1. The general formula for an alkene is C_nH_{2n}.

A **general equation** for the complete combustion of alkenes uses the number of carbon atoms in the alkene to balance the equation.

general equation $\quad C_nH_{2n} + 1.5nO_2 \rightarrow nCO_2 + nH_2O$

(i) Use the general equation to write a balanced equation for the combustion of butene, C_4H_8.

Explain your reasoning for each part of the equation.

Equation ----------

Reasons ----------

---------- **[3]**

(ii) This general equation can be used to balance equations for the complete combustion of alkenes, but does **not** work for alkanes.

Give **one** reason why the equation does **not** work for alkanes.

---------- **[1]**

2. An alkane in petrol contains 8 carbon atoms.

Draw a fully displayed formula for this alkane.

[2]

3(a). The table shows the names and chemical formulae of some alkanes and alkenes.

Number of carbon atoms (n)	Alkanes		Alkenes	
1	methane	CH_4		
2	ethane	C_2H_6	ethene	C_2H_4
3	propane	C_3H_8	propene	C_3H_6
4	butane	C_4H_{10}	butene	C_4H_8

All the alkenes are members of the same homologous series.

(i) How do the formulae of the alkenes show that they are from the same homologous series?

---

[1]

(ii) How do the formulae of the alkanes and alkenes show that they are from different homologous series'?

---

[2]

(b). An alkene called 'methene' cannot exist.

Explain why.

---

[2]

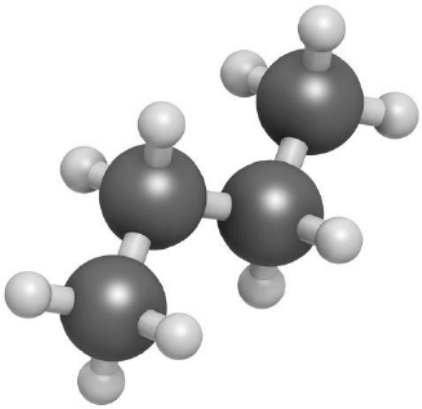
(c). The general formula for an alkane is $C_nH_{(2n+2)}$.

Use this general formula to predict the chemical formula for an alkane which contains 50 carbon atoms.

---

[1]

4. The diagram shows a ball and stick model of a hydrocarbon.



Give the molecular formula and the name of this hydrocarbon.

Molecular formula _____

Name _____

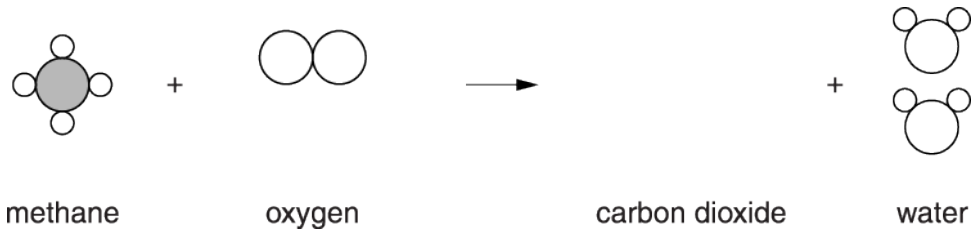
[2]

5. Methane, CH_4, is a chemical in natural gas.

When methane burns in a plentiful supply of air, **complete combustion** takes place.

The products are carbon dioxide and water.

(i) Finish this diagram to show the complete combustion of one molecule of methane.



[2]

(ii) When hydrocarbons burn in a limited supply of oxygen, **incomplete combustion** takes place.

Describe what happens during the incomplete combustion of hydrocarbons and explain why this can be harmful to health.

The quality of written communication will be assessed in your answer.

---

[6]

6(a). Crude oil is a mixture of hydrocarbons.

(i) Crude oil is refined to make chemicals that are used in different ways.

One way they are used is as raw materials, for example to make polymers.

Write down **two other** ways that chemicals from refined crude oil are used.

1

2

---

[2]

(ii) During the refining process crude oil is heated.

The hydrocarbons are vapourised and then condensed into fractions.

Each fraction contains hydrocarbons of similar chain length.

Which of these statements explains why this process separates the hydrocarbons into fractions?

Put ticks (✓) in the boxes next to the **two** best statements.

The energy needed to break molecules away from each other decreases as they get bigger. ☐

The longer the hydrocarbon chains, the larger the forces between them. ☐

All hydrocarbons boil at the same temperature. ☐

Small molecules are held together by larger forces than large molecules. ☐

Large molecules need more energy to vapourise than small molecules. ☐

Small molecules boil at higher temperatures than large molecules. ☐

[2]

(b). Ethene, C_2H_4, is obtained from crude oil.

Ethene reacts with water (steam) to make ethanol, C_2H_5OH.

Complete the table to show **the number of atoms** of each element when **one** molecule of ethene reacts.

	carbon	hydrogen	oxygen
ethene			
water			
ethanol			

[3]

7(a). Crude oil is a mixture of hydrocarbons.

Information about some of these hydrocarbons is given in the table.

Hydrocarbon	Formula	Melting point in °C	Boiling point in °C
methane	CH_4	−182	−164
ethane	C_2H_6	−183	−89
propane	C_3H_8	−188	−42
butane	C_4H_{10}	−138	−0.5
pentane	C_5H_{12}	−130	36

Which of these hydrocarbons is a liquid at 25 °C?

---

[1]

(b).

(i) Describe the trend in the boiling points of these hydrocarbons.

---[1]

(ii) Butane gas is used as a fuel. It is sold in cylinders for use when camping.

It is difficult to use a butane stove at temperatures below 0 °C.

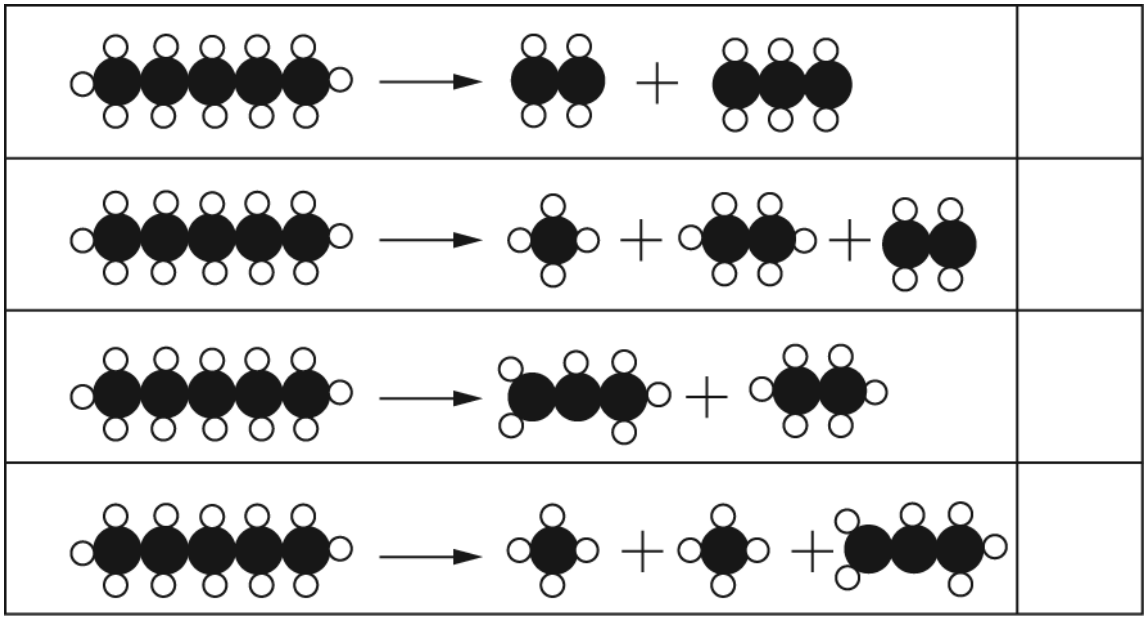
Explain why.

---[2]

8. Pentane is a hydrocarbon found in crude oil.
Pentane can be broken up in a refinery.

The diagrams represent the rearrangement of atoms when pentane is broken up.
Only **one** of them is correct.

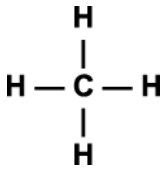
Put a tick (✓) in the box next to the correct diagram.



[1]

9(a). The surface of the planet Neptune is covered with clouds of dense material. The clouds contain substances in solid, liquid and gas states.

One of the compounds in the clouds is methane.



The table shows the melting point and boiling point of methane.

melting point (°C)	–182.5
boiling point (°C)	–161.5

What is the bonding and structure of methane at room temperature?

--- [2]

(b). What is the name for the family of organic compounds (homologous series) that includes methane?

--- [1]

10. Crude oil is separated into different fractions.
Petrol and fuel oil are fractions from crude oil.

Here are the boiling ranges of these fractions.

Fraction	Boiling range (°C)
Petrol	30 – 80
Fuel oil	300 – 340

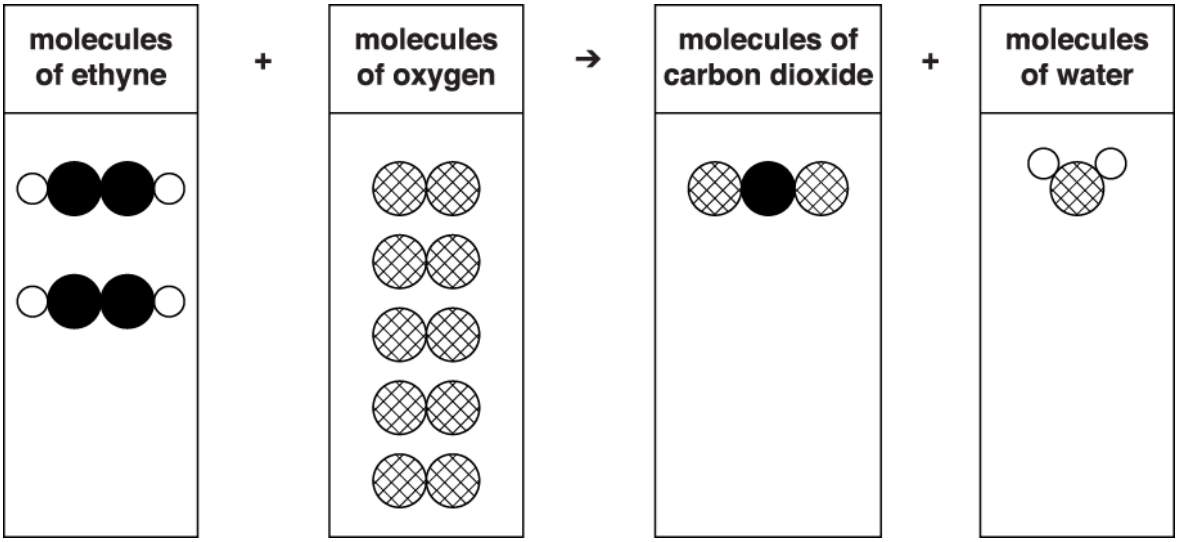
How do the sizes of molecules in petrol and fuel oil differ? Explain why the boiling range for petrol is different from the boiling range of fuel oil.

[4]

11. Ethyne reacts with oxygen to make carbon dioxide and water.
The boxes show the four types of molecule in this reaction.

2 molecules of ethyne react with 5 molecules of oxygen.

Complete the diagram to show the number of molecules of carbon dioxide and water made in this reaction.



[2]

12(a) This is a question about crude oil.

. Crude oil is separated by fractional distillation.

This is possible because the compounds in crude oil boil at different temperatures.

These sentences are about what happens in fractional distillation.

Which **two** sentences explain why the compounds in crude oil boil at **different** temperatures?

Put ticks (✓) in the boxes next to the **two** correct answers.

Energy is needed to break the molecules. ☐

Energy is needed to heat each compound to its boiling point. ☐

Gas molecules have stronger forces between them than liquid molecules. ☐

Larger molecules have larger forces between them. ☐

More energy is needed to overcome strong forces than weak ones. ☐

The forces between atoms in a molecule depend on the size of that molecule. ☐

[2]

(b). The fractions from crude oil have many **uses**.

Name **two** uses of fractions from crude oil.

1) _____

2) _____

[2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1		i	$C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$ ✓ Reasoning: n is 4 / n gives $4CO_2$ and $4H_2O$ ✓ (1.5n =) 1.5 × 4 = 6 (O_2) ✓	3 (AO 3 × 2.1)	<u>Examiner's Comments</u> Many candidates successfully wrote and balanced the equation correctly. Many showed clearly how they had used algebra (as expected in the mathematical requirements) to produce the equation. In giving reasons, however, some candidates explained how they would normally balance the equation (referring to numbers of atoms of each element on each side) rather than explaining in terms of the general equation they had been given.
		ii	Alkanes have (two) more hydrogen atoms / alkanes produce more water / alkanes need more oxygen to burn ✓	1 (AO 2.1)	ALLOW 'different number of hydrogens' <u>Examiner's Comments</u> In common with part (b) candidates need to take care not to repeat again answers that they have given for earlier questions. 'They have a different general formula' is a true statement but does not fully explain why this leads to the general equation failing to work. Better answers contrasted the number of hydrogen atoms and water molecules on each side of the equation when alkanes undergo combustion.
			Total	4	
2			shows a formula with 8 carbon and 18 H atoms ✓ fully correctly displayed with 4 bonds around each C atom ✓	2	
			Total	2	
3	a	i	increase by CH_2 each time / all have same <u>general</u> formula / all have formula C_nH_{2n} / all have twice as many hydrogen (atoms) as carbon (atoms) ✓	1 (AO 2.1)	IGNORE all have similar formulae / same empirical formula

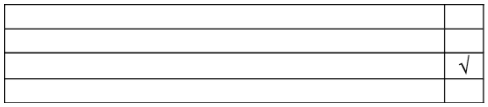
Question			Answer/Indicative content	Marks	Guidance
		ii	For two marks: (numbers) for alkenes hydrogen atoms are twice number of carbon atoms but for alkanes it is not / alkanes have two extra hydrogens for each carbon ORA / general formula for alkenes is C_nH_{2n} and general formula for alkanes is C_nH_{2n+2} ✓✓ For one mark: (general comment) have a different number of hydrogen (atoms) per carbon (atom) / same number of carbon (atoms) but different numbers of hydrogen (atoms) / ratio of carbon atoms to hydrogen atoms is different / different general formula ✓	2 (AO 2 × 2.1)	ALLOW 'amount' for 'number' Need both general formulae for (2) marks IGNORE one general formulaIGNORE empirical formula IGNORE 'have a different number of hydrogen atoms' alone ALLOW 'alkanes have (C-C) single bonds and alkenes have (C=C) double bonds for 1 mark only. IGNORE saturated/unsaturated Examiner's Comments In common with question 5, this question is a typical 'depth' question where candidates need to develop their thinking across multiple question parts within a narrow specification area. In this case, candidates need to carefully consider their answers to make sure that they do not merely repeat a statement across multiple part questions, but instead make sure that they make clear points relevant to each part. In this case, a common correct answer to (b) (i) was 'they have the same general formula' (there are other alternative correct answers given on the mark scheme). For (b) (ii) candidates who only said 'they have different general formula' gained only one mark. Better answers looked at the mark allocation and gave more detail, or gave two separate points, for example by contrasting the ratio of carbon to hydrogen in terms of numbers. A few made comments about differences which were not shown by the formulae (as the question asks), for example by commenting on their effects on bromine water. Although such answers are correct statements, they do not answer the question and so earned no marks.

Question			Answer/Indicative content	Marks	Guidance
	b		alkenes have a (C=C) double bond / needs a double bond ✓ (methene would have) one carbon atom / would be CH_2 / meth indicates one carbon atom / does not have enough carbon atoms / needs two carbon atoms ✓	2 (AO 2 × 2.1)	Examiner's Comments This question was well answered, with most candidates earning at least one mark either for identifying that 'methene' would only have one carbon atom or for stating that alkenes have a double bond (hence methene cannot have one). Candidates need to check that the mark allocation matches the number of points that they make to make sure that where a question has a two mark allocation, their answer addresses two separate, clear points.
	c		$C_{50}H_{102}$ ✓	1 (AO 2.1)	Examiner's Comments Almost all candidates correctly used the general formula to predict the formula of the alkane, showing good understanding of this specification area.
			Total	6	
4			C_4H_{10} ✓ butane ✓	2	
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
5		i	one additional oxygen molecule on left / 2 in front of the one oxygen molecule on left (1) one carbon dioxide molecule on right (1)	2	**do not allow** if there is a visible gap between the oxygens **allow** slightly overlapping circles Any shape but no gaps between carbon and oxygens and the two oxygens must not touch **allow** circle with C for carbon / O for oxygen **do not allow** oxygen circles same size as hydrogen unless labelled with O Examiner's Comments Though many candidates correctly drew a carbon dioxide molecule on the right to gain one mark, very few also drew an oxygen molecule on the left to gain a second mark. Most of the weaker candidates clearly had little idea of what to draw

Question			Answer/Indicative content	Marks	Guidance
		ii	**(Level 3)** Answer describes what happens in incomplete combustion and explains the health problems it causes. Quality of written communication does not impede communication of the science at this level. **(5–6 marks)** **(Level 2)** Answer **partially includes both** a description of what happens in incomplete combustion **and** an explanation of the health problems it causes, OR **completely includes only one** of the two. Quality of written communication partly impedes communication of the science at this level. **(3–4 marks)** **(Level 1)** Answer includes some of the relevant points but there is not enough detail to give a complete answer. Quality of written communication impedes communication of the science at this level. **(1–2 marks)** **(Level 0)** Insufficient or irrelevant science. Answer not worthy of credit. **(0 marks)**	6	**This question is targeted at grades up to A** **Indicative scientific points may include:** explanation of what happens during incomplete combustion: • not enough oxygen for (all) carbon to form carbon dioxide • some carbon forms carbon monoxide • some carbon does not react • carbon particulates are formed • unburned hydrocarbons / named hydrocarbon released health problems it causes • carbon monoxide is poisonous • carbon monoxide combines with haemoglobin • carbon monoxide reduces amount of oxygen blood can carry • carbon particulates / hydrocarbons cause breathing problems / affect those with asthma / cause cancer • carbon particulates help to cause smog. **do not credit** references to nitrogen monoxide etc **Use the L1, L2, L3 annotations in Scoris; do not use ticks** **Examiner's Comments** Most candidates gave answers based on only one harmful product of incomplete combustion and gave minimum details of why this product is harmful to health. Many attempts at the question were confused and rambling. Only the stronger candidates gave clear, concise and detailed answers.
			Total	**8**	

Question			Answer/Indicative content	Marks	Guidance
6	a	i	as fuels (1) as lubricants (1)	2	**ignore** named examples of fractions eg diesel, bitumen **ignore** reference to monomers / polymers / plastics / named polymers / making pharmaceuticals etc **allow** making roads **Examiner's Comments** Most candidates scored at least one mark in (i), but many gave names of fractions rather than ways that chemicals refined from crude oil are used. The majority of candidates gained both marks in (ii).
		ii	The longer the hydrocarbon chains, the larger the forces between them. ✓ Large molecules need more energy to vapourise than small molecules. ✓	2	
	b		<table><tr><th></th><th>carbon</th><th>hydrogen</th><th>oxygen</th></tr><tr><td>ethene</td><td>2</td><td>4</td><td>0</td></tr><tr><td>water</td><td>0</td><td>2</td><td>1</td></tr><tr><td>ethanol</td><td>2</td><td>6</td><td>1</td></tr></table>	3	one mark for each correct **row** **allow** blank spaces in place of zeros **Examiner's Comments** Only the most able gave the correct numbers of atoms. A very wide variety of numbers were given, many in double figures. Some weaker candidates gave formulae instead of numbers. Most who scored any marks gained all three.
			Total	**7**	

Question			Answer/Indicative content	Marks	Guidance
7	a		pentane	1	**allow** C_5H_{12} **do not allow** ?130 or 36 **Examiner's Comments** A large majority of candidates correctly identified pentane. Incorrect suggestions included all of the other hydrocarbons.
	b	i	as (molecule) size increases the boiling point increases / owtte	1	**allow** "positive correlation between bp and size / length / number of carbons / number of atoms etc" **do not allow** "positive correlation" unqualified **do not allow** "more molecules higher bp" **do not allow** "bp increases down table" **Examiner's Comments** Stronger candidates could correctly describe the trend in boiling points. A common error was to link melting points to boiling points
		ii	butane is a liquid (below 0°C) (1) it has to be a gas (1)	2	**do not allow** "its bp is ?0.5 °C / just below 0°C" **do not allow** "will not work" unqualified **Examiner's Comments** Stronger candidates could correctly describe the trend in boiling points, only a few of the stronger candidates realised that butane would be a liquid and even fewer suggested that it could only be used as a fuel when a gas. Common errors included the idea that the butane would be too cold to heat anything and that the butane would begin to boil.
			Total	**4**	
8			 (1)	1	**Examiner's Comments** Most candidates could recognise a balanced diagram for the splitting of pentane.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
9	a		covalent ✓ simple structure / single molecules ✓	2	
	b		alkanes ✓	1	
			Total	**3**	
10			molecules in petrol are smaller than those in fuel oil;(1) intermolecular forces are smaller/weaker in petrol molecules than fuel oil molecules;(1) less **energy** required to overcome imf / separate molecules in petrol than fuel oil;(1) petrol boils at a lower temperature / has a lower boiling range than fuel oil;(1)	4	**Allow**: chains **Allow**: bonds between molecules **Ignore**: bonds **Ignore**: bonds breaking ORA for all statements **Examiner's Comments** This was another discriminating question. Most could link molecular size to boiling range, but only better candidates were able to describe the role of intermolecular forces in the boiling ranges. Confusion over intermolecular forces and bonds was common with candidates believing that bonds in the molecules broke when liquids boiled. Some had learned about fractional distillation and wrote about this instead of answering the question. And there are still some candidates who confuse boiling and burning.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
11			4 mols CO_2 ;(1) 2 mols H_2O;(1)	2	**Allow** indication of '4' CO_2 and 2 H_2O Diagrams **MUST** make it clear which atom is which, look for additional 3 molecules of CO_2 and an additional 1 extra molecule of H_2O to have been drawn in the respective boxes. Molecules should not touch each other. Atoms within the molecule should touch. **Examiner's Comments** Balancing the reaction was well done, though a number of candidates lost marks because of poor drawing. Representations of molecules of water and carbon dioxide were given so there is no excuse for repeating these diagrams without touching atoms.
			Total	**2**	
12	a		Larger mols….. larger forces between them. √ (1) More energy…strong forces than weak ones. √ (1)	2	**Examiner's Comments** This question about the boiling points of different compounds of crude oil was discriminating.
	b		Any two from: Fuel or named fuel; lubricant; chemical synthesis; waxes; road surfaces;	2	Answers in any order More than 1 fuel = 1 mark **Ignore**: bitumen on its own **Examiner's Comments** This question asked for two uses and it is important, when answering, that these are distinct and different. Giving two uses that are both fuels can only score 1 mark. Sometimes candidates would just write 'plastics', as if plastics were fractions, rather than indicating that fractions were used to make plastics.
			Total	**4**	