Digital Teachers

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Chapter 2: Alkanes

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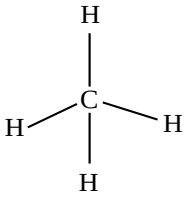
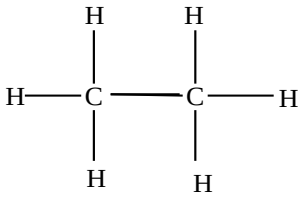
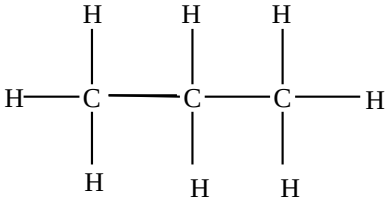
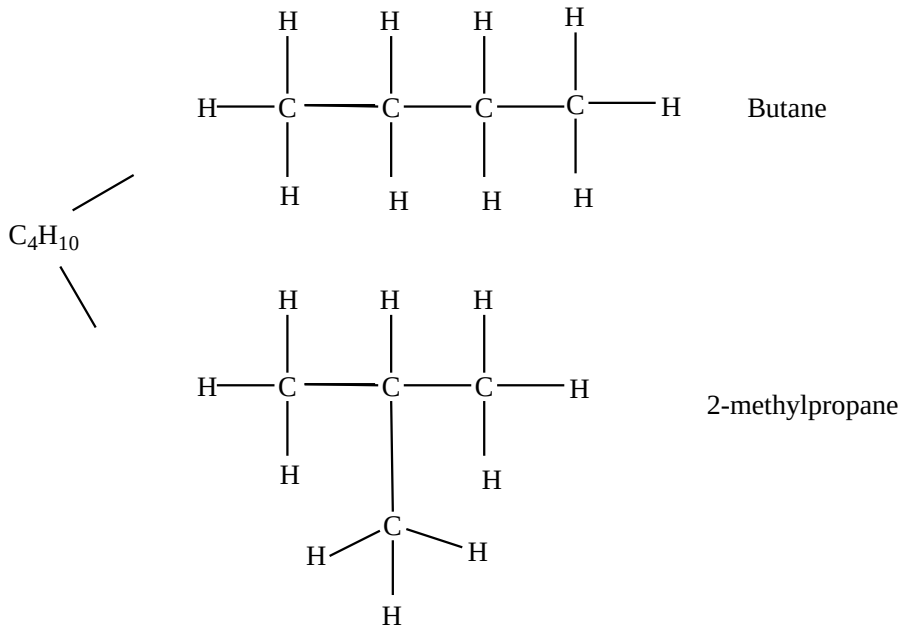
Alkanes

This is the simplest honmologous series

General formula: C_nH_{2n} where $n \geq 1$

Examples

Molecular Formula	Structural Formulae	Names
CH_4		Methane
C_2H_4		Ethane
C_3H_8		Propane



Compounds that contain the same molecular formula but different structural formulae like butane and 2-methylpropane are called isomers.

Definitions.

Isomerism is the existence of compound with the same molecular formulae but different arrangement of atoms in a compound.

Types of isomerism

1. Structural isomerism
2. Optical isomerism

Structural isomerism

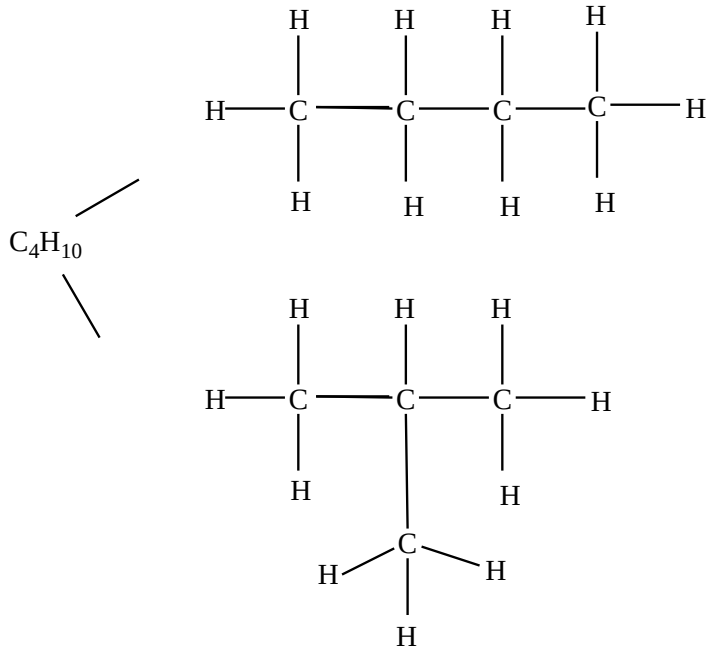
Here compounds differ in arrangement of atoms in a compound.

(a) Chain isomerism: compound have the same molecular formula but different arrangement of atoms in the chain.

(i) Structure isomers:

These are common to alkanes, isomers differ in arrangement of atoms in the chain

Examples



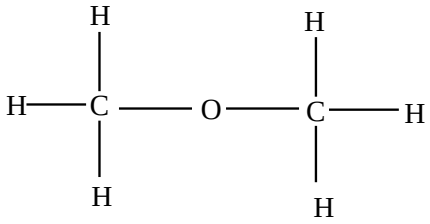
Butane

2-methylpropane

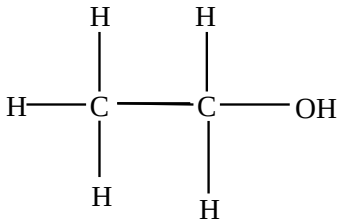
(ii) Functional isomerism

Compounds have the same molecular formula but different functional groups such as alcohols and ether.

Example



Dimethylether



Ethanol

(iii) Positional Isomer:

The isomers have the same molecular formula, same functional group but different positions of the functional group on a molecule.

Examples

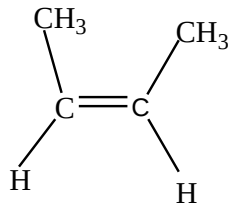
$CH_3CH_2CH=CH_2$ but-1ene
$CH_3CH=CHCH_3$ but-2-ene

(b) Stereo isomerism

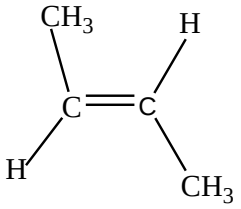
Compounds have the same molecular formula, the same functional group but different arrangement of atoms in space.

(i) Geometrial isomerim: atoms, molecules are arranged differently about a double bonds:

Example



Cis but-2-ene



Trans but-2-ne

(ii) Optical isomers:

Compounds have the same molecular formula, the same functional group but differ in optical properties towards plane polarised light. Those that rotate light towards the right are called **dextro** isomers and those that rotate light towards the left are called **levo** isomers.

Nomenclature

(a) Straight chain isomers

Straight chain isomers are named according to the number of carbon atoms in the chain.

The names of the first ten straight chain isomers are given below;p

CH_4	Methnane
CH_3CH_3	Ethane
$CH_3CH_2CH_3$	Propane
$CH_3CH_2CH_2CH_3$	Butane
$CH_3CH_2CH_2CH_2CH_3$	Pentane
$CH_3CH_2CH_2CH_2CH_2CH_3$	Hexane
$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$	Heptane
$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	Octane
$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	Nonane
$CH_3CH_3CH_3CH_3CH_2CH_2CH_2CH_2CHCH_3$	Decane

An alkyl group

is an alkane less one hydrogen atom.

Example

CH_4	Methane	CH_3-	methyl group
CH_3CH_3	Ethyl	CH_3CH_2-	Ethyl group
$CH3CH2CH_3$	Propane	$CH_3CH_2CH_2$-	Propyl group
$CH_3CH_2CH_2CH_3$	Butane	$CH_3CH_2CH_2CH_2$-	Butyl group

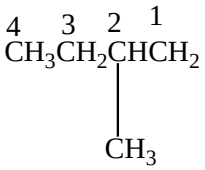
Because alkyl group do not have chemical properties, they are generally represented by a letter R,

(a) Naming branched alkanes

(i) Determine the number of carbon atoms in the longest carbon chain that contain the branch.

(ii) Number the carbon atoms from the side nearest the branch.

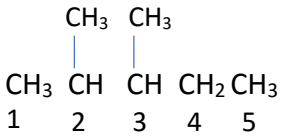
Example



2-Methylbutane

(iii) If there more than one similar alkyl groups on the longest chain; use di, tri, tetra to indicate the number of such groups on the main cahin.

Example.

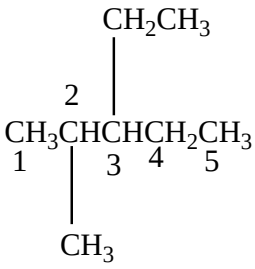


2,3-dimethylpentane

Note that

- This name implies that there is a methyl goup attached to carbon 2 and another to carbon 3 of the pentane.
- When writing the name of organic compound, a coma (,) is placed between figures and a dash (-) between a figure and a letter.

(iv) If different branches name them alphabetically



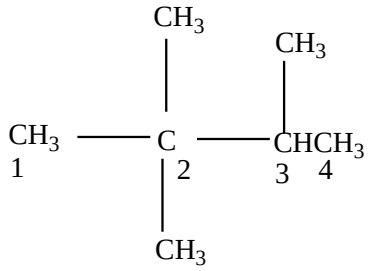
3-Ethyl-2-methypentane

Note that

"E" for ethyl group comes before "M" for methyl group in the alphabets.

(v) If branching occurs equal distance from either side, choose a name that gives the least sum of combination of numbers.

Example



2,2,3-Trimethylbutane AND NOT 2,3,3-Triethylbutane

sum = 7 sum = 8

2,2,3-trimethylbutane is the correct name because it gives the least sum for the combination of numbers.

Exercise

Name the following compounds

(a) $CH_3CH_2CH_2CH_2CH_2CH_3$

(b) $CH_3CHCH_3CH_2CH_3$ with CH_3 on the second carbon

(b) $CH_3CH_2CHCH_2CH_3$ with CH_3 on the third carbon

(d) $CH_3CHCHCH_3$ with CH_3 on the second carbon and CH_3 on the third carbon

(e) $CH_3C(CH_3)_2CH_3$

Solution

(a) $CH_3CH_2CH_2CH_2CH_2CH_3$

Hexane

(b) $CH_3CHCH_3CH_2CH_3$ (with CH_3 branch)

2-methylpentane

(b) $CH_3CH_2CHCH_2CH_3$ (with CH_3 branch)

3-methylpentane

(d) $CH_3CHCHCH_3$ (with CH_3 branches)

2,3-dimethylbutane

(e) $CH_3C(CH_3)_2CH_3$

2,2-dimethypropane

Physical properties of alkane

- they are insoluble in water
- they are soluble in organic solvents
- they range from gases to liquids to waxy solides

Chemical properties

1. They burn in air to produce carbon dioxide, water and heat. Due to production of heat they are used as fuel.
   Example
   $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{heat}$

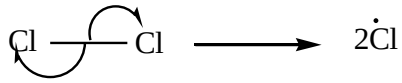
2. Chlorination: they react with chlorine in presence of sunlight or u.v-light to produce chlorinated alkanes.
   Example
   $CH_4 + Cl_2$ may give
   CH_3Cl chloromethane
   CH_2Cl_2 dichloromethane
   $CHCl_3$ trichloromethane
   CCl_4 tetrachloromethane

Mechanism

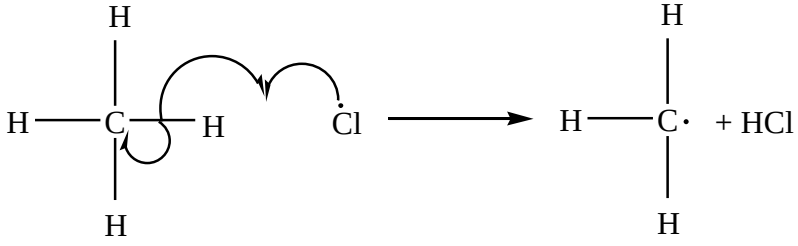
A mechanism are steps followed by a reaction from the reactant to the products.

The following are steps followed in chlorination of methane

1. Chlorine molecules dissociates into atoms with unpaired electron. Atoms or molecules with unpaired electron are called free radicals. Free radicals are indicated by a dot on the atom that posses un paired electron

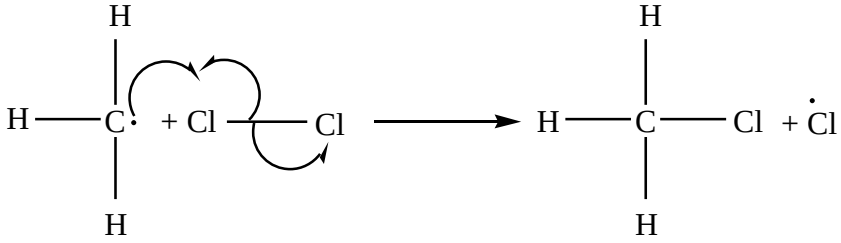


2. Chlorine radical attacks a methane to produce hydrogen chloride and a methyl radical.



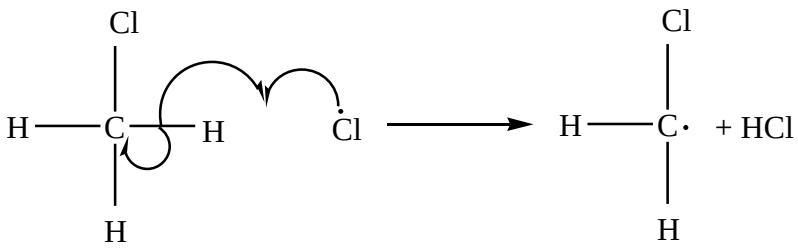
Methyl radical

3. Methyl radical reacts with a chlorine molecule to form chloromethane and a chlorine radical



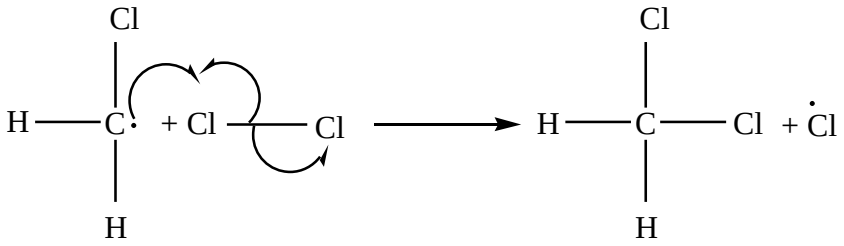
chloromethane

4. Chlorine radical attacks a chloromethane to produce hydrogen chloride and a chloromethyl radical.



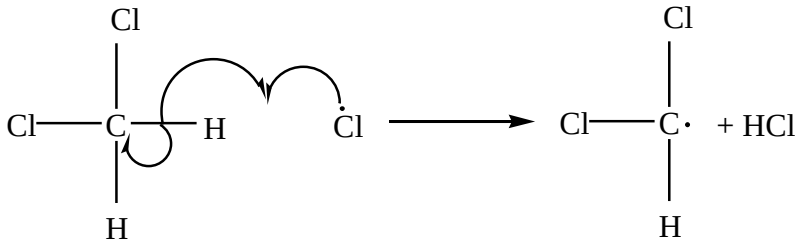
Chloromethyl radical

5. Chloromethyl radical reacts with a chlorine molecule to form dichloromethane and a chlorine radical



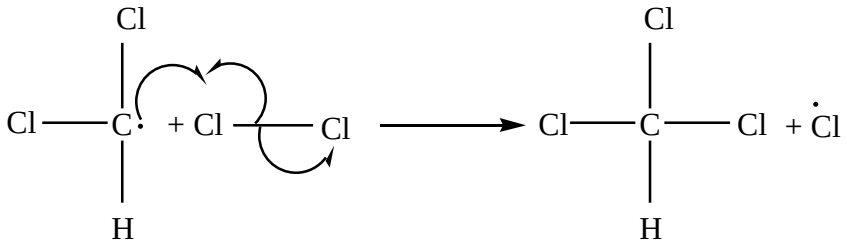
Chloromethyl radical dichloromethane

6. Chlorine radical attacks a dichloromethane to produce hydrogen chloride and a dichloromethyl radical.



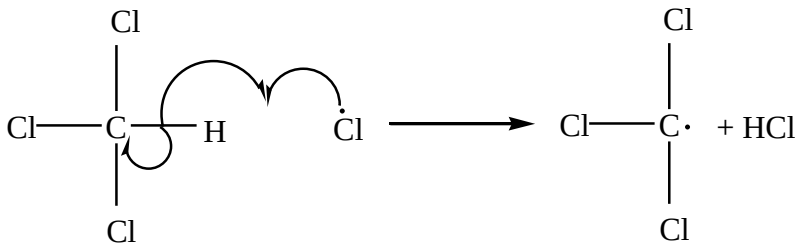
Dichloromethane dichloromethyl radical

7. Dichloromethyl radical reacts with a chlorine molecule to form trichloromethane and a chlorine radical



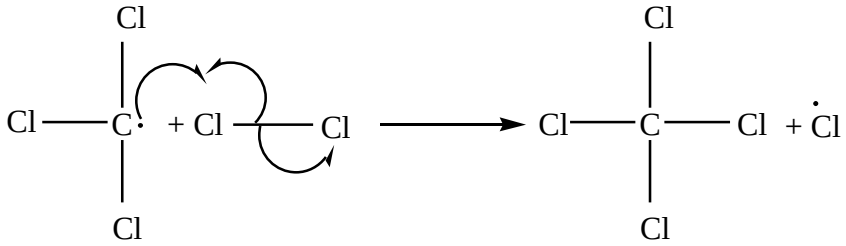
Dichloromethane trichloromethane

8. Chlorine radical attacks a trichloromethane to produce hydrochloride and a trichloromethyl radical.



Trichloromethane Trichloromethyl radical

9. Trichloromethyl radical reacts with a chlorine molecule to form tetrachloromethane and a chlorine radical



Trichloromethyl radical teterachloromethane

Terminating steps

Meamwhile the radicals may combine to produce molecules. The reactions where radicals react to produce molecules is called terminating steps i.e, they prevent the reaction from continuing. Some of the terminating steps are:-

1. Chlorine radical + chlorine radical produces chlorine molecule

   $\dot{Cl} + \dot{Cl} \longrightarrow Cl_2$

2. Methyl radical + methyl radical produces ethane

   $H_3\dot{C} + \dot{C}H_3 \longrightarrow CH_3CH_3$

3. Methyl radical reacts with chlorine radical to form chloromethane and so on.

   $H_3\dot{C} + \dot{Cl} \longrightarrow CH_3Cl$

Sources of alkanes

1. Petroleum product
2. Biogas

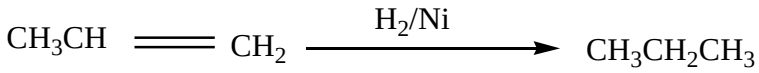
Biogas is prduced by anaerobic decomposition of organic matter (such as cow dung, plant remains, faeces) in presence of water. The main component of biogas is methane.

Laboratory preparation

1. By coupling reaction of alkylhalide in presence of sodium and dry ether. For instance chlomethane couple with chloromethane to form ethane

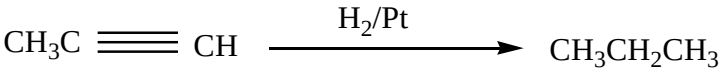
   $2CH_3Cl \xrightarrow{Na/dry\ ether} CH_3CH_3$

2. By reduction of alkenes
   Example



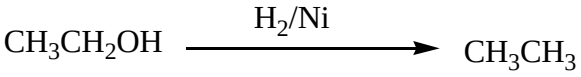
propene propane

3. Reduction of alkynes
   Example



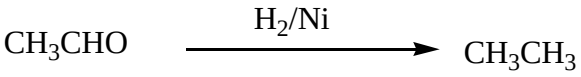
Propyne propane

4. Reduction of alcohols
   Example



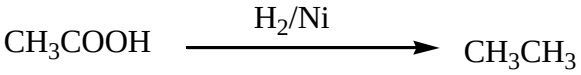
Ethanol ethane

5. Reduction of carbonyl compound
   Example



Ethanal ethane

6. By reduction of carboxylic acid
   Example



Ethanoic acid ethane

7. By cracking long alkane
   Cracking is the breakdown of long chain hydrocarbons into short alkanes.
   Cracking may be catalytic where a catalyst is used or thermal when heat is used.

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