Alkanes

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Hydrocarbons
Sub-Topic	Alkanes
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: **82 minutes**

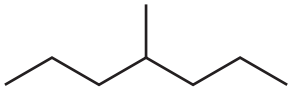
Score: **/68**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** Long chain alkanes such as 4-methylheptane can be 'cracked' to produce shorter chain hydrocarbons.



4-methylheptane

B
C_3H_8

\+

a mixture of **C**, **D** and **E**
(isomers of C_5H_{10})

(i) State the conditions necessary for this reaction to take place.

..... [1]

(ii) Suggest the structure of **B**.

B

[1]

(iii) Compounds **C**, **D** and **E** are isomers with the molecular formula C_5H_{10}.
On heating with concentrated acidified $KMnO_4$,

- compound **C** gives CO_2 and compound **F** ($C_4H_8O_2$),
- **D** and **E** each give a 1 : 1 mixture of compounds **G** ($C_2H_4O_2$) and **H** ($C_3H_6O_2$).

Suggest structures for compounds **C** - **H**.

C

D

E

F

G

H

[3]

(iv) Name the type of isomerism shown between **D** and **E**.

..... [1]

(b) Propene, $CH_3CH=CH_2$, reacts with bromine to give 1,2-dibromopropane.

(i) How is this reaction usually carried out?

..... [1]

(ii) State the *type of reaction* that is occurring here.

..... [1]

(iii) Draw the mechanism of this reaction, including the structures of any intermediates, and any dipoles, lone pairs and curly arrows to show the movements of electrons.

[2]

[Total: 10]

2 Crude oil is processed to give a wide variety of hydrocarbons.

(a) Give the names of one physical process and one chemical process carried out during the processing of crude oil.

physical process .....

chemical process .....
[2]

(b) Alkanes and alkenes can both be obtained from crude oil.

(i) Explain why alkanes are unreactive.

.....

..... [2]

(ii) State the bond angles in a molecule of

ethane, ...

ethene. .....
[1]

(iii) State the shape of each molecule in terms of the arrangement of the atoms bonded to each carbon atom.

ethane ..... ethene ..... [1]

(iv) Explain why these molecules have different shapes in terms of the carbon-carbon bonds present.

.....

..... [1]

(c) Use a series of equations to describe the mechanism of the reaction of ethane with chlorine to form chloroethane. Name the steps in this reaction.

.....

.....

.....

.....

..... [5]

(ii) Write an equation to show how butane could be produced as a by-product of this reaction.

..... [1]

[Total: 13]

3 **(a)** Define the term *mole*.

.....

..... [1]

(b) 10 cm^3 of a gaseous hydrocarbon, C_xH_y, was reacted with 100 cm^3 of oxygen gas, an excess.

The final volume of the gaseous mixture was 95 cm^3.

This gaseous mixture was treated with concentrated, aqueous sodium hydroxide to absorb the carbon dioxide present. This reduced the gas volume to 75 cm^3.

All gas volumes were measured at 298 K and 100 kPa.

(i) Write an equation for the reaction between sodium hydroxide and carbon dioxide.

..... [1]

(ii) Calculate the volume of carbon dioxide produced by the combustion of the hydrocarbon.

volume of CO_2 produced = ... cm^3 [1]

(iii) Calculate the volume of oxygen used up in the reaction with the hydrocarbon.

volume of O_2 used = ... cm^3 [1]

(iv) Use your answers to **(b)(ii)** and **(b)(iii)**, together with the initial volume of hydrocarbon, to balance the equation below.

.....C_xH_y + ...O_2 → .....CO_2 + zH_2O [2

(v) Deduce the values of *x*, *y* and *z* in the equation in **(iv)**.

x = ...

y = ...

z = ...

[3]

(c) Another hydrocarbon, **W**, with the formula C_4H_8, reacts with hydrogen bromide, HBr, to give two products **X** and **Y**. **X** and **Y** are structural isomers of molecular formula C_4H_9Br.

Reaction of **X** with aqueous alkali produces an alcohol, **Z**, that has **no** reaction with acidified dichromate(VI).

(i) Give the structures **and** names of the compounds **W**, **X**, **Y**, and **Z**

W

....

Y

....

[4]

(ii) When **W** reacts with hydrogen bromide, more **X** than **Y** is produced. Explain why.

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.....

..... [2]

[Total: 15]

4 Propane, C_3H_8, and butane, C_4H_{10}, are components of Liquefied Petroleum Gas (LPG) which is widely used as a fuel for domestic cooking and heating.

(a) (i) To which class of compounds do these two hydrocarbons belong?

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(ii) Write a balanced equation for the complete combustion of butane.

.....
[2]

(b) When propane or butane is used in cooking, the saucepan may become covered by a solid black deposit.

(i) What is the chemical name for this black solid?

.....

(ii) Write a balanced equation for its formation from butane.

.....
[2]

(c) Propane and butane have different values of standard enthalpy change of combustion.

Define the term *standard enthalpy change of combustion*.

.....

.....

..... [2]

(d) A 125 cm^3 sample of propane gas, measured at 20 °C and 101 kPa, was completely burnt in air.
The heat produced raised the temperature of 200 g of water by 13.8 °C.
Assume no heat losses occurred during this experiment.

(i) Use the equation $pV = nRT$ to calculate the mass of propane used.

(ii) Use relevant data from the *Data Booklet* to calculate the amount of heat released in this experiment.

(iii) Use the data above and your answers to **(i)** and **(ii)** to calculate the energy produced by the burning of 1 mol of propane.

[5]

(e) The boiling points of methane, ethane, propane, and butane are given below.

compound	CH_4	CH_3CH_3	$CH_3CH_2CH_3$	$CH_3(CH_2)_2CH_3$
boiling point / K	112	185	231	273

(i) Suggest an explanation for the increase in boiling points from methane to butane.

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(ii) The isomer of butane, 2-methylpropane, $(CH_3)_3CH$, has a boiling point of 261 K. Suggest an explanation for the difference between this value and that for butane in the table above.

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[4]

[Total: 15]

5 Crude oil contains a mixture of hydrocarbons together with other organic compounds which may contain nitrogen, oxygen or sulfur in their molecules.

At an oil refinery, after the fractional distillation of crude oil, a number of other processes may be used including 'cracking', 'isomerisation', and 'reforming'.

(a) (i) What is meant by the term '*cracking*' and why is it carried out?

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(ii) Outline briefly how the cracking of hydrocarbons would be carried out.

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.....

(iii) Construct a balanced equation for the formation of heptane, C_7H_{16}, by cracking tetradecane, $C_{14}H_{30}$.

.....

[4]

One of the sulfur-containing compounds present in crude oil is ethanethiol, C_2H_5SH, the sulfur-containing equivalent of ethanol. Ethanethiol is toxic and is regarded as one of the smelliest compounds in existence.

(b) The boiling point of ethanol, C_2H_5OH, is higher than that of C_2H_5SH.
Suggest a reason for this difference.

.....

..... [1]

When ethanethiol is burned in an excess of air, three oxides of different elements are formed.

(c) **(i)** Construct a balanced equation for this reaction.

.....

(ii) **Two** of the oxides formed cause serious environmental damage.

For **each** of these oxides, identify the type of pollution caused and describe one consequence of this pollution.

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.....

[6]

(d) A small amount of ethanethiol is added to liquefied gases such as butane that are widely used in portable cooking stoves.

Suggest a reason for this.

.....[1]

Sulfur-containing compounds are removed from oil products at the refinery. The sulfur is recovered and converted into SO_2, which is then used in the Contact process.

(e) State the main operating details of the formation of SO_3 in the Contact process.

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.....[3]

[Total: 15]