yellow/brown</p>	2

Question Number	Answer	Additional guidance	Mark
20(c)	<ul style="list-style-type: none"> <li>poly(propene) structure containing two repeat units with extension bonds</li> </ul>	<p>Example of diagram:</p> $  \begin{array}{cccc}  & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \\  &   &   &   &   \\  \text{---} & \text{C} & \text{---} & \text{C} & \text{---} & \text{C} & \text{---} & \text{C} & \text{---} \\  &   & &   & &   & &   \\  & \text{H} & & \text{H} & & \text{H} & & \text{H}  \end{array}  $ <p>Accept CH<sub>3</sub> groups on same or opposite sides</p> <p>Allow head-to-head and tail-to-tail configurations eg</p> $  \begin{array}{cccc}  & \text{CH}_3 & \text{H} & \text{H} & \text{CH}_3 \\  &   &   &   &   \\  \text{---} & \text{C} & \text{---} & \text{C} & \text{---} & \text{C} & \text{---} & \text{C} & \text{---} \\  &   & &   & &   & &   \\  & \text{H} & & \text{H} & & \text{H} & & \text{H}  \end{array}  $ <p>Allow displayed, structural, skeletal formulae or any combination of these</p> <p>Ignore connectivity of vertical C-CH<sub>3</sub> bond</p> <p>Ignore brackets and 'n'</p>	1

Question Number	Answer	Additional guidance	Mark
20(d)(i)	<ul style="list-style-type: none"><li>• correct dipole</li></ul>	<p>Example of correct diagram:</p> $\begin{array}{ccc} \delta+ & & \delta- \\ \text{Br} & \text{---} & \text{Cl} \end{array}$ <p>Allow correct indication of net dipole moment:</p> $\begin{array}{ccc} \text{+} & \text{---} & \text{+} \\ \text{Br} & \text{---} & \text{Cl} \end{array}$ <p>Ignore horizontal arrow from Br to Cl, on or above the bond Ignore bond pair electrons on diagram Ignore lone pairs on Br/Cl Ignore electron density map Ignore double-headed curly arrow from bond to Cl Do not award full charges</p>	<b>1</b>



Question Number	Answer	Additional guidance	Mark
20(d)(ii)	<p>A mechanism showing:</p> <ul style="list-style-type: none"> <li>• curly arrow from C=C bond to (δ+)halogen <b>and</b> curly arrow from Br–Cl bond to (δ-)halogen or just beyond (1)</li> <li>• secondary carbocation (1)</li> <li>• curly arrow from lone pair on halide ion to C<sup>(+)</sup> <b>and</b> correct product (1)</li> </ul>	<p>Example of mechanism:</p>  <p>Allow displayed, structural, skeletal formulae or any combination of these</p> <p>Penalise incorrect propene structure once only</p> <p>Penalise half-headed curly arrows once only</p> <p>Allow primary carbocation for mechanism involving ethene only</p> <p>Allow curly arrow from lone pair to positive charge</p> <p>Do not award δ- on halide ion</p>	3

Question Number	Answer	Additional guidance	Mark
20(e)	<p>A mechanism showing:</p> <ul style="list-style-type: none"> <li>• curly arrow from C=C bond to H<sup>+</sup> (1)</li> <li>• curly arrow from lone pair on water to C<sup>+</sup> (1)</li> <li>• correct structure for propan-2-ol and H<sup>+</sup> (catalyst regenerated) (1)</li> </ul>	<p>Example of correct mechanism:</p>  <p>Do not award any additional curly arrows from/to/on propene/H<sup>+</sup></p> <p>Allow curly arrow from lone pair to positive charge Do not award any additional curly arrows shown in this step</p> <p>Allow any combination of displayed/structural/skeletal formulae Ignore atom connectivity except displayed C-H-O Ignore any additional curly arrows added to the central intermediate</p>	3

(Total for Question 20 = 12 marks)

Question Number	Answer	Additional guidance	Mark
21(a)	<p>Any <b>two</b> from the following:</p> <ul style="list-style-type: none"> <li>• chemically stable / inert / does not (easily) oxidise (1)</li> <li>• colourless (1)</li> <li>• odourless (1)</li> <li>• non-toxic / non-irritant (1)</li> <li>• hydrophobic / immiscible with water (1)</li> <li>• hypoallergenic (1)</li> </ul>	<p>Ignore any reference to:  carbon chain length  intermolecular forces  melting/boiling temperature  flammability/volatility  liquid/moisturising/softening/lubricating/hydrating  spreads easily/absorbed easily  natural/in human skin  cheap</p> <p>Allow unreactive / not very reactive / long shelf life / durable / does not breakdown (easily)  Ignore just stable</p> <p>Ignore transparent/clear</p> <p>Allow not harmful / non-hazardous / non-corrosive  Ignore safe</p> <p>Allow insoluble  Ignore oily</p>	2

Question Number	Answer	Additional guidance	Mark
21(b)	<ul style="list-style-type: none"><li><math>C_{30}H_{62}</math></li></ul>	Accept $H_{62}C_{30}$	1

Question Number	Answer	Additional guidance	Mark
21(c)(i)	<ul style="list-style-type: none"><li>nickel</li></ul>	Accept palladium or platinum Allow correct symbol	1

Question Number	Answer	Additional guidance	Mark
21(c)(ii)	<ul style="list-style-type: none"><li><math>0.00001 / (1 \times 10^{-5}) \text{ (g)}</math></li></ul>	Example of calculation: $\text{mass} = \frac{50}{10^6} \times 0.2 = 0.00001 \text{ (g)}$ <p>Do not award incorrect unit</p> <p>Accept <math>10 \mu\text{g}</math> / <math>0.01 \text{ mg}</math></p> <p>Allow answer as fraction eg <math>\frac{1}{10^5}</math> (g)</p> <p>Ignore SF Correct answer with no working scores (1)</p>	1

Question Number	Answer	Additional guidance	Mark
21(c)(iii)	<ul style="list-style-type: none"> <li>• conversion of temperature to K</li> <li>• rearrangement of ideal gas equation</li> <li>• evaluation to give moles of hydrogen</li> <li>• evaluation of mole ratio</li> </ul> <p><b>and</b></p> <p>number of C=C bonds per molecule of squalene</p>	<p>Example of calculation:</p> <p>(1) <math>T = 200 + 273 (= 473 \text{ K})</math></p> <p>(1) <math>n = \frac{pV}{RT}</math></p> <p>or</p> $n = \frac{4.0 \times 10^5 \times 500}{8.31 \times 473}$ <p>(1) <math>n(\text{H}_2) = 50882.429</math>            Ignore SF except 1 SF            TE on temperature            M3 dependent on correct use of ideal gas equation</p> <p><math>n(\text{H}_2) : n(\text{squalene})</math>  <math>50882 : 8500</math>  <math>6 : 1</math></p> <p>(1) 6 (× C=C bonds per molecule)            TE on <math>n(\text{H}_2)</math> provided <math>n(\text{H}_2) &gt;</math> than 8500 and answer is rounded to nearest integer</p> <p>6 (× C=C bonds per molecule) with no working scores            (1)</p> <p>2 (× C=C bonds per molecule) from use of <math>24 \text{ dm}^3 \text{ mol}^{-1}</math> as molar gas volume scores (2)</p>	<b>4</b>

<p><b>21(c)(iii)</b> <b>cont</b></p>	<p><b>Alternative route to M2, M3 and M4</b></p> <ul style="list-style-type: none"> <li>rearrangement of ideal gas equation (1)</li> <li>evaluation to give volume of squalene (1)</li> <li>evaluation of volume ratio</li> </ul> <p><b>and</b></p> <p>number of C=C bonds per molecule of squalene (1)</p>	<p><u>Example of calculation:</u></p> $V = \frac{nRT}{p}$ <p>or</p> $V = \frac{8500 \times 8.31 \times 473}{4.0 \times 10^5}$ <p><math>V(\text{squalene}) = 83.52589 \text{ (m}^3\text{)}</math> Ignore SF except 1 SF TE on temperature M3 dependent on correct use of ideal gas equation</p> <p><math>V(\text{H}_2) : V(\text{squalene})</math> 500 : 83.52589 6 : 1</p> <p>6 (× C=C bonds per molecule) TE on <math>V(\text{squalene})</math> provided <math>V(\text{squalene}) &lt; 500 \text{ (m}^3\text{)}</math> and answer is rounded to nearest integer</p>	
--	---	--	--

Question Number	Answer	Additional guidance	Mark
21(c)(iv)	<ul style="list-style-type: none"><li><math>C_{30}H_{50} + 6H_2 \rightarrow C_{30}H_{62}</math></li></ul>	<p>Ignore state symbols</p> <p>TE on (c)(iii) for any <math>C_nH_{2n+2}</math> product formula where <math>24 \leq n \leq 30</math></p> <p>If the number of C=C bonds is not stated in (c)(iii) then award (1) for an equation of the form: <math>C_nH_{2n-2y+2} + yH_2 \rightarrow C_nH_{2n+2}</math> Where <math>24 \leq n \leq 30</math> and <math>1 \leq y \leq 14</math></p>	1

Question Number	Answer	Additional guidance	Mark
21(d)(i)	<ul style="list-style-type: none"><li>(fractional) distillation</li></ul>	<p>Ignore solvent extraction</p> <p>Ignore filtration as part of the separation process</p> <p>Do not award just filtration</p> <p>Do not award chromatography</p>	1

Question Number	Answer	Additional guidance	Mark
21(d)(ii)	<ul style="list-style-type: none"> <li data-bbox="387 312 1111 432">• calculation of mass of squalene in 2.8 million dm<sup>3</sup> <b>or</b> calculation of volume of squalene per shark (1)</li>   <li data-bbox="387 539 992 571">• calculation of number of sharks required (1)</li> </ul>	<p data-bbox="1223 220 1536 252">Example of calculation:</p> <p data-bbox="1223 300 1756 336">mass = <math>2.8 \times 10^9 \times 0.86 = 2.408 \times 10^9</math> (g)</p> <p data-bbox="1223 344 1256 368"><b>or</b></p> <p data-bbox="1223 379 1637 451">volume = <math>\frac{300}{0.86} = 348.8372</math> (cm<sup>3</sup>)</p> <p data-bbox="1223 539 1921 611"><math>\frac{2.408 \times 10^9}{300} = 8.0267 \times 10^6 = 8026666.667 / 8.0 \times 10^6</math></p> <p data-bbox="1223 624 1379 647">TE on mass</p> <p data-bbox="1223 663 1256 687"><b>or</b></p> <p data-bbox="1223 699 1888 770"><math>\frac{2.8 \times 10^9}{348.8372} = 8.0267 \times 10^6 = 8026666.667 / 8.0 \times 10^6</math></p> <p data-bbox="1223 783 1406 807">TE on volume</p> <p data-bbox="1223 863 1350 887">Ignore SF</p> <p data-bbox="1223 903 1738 927">Penalise incorrect rounding once only</p> <p data-bbox="1223 943 1794 967">Correct answer with no working scores (2)</p>	2



Question Number	Answer	Additional guidance	Mark
21(d)(iii)	<p><b>Method 1</b></p> <ul style="list-style-type: none"> <li>• calculation of mass of corn starch required (1)</li> <li>• calculation of required land area in hectares (1)</li> <li>• conversion of land area from hectares to km<sup>2</sup> (1)</li> </ul> <p><b>Method 2</b></p> <ul style="list-style-type: none"> <li>• conversion of land area from hectares to km<sup>2</sup> (1)</li> <li>• calculation of required land area in km<sup>2</sup> to produce 2500 tonnes of corn starch (1)</li> <li>• calculation of required land area in km<sup>2</sup> to produce 2500 tonnes of squalene (1)</li> </ul>	<p>Ignore SF and do not penalise correct premature rounding</p> <p>Penalise incorrect rounding once only</p> <p>Penalise incorrect units in final answer only</p> <p>mass = <math>\frac{2500}{23} \times 100 = 10869.57</math> (tonnes)</p> <p>Allow conversion of mass of corn starch to kg / g</p> <p>land area = <math>10869.57 \times 0.093 = 1010.87</math> (hectares)</p> <p>land area = <math>1010.87 \times 0.01 = 10.1087 = 10</math> (km<sup>2</sup>)</p> <p><math>0.093 \times 0.01 = 0.00093 / 9.3 \times 10^{-4}</math> (km<sup>2</sup>)</p> <p>land area = <math>0.00093 \times 2500 = 2.325</math> km<sup>2</sup></p> <p>Allow conversion of mass of corn starch to kg / g</p> <p>land area = <math>\frac{2.325}{23} \times 100 = 10.1087 = 10</math> (km<sup>2</sup>)</p>	3

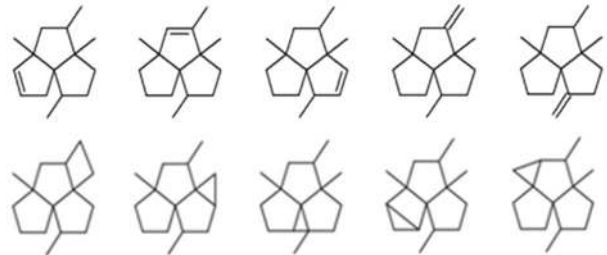
<b>21(d)(iii) cont</b>	<b>Method 3</b> <ul style="list-style-type: none"><li>• calculation of required land area in hectares to produce 2500 tonnes of corn starch (1)</li><li>• calculation of required land area in hectares to produce 2500 tonnes of squalene (1)</li><li>• conversion of land area from hectares to km<sup>2</sup> (1)</li></ul>	land area = $2500 \times 0.093 = 232.5$ (hectares) Allow conversion of mass of corn starch to kg / g  land area = $\frac{232.5}{23} \times 100 = 1010.87$ (hectares)  land area = $1010.87 \times 0.01 = 10.1087 = 10$ (km <sup>2</sup> )  If no other mark awarded, 1 tonne corn starch yields 230 kg squalene scores (1)	
----------------------------	--	---	--

Question Number	Answer	Additional guidance	Mark
21(e)(i)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"><li data-bbox="421 316 987 344">• restricted rotation about/around C=C (1)</li><li data-bbox="421 632 1223 703">• (only) central C=C has two different groups attached to each carbon of the C=C (1)</li></ul>	<p><b>Mark M1 and M2 independently</b></p> <p>Accept pi-bond for C=C Allow just double bond for C=C Allow limited/no rotation about/around C=C Allow C=C restricts rotation Allow C=C cannot rotate Ignore just restricted rotation Do not award molecule cannot rotate</p> <p>Accept C=C from 6<sup>th</sup> carbon/6-ene for central C=C Allow (only) central C=C has four different groups Allow indication of central C=C on diagram Do not award if any other C=C bond identified as <i>E/Z</i></p>	<b>2</b>



Question Number	Answer	Additional guidance	Mark
21(f)(i)	<ul style="list-style-type: none"> <li>(compounds with the) same molecular formula (1)</li> <li>different structural formula (1)</li> </ul>	<p><b>Mark M1 and M2 independently</b></p> <p>Ignore just same formula            Ignore compounds with the same atoms            Do not award same molecule            Do not award same general formula</p> <p>Allow just different structure            Allow different position of the C=C/double bonds            Allow different displayed/skeletal formulae            Ignore different arrangement of atoms (in space)</p>	2

Question Number	Answer	Additional guidance	Mark
21(f)(ii)	<ul style="list-style-type: none"> <li>four / 4</li> </ul>	Ignore <i>E/Z</i>	1

Question Number	Answer	Additional guidance	Mark
21(f)(iii)	<ul style="list-style-type: none"> <li>valid structure containing <b>one</b> C=C bond</li> <li>or</li> <li>valid structure containing <b>one</b> bridging carbon-carbon bond</li> </ul>	<p>Examples of valid structure:</p>  <p>Ignore bond lengths and bond angles</p>	1

(Total for Question 21 = 24 marks)  
**TOTAL FOR SECTION B = 60 MARKS**  
**TOTAL FOR PAPER = 80 MARKS**

Pearson Education Limited. Registered company number 872828  
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom