PENANG SANGAM HIGH SCHOOL
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LESSON NOTES

Subject: Chemistry **Year/Level:** 12
Week 24

Strand	4 MATERIALS
Sub Strand	4.2 Organic chemistry
Content Learning Outcome	To define hydrocarbons and discuss alkanes in terms of naming, drawing structures, properties and reactions

- **Hydrocarbons** are organic compounds that contain only carbon and hydrogen atoms joined together by covalent bonds. Eg. alkanes, alkenes & alkynes.

- Hydrocarbons are divided into two groups: **Saturated** and **unsaturated** hydrocarbons.

Saturated hydrocarbon	Unsaturated hydrocarbon
✓ Hydrocarbon that contains only carbon-carbon single bonds (*There are no carbon-carbon double bonds or triple bonds*). ✓ Alkanes are saturated hydrocarbons.	✓ A hydrocarbon that contains one or more carbon-carbon double bonds and triple bonds. ✓ Alkenes and alkynes are unsaturated hydrocarbons.

- **Homologous series**: is a series of compounds with the same general formula. They have the same functional group and have similar chemical properties. Each successive member of this series differs from the previous one by a $-CH_2$ group.

- **Functional group:** A functional group is an atom or group of atoms within a molecule which gives the molecule its chemical behaviour. Functional groups are the reactive part of a molecule

  Functional groups are important in organic chemistry because:
  1. They take part in chemical reactions.
  2. They determine the physical properties of a molecule.
  3. They help in classifying and naming organic compounds.

  Examples:

Class of Organic Compound	Functional Group
Alkane	C – C
Alkene	C = C
Alkyne	C ≡ C
Alcohol	– OH
Carboxylic acid	O // C -OH
Ester	O // R-C –O-R

Alkanes

- The general formula of this group of hydrocarbons is **CnH2n+2.**
  (n is the number of carbon atoms, 2n + 2 is the number of hydrogen atoms).
- Alkanes form homologous series because each successive member differs from the next by a CH2 group.

Nomenclature of Alkanes [IUPAC Rules for Alkane Nomenclature]

1. Find and name the longest continuous carbon chain. **Note: The chain does NOT have to be only straight. This means it can be from any direction.**
2. Identify and name the substituents attached to this chain.
3. Number the chain consecutively, starting at the end nearest a substituent group.
4. Designate the location of each substituent group by an appropriate number and name.
5. Assemble the name, listing groups in alphabetical order using the full name.**Note: Always use a dash between a number and a word and always use a comma between numbers.**
6. If the alkyl group is present more than once, prefixes are used in front of the alkyl group.*(Example: The prefixes di for 2, tri for 3 and tetra for 4 are used to designate several groups of the same kind. The prefixes are **not** considered when alphabetizing).*
7. If two possible longest chains of equal length exist, the chain with the greatest number of substituents is selected as the parent chain.
8. When more than one substituents are present at an equal distance from either end of the parent chain, the parent chain should be numbered in such a way that gives the lowest position to the substituents.
9. When two or more substituents are present at an equal position from either side of the longest chain, alphabetical order of the substituent's names must be used in assigning a lower number.

The parent name of the longest continuous carbon chain is as follows:

Number of carbon atoms in the longest chain	Parent name
1	Methane
2	Ethane
3	Propane
4	Butane
5	Pentane
6	Hexane

Substituent groups

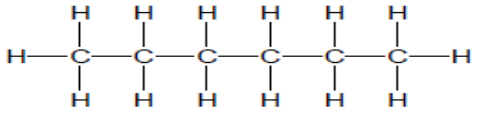
Substituents groups are the side branches in organic compounds. A substituent group derived from an alkane by removal of a hydrogen atom is called an **alkyl group (R-)**. Alkyl groups are named by dropping the "-ane" from the name of the parent alkane and adding the suffix "**-yl**".

Example

Number of carbon atoms in the substituent	Name of substituent
1 (CH_3)	methyl
2 (C_2H_5)	ethyl
3 (C_3H_7)	propyl
4 (C_4H_9)	butyl
Some substituents derived from other elements or other species than alkanes	
F	Fluoro
Cl	Chloro
Br	Bromo

Example 1

Name the organic compound shown below.

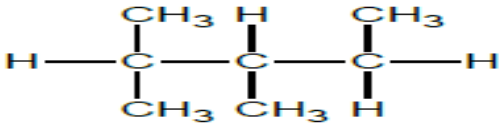


Solution

This is an unbranched alkane. The longest chain has 6 carbon atoms. Thus the name is **hexane**.

Example 2

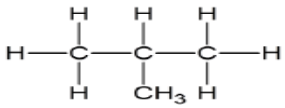
Name the organic compound shown below



The compound given above is a branched alkane because it has substituents (side branches) sticking out of the parent chain (longest chain). *Parent chain - contains 5 carbon atoms – so pentane***.** *The alkane has **2 side branches**, both are **methy**l groups. The first one is located on the **2nd** carbon atom and the second one is on the **3rd** carbon atom. Thus, location and name of the substituents is: 2,3-dimethyl.* Hence, the name of the above alkane is **2, 3-dimethlypentane**

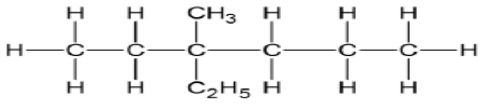
Other examples

3.



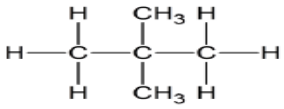
2-methylpropane

5.



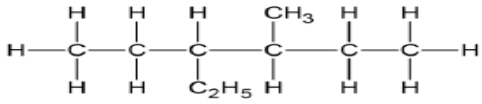
3-ethyl-3-methylhexane

4.



2,2-dimethylpropane

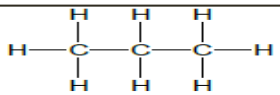
6.



3-ethyl-4-methylhexane

Representation of organic compounds

The formula of an organic compound can be represented by the molecular formula or by the structural formula. Structural formulas can be represented in three ways.

Structural formula	Description	Propane as an example
Expanded (Complete) Structural formula	The carbon atoms are shown attached to all hydrogen atoms. In other words, all connections are shown.	
Condensed structural formula	The hydrogen atoms are grouped with their carbon atom. The number of hydrogen atoms is written as subscript. *(Hydrogen atoms are shown right next to the carbon atoms to which they are attached).*	$CH_3CH_2CH_3$ or CH_3-CH_2-CH_3
Line-angle formula.	Carbon atoms are implied at the corners and ends of lines, and each carbon atom is understood to be attached to enough hydrogen atoms to give each carbon atom four bonds.	 or

Physical properties of alkanes

- They are nonpolar compounds.

- They are generally insoluble in water (because water is polar) and they are soluble in nonpolar solvents.
- They have a lower density than water.
- Nearly all alkanes have densities less than 1.0 g mL-1 and are therefore less dense than water.
- They can be gases (with 1 to 4 carbon atoms), liquids (with 5 to 17 carbon atoms), or solids (with 18 or more carbon atoms).
- Melting and boiling points of alkane's increases with increasing number of carbon atoms.

Chemical properties of alkanes

In general, alkanes have low reactivity. Their most important reactions are **combustion** (reaction with oxygen) and **substitution** reactions.

1. Combustion Reactions

- Alkanes react with oxygen to produce carbon dioxide (CO_2), water (H_2O), and heat energy depending on whether the reaction is complete or incomplete.

Complete combustion	Incomplete combustion
▪ Occurs in excess oxygen and gives blue non smoky flame. **Example:** $CH_{4\,(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$	▪ Occurs in limited amount of oxygen and produces carbon (sooty flame) or carbon monoxide, depending on the amount of oxygen available. **Example:** $2CH_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{(g)} + 4H_2O_{(l)}$ or $CH_{4(g)} + O_{2(g)} \rightarrow C_{(s)} + 2H_2O_{(l)}$

2. Substitution Reactions

- Alkanes are saturated hydrocarbons therefore they undergo substitution reactions.
- In this reaction, a single hydrogen atom is successively replaced by a halogen such as chlorine or bromine.
- These reactions are catalyzed in the presence of sunlight or UV light.

Example

The reaction of methane with chlorine (Cl_2):

$$CH_4 + Cl_2 \xrightarrow{\text{light}} \underset{\text{Chloromethane}}{CH_3Cl} + HCl$$

If chloromethane is allowed to react with more chlorine:

$$CH_3Cl + Cl_2 \xrightarrow{\text{light}} \underset{\text{Dichloromethane}}{CH_2Cl_2} + HCl$$

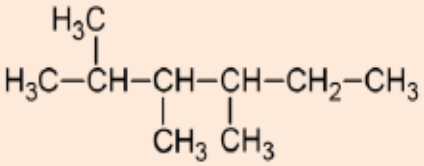
$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{light}} \underset{\text{Trichloromethane}}{CHCl_3} + HCl$$

$$CHCl_3 + Cl_2 \xrightarrow{\text{light}} \underset{\text{Tetrachloromethane}}{CCl_4} + HCl$$

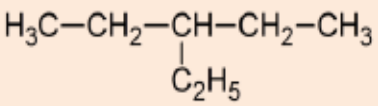
Exercise

1. Name the alkanes shown below.

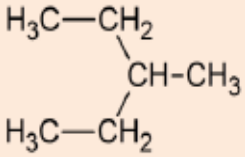
A.



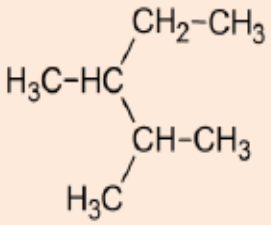
B.



C.



D.



Answers:

A - _____

B - _____

C - _____

D - _____

3. Name the following alkanes:

i. $CH_3CH(CH_3)CH_3$ ii. $CH_3CH(CH_3)CH_2(CH_3)$ iii. $(CH_3)_3CCH_2(CH_3)$

(Hint: Draw the structures first)

i._____

ii._____

iii._____