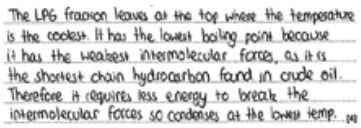
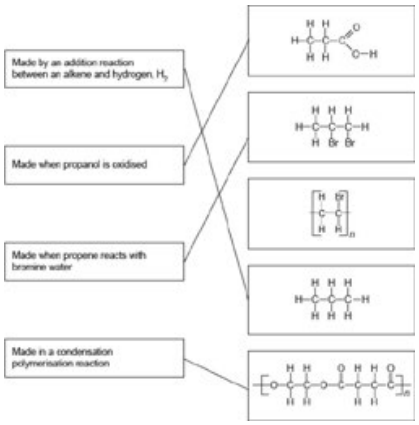
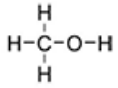
Mark scheme

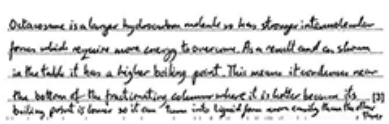
Question			Answer/Indicative content	Marks	Guidance
1	a		$C_{10}H_{22}$ ✓	1 (AO 2.1)	**DO NOT ALLOW** C10H22 / $C^{10}H^{22}$ **Examiner's Comments** Most candidates correctly stated $C_{10}H_{22}$. Some candidates followed the example of methane and gave an incorrect response of $C_{10}H_{40}$ and lower attaining candidates tended to give the name, decane, rather than the formula.
	b		$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ Formulae ✓ Balancing ✓	2 (2 x AO 2.1)	**ALLOW** any correct multiple, including fractions **ALLOW** = for → **DO NOT ALLOW** and / & instead of '+' **IGNORE** state symbols Balancing mark is dependent on the correct formulae but **ALLOW 1** mark for a balanced equation with a minor error in subscripts / formulae e.g. $Ch_4 + 2O_2 \rightarrow Co_2 + 2H2O$ **Examiner's Comments** Most candidates were able to write the correct balanced symbol equation. The most common error was giving H_2, usually instead of H_2O, as a product.
	c		Carbon / C ✓	1 (AO 1.1)	**ALLOW** soot **IGNORE** particulates **Examiner's Comments** Most candidates stated hydrogen instead of carbon/soot.
	d		Idea that (fractionating) column has a temperature gradient and is cooler at the top ✓ Idea that LPG fraction contains small molecules / propane and/or butane are small molecules ✓	4 (4 x AO 1.1)	**ALLOW** short chain for small molecules **ALLOW** bonds between molecules for forces between molecules

			Intermolecular forces between smaller molecules are weak(er) / intermolecular forces between propane and/or butane are weak(er) / LPG has weak(er) intermolecular forces ✓ The weaker the intermolecular forces the lower the boiling point or less energy is required to break these forces ✓		**DO NOT ALLOW** references to covalent bonds **ALLOW** fewer intermolecular forces for weak(er) intermolecular forces **ALLOW** heat for energy **DO NOT ALLOW** references to covalent bonds **Examiner's Comments** This question differentiated between candidates well. A common misconception was that because the LPG fraction leaves at the top of the column there are strong intermolecular forces between molecules and hence the fraction has a high boiling point. Many candidates gained 3 marks often missing that the LPG fraction contains small molecules or the idea that the fractionating column has a temperature gradient. Exemplar 1  The LPG fraction leaves at the top where the temperature is the coolest. It has the lowest boiling point because it has the weakest intermolecular forces, as it is the shortest chain hydrocarbon found in crude oil. Therefore it requires less energy to break the intermolecular forces so condenses at the lowest temp. [4] This response states that the fractionating column is coolest at the top. The idea that the LPG fraction contains small molecules, so has weaker intermolecular forces which need less energy to break is clearly stated. This response was given 4 marks. Lower attaining candidates often referred to breaking bonds, rather than intermolecular forces.
	e		Petrochemical ✓	1 (AO 1.1)	**Examiner's Comments** Very few candidates could recall that crude oil is a feedstock for the petrochemical industry, as stated in topic C6.2 of the specification.

	f		 ✓ ✓ ✓ ✓	4 (4 x AO 2.1)	**Examiner's Comments** Most candidates gained 4 marks for this question. The most common error was linking 'Made when propene reacts with bromine water' to the polymer poly(bromoethane), the third option in the list on the right.
			Total	**13**	
2			A ✓	1 (AO 1.1)	**Examiner's Comments** Selecting B or C were common misconceptions in this question, probably because candidates recalled that water is made in a hydrogen/oxygen fuel cell. Candidates should be encouraged to take note of key words written in **bold** in a question, as **anode** was in this question.
			Total	**1**	
3			A ✓	1 (AO 1.1)	**Examiner's Comments** Only the higher attaining candidates correctly answered A, with C being a very common incorrect answer as water is the product in many condensation polymerisation reactions.
			Total	**1**	
4			A ✓	1 (AO 1.1)	
			Total	**1**	
5			B ✓	1 (AO 1.1)	
			Total	**1**	
6	a	i	Addition ☐ Condensation ☑ ✓	1 (AO 1.1)	**Examiner's Comments** Most candidates correctly identified

			Decomposition ☐ Neutralisation ☐		the reaction as a condensation reaction.
		ii	Water ✓	1 (AO 1.1)	**ALLOW** H_2O **Examiner's Comments** Water was usually correctly given as the answer; however, hydrogen was a common incorrect response.
	b	i	 -O-H group correctly bonded to C ✓ Rest of structure correct ✓	2 (2 × AO 1.1)	Bond between O and H **must** be shown for MP1, but MP2 can still be awarded if shown as -OH **Examiner's Comments** The most common error in this question was the omission of the covalent bond between the O and the H atom. However, over half of all candidates were successful and were given 2 marks.
		ii	−OH / OH ✓	1 (AO 1.1)	**ALLOW** hydroxy / hydroxyl ✓ **IGNORE** alcohol **DO NOT ALLOW** hydroxide **Examiner's Comments** **Misconception** A common misconception was stating the function group as 'alcohol'.
	c		Potassium manganate(VII) / $KMnO_4$ ✓	1 (AO 1.2)	**ALLOW** potassium permanganate / just potassium manganate **ALLOW** potassium dichromate(VI) **Examiner's Comments** This question was quite challenging for the majority of candidates. Only high attaining candidates were able to state that potassium manganate(VII) is the oxidising agent. Oxygen was the most common incorrect response.

			Total	**6**	
7	a		Idea that the higher the number of carbon atoms the less the energy given out / **ORA** ✓	1 (AO 3.1a)	**Examiner's Comments** A good majority of candidates gained 1 mark here. Lower attaining candidates stated that as the number of carbon atoms increased, the energy given out increased.
	b	i	Any value in range 375 – 400 (°C) ✓	1 (AO 3.2a)	Note – Boiling point of tetracosane is 391°C **Examiner's Comments** Most candidates correctly predicted the boiling point of tetracosane within the allowable range.
		ii	**Any three from:** Octacosane has a higher boiling point ✓ Octacosane contains large(r) molecules ✓ Idea that the (fractionating) column is hotter at the bottom / cooler at the top ✓ The larger the molecule the greater or stronger the intermolecular forces ✓ The greater or stronger the intermolecular forces the more energy needed to break them ✓ The greater or stronger the intermolecular forces the higher the boiling point ✓ The more energy needed to break the intermolecular forces the higher the boiling point ✓	3 (3 × AO 1.1)	**ALLOW** fractions lower down the fractionating column for octacosane **IGNORE** melting point **ALLOW** octacosane is a long hydrocarbon chain / idea that octacosane contains more carbon atoms **ALLOW** the larger the molecule the more intermolecular forces **ALLOW** intermolecular bonds for intermolecular forces **Examiner's Comments** Successful responses to this question made the link that molecules separated lower down the fractionating column have stronger intermolecular forces, which require more energy to break, and hence have higher boiling points. Less successful candidates tended to suggest that intermolecular forces between atoms were broken. Exemplar 2

					 This response identified that octacosane is a larger molecule and then made a clear link between molecular size, the strength of the intermolecular forces and the energy required to overcome the forces. The response scored all 3 marks in the first sentence, but also then correctly stated that octacosane has a higher boiling point and appreciated that the fractionating column is hotter at the bottom.
	c		($C_{28}H_{58} \rightarrow C_{12}H_{26}$ +) **$8C_2H_4$** Formula of ethene ✓ Balancing ✓	2 (2 × AO 2.2)	**ALLOW** any correct multiple, including fractions **ALLOW** $C_{16}H_{32}$ or $4C_4H_8$ for 2 marks **Examiner's Comments** $C_{16}H_{32}$ was the most common correct response.
	d		Kerosene / fuel oil ✓ Idea that the supply is greater than the demand ✓	2 (2 × AO 3.2b)	**ALLOW** naphtha **Examiner's Comments** Most candidates correctly suggested cracking fuel oil or kerosene as the supply of those fractions exceeds the demand. Less successful responses saw candidates choose diesel oil because the percentage demand is the same as petrol.
	e		$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ **OR** $C_4H_{10} + 6½O_2 \rightarrow 4CO_2 + 5H_2O$ Formulae ✓ Balancing ✓	2 (2 × AO 2.2)	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** and / & instead of '+' Balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g., $C_4h_{10} + 6½O_2 \rightarrow 4Co_2 + 5H2O$ **Examiner's Comments** Hydrogen, rather than water, was often seen as a product in this

					combustion reaction. Just over half of candidates gained some marks from this question.
			Total	**11**	
8			**B**	1 (AO 1.1)	**Examiner's Comments** C and D were common incorrect responses, with candidates focusing on reactions of H+ ions, rather than the loss of electrons by hydrogen molecules at the anode to become hydrogen ions.
			Total	**1**	
9			**C**	1 (AO 1.1)	
			Total	**1**	
10			**D**	1 (AO 1.1)	
			Total	**1**	
11			**C**	1 (AO 1.1)	
			Total	**1**	
12			**C**	1 (AO 1.1)	
			Total	**1**	
13	a	i	$\% = \frac{0.7}{4.9} \times 100 = 14.3 / 14\%$ ✓	1(AO3.1)	**ALLOW** answer in range 12 to 15% **Examiner's Comments** Less successful candidates appeared to just guess the answer to this question rather than taking measurements from the graph.
		ii	Coal is a hydrocarbon ✓ When hydrocarbons burn, they produce carbon dioxide ✓	2(2 × 3.2b)	**ALLOW** coal is a fossil fuel **ALLOW** renewable energy emits less CO_2 **ALLOW** burning coal or fossil fuels produces CO_2 **IGNORE** just fossil fuel increase CO2 emissions, without reference to

					burning **Examiner's Comments** More successful candidates appreciated that coal is a fossil fuel, although very few stated it is a hydrocarbon. Many candidates realised that burning coal produces carbon dioxide.
	b		Petrol has weaker intermolecular forces (than diesel) / ORA ✓	1(AO1.1)	**Assume unqualified answer refers to petrol** **ALLOW** petrol has less or smaller intermolecular forces (than diesel) / ORA **ALLOW** less energy is required to break the intermolecular forces in petrol / ORA **IGNORE** references to breaking bonds **Examiner's Comments** Many candidates were able to explain that petrol has weaker intermolecular forces than diesel. Less successful candidates stated that petrol has less or weaker bonds to break.
			Total	**4**	
14	a		C_nH_{2n+2} ✓	1(AO2.1)	**ALLOW** $H_{2n+2}C_n$ **NOT** CnH2n+2 / CnH2n+2 **Examiner's Comments** **Misconception** C_n + H_{2n+2} was a common misconception, with an incorrect + implying two compounds.
	b		Alcohols ☐ Alkenes ☐ Carboxylic acids ☑	1(AO2.1)	**Examiner's Comments**

			Esters ☐ ✓		Most candidates recognised that compound C was a carboxylic acid. **Misconception** Alcohol was the most common misconception.
	c		$C_2H_4 + 2O_2 \rightarrow 2CO + 2H_2O$ OR $C_2H_4 + O_2 \rightarrow 2C + 2H_2O$ OR $2C_2H_4 + 3O_2 \rightarrow 2C + 2CO + 4H_2O$ Formulae ✓ Balancing ✓	2(2 × 2.1)	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** and / & instead of '+' balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g. $C_2H_4 + 2O2 \rightarrow 2Co + 2h_2O$ **ALLOW** any (balanced) equation that includes H_2O as the only hydrogen containing product and C and/or CO among the carbon containing products. Equation may also produce CO_2 in addition to C and/or CO. **IGNORE** state symbols **Examiner's Comments** Less successful candidates wrote an equation for complete, rather than incomplete, combustion. Hydrogen and methane were also often seen as incorrect products.
	d		Idea that hydrocarbons have different boiling points ✓ **And any <u>two</u> from**: Larger molecules or longer chains have higher boiling points / ORA ✓ Larger molecules or longer chains have stronger intermolecular forces / ORA ✓	3(3 × 1.1)	**IGNORE** melting points / evaporating points **MP2, 3 & 4 must be comparative** **ALLOW** molecules with higher mass have higher boiling points / ORA **ALLOW** larger molecules or longer chains have more intermolecular forces / ORA

			Stronger intermolecular forces result in higher boiling point / ORA ✓		**ALLOW** idea that stronger or more intermolecular forces result in more energy needed (to boil or to break the intermolecular forces) / ORA **Examiner's Comments** Good responses to this question made the link that larger molecules have stronger intermolecular forces and hence higher boiling points. Less successful candidates tended to ignore the hint in the question to use ideas about intermolecular forces and wrote instead about the process of fractional distillation in terms of the fractionating column, temperature gradient and alkanes condensing at different levels with no reference to intermolecular forces of molecular size. Some described that compound E had a higher boiling point, but then did not explain why.
	e		Finite (resource) ✓	1(AO1.1)	**NOT** non-renewable **Examiner's Comments** **Misconception** The term finite was only known by the highest attaining candidates, with non-renewable being the most common misconception. Fossil fuel was also a common incorrect response.
			Total	**8**	
15			A ✓	1 (AO1.1)	
			Total	**1**	
16			C ✓	1 (AO1.1)	
			Total	**1**	
17			B ✓	1 (AO1.1)	
			Total	**1**	