

1.4 Introductory organic chemistry and alkanes

Name: _____ Class: _____ Date: _____

Total: 17 marks

KEY WORDS homologous series • structural isomers • initiation
• propagation • termination • cracking

Objective

Practise Topic 4: nomenclature and isomers, homologous series, crude oil and cracking, combustion equations, and the free-radical substitution mechanism.

1 Key knowledge and worked examples

■ Name by the rules

Longest chain containing the functional group → lowest locants → prefixes alphabetically. 2-methylbutane, not 3-methylbutane. Count structural isomers systematically by carbon skeleton, then by position.

■ Radical substitution – the three stages

- **Initiation** : $\text{Cl}_2 \rightarrow 2\text{Cl} \cdot$ (UV light homolyses the bond).
- **Propagation** : $\text{Cl} \cdot + \text{CH}_4 \rightarrow \text{HCl} + \text{CH}_3 \cdot$; $\text{CH}_3 \cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl} \cdot$. The radical is regenerated – a chain reaction.
- **Termination** : any two radicals combine ($\text{CH}_3 \cdot + \text{Cl} \cdot \rightarrow \text{CH}_3\text{Cl}$; $\text{CH}_3 \cdot + \text{CH}_3 \cdot \rightarrow \text{C}_2\text{H}_6$).

Worked check. Why does the product mixture include C_2H_6 ? Because a termination step joins two methyl radicals – the mechanism itself predicts the trace by-product.

■ Cracking and combustion

Cracking converts long alkanes to shorter alkanes PLUS alkenes (the $\text{C}=\text{C}$ is the signature in any "which mixture" question). Complete combustion: $\text{C}_x\text{H}_y + (\text{x} + \text{y}/4) \text{O}_2 \rightarrow \text{x CO}_2 + (\text{y}/2) \text{H}_2\text{O}$. Incomplete combustion gives CO or C – the toxicity questions.

2 Practice

2.1 Give the IUPAC name for the alkane $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{CH}_3$. [1]

2.2 State the energy source that starts radical substitution of methane by chlorine, and explain its role. [2]

2.3 Write the equation for the complete combustion of dodecane, $\text{C}_{12}\text{H}_{26}$. [2]

3 Exam-style questions

3.1 A single molecule of $\text{C}_{12}\text{H}_{26}$ is cracked. The products are two molecules of ethene, one molecule of propene and one molecule of an alkane. Deduce the molecular formula and give a possible structure of the alkane. [3]

3.2 Give the equations for the initiation step and the TWO propagation steps in the reaction between chlorine and ethane, and explain why a trace of butane appears in the products. [5]

3.3 How many structural isomers have the formula C_6H_{14} ? Draw skeletal formulas for any three of them. [4]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 2-methylpentane.

2.2 Ultraviolet light provides energy for homolytic cleavage of the Cl–Cl bond, producing chlorine radicals. Heating is not a second required condition for this stated UV route.

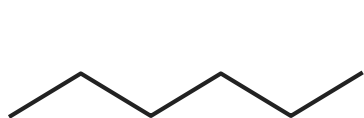
2.3 $\text{C}_{12}\text{H}_{26} + 18.5 \text{O}_2 \rightarrow 12 \text{CO}_2 + 13 \text{H}_2\text{O}$.

3.1 Subtract the atoms in two ethene molecules and one propene molecule: $\text{C} = 12 - 4 - 3 = 5$; $\text{H} = 26 - 8 - 6 = 12$. The alkane is C_5H_{12} , for example $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$.

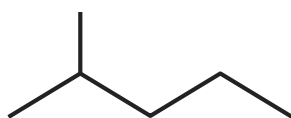
3.2 Initiation: $\text{Cl}_2 \rightarrow 2\text{Cl} \cdot$. Propagation: $\text{Cl} \cdot + \text{C}_2\text{H}_6 \rightarrow \text{HCl} + \text{C}_2\text{H}_5 \cdot$; $\text{C}_2\text{H}_5 \cdot + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl} \cdot$. Butane: a termination step $\text{C}_2\text{H}_5 \cdot + \text{C}_2\text{H}_5 \cdot \rightarrow \text{C}_4\text{H}_{10}$ – two ethyl radicals combining.

3.3 Five: n-hexane, 2-methylpentane, 3-methylpentane, 2,2-dimethylbutane, 2,3-dimethylbutane – any three skeletal formulas.

Every end and corner is a carbon; add H to make four bonds.



hexane



2-methylpentane



3-methylpentane