

# Alkanes: Fuels & Pollution

## Question Paper

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	Edexcel
<b>Topic</b>	The Core Principles of Chemistry
<b>Sub Topic</b>	Alkanes: Fuels & Pollution
<b>Booklet</b>	Question Paper

**Time Allowed:** 47 minutes

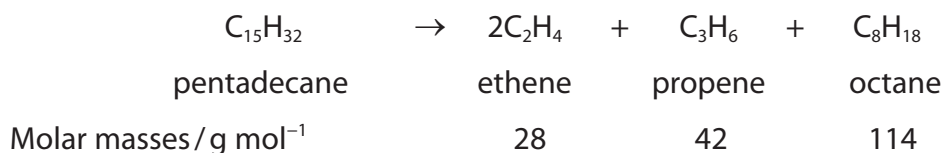
**Score:** /39

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1 An example of an equation to illustrate the cracking of an alkane from crude oil is



(a) What is the atom economy for this reaction in terms of production of alkenes?

Use the expression

$$\text{Atom economy} = \frac{\text{Total mass of desired product(s)}}{\text{Total mass of all products}} \times 100\%$$

(1)

- A 26%
- B 33%
- C 38%
- D 46%

(b) The chemical industry uses cracking in the processing of crude oil because

(1)

- A fractional distillation is too slow and expensive.
- B crude oil contains insufficient quantities of desired compounds.
- C reforming requires a catalyst.
- D cracking separates crude oil components.

**(Total for Question 1 = 2 marks)**

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2 Scientists are developing alternatives to fossil fuels.

Which of the following is **not** a result of carbon dioxide emissions?

- A The increase in global warming.
- B The melting of the ice caps.
- C The increase in pH of the oceans.
- D The rise in sea level.

**(Total for Question 2 = 1 mark)**

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3 Which of the following fuels, when burned, would make no significant contribution to climate change?

- A Hydrogen
- B Methane
- C Petrol
- D Coal

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**(Total for Question 3 = 1 mark)**

4 In addition to water, which of the following could be formed during the **incomplete** combustion of a hydrocarbon?

- A Carbon, carbon monoxide and hydrogen
- B Carbon and hydrogen
- C Carbon monoxide and hydrogen
- D Carbon and carbon monoxide

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**(Total for Question 4 = 1 mark)**

5 Which of the following statements correctly describes an environmental problem caused by the burning of hydrocarbon fuels?

- A The carbon dioxide produced is toxic and kills plants.
- B The smoke produced obscures sunlight and leads to global warming.
- C The water produced results in a damaging increase in rainfall.
- D The carbon dioxide produced traps heat radiated from the Earth and leads to global warming.

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**(Total for Question 5 = 1 mark)**

- 6 A 27.0 g sample of an unknown hydrocarbon,  $C_xH_y$ , was burned completely in excess oxygen to form 88.0 g of carbon dioxide and 27.0 g of water.

[Molar masses /  $\text{g mol}^{-1}$ :  $\text{CO}_2 = 44$ ;  $\text{H}_2\text{O} = 18$ ]

Which of the following is a possible formula of the unknown hydrocarbon?

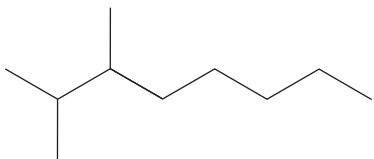
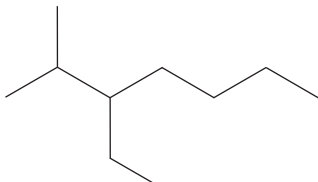
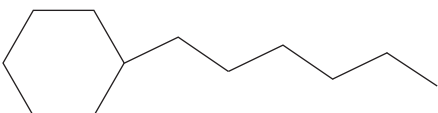
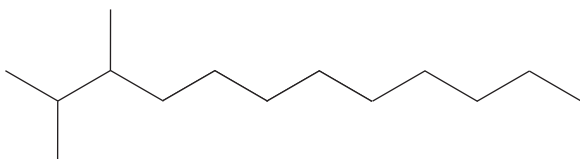
- A  $\text{CH}_4$
- B  $\text{C}_2\text{H}_6$
- C  $\text{C}_4\text{H}_6$
- D  $\text{C}_6\text{H}_6$

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(Total for Question 6 = 1 mark)

7 A propellant for a rocket consists of a fuel, kerosene, and an oxidizer, liquid oxygen.

(a) The formulae of some hydrocarbons present in kerosene are shown in the table below.

Hydrocarbon	Formula
<b>A</b>	
<b>B</b>	$\text{CH}_3(\text{CH}_2)_{10}\text{CH}_3$
<b>C</b>	
<b>D</b>	
<b>E</b>	

(i) Name the homologous series to which the compounds **A**, **B**, **C** and **E** belong.

(1)

.....

(ii) Name the compound **A**.

(1)

.....  
(iii) Explain the term **structural isomers**, by reference to two molecules selected from the table in part (a).

(3)

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.....  
.....  
(iv) Give the **molecular** formula of the compound **D**.

(2)

- (b) In the petrochemical industry, other fuels are obtained by the cracking and reforming of kerosene.

Using appropriate letters, **A** to **D**, identify a molecule listed in the table that could be formed from **E** by

- (i) cracking alone (1)

- 
- (ii) cracking and then reforming (1)

- 
- (c) Suggest how engine performance is improved by using a fuel containing the molecule that you have identified in (b)(ii). (1)

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- (d) The **energy density** of a fuel is defined as the energy produced per kilogram of fuel.

Calculate the energy density of dodecane,  $C_{12}H_{26}$ , in  $\text{kJ kg}^{-1}$ . Give your answer to **two** significant figures.

The enthalpy change of combustion of dodecane is  $-8086 \text{ kJ mol}^{-1}$ .

- [Molar mass:  $C_{12}H_{26} = 170 \text{ g mol}^{-1}$ ] (3)

energy density = .....  $\text{kJ kg}^{-1}$

**(Total for Question 7 = 13 marks)**

8 Crude oil is a source of alkanes.

(a) Name the process by which the hydrocarbons in crude oil are separated.

(1)

(b) The alkane **X** is composed of straight-chain molecules, each with nine carbon atoms.

(i) Give the molecular formula of **X**.

(1)

(ii) **Y** is a branched-chain isomer of **X**.

**Y** has eight carbon atoms in a straight-chain with **one** methyl group as a side-chain.

Draw the **skeletal formula** of **one** possible structure for **Y**.

Give the name of the structure that you have drawn.

(2)

Skeletal formula:

Name:



(c) A reaction called cracking occurs when the alkane pentadecane,  $C_{15}H_{32}$ , is heated in the presence of a catalyst.

- (i) Give an equation to show the cracking of one molecule of  $C_{15}H_{32}$  to form one molecule of ethene and a molecule of **one** other product.  
State symbols are not required.

(1)

(ii) In practice, cracking pentadecane forms a large number of products.

Suggest why this is so.

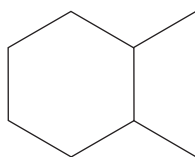
(1)

(d) In the petroleum industry, some straight-chain alkanes are processed to form cyclic hydrocarbons.

When octane is processed, each molecule of octane produces one molecule of a cyclic hydrocarbon,  $C_8H_{16}$ , and three molecules of hydrogen as the only products.

- (i) Complete the **skeletal** formula of one of the possible cyclic hydrocarbons.

(1)



- (ii) Suggest why the petroleum industry processes straight-chain alkanes to form cyclic hydrocarbons.

(1)

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(Total for Question 8 = 8 marks)

9 Alkanes are used as fuels in homes and in industry. It is, therefore, important that the enthalpy changes involving alkanes are known.

(a) Define the term **standard enthalpy change of formation** of a compound.

Give the conditions of temperature and pressure that are used when measuring a **standard** enthalpy change.

(3)

Definition .....

.....

.....

.....

Standard temperature is .....

Standard pressure is .....

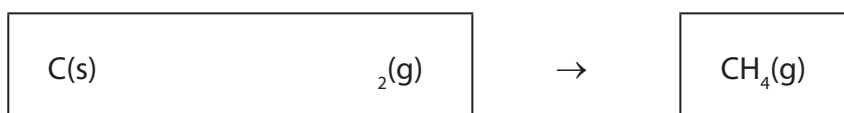
(b) Write the equation, with state symbols, that accompanies the enthalpy change of formation of hexane,  $C_6H_{14}(l)$ .

(2)

- (c) Enthalpy changes can be calculated using enthalpy changes of combustion. Values for some standard enthalpy changes of combustion are shown in the table below.

Substance	$\Delta H_c^\ominus / \text{kJ mol}^{-1}$
C(s)	-394
H <sub>2</sub> (g)	-286
CH <sub>4</sub> (g)	-890

Use these data to complete the Hess cycle below for the reaction and then calculate the standard enthalpy change for the reaction, in  $\text{kJ mol}^{-1}$ .



(3)

**Space for working**

standard enthalpy change for the reaction = .....  $\text{kJ mol}^{-1}$

- (d) The equations for the combination of gaseous carbon atoms and gaseous hydrogen atoms to form methane,  $\text{CH}_4$ , and ethane,  $\text{C}_2\text{H}_6$ , are shown below.



Use these data to calculate

- (i) the mean bond enthalpy of a C—H bond in methane, in  $\text{kJ mol}^{-1}$ .

(1)

- (ii) the bond enthalpy of a C—C bond, in  $\text{kJ mol}^{-1}$ , clearly showing your working.

(2)

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**(Total for Question 9 = 11 marks)**