

## Assessment Schedule – 2014

## Chemistry: Demonstrate understanding of aspects of carbon chemistry (90932)

## Evidence Statement

ONE	Evidence	Achievement	Merit	Excellence
(a)(i)  (ii)  (iii)  (iv)  (b)  (c)	<p>Butane</p> <pre>       H H H H H H H                     H - C - C - C - C - C - C - H                           H H H H H H H           </pre> <p>(iii)</p> <pre>       H   H        \ /         C        / \       H   H           </pre> <p>Ethanol</p> <p>Covalent bonding occurs in organic compounds. These organic compounds are made of carbon and hydrogen atoms, which are <b>non-metal atoms</b>. Non-metal atoms <b>share</b> their valence <b>electrons to gain full outer shells</b>, resulting in stable bonds. Sharing electrons in a bond is covalent bonding.</p> <p><b>General formulae:</b> Alkanes (straight-chain) have the general formula <math>C_nH_{2n+2}</math> and alkenes have the general formula <math>C_nH_{2n}</math>.</p> <p><b>Similarities and differences in chemical bonding:</b> In both alkanes and alkenes, the carbon and hydrogen atoms are <b>covalently bonded</b> to each other (could be from (b)). Alkanes are <b>saturated</b> hydrocarbon molecules, where <b>each carbon atom has</b></p>	<ul style="list-style-type: none"> <li>Any 3 correct from 1(a).</li> <li>Correctly identifies that alkanes and alkenes have covalent bonding.</li> <li>Correctly identifies the general formula for EITHER alkanes or alkenes.</li> <li>Identifies / names / draws the functional group of alkenes or the lack of a functional group in alkanes.</li> </ul>	<ul style="list-style-type: none"> <li>Explains that covalent bonds share electrons to complete their valence / outer shell or energy level / gain full outer shell.</li> <li>Explains similarities and differences in the bonding of alkanes and alkenes.</li> <li>Links chemical bonding to a property (e.g. reactivity) or use for BOTH alkanes and alkenes.</li> </ul>	<ul style="list-style-type: none"> <li>Links <b>non-metal</b> atoms to the <b>sharing of valence electrons to complete a valence shell / gain full outer shell</b>, resulting in a covalent bond.</li> <li>Explains similarities and differences in the bonding of alkanes and alkenes AND Links chemical bonding to a property (e.g. reactivity), and then to a use for BOTH alkanes and alkenes.</li> </ul>

	<p><b>four single covalent bonds.</b> Alkenes are <b>unsaturated</b> hydrocarbon molecules containing mostly single covalent bonds, but also a <b>carbon–carbon double bond</b>.</p> <p><b>Chemical bonding linked to property and use:</b> Alkanes do <b>not have a functional group</b>, so they are generally <b>chemically unreactive / readily combust (property)</b>. Alkanes are commonly used as <b>fuels (use)</b>, because, while they are mostly unreactive, they do <b>undergo combustion reactions since single bonds do not require as much energy to break</b>. So a lot of energy is released as they combust.</p> <p>The <b>double bond</b> in alkenes is a <b>functional group</b> and is <b>easily broken</b>, so alkenes are <b>chemically reactive (property)</b>. Since alkenes are chemically reactive, they can also undergo other chemical reactions, and are therefore commonly <b>used to make other organic molecules such as polymers (use) since the double bond easily breaks to form long chain</b>.</p>	<ul style="list-style-type: none"> <li>• Describes the reactivity of EITHER alkanes or alkenes.</li> </ul>	<ul style="list-style-type: none"> <li>• Links chemical bonding to a property (e.g. reactivity), and then to a use for EITHER alkanes or alkenes.</li> </ul>	
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NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence	1a	2a	3a	4a	2m	3m	2e with minor error or omission	2e

TWO	Evidence	Achievement	Merit	Excellence
<p>(a)</p> <p>(b)</p> <p>(c)</p>	<p><math>C_{10}H_{22} \rightarrow C_5H_{12} + C_2H_4 + C_3H_6</math></p> <p><b>Large</b> organic molecules are <b>inefficient fuels</b> because they do <b>not flow easily</b> and are <b>hard to ignite</b> (not volatile enough – ie not easily made gaseous). They need to be cracked into <b>smaller molecules</b> that do <b>burn more efficiently</b>. Cracking also produces <b>small alkenes</b>, which are useful in making many other carbon compounds, including <b>polymers</b>.</p> <p>Ethane is an alkane containing <b>only single (covalent) bonds</b>.</p> <pre>       H   H                 H-C---C-H                   H   H   </pre> <p>The single bonds are <b>stable</b>, so ethane does <b>not react</b> to form the long chains of a polymer.</p> <p>Ethene is an alkene containing a <b>double (covalent) bond</b>, which acts as a <b>functional group</b> / is <b>reactive</b> / is <b>easily broken</b>, allowing ethene to act as a monomer.</p> <pre>       H     H        \   /         C=C        /   \       H     H   </pre> <p>(In high temperatures and high pressures, with a catalyst) the <b>double bond breaks</b> in the ethene molecules, allowing the different molecules to join together with single covalent bonds forming a long chain called a polymer. Ethene makes polyethene.</p> <pre>   [  H   H   ]    [  C=C  ]    [  H   H   ]   ]_n   </pre> <p>many ethene molecules</p> $\longrightarrow$ <pre>       H H H H H H H H                           -C-C-C-C-C-C-C-C-                             H H H H H H H H   </pre> <p>poly (ethene)</p>	<ul style="list-style-type: none"> <li>Two product formulae correct.</li> <li>Identifies that large organic molecules do not make good fuels / cannot be used to make polymers.</li> <li>Identifies ethane has all single bonds (saturated) and ethene has a double bond (unsaturated). Evidence could be from diagrams.</li> </ul>	<ul style="list-style-type: none"> <li>Equation is completed correctly.</li> <li>Explains why large organic molecules do not make good fuels / cannot be used to make polymers (no C=C bond).</li> <li>Explains why ethane cannot form polymers. OR Explains why ethene can form polymers.</li> </ul>	<ul style="list-style-type: none"> <li>Links explanation of why large organic molecules do not make good fuels and an explanation of how cracking makes smaller molecules that are more efficient fuels / useful in making other compounds, e.g. alkenes make polymers, ethene makes ethanol for solvent use, etc.</li> <li>Links the explanation for why ethane cannot form polymers to the explanation for why ethene can form polymers. (<i>Conditions for polymerisation are not required, neither are diagrams.</i>)</li> </ul>

(d)	<p><b>Chemical structure and bonding:</b> They are both made up of <b>long chains of carbon atoms</b> bonded together with <b>single covalent bonds</b>.</p> <p>polyethene section</p> $\begin{array}{cccc} & \text{H} & \text{H} & \text{H} & \text{H} \\ &   &   &   &   \\ - & \text{C} & - \text{C} & - \text{C} & - \text{C} - \\ &   &   &   &   \\ & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ <p>polypropene section</p> $\begin{array}{cccc} & \text{H} & \text{H} & \text{H} & \text{H} \\ &   &   &   &   \\ - & \text{C} & - \text{C} & - \text{C} & - \text{C} - \\ &   &   &   &   \\ & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \end{array}$ <p><b>Chemical reactivity:</b> Since <b>neither has a functional group / only have single covalent bonds</b>, they are <b>both unreactive</b> (non-biodegradable), which means they will <b>not break down in the oceans, so polyethene and polypropene float on the ocean's surface</b>.</p>	<ul style="list-style-type: none"> <li>Describes or draws the chemical structure / bonding of both polymers. OR Identifies that neither polymer has a functional group. OR States that the polymers are non-biodegradable / unreactive / do not naturally break down.</li> </ul>	<ul style="list-style-type: none"> <li>Explains why the polymers are non-biodegradable / unreactive / do not naturally break down.</li> </ul>	<ul style="list-style-type: none"> <li>Links explanation of why the polymers are non-biodegradable / unreactive / do not naturally break down, resulting in the floating islands of plastic in the ocean. (Diagrams not required).</li> </ul>
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NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence	1a	2a	3a	4a	2m	3m	2e	3e

THREE	Evidence	Achievement	Merit	Excellence
(a)	<p>The boiling point of a chemical is the <b>temperature</b> at which the chemical changes from the <b>liquid state to the gaseous state</b>.</p> <p><i>(Technically the boiling point is the temperature at which the vapour pressure of a liquid equals the external pressure surrounding the liquid. Therefore, the boiling point of a liquid depends on atmospheric pressure. The boiling point becomes lower as the external pressure is reduced. However, this is beyond what we would reasonably expect at Level 1.)</i></p>	<ul style="list-style-type: none"> <li>Defines the term boiling point as the temperature at which a liquid becomes a gas.</li> </ul>		
(b)	<p><b>Describe the trend:</b></p> <p>As the number of carbon atoms increases in the alkane family, the boiling point increases.</p> <p><b>Explain the trend:</b></p> <p>As the number of carbon atoms increases, the molecules also increase in size, resulting in a larger / stronger attractive force between the molecules. This results in more heat energy being required to separate the molecules to allow them to become gases.</p>	<ul style="list-style-type: none"> <li>States that the boiling points increase as the number of carbon atoms increases.</li> </ul>	<ul style="list-style-type: none"> <li>Explains that the larger the molecule, the larger / stronger the attractive force between the molecules.</li> </ul> <p>OR</p> <p>Explains that more heat energy is required to separate the molecules the larger they get.</p> <p>OR</p> <p>Explains that as the number of carbon atoms increases, the larger / stronger the attractive force between molecules.</p>	<ul style="list-style-type: none"> <li>Links the number of C atoms / size of molecule to the relative strength of the forces between the molecules, the energy required to separate the molecules, and their boiling points.</li> </ul>
(c)	<p><b>Structure and chemical bonding:</b></p> <p>Ethane and ethanol <b>both contain 2C and 6H atoms, but ethanol also has an additional oxygen atom</b> which forms a hydroxyl group, -OH.</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{H} &amp; \text{H} \\   &amp;   \\ \text{H}-\text{C}-\text{C}-\text{H} \\   &amp;   \\ \text{H} &amp; \text{H} \end{array}</math> <p>ethane</p> </div> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{H} &amp; \text{H} \\   &amp;   \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\   &amp;   \\ \text{H} &amp; \text{H} \end{array}</math> <p>ethanol</p> </div> </div> <p><b>Both ethane and ethanol contain single covalent bonds.</b></p>	<ul style="list-style-type: none"> <li>Accurately describes or draws the chemical structure of ethane and ethanol.</li> <li>States ethanol has strong attractions between molecules / ethane has weak attractions between molecules.</li> </ul> <p>OR</p> <p>States ethanol is attracted to water / ethane is not attracted to water.</p>	<ul style="list-style-type: none"> <li>Explains solubility in terms of chemical structure and lack of attractions / attractions between ethane and water, and ethanol and water, respectively.</li> <li>Explains the boiling point in terms of chemical structure and the attractions between ethane and ethanol molecules.</li> </ul>	<ul style="list-style-type: none"> <li>Compares and contrasts the <b>bonding</b> and <b>structure</b> of each compound to each other to allow explanations for the differences in solubility and boiling points.</li> </ul> <p><i>(Must compare and contrast to get Excellence – not just writing explanations).</i></p>

	<p><b>Link to solubility:</b> Ethane is not soluble in water as there are <b>no attractions between ethane and water</b>. However, ethanol is an alcohol that is soluble in water because (they both contain –OH groups) they are <b>attracted to each other</b>.</p> <p><b>Link to boiling point:</b> Ethane has a lower boiling point than ethanol because it has <b>weaker attractions between the molecules</b>, so does <b>not need as much heat energy</b> (<i>do not accept temperature</i>) to boil.</p>		<ul style="list-style-type: none"> <li>Explains BOTH physical properties for either ethane or ethanol. (<i>May not have compared and contrasted</i>).</li> </ul>	
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NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence	1a	2a	3a	4a	2m	3m	2e minor error / omission allowed.	2e

FOUR	Evidence	Achievement	Merit	Excellence
(a)	$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{H} \\   \\ \text{H} \\ \text{methane} \end{array} \quad \begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{O}-\text{H} \\   \\ \text{H} \\ \text{methanol} \end{array}$	<ul style="list-style-type: none"> <li>Both structures correct.</li> </ul>		
(b)(i)	$\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2$ <p style="text-align: center;">Ni</p> <p><i>(Catalysts and heat are not required in the equations).</i></p>	<ul style="list-style-type: none"> <li>Most formulae correct in (i) and (ii), i.e. one incorrect formula allowed in each of (i) and (ii).</li> </ul>	<ul style="list-style-type: none"> <li>All formulae correct but equations not balanced.</li> </ul>	<ul style="list-style-type: none"> <li>Both equations correct in (b). <i>(States, catalysts and heat are not required in balanced equations).</i></li> </ul>
(ii)	$\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$ <p style="text-align: center;">250°C Cu-Zn</p>			
(c)	<p><b>Describe combustion reactions:</b></p> <p><b>Methanol</b> undergoes <b>complete combustion</b> (since it burns with an almost invisible flame) to produce <b>carbon dioxide</b> gas and <b>water vapour</b>.</p> $\text{CH}_3\text{OH}(l) + 1\frac{1}{2} \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g)$ <p><b>Methane</b> undergoes <b>incomplete combustion</b> (since it burns with an orange, probably sooty flame) to produce <b>carbon</b> (soot), <b>carbon monoxide</b>, (carbon dioxide), and <b>water vapour</b>.</p> $2\text{CH}_4(g) + 2\frac{1}{2} \text{O}_2(g) \rightarrow \text{C}(s) + \text{CO}(g) + 4\text{H}_2\text{O}(g)$ <p>(or any appropriate variation of incomplete combustion).</p> <p><b>Effects of combustion:</b></p> <p><b>Complete combustion of methanol</b> produces <b>carbon dioxide gas and water vapour</b>, both of which are <b>greenhouse gases</b>, so they contribute to the greenhouse effect / global warming.</p> <p><b>Incomplete combustion in methane</b>, as well as producing carbon dioxide and water vapour, can also produce <b>carbon particles</b>, which can cause <b>asthma</b> and other respiratory problems in people, <b>visual pollution in the environment</b>, eg blackening of limestone walls and monuments, and <b>slow photosynthesis</b> by coating leaves. It also produces <b>carbon monoxide, which is toxic to humans</b>, and can, in extreme situations, result in death since it <b>replaces oxygen in the blood supply</b>.</p>	<ul style="list-style-type: none"> <li>Correctly identifies methanol as the substance undergoing complete and methane undergoing incomplete combustion.</li> <li>Identifies products of complete and incomplete combustion correctly.</li> <li>Describes one effect of either type of combustion on the environment or human health.</li> </ul>	<ul style="list-style-type: none"> <li>Links methanol and methane to the correct type of combustion and products OR Relates one type of combustion to TWO effects on the environment or human health. OR Relates each type of combustion to ONE effect on the environment or human health (TWO effects total).</li> <li>Writes ONE unbalanced symbol equation, with all formulae correct.</li> </ul>	<ul style="list-style-type: none"> <li>Links methanol and methane to the correct type of combustion and products. AND Relates each type of combustion to ONE effect on the environment or human health (TWO effects total).</li> <li>Writes ONE balanced symbol equation from (c). <i>(States are not required).</i></li> </ul>

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence	1a	2a	3a	4a	2m	3m	Excellence level explanation plus balanced equation(s) from either (b) OR (c).	Excellence level explanation plus balanced equations from (b) AND (c)

**Cut Scores**

	<b>Not Achieved</b>	<b>Achievement</b>	<b>Achievement with Merit</b>	<b>Achievement with Excellence</b>
<b>Score range</b>	0 – 10	11 – 17	18 – 24	25 – 32