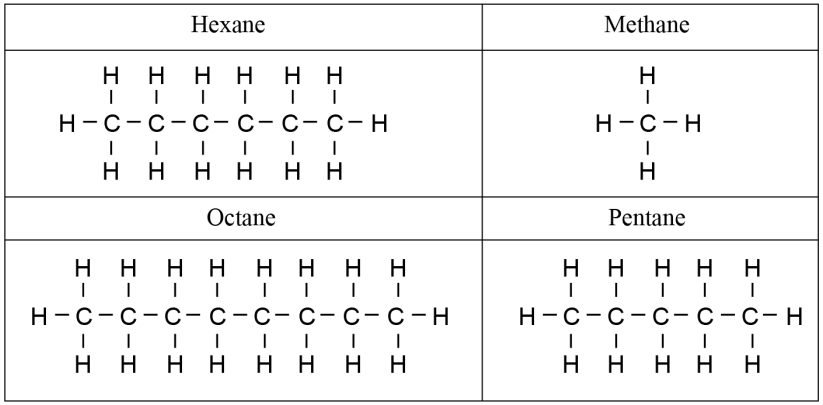
Assessment schedule – 2021

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

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i)		• Three correct structures.		
(b)(i)	True Reason: Hydrocarbons are composed of only carbon and hydrogen atoms, and all four of these substances have only carbon and hydrogen atoms.	• (i) or (ii) correct with reason.		
(ii)	False Reason: These compounds are alkanes as they only contain single covalent bonds between C atoms. They would need to have at least one double covalent bond between C atoms to be an alkene.			
(iii)	False Justification: When alkanes burn with a limited supply of air / oxygen / incompletely they do still produce water, but carbon monoxide and / or carbon (soot) are produced instead of carbon dioxide, since there is not enough oxygen for all of the carbon to react to produce carbon dioxide. When alkanes burn with a plentiful / excess supply of air / oxygen, they burn completely and produce water and carbon dioxide.	• (iii) or (iv) correct with valid reason	• (iii) correct with explanation of possible products during incomplete combustion.	

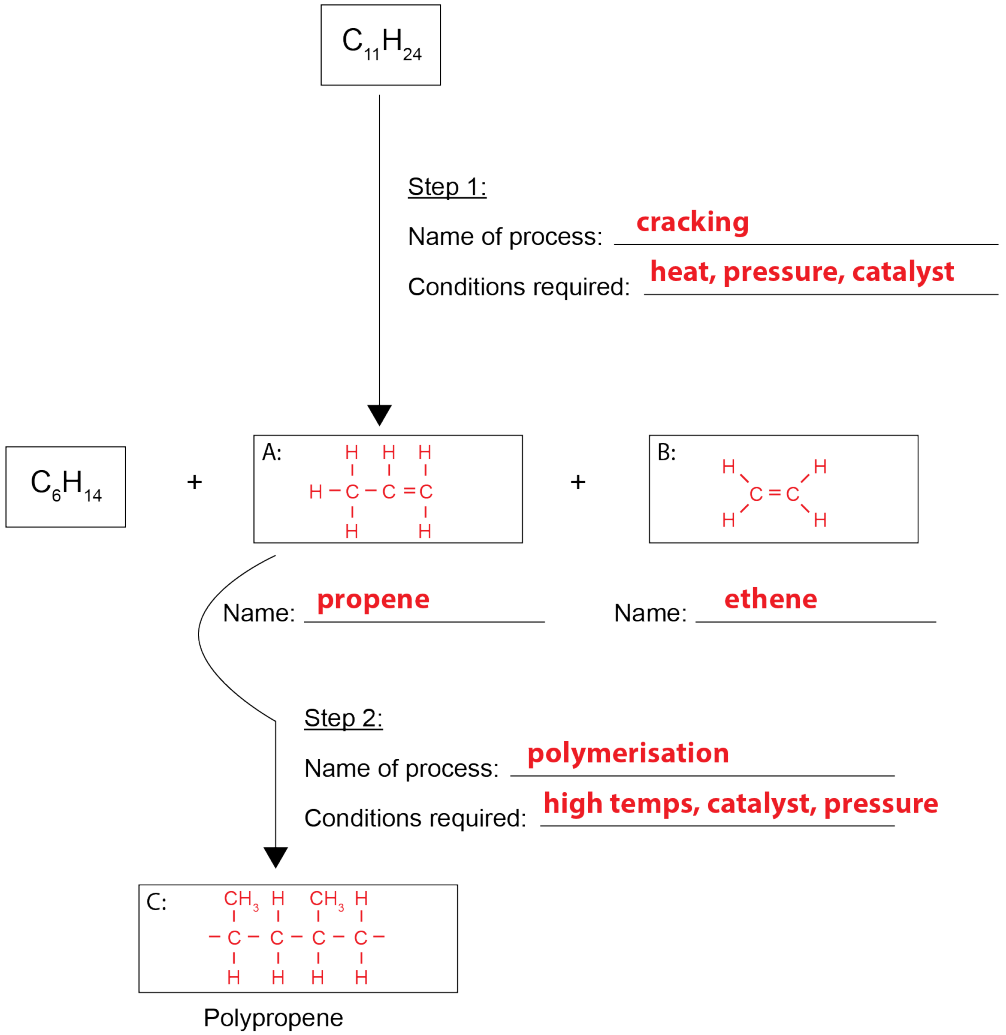
(iv)	False Justification: Methanol burns cleanly in air as it already contains an oxygen atom, reducing the amount of oxygen gas that is needed from the atmosphere for complete combustion to occur AND There is no relationship between the production of methanol from natural gas and its combustion outcome.		• (iv) correct with full explanation.	
(c)(i)	The process of fermentation involves the conversion of a solution of glucose molecules (in water / moisture) into ethanol and carbon dioxide in warm, anaerobic conditions using yeast as a catalyst. Yeast is a living organism and requires warmth and moisture to carry out fermentation / anerobic conditions is without a supply of oxygen otherwise the fermentation products will be different. Equation: $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$	• Glucose is converted into ethanol.	• Explains the process with links to the conditions required. OR ONE unbalanced symbol equation (i) fermentation or (ii) combustion.	• Fermentation process explained fully, including all required conditions. AND ONE equation from (i) OR (ii) correctly balanced.
(ii)	Complete combustion of ethanol equations: ethanol + oxygen → carbon dioxide + water $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$	• Word equation completed correctly.		
(iii)	Advantages of burning ethanol compared to burning petrol include: • Ethanol contains fewer C atoms than fuels such as petrol, so less greenhouse gas emissions (CO_2), which contribute to climate change / global warming due to increased trapping of infra-red radiation / heat and this affects the environment with rising sea levels / melting of polar ice / unusual weather changes etc. OR CO_2 is absorbed by the ocean / reacts with water in clouds to form (carbonic) acid and this decreases the pH of the ocean, affecting marine ecosystems OR causes acid rain which can erode buildings, etc. • Cleaner burning than fuels such as petrol (which are more likely to undergo incomplete combustion); produces less C / soot. These carbon particles can produce visual pollution in the environment, e.g. blackening of limestone walls and monuments as carbon particles are deposited on them, or slow down photosynthesis due to carbon particles coating leaves, which prevents entry / exit of gases and water, or carbon particles in waterways affecting fish and plants, etc. • Ethanol is renewable, whereas fuels such as petrol are non-renewable. Renewable fuels are produced from plants which remove carbon / carbon dioxide from the atmosphere as they grow, resulting in lower net / overall contributions to greenhouse gas emissions when combusted. Non-renewable hydrocarbon-based fuels only add further carbon / carbon dioxide into the atmosphere, without taking any away, resulting in greater impacts to greenhouse gas levels. Allow for other valid advantages.	• Gives one advantage of using ethanol as a fuel. OR • Gives one disadvantage of using petrol as a fuel.	• Links an advantage of burning ethanol to a reason. OR • Links a disadvantage of burning petrol to a reason.	• Discusses TWO advantages of using ethanol over petrol as a fuel. Must include explanation of effects on environment.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	1e	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	A: methanol B: heptane C: ethanol Compound B is heptane as it is an alkane, which means it is insoluble in water because the attraction between heptane and water is less than the attraction between heptane molecules. It also has the highest boiling point due to the greater molecular mass / number of C atoms, which requires more energy to overcome and form a gas. Compounds A and C are the two alcohols since they are soluble in water, which is because they contain an –OH group. This means that the **attractions between the alcohols and water are greater than the attractions between alcohol molecules**. Compound A is methanol and Compound C is ethanol since Compound A has a **lower boiling point**. Methanol has a **lower molecular mass / number of C atoms** than ethanol, **so less heat energy is required to overcome the forces of attraction** between molecules and form gaseous molecules.	• All three compounds correct. • One description of solubility OR boiling point.	• Explains solubility with reference to attractions between compound – water, and compound – compound. • Links greater number of carbons / higher molecular mass to increased forces between molecules to more heat **energy** required to overcome and hence a higher boiling point.	Fully justifies all three choices with reference to structure and properties of all three compounds.
(b)	Butane gas burner warning: If butane gas burners are used indoors or in confined spaces, **incomplete** combustion can occur due to a **shortage of oxygen**. If there is enough oxygen for complete combustion to occur, then carbon dioxide and water will be produced, which do not affect human health. However, if there is a shortage of oxygen then incomplete combustion occurs and **C (soot) and CO are produced**, which are harmful to human health. C (soot) can be **inhaled** and cause **respiratory problems** and damage the heart; it is also a carcinogen. CO is a poisonous gas, as it **binds to red blood cells** (preventing oxygen binding) leading to oxygen deficiency, and may cause death. Balanced symbol equations for combustion of butane: Sufficient oxygen / complete combustion $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ (or $C_4H_{10} + 6½O_2 \rightarrow 4CO_2 + 5H_2O$) Limited oxygen / incomplete combustion $2C_4H_{10} + 9O_2 \rightarrow 8CO + 10H_2O$ (Accept balanced alternatives with different # CO and C.) Equations may have C and / or CO.)	• States that incomplete combustion may occur. • States a product of incomplete combustion. • States a valid effect of incomplete combustion on human health.	• Explains that incomplete combustion may occur due to lack of oxygen / air indoors or in confined space. OR Explains that complete combustion will only occur if sufficient oxygen / air in open space. • Gives unbalanced symbol equation for either complete or incomplete combustion of butane. • Full explanation of ONE product of incomplete combustion to an effect on human health.	Explains TWO effects of incomplete combustion products on **human health.** AND Correct balanced equation for incomplete or complete combustion.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	1e	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)(i)	A: methane, CH_4 B: nonane, C_9H_{20} C: eicosane, $C_{20}H_{42}$	• Correct identification of all 3 fractions OR Methane has the lowest boiling point, then nonane, then eicosane.		
(ii)	Crude oil consists of a mixture of hydrocarbons, including alkanes, of different sizes. A distillation tower can be used to separate different alkanes because of their different molecular masses and hence different boiling points. Smaller molecules have a smaller mass and therefore weaker intermolecular forces between molecules and hence lower boiling points. As shown in the diagram, heated crude oil containing hydrocarbons, including eicosane, methane and nonane, enters the tower near the base. The column is hotter at the bottom and cooler at the top. In the tower smaller hydrocarbons with lower boiling points are collected higher up in the tower while larger molecules with higher boiling points are collected lower down in the tower. The vapour, containing methane (A) rises to the top since it has a low molecular mass (only 1 C atom) and having a very low boiling point, it remains a gas at the lower temperature. The top of the tower is not cool enough to condense the methane, so it leaves as gaseous molecules. Nonane has a higher molecular mass than methane (9 carbons) and so has a higher boiling point than methane. The vapour containing nonane (B) rises about halfway up the tower where the temperature is lower that its boiling point and then condenses as the particles hit the cool 'caps', and the liquid containing nonane is collected and leaves the tower. Eicosane has the highest molecular mass of the three compounds (20 carbons) and so has the highest boiling point. The vapour containing eicosane does not rise very far in the tower before it reaches a temperature lower than its boiling point and so the particles hit the caps and condense to form liquid eicosane, which leaves the tower at point C.	• Recognises the separation of the (lighter and heavier) fractions depends on differences in the boiling points. OR Recognises that the top of the tower is cooler / bottom of tower is hotter.	• Correct identification of fractions. AND Links the size of TWO of the hydrocarbons A, B, C to their boiling points and where the fraction collects in the tower.	• **Comprehensive description of distillation tower,** separation process of the two selected compounds in the distillation tower with **links** to molecular mass, boiling point, and place in the tower where the fractions are collected.

(b)(i)		• Steps 1 and 2 are correctly named. • Describes conditions for either Step 1 or 2. • TWO compounds correct.	• All THREE Achieved points correct	

(ii)	C_6H_{14} is an alkane, so only contains carbon to carbon single bonds. For a hydrocarbon to undergo polymerisation, it must contain a carbon-to-carbon double bond, which can be broken. The carbon atoms will then form single bonds with neighbouring monomers / molecules to form a long chain molecule. Therefore C_6H_{14} (hexane) cannot form polypropene (or any other polymer). Ethene does contain carbon-to-carbon double bonds and can therefore undergo polymerisation when the carbon-to-carbon double bonds are broken, and single covalent bonds are formed between carbon atoms of neighbouring molecules, forming a long carbon chain molecule (polyethene). However, it only contains two carbon atoms, so when it undergoes polymerisation, both carbon atoms in the monomer unit bond with carbon atoms on neighbouring molecules. Ethene cannot form compound C, polypropene, as it does not contain a third carbon atom (as propene does) to form methyl groups along the chain of carbon atoms.	• Recognises that C=C required for polymerisation.	• Explains why C_6H_{14} cannot form polypropene. AND Identifies that ethene only contains two carbons so cannot form polypropene. OR Full explanation of C_6H_{14} linking to polymerisation process.	• Comprehensive explanation of why C_6H_{14} and ethene cannot be used to make polypropene, with reference to their structures, and the structure of polypropene.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	1m	2m	1e	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 8	9 – 12	13 – 18	19 – 24