Alkanes: Formulae, Reactions & Structure

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Alkanes: Formulae, Reactions & Structure
Booklet	Question Paper 2

Time Allowed: **54 minutes**

Score: **/45**

Percentage: **/100**

Grade Boundaries:

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

1 Crude oil is a source of alkanes.

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

(1)

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

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

(1)

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(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)

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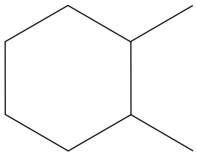
(d) In the petroleum industry, some straight-chain alkanes are processed to form cyclic hydrocarbons.

When octane is processed, each molecule of octane produces one molecule of a cyclic hydrocarbon, C_8H_{12}, 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 1 = 8 marks)

2 Iodine monochloride, ICl, is an interhalogen compound. Molecules of iodine monochloride have a permanent dipole. Alkenes react with ICl, under suitable conditions, in a similar way to the reaction of alkenes with hydrogen chloride, HCl.

(a) Propene reacts with ICl to form two possible organic products. One of these products is 2-chloro-1-iodopropane.

(i) Complete the mechanism below, by adding curly arrows and the intermediate species.

(3)

(ii) Classify the type and mechanism for the reaction in (a)(i).

(2)

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(iii) Draw the structure of the other possible organic product of the reaction of propene with ICl.

(1)

(b) Methane reacts with ICl, under suitable conditions, to form many products. Two of these products are iodomethane and hydrogen chloride.
The reaction between methane and ICl is similar to that between methane and chlorine, Cl_2.

(i) Suggest the essential condition needed for this reaction.

(1)

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*(ii) The mechanism for the reaction between methane and ICl involves three stages. One of these is the third and final stage, called termination.

Describe the mechanism of the reaction to form iodomethane and hydrogen chloride.

In your answer, include:

- the type of reaction and mechanism
- the type of bond fission occurring
- the name and equation for the **first** stage of the mechanism
- the name and equations for the **second** stage of the mechanism
- one equation for a termination step

Curly (half-) arrows and state symbols are **not** required in your equations.

(7)

Type of reaction and mechanism .....

Type of bond fission occurring .....

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(Total for Question 2 = 14 marks)

3 Bromine, Br_2, can react with both alkanes and alkenes. The type of reaction that occurs depends on whether the Br—Br bond breaks by homolytic or heterolytic fission.

(a) (i) Write an equation to show the **homolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

(ii) Write an equation to show the **heterolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

(iii) Choosing from the products you have given in (a)(i) and (a)(ii), write the formula of a free radical and an electrophile.

(2)

Free radical .....

Electrophile .....

(b) The compound hexane, C_6H_{14}, can react with bromine, in the presence of UV light, according to the equation

$$C_6H_{14} + Br_2 \rightarrow C_6H_{13}Br + HBr$$

(i) Give the displayed formulae of the three structural isomers of $C_6H_{13}Br$ that could be formed in the above reaction.

(3)

First isomer

Second isomer

Third isomer

(ii) The bromoalkanes and the hydrogen bromide formed in this reaction are hazardous.

The bromoalkanes would be labelled as 'flammable'. Suggest a suitable hazard warning for the hydrogen bromide.

(1)

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(iii) Calculate the percentage atom economy by mass for the formation of $C_6H_{13}Br$.

Give your answer to **three** significant figures.

Use the expression

$$\text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\%$$

(2)

(c) Fluorine, F_2, and chlorine, Cl_2, react with **methane**, CH_4, by a similar mechanism, although the rates of reaction are very different.

(i) Write an equation for the reaction between **methane** and fluorine, assuming they react in a 1:1 mole ratio. State symbols are not required.

(1)

*(ii) On the basis of comparing the relative sizes of the fluorine and chlorine atoms, it might be predicted that the F—F bond energy would be greater than the Cl—Cl bond energy.
Suggest an explanation for this prediction.

(2)

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(iii) Draw a dot and cross diagram to show the arrangement of the outermost electrons in a fluorine molecule, F_2.

(2)

(iv) The actual bond energies are shown below.

Bond	Bond energy / kJ mol^{-1}
F—F	158
Cl—Cl	243

By referring to your dot and cross diagram in your answer to (c)(iii), suggest an explanation for the fact that the F—F bond energy is **less** than that of the Cl—Cl bond energy.

(2)

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(v) Suggest why a mixture of methane and chlorine requires exposure to UV light, or heat, before a reaction occurs, whereas methane reacts rapidly with fluorine at room temperature in the absence of UV light or heat.

(1)

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(d) The alkene hex-3-ene reacts with bromine to produce 3,4-dibromohexane. Complete the mechanism below by adding curly arrows to show the movement of electron pairs in both steps and by giving the structural formula of the intermediate carbocation.

(3)

3,4-dibromohexane

(e) The mechanism shown in (d) shows *Z*-hex-3-ene reacting with bromine. *E*-hex-3-ene also reacts with bromine to form 3,4-dibromohexane.

(i) Draw the structure of *E*-hex-3-ene.

(1)

(ii) Explain why both *Z*-hex-3-ene and *E*-hex-3-ene react with bromine to produce the **same** structural isomer.

(1)

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(Total for Question 3 = 23 marks)