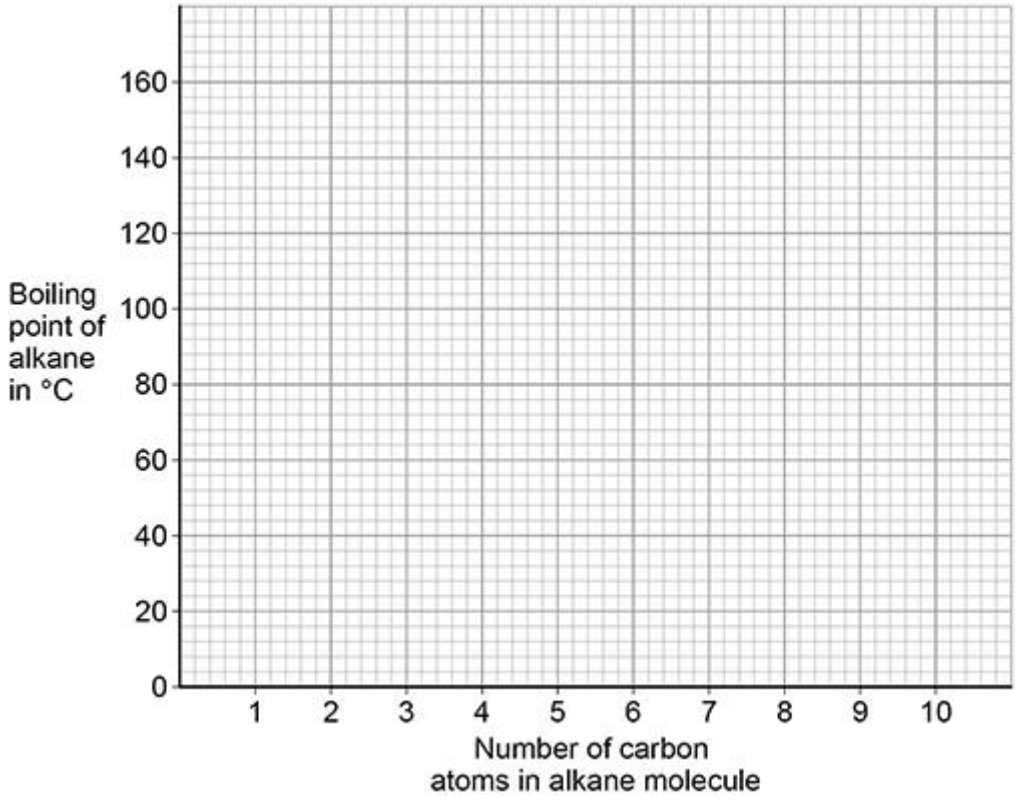
C9.1 Crude oil

1. This question is about alkanes.

The table below shows information about some alkanes.

Number of carbon atoms in alkane molecule	Boiling point of alkane in °C
4	0
5	36
6	69
7	**X**
8	126
9	151

(a) Plot the data from the table above on the graph below.



(2)

(b) Predict the boiling point **X** of the alkane with seven carbon atoms in a molecule.

Use the table and the graph.

X = _____ °C

(1)

(c) The graph above is **not** suitable to show the boiling point of the alkane with three carbon atoms in a molecule.

Suggest **one** reason why.

_____

_____

(1)

(d) What is the state at 20 °C of the alkane with four carbon atoms in a molecule?

Use the table above.

_____

(1)

The table in part (a) is repeated below.

Number of carbon atoms in alkane molecule	**Boiling point of alkane in °C**
4	0
5	36
6	69
7	**X**
8	126
9	151

The alkane with nine carbon atoms in a molecule is called nonane.

(e) Complete the formula of nonane.

$C_9H\_\_\_$

(1)

(f) Nonane will condense lower in a fractionating column during fractional distillation than the other alkanes in the table above.

Explain why.

You should refer to the temperature gradient in the fractionating column.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q2. This question is about hydrocarbons.

Hexane and hexene are hydrocarbons containing six carbon atoms in each molecule.

Hexane is an alkane and hexene is an alkene.

(a) Draw **one** line from each hydrocarbon to the formula of that hydrocarbon.

Hydrocarbon	**Formula**
	C_6H_8
Hexane	C_6H_{10}
	C_6H_{12}
Hexene	C_6H_{14}
	C_6H_{16}

(2)

(b) Bromine water is added to hexane and to hexene.

What would be observed when bromine water is added to hexane and to hexene?

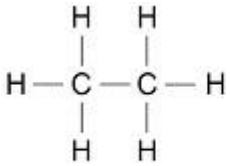
Hexane _____

Hexene _____

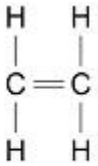
(2)

(c) Ethane is an alkane and ethene is an alkene.

The diagram below shows the displayed structural formulae of ethane and of ethene.



Ethane



Ethene

Compare ethane with ethene. You should refer to:

- their structure and bonding
- their reactions.

_____

_____

_____

_____

_____

_____

(6)

(Total 10 marks)

Higher Tier Questions

Q3 This question is about organic compounds.

Hydrocarbons can be cracked to produce smaller molecules.

The equation shows the reaction for a hydrocarbon, $C_{18}H_{38}$

$$C_{18}H_{38} \rightarrow C_6H_{14} + C_4H_8 + 2\,C_3H_6 + C_2H_4$$

(a) Which product of the reaction shown is an alkane?

Tick **one** box.

C_2H_4 ☐

C_3H_6 ☐

C_4H_8 ☐

C_6H_{14} ☐

(1)

(b) The table below shows the boiling point, flammability and viscosity of $C_{18}H_{38}$ compared with the other hydrocarbons shown in the equation.

	Boiling point	**Flammability**	**Viscosity**
A	highest	lowest	highest
B	highest	lowest	lowest
C	lowest	highest	highest
D	lowest	highest	lowest

Which letter, **A**, **B**, **C** or **D**, shows how the properties of $C_{18}H_{38}$ compare with the properties of C_2H_4, C_3H_6, C_4H_8 and C_6H_{14}?

Tick **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(c) The hydrocarbon C_4H_8 was burnt in air.

Incomplete combustion occurred.

Which equation, **A**, **B**, **C** or **D**, correctly represents the incomplete combustion reaction?

A $C_4H_8 + 4O \rightarrow 4CO + 4H_2$

B $C_4H_8 + 4O_2 \rightarrow 4CO + 4H_2O$

C $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

D $C_4H_8 + 8O \rightarrow 4CO_2 + 4H_2$

Tick **one** box.

A ☐

B ☐

C ☐

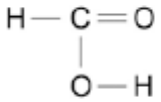
D ☐

(1)

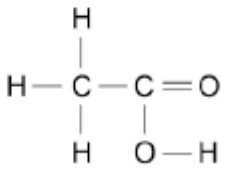
(d) Propanoic acid is a carboxylic acid.

Which structure, **A**, **B**, **C** or **D**, shows propanoic acid?

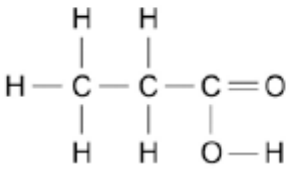
A



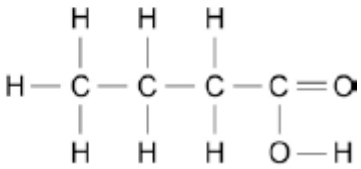
B



C



D



Tick **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(e) Propanoic acid is formed by the oxidation of which organic compound?

Tick **one** box.

Propane ☐

Propene ☐

Propanol ☐

Polyester ☐

(1)

(Total 5 marks)

Q4.

This question is about combustion of fuels.

(a) Some central heating boilers use wood as a fuel.

Suggest **two** reasons why wood is more sustainable than natural gas as a fuel for central heating boilers.

1 _____

2 _____ **(2)**

Natural gas is mainly methane.

When methane burns it can produce both carbon monoxide and carbon dioxide.

(b) Explain the process by which carbon monoxide can be produced when methane is burned.

_____

_____

_____

_____

(2)

(c) Balance the equation for the combustion of methane to produce carbon monoxide.

$$\_\_\_\_ CH_4(g) + \_\_\_\_ O_2(g) \rightarrow \_\_\_\_ CO(g) + \_\_\_\_ H_2O(l)$$

(1)

(d) Propane burns to form carbon dioxide and water.

The equation for the reaction is:

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(l)$$

3.60 dm^3 carbon dioxide is produced when a sample of propane is burned in 7.25 dm^3 oxygen.

Calculate the volume of unreacted oxygen.

Give your answer in cm^3

_____

_____

_____

_____

_____

_____

_____

_____

Volume of unreacted oxygen = _____ cm^3

(4)

(Total 9 marks)

Mark schemes

Q1.

(a) all five points plotted correctly

allow a tolerance of ± ½ a small square

*allow **1** mark for three or four points plotted correctly*

2

(b) 98 (°C)

allow a value in the range 92 to 104 (°C)

1

(c) the boiling point is lower than 0 (°C)

allow the graph cannot show negative temperatures

1

(d) gas

allow (g)

1

(e) C_9H_{20}

1

(f) (nonane) has a higher boiling point

allow converse for the other alkanes

1

(so nonane) condenses where the column has a higher temperature

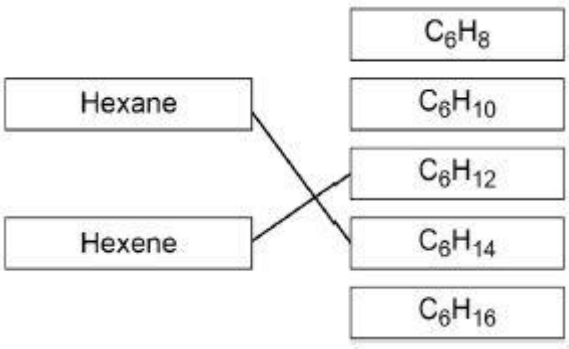
allow (so nonane) collects where the column has a higher temperature

1

[8]

Q2.

(a)



1

additional line from a box on the left negates the mark for that box

1

(b) (remains) orange

must be in this order
allow no (colour) change

1

(becomes) colourless

ignore initial colour ignore clear

1

(c) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.

4–6

Level 1: Relevant features are identified and differences noted.

1–3

No relevant content

0

Indicative content

Structure and bonding

- both are hydrocarbons
- both contain two carbon atoms (per molecule)
- ethane contains six hydrogen atoms (per molecule)
- (but) ethene contains four hydrogen atoms (per molecule)

- both have covalent bonds
- ethane contains a single C—C bond
- (but) ethene contains a double bond
- both contain C—H bonds

- both small molecules

Reactions

- both react with oxygen in complete combustion reactions
- to produce water and carbon dioxide
- both react with oxygen in incomplete combustion reactions
- to produce water, carbon monoxide and carbon
- incomplete combustion is more likely with ethene

- ethene decolourises bromine water
- (but) ethane does not decolourise bromine water

- ethene is more reactive (than ethane)
- ethene can react with hydrogen (to produce ethane)
- ethene can react with water (to produce ethanol)
- ethene can react with halogens (to produce halogenoalkanes)
- ethene can undergo addition reactions
- ethene can polymerise (to produce poly(ethene))

ignore physical properties
ignore references to flammability

[10]

Q3.

(a) C_6H_{14}

1

(b) **A**

1

(c) **B**

1

(d) **C**

1

(e) Propanol

1

[5]

Q4.

(a) wood is renewable
or
(natural) gas is finite

1

(burning) wood produces the same amount of carbon dioxide as the trees absorbed

allow wood is carbon-neutral allow wood does not add to global warming

or
(burning natural) gas increases the amount of carbon dioxide (in the atmosphere)

allow (burning natural) gas adds to global warming
allow (burning natural) gas adds greenhouse gases (to the atmosphere)
ignore references to energy / cost

1

(b) not enough oxygen

allow not enough air
*do **not** accept no oxygen / air*

1

(so) incomplete combustion

1

(c) $\mathbf{2}CH_4(g) + \mathbf{3}O_2(g) \rightarrow \mathbf{2}CO(g) + \mathbf{4}H_2O(g)$

allow correct multiples / fractions

1

(d)

*an answer of 1250 (cm^3 oxygen unreacted) scores **4** marks*

ratio of $O_2 : CO_2 = 5 : 3$

1

(oxygen needed = $\frac{3.60 \times 5}{3}$)
= 6.0 (dm^3)

allow correct calculation using an incorrectly determined mole ratio

1

(oxygen unreacted = 7.25 − 6.0) = 1.25 (dm^3)

allow correct subtraction of an incorrectly calculated volume of oxygen

1

(oxygen unreacted = 1.25 × 1000)
= 1250 (cm^3)

allow correct conversion to cm^3 anywhere in response

1

alternative approach for MP1 and MP2

moles CO_2 = 0.15
and
moles O_2 = 0.25 (1)
(0.25 x 24 =) 6.0 (dm^3 oxygen needed) (1)

[9]