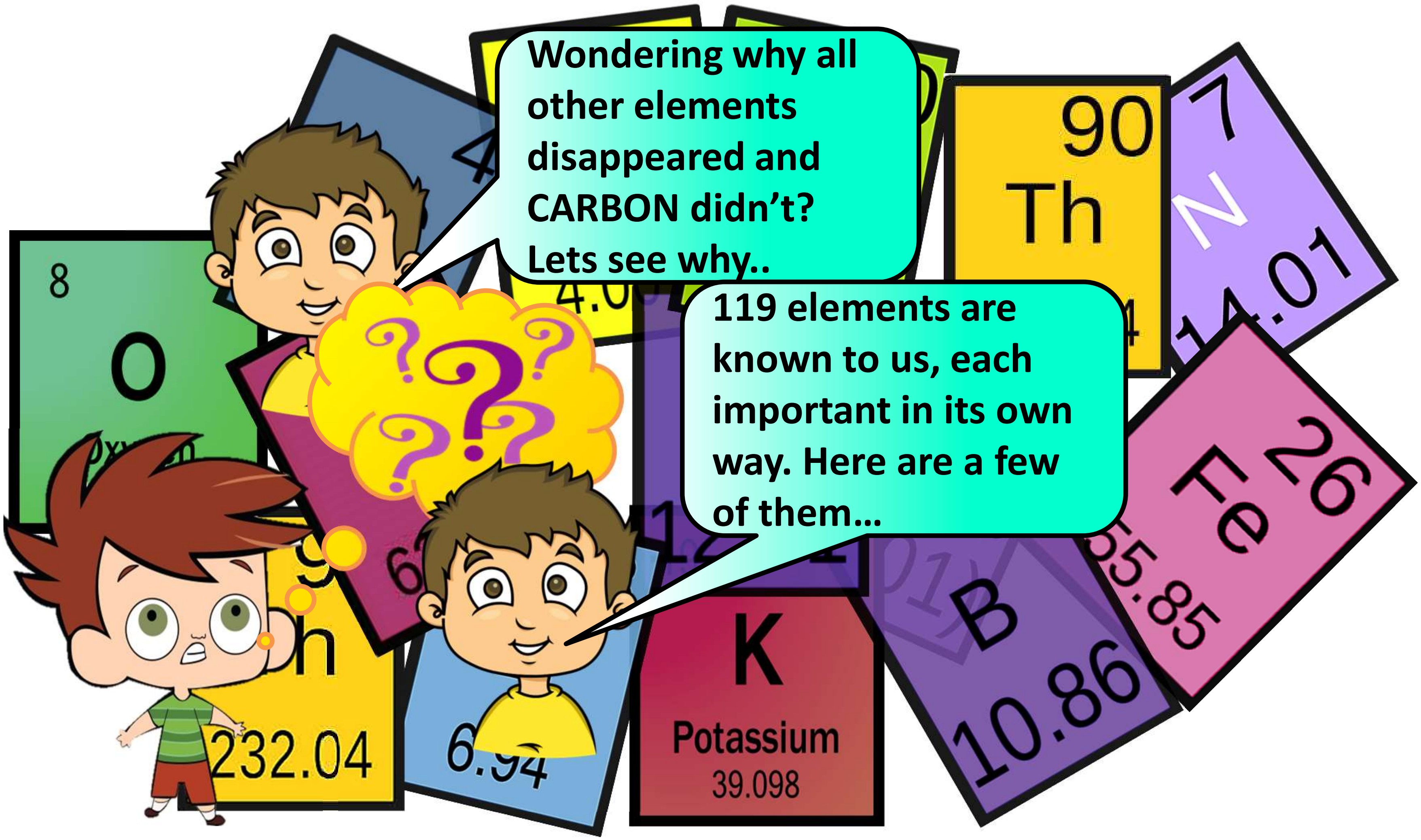
CARBON AND ITS COMPOUNDS

- **Introduction**
- **Carbon**


Wondering why all other elements disappeared and CARBON didn't? Lets see why..
119 elements are known to us, each important in its own way. Here are a few of them…
8
O
90
Th
7
N
26
Fe
K
Potassium
39.098
B
10.86
232.04
6.94

Lets distinguish them into

Things made of metal

Things made of glass and clay

Others

Can you guess the common element found in all ?

CARBON

The earth's crust – 0.02% carbon in the form of minerals (carbonates, hydrogen carbonates, coal and petroleum).

Atmosphere – 0.03% carbon dioxide.

Carbon

ELEMENT NON-METAL

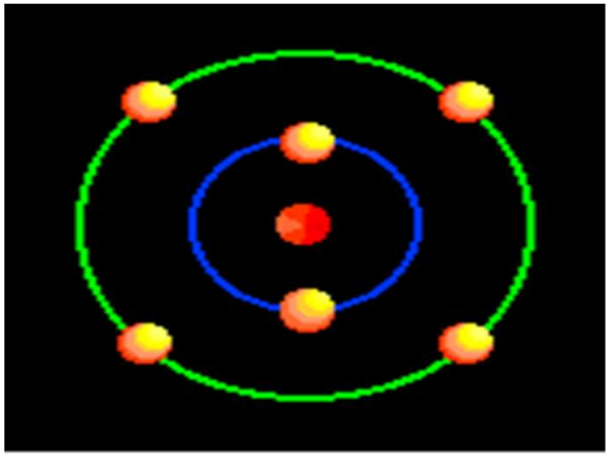
MAJOR CONSTITUENT OF COAL (CARBON)

SYMBOL – C

ATOMIC NO. – 6

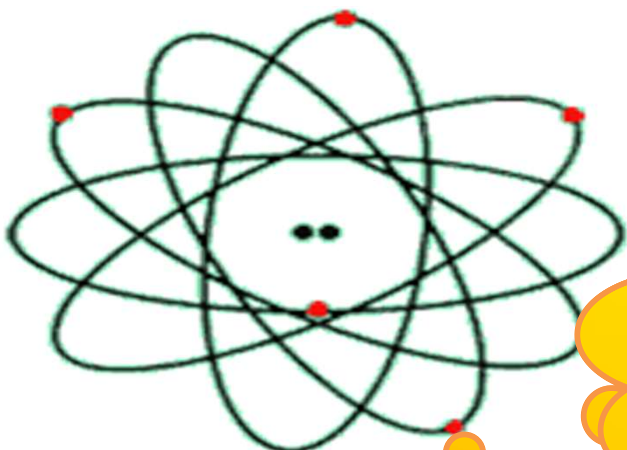
ELECTRONIC CONFIGURATION – (2,4)

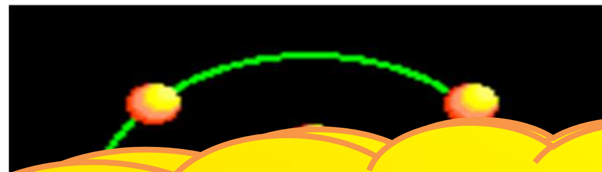
VALENCY – 4



Carbon

To gain stable state





But it would require a large amount of energy to remove four electrons leaving behind a carbon cation with six protons in its nucleus holding on to just two electrons

Either can gain 4 electrons

or

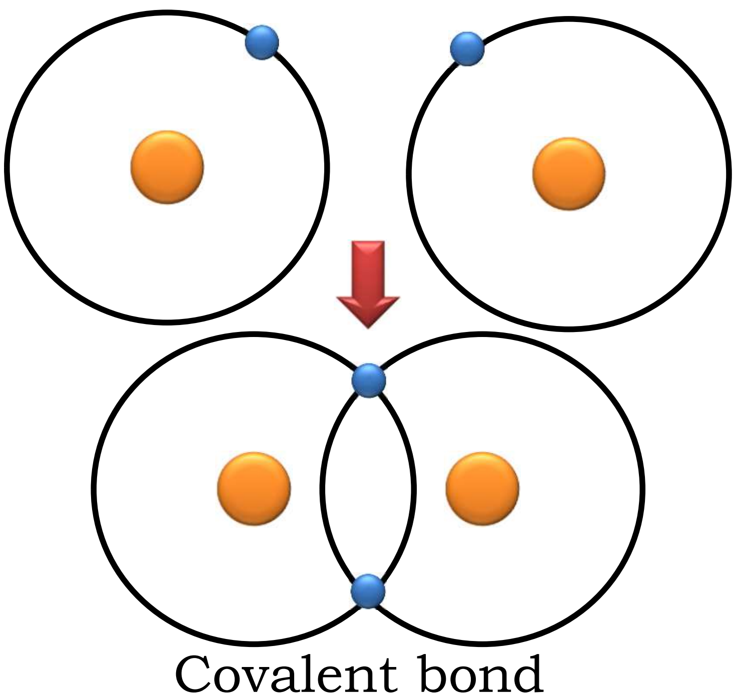
Lose 4 electrons

CARBON AND ITS COMPOUNDS

- **Carbon shares its valence electrons forming covalent bonds**
- **Formation of covalent Compounds**

<u>Carbon shares its valence electrons forming covalent bonds</u>

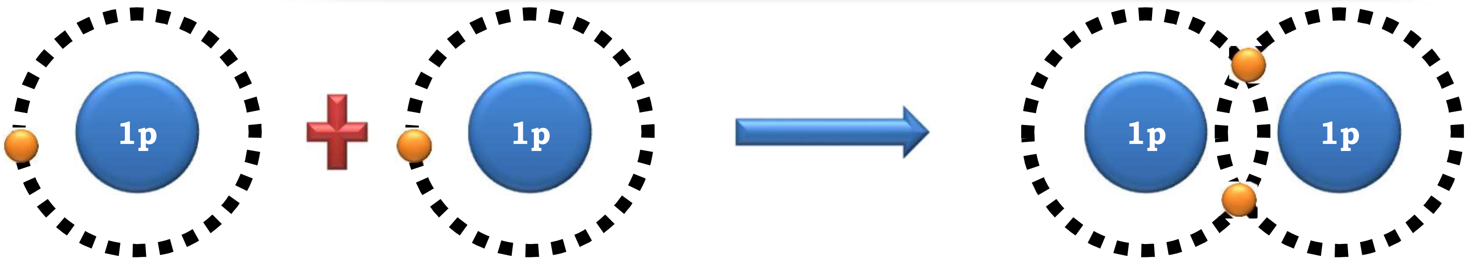
- **Chemical bond formed by sharing of electrons between two atoms is called covalent bonding.**



ALL NON METALS FORM COVALENT BONDS

FORMATION OF COVALENT COMPOUNDS

Formation of Hydrogen Molecule



H (Z=1) (1)

H (Z=1) (1)

To become stable one H atom shares 1 electron with other H atom.

Since total 2 electrons (1pair) are shared we say that...

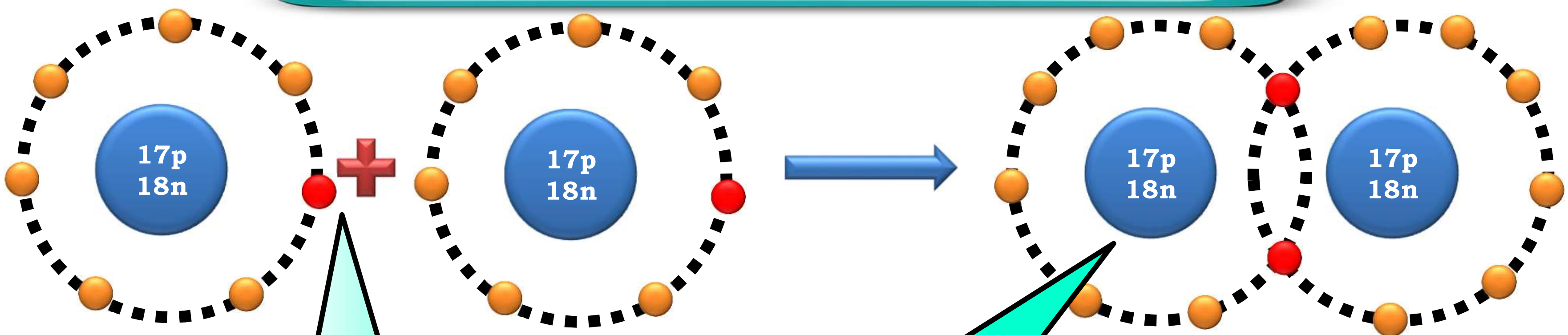
of
represented by same symbol (either dot or cross)

H : H

H — H

A chemica... y SHARING ...ele... is called as SINGLE COVALE... BOND.

Formation of Chlorine Molecule



Cl (Z=17) (2,

Cl (Z=17) (2,8,7

To become stable one Cl atom shares 1 electron with other Cl atom.

Since total 2 electrons (1pair) are shared we say that…

of … represented by same symbol (either dot or cross)

Cl • • Cl

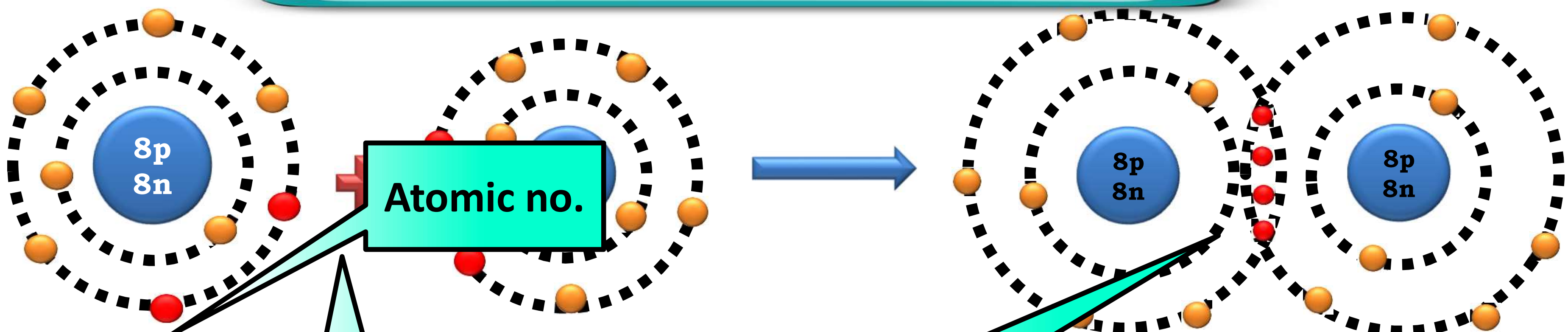
Cl — Cl

A chemi… SHARING … e is called as SINGLE COVALE… BOND.

CARBON AND ITS COMPOUNDS

- Formation of oxygen molecule
- Formation of nitrogen molecule

Formation of Oxygen Molecule



O (Z=8) (2,6)

O (Z=8) (2,6)

O : : O

O = O

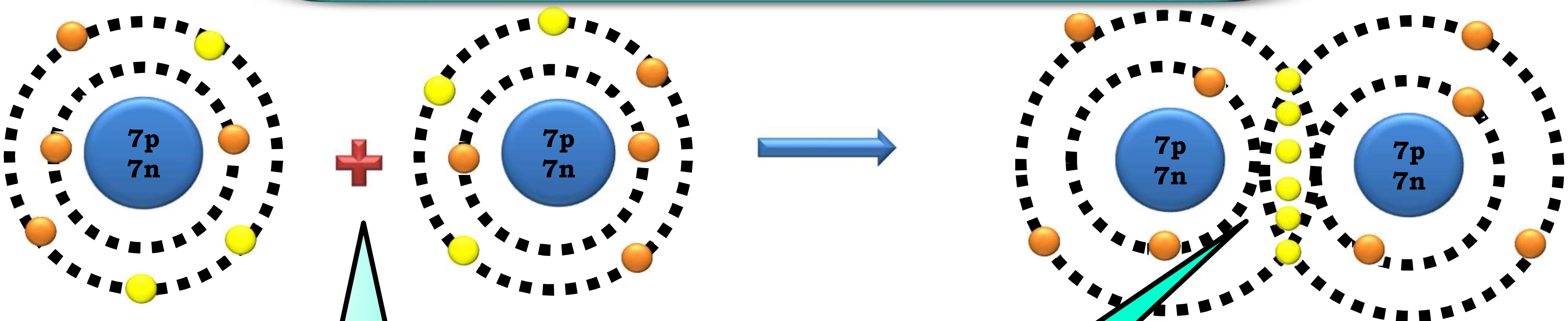
To become stable one O atom shares 2 electrons with other O atom.

Since total 4 electrons (2pairs) are shared we say that…

…of … …he symbol (either dot or cross)

A chemica… SHARING … electrons is called as DOUBL… COVALENT BOND.

Formation of Nitrogen Molecule



N (Z=7)
(2,5)

N (Z=7)
(2,5)

N ⋮ N

N ≡ N

To become stable one N atom shares electrons with another N atom.

Since total 6 electrons i.e. 3 pairs of electrons are shared we say that...

A chemic
of THREE PAIRS of elect
called as TRIPLE COVALENT BOND.

CARBON AND ITS COMPOUNDS

- **Formation of water molecule**
- **Formation of methane molecule**
- **Formation of Carbon dioxide molecule**

Formation of water molecule (H_2O)

ATOMIC NUMBER OF HYDROGEN IS 1.

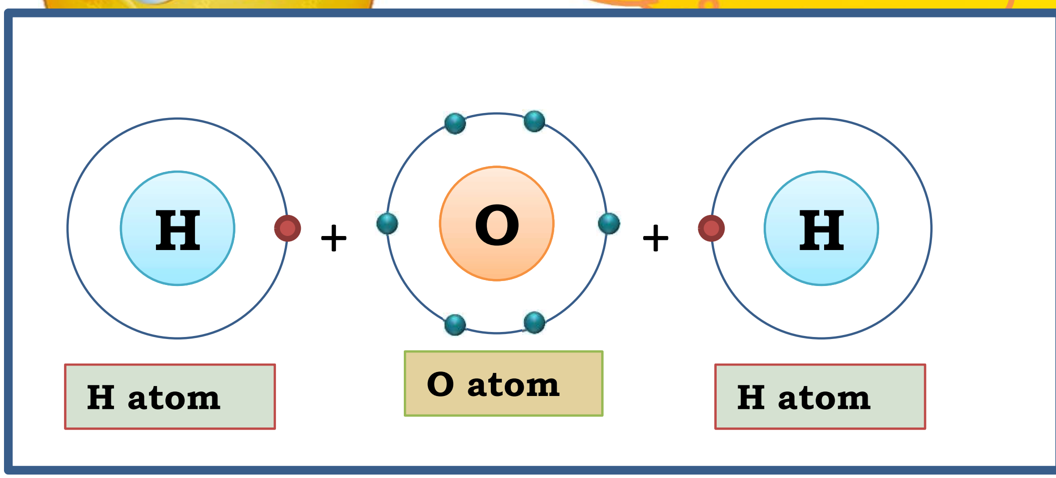
THUS VALENCY OF HYD

ATOMIC NUMBER OF

T OF O

THEY WILL SHARE 1 ELCTRON WITH EACH OTHER.

HOW RONS WILL THEY SHARE?



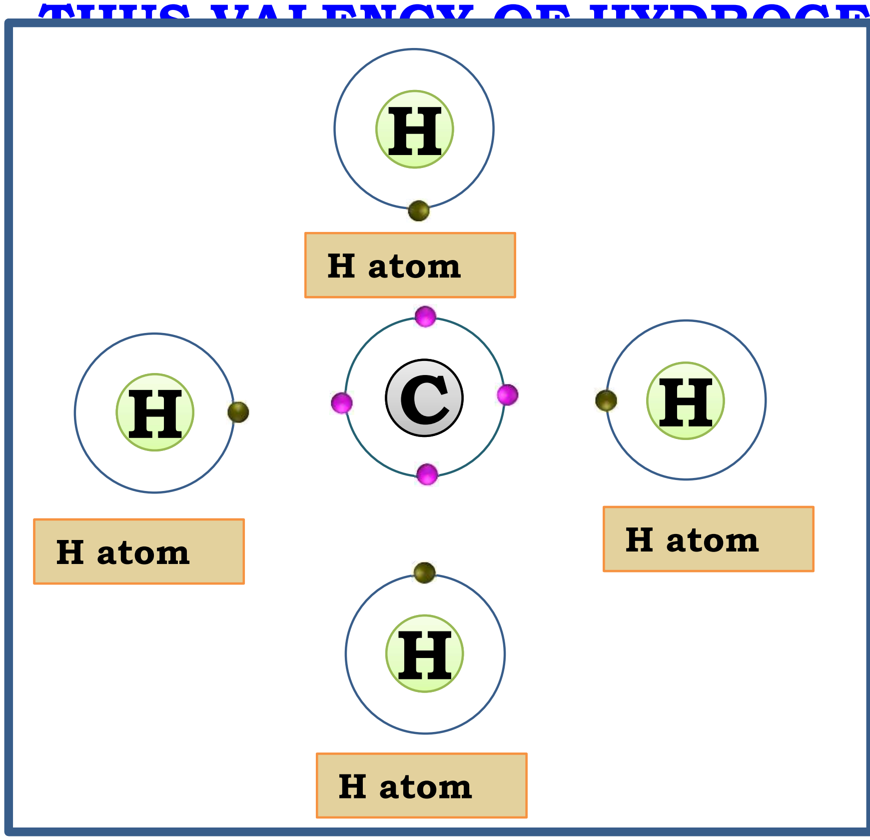
Formation of methane molecule (CH_4)

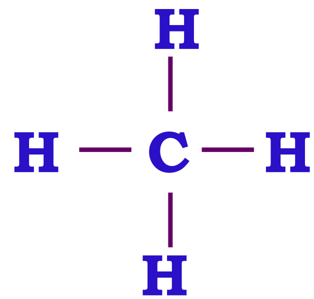
ATOMIC NUMBER OF HYDROGEN IS 1.

THUS VALENCY OF HYDROGEN IS 1.

IS 6 (2,4).

S 4.





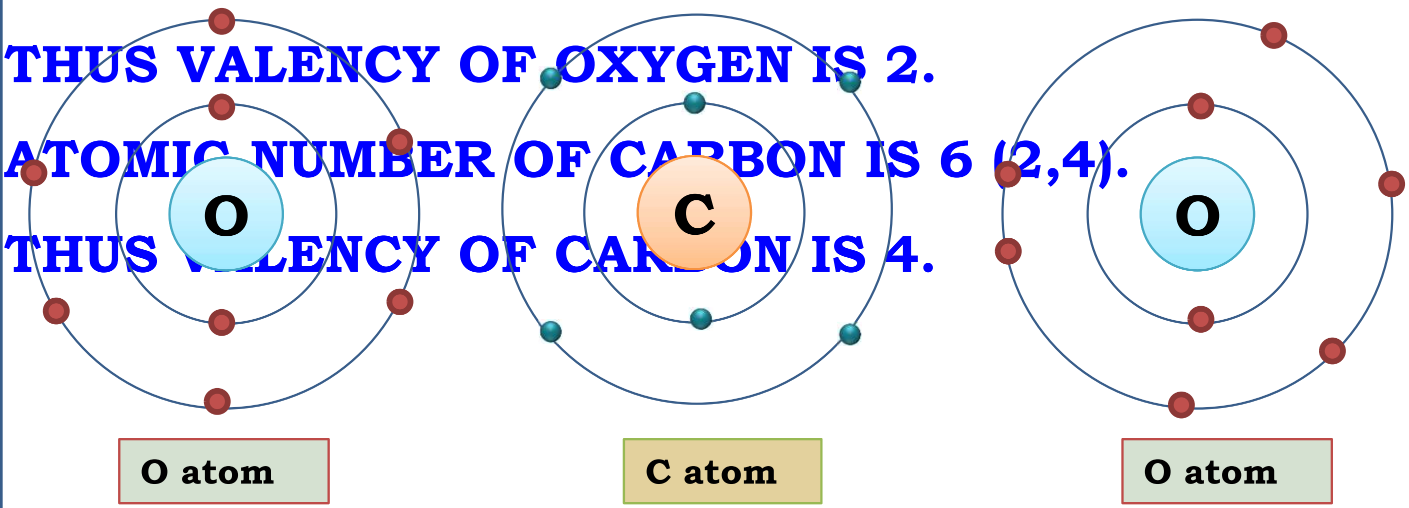
Formation of carbon dioxide molecule (CO_2)

ATOMIC NUMBER OF OXYGEN IS 8.

THUS VALENCY OF OXYGEN IS 2.

ATOMIC NUMBER OF CARBON IS 6 (2,4).

THUS VALENCY OF CARBON IS 4.



$$O = C = O$$

CARBON AND ITS COMPOUNDS

- **Properties of Organic Compounds**
- **Allotropes of carbon**

Properties of Organic Compounds

- Covalent compounds have low MELTING & BOILING POINTS.
- They are generally insoluble in WATER but are soluble in ORGANIC SOLVENTS.

Carbon containing solvent

- They … NDUCTORS of hea… city.

PROPERTIES OF COVALENT COMPOUNDS

- They are usually liquids or gases due to weak force of attraction between their molecules. Only some are solids.
- They have **LOW MELTING AND BOILING POINTs** except diamond graphite. Due to weak molecular force of attraction little energy is required to beak these forces.
- They are generally Insoluble in water but soluble in organic solvents
- **POOR CONDUCTORS OF HEAT AND ELECTRICITY** because they do not contain ions.

OCCURENCE OF CARBON

FREE STATE

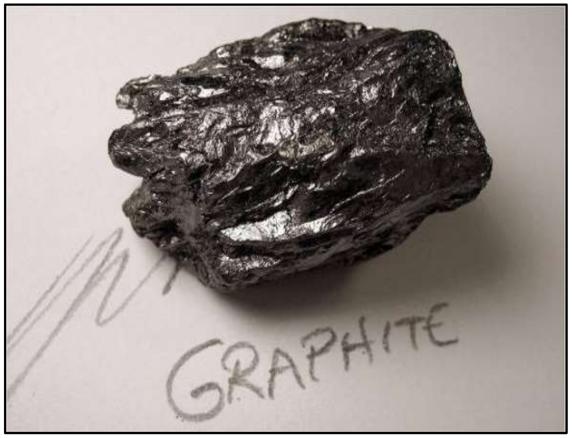
- DIAMOND
- GRAPHITE
- BUCKMINSTER FULLERENE

COMBINED STATE

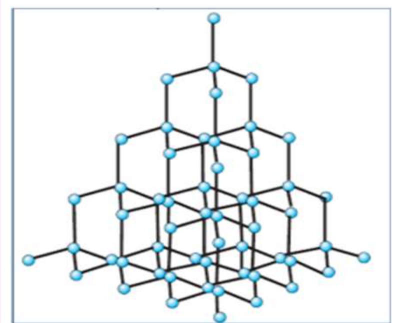
- CARBON DIOXIDE
- CARBONATES (LIMESTONE)
- FOSSIL FUELS (COAL, PETROLEUM, NATURAL GAS)

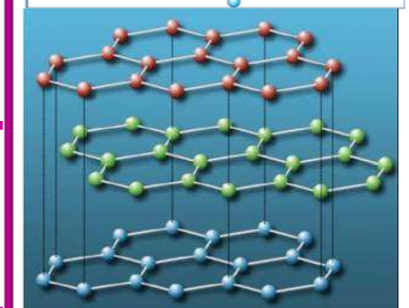
Allotropes of carbon

The various physical forms in which an element can exist are called allotropes of the element.



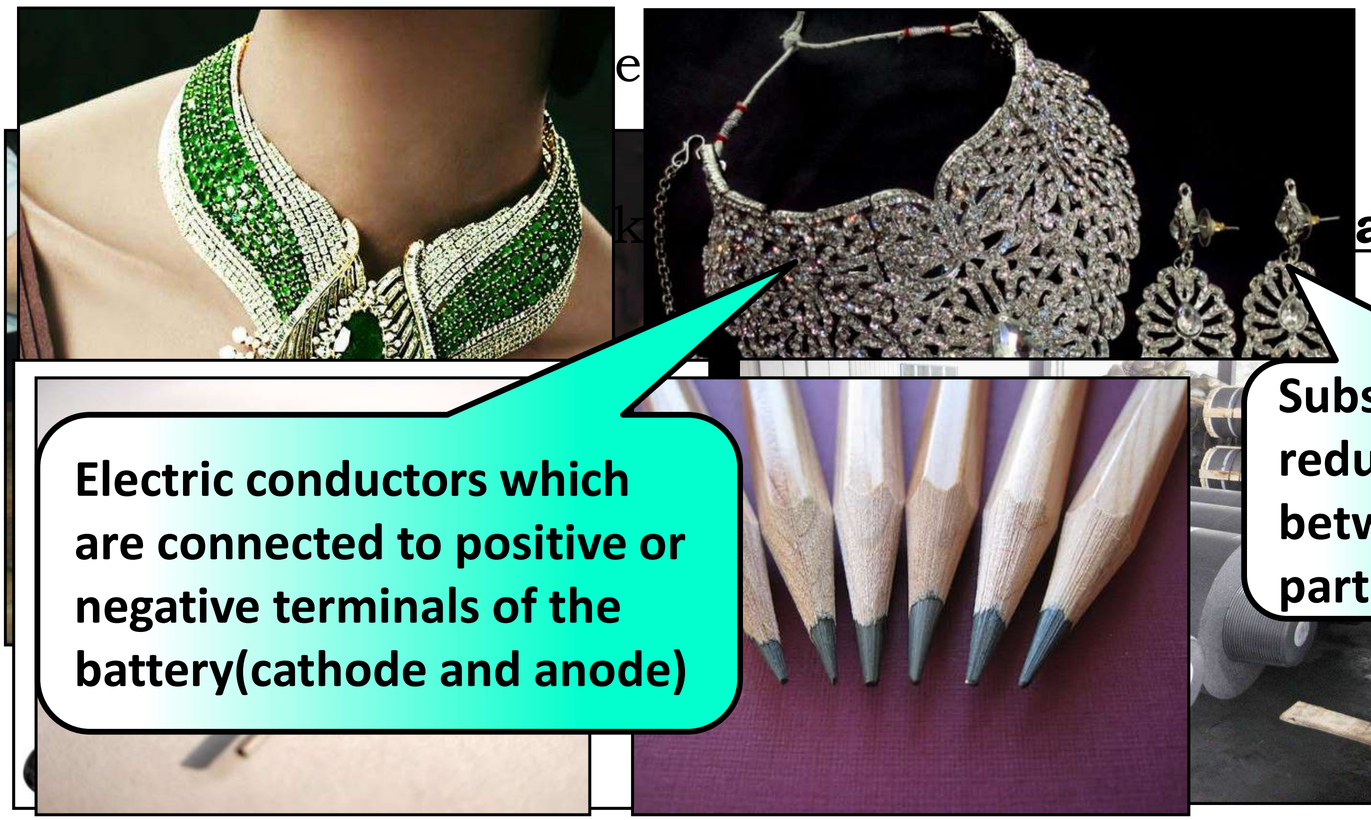
Diamond	Graphite
Colourless transparent substance having extraordinary brilliance.	Grayish black opaque substance.
Each carbon linked to four other neighboring carbon atoms	Each carbon linked to three other neighboring carbon atoms.
It has rigid three dimensional structure.	It has sheet like structure forming an hexagonal array.
Does not conduct electricity because no free electrons present.	Conducts electricity due to presence of free electrons.
Extremely hard and heavy.	Soft and light as compared to diamond.





Uses

Diamond is used as **precious stones in jewellery**.



e

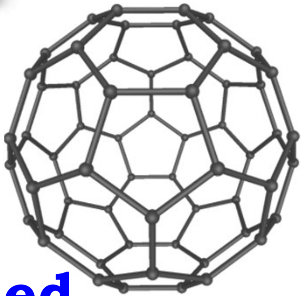
k **and lead pencils.**

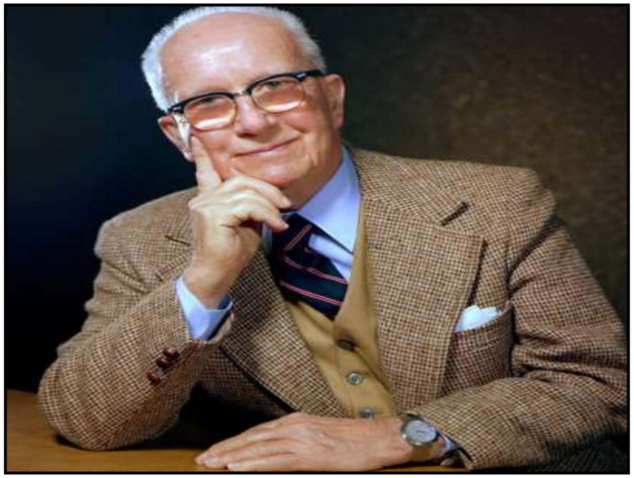
Electric conductors which are connected to positive or negative terminals of the battery(cathode and anode)

Substances used to reduce the friction between moving parts.

Fullerene

- ✓ Allotrope of carbon
- ✓ C- 60
- ✓ Arranged in the shape of a football.
- ✓ It looked like geodesic dome designed by US architect Buckminster Fuller.





CARBON AND ITS COMPOUNDS

- Versatile nature of carbon
- Catenation
- Tetravalency
- Types of organic compounds

<u>Versatile nature of carbon</u>

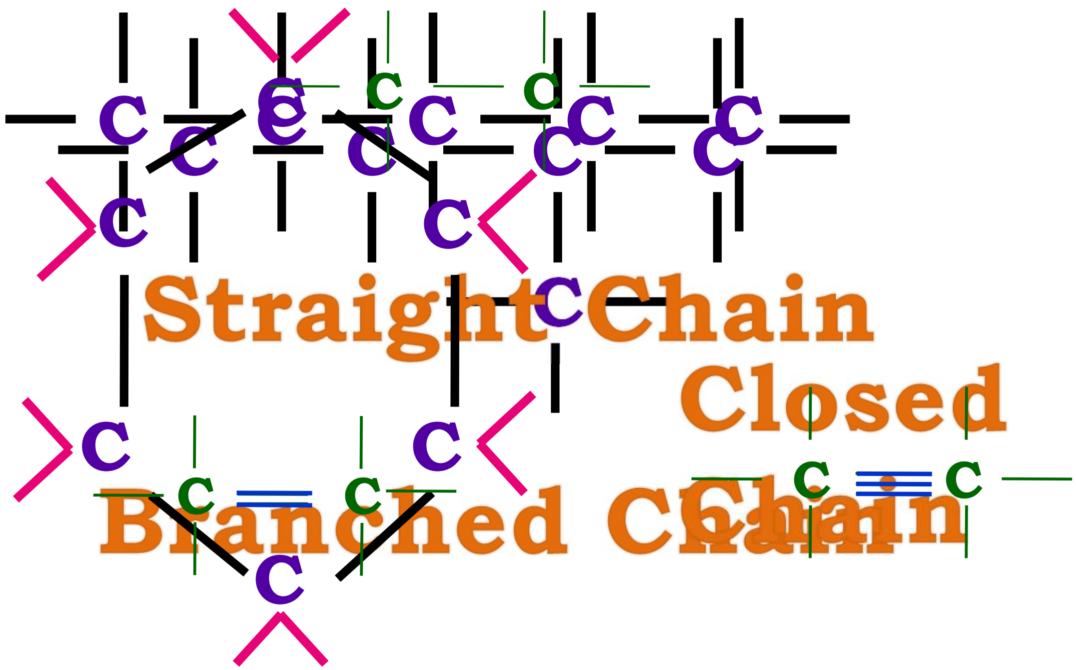
Carbon forms covalent bonds. The nature of these covalent bonds enables carbon to form large number of compounds.

Two factors responsible for large number of carbon compounds are CATENATION & TETRAVALENCY

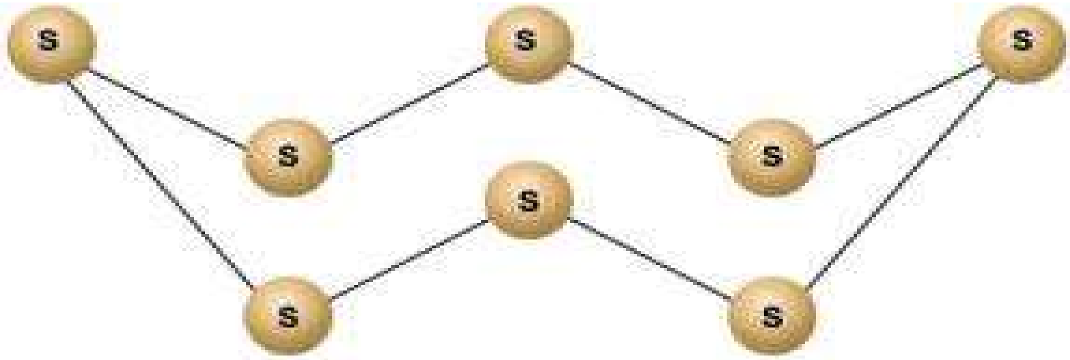
Catenation

The property of self combination of atoms to form large molecules is called catenation

Carbon atoms may be linked by single, double or triple bonds.

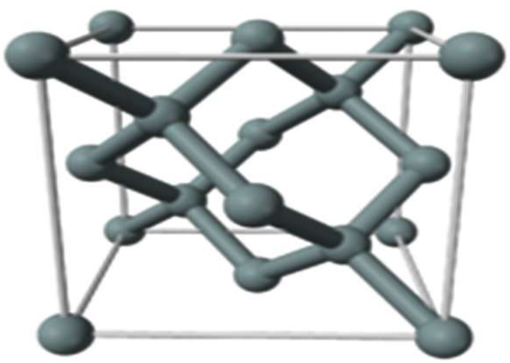


Elements that show catenation



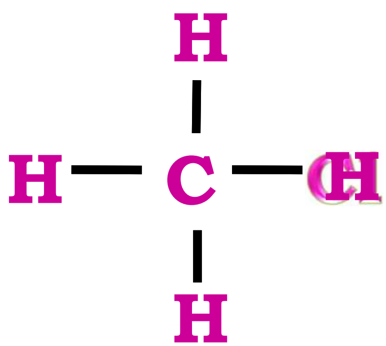
Structure of a sulphur molecule, S_8

- ❖Carbon
- ❖Sulphur
- ❖Silicon
- ❖Phosphorous



Tetravalency

Since, carbon has valency of four, it is capable of bonding with four other atoms of carbon or atoms of some other mono-valent element.



At the beginning of the 19th century – compounds obtained directly or indirectly from

Plants

Animals

For organic compounds it was postulated that a vital force was necessary for their synthesis

Inorganic

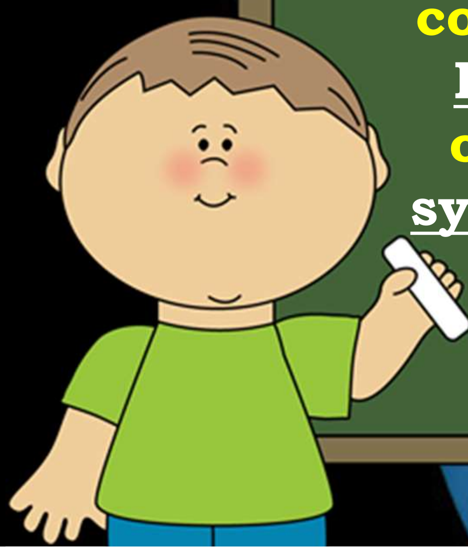
GERMAN CHEMIST - WOHLER

Germany

In 1828, he made urea from Ammonium cyanate.

An organic compound

An inorganic compound



<u>Organic compounds</u> refers to all compounds containing <u>Carbon</u> and <u>Hydrogen</u> which are obtained from <u>living system</u> and now-a-days which can also be <u>synthesized</u> in the <u>laboratory.</u>

Types of organic compounds

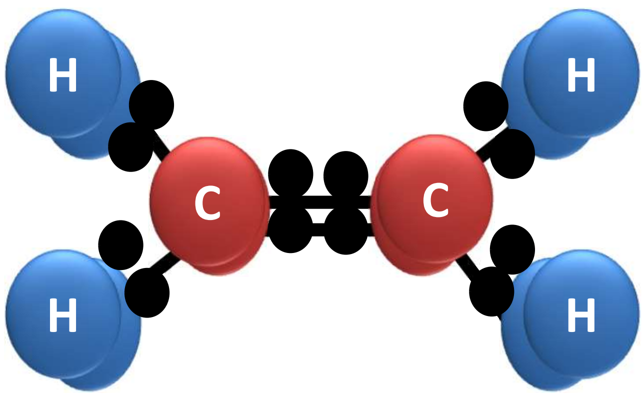
- Hydrocarbons
- Haloalkanes
- Alcohol
- Aldehyde
- Ketone
- Vinegar

CARBON AND ITS COMPOUNDS

- **Hydrocarbons**
- **Alkane, Alkene, Alkyne**

Hydrocarbon

COMPOUNDS CONTAINING CARBON AND HYDROGEN



Hydrocarbons

All organic compounds contain hydrogen along with carbon

fundamental organic comp

compounds. These compou

Open chain Hydrocarbons

Closed-chain/ring cyclic hydrocarbon

Saturated

Unsaturated

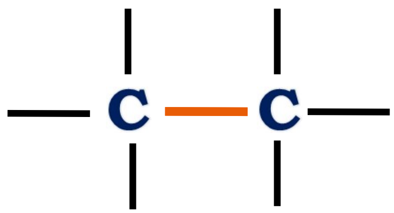
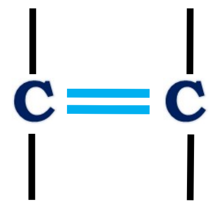
Alkane

Alkene

Alkyne

$C-C$ $\quad$ $C=C$ $\quad$ $C\equiv C$

A hydrocarbon in which the Carbon atoms are linked to each other by double or triple bonds are called as unsaturated hydrocarbon.

Alkane	Alkene	Alkyne
		
Single bond	Double bond	Triple bond

General formula :

C_nH_{2n+2}	C_nH_{2n}	C_nH_{2n-2}

Alkenes contain 2 H atoms less as compared to corresponding alkanes.

Alkynes contain 2 H atoms less as compared to corresponding alkenes and 4 H atoms less as compared to corresponding alkanes.

In alkanes, ane indicates single bond.

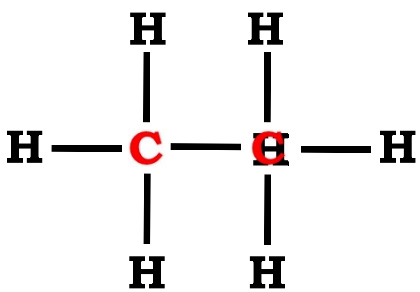
	Root word
Compound with 1 C atom	Meth-
Compound with 2 C atoms	Eth-
Compound with 3 C atoms	Prop-
Compound with 4 C atoms	But-
Compound with 5 C atoms	Pent-
Compound with 6 C atoms	Hex-
Compound with 7 C atoms	Hept-
Compound with 8 C atoms	Oct-
Compound with 9 C atoms	Non
Compound with 10 C atoms	Dec

l.

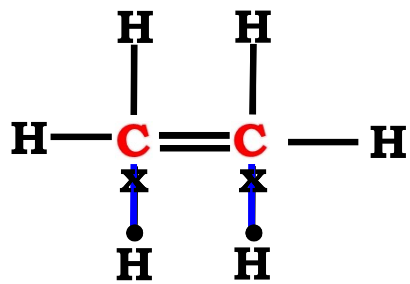
ll.

d is called the root word.

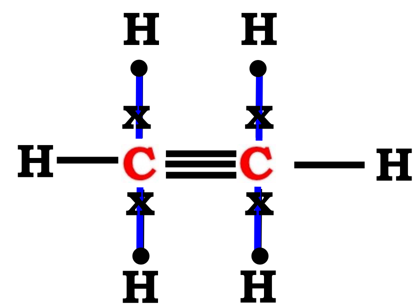
Formation of Hydrocarbon



Methane Ethane



Ethene



Ethyne

As the number of carbo
this molecule is two me
gets replaced by eth.

As the single bond ha
replaced by a double
ane gets replaced by

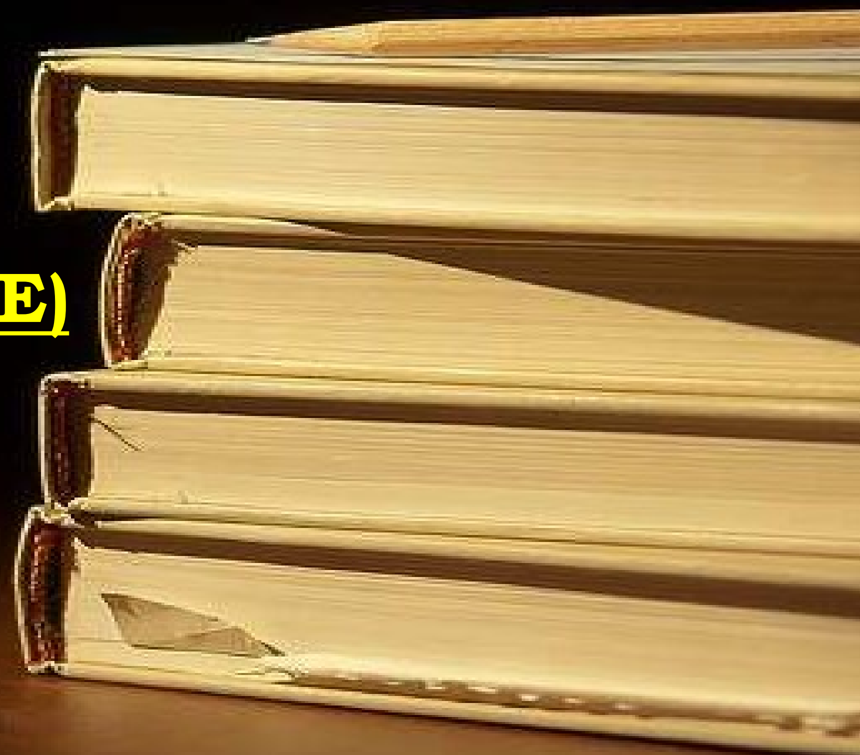
As the single bond has been
replaced by a triple bond
ane gets replaced by yne.

CARBON AND ITS COMPOUNDS

- **Saturated hydrocarbons (Alkane) C_nH_{2n+2}**

SATURATED HYDROCARBONS(ALKANE)

C_nH_{2n+2}



ALKANE

General formula : C_nH_{2n+2}

Put n=1,

$C_1H_{2(1)+2}$

C_1H_{2+2}

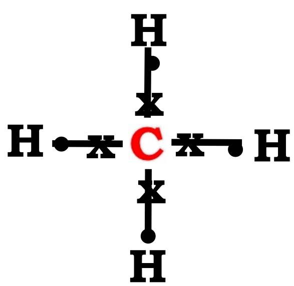
C_1H_4

CH_4

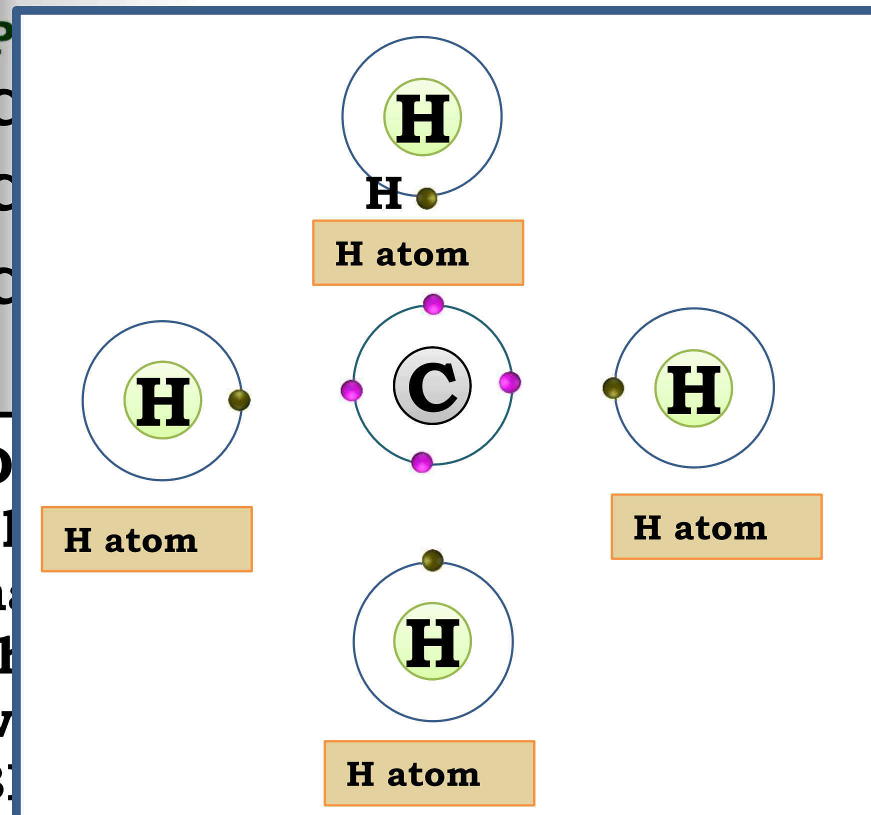
Always remember :
To draw the structures of carbon compounds always draw the carbon atoms first.

Methane

Electron cross dot structure



Methane



Ethane

ALKANE

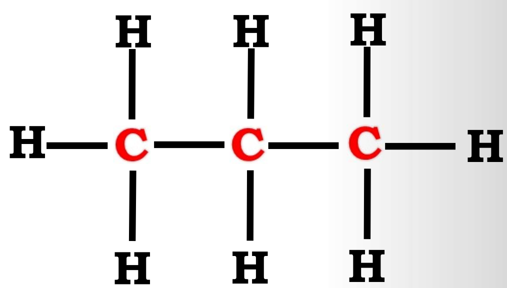
General formula : C_nH_{2n+2}

Put n=3,

$C_3H_{2(3)+2}$

C_3H_{6+2}

C_3H_8



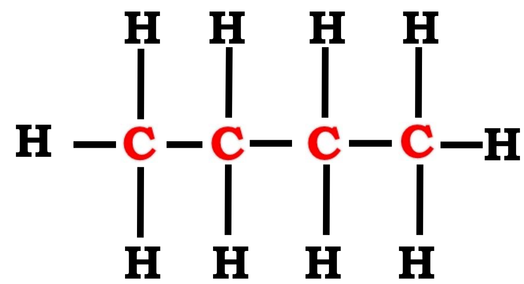
Propane

Put n=4,

$C_4H_{2(4)+2}$

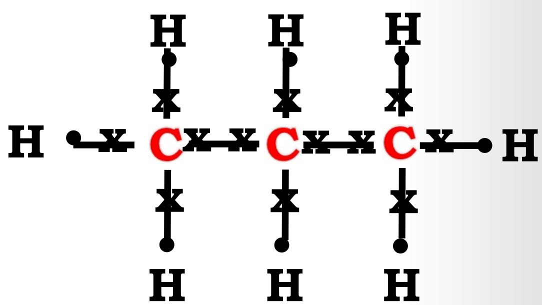
C_4H_{8+2}

C_4H_{10}



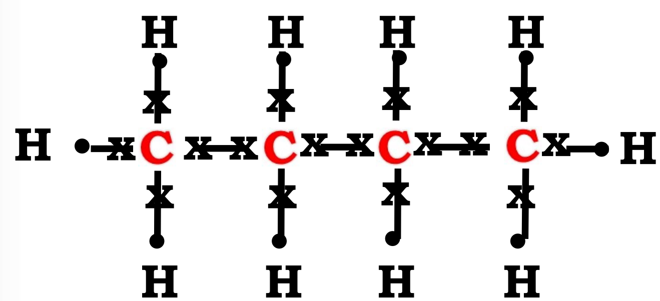
Butane

Electron cross dot structure



Propane

Electron cross dot structure

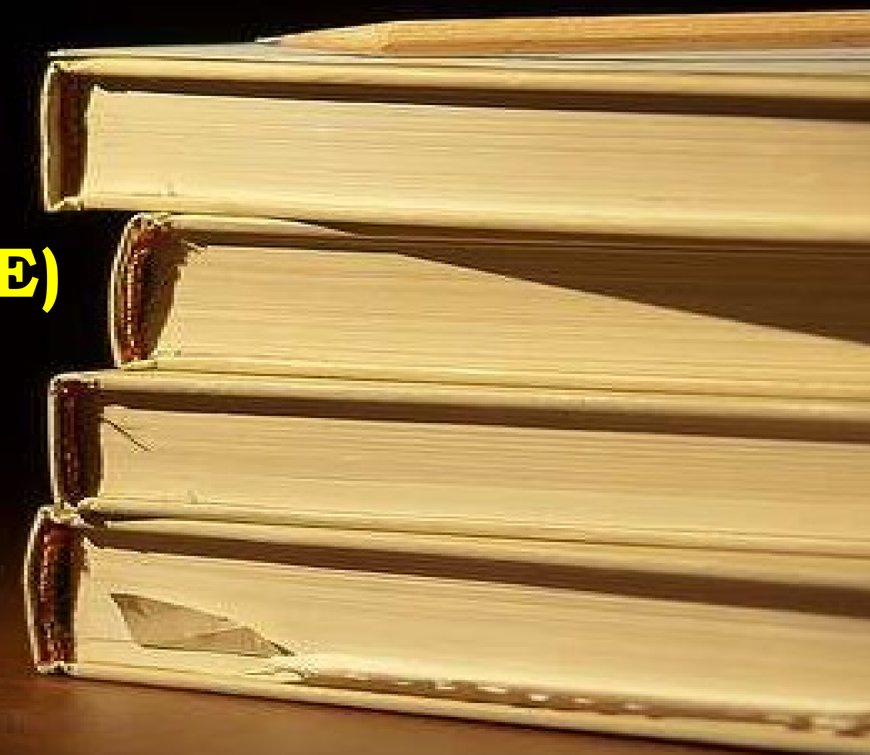


Butane

CARBON AND ITS COMPOUNDS

- **Unsaturated hydrocarbons (Alkene) C_nH_{2n}**

UNSATURATED HYDROCARBONS(ALKENE)
C_nH_{2n}



ALKENE General formula : C_nH_{2n}

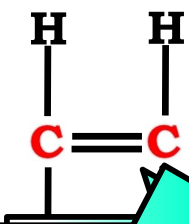
We cannot substitute n=1 for alkenes, as alkenes contain double bond. Double bond can exist only between carbon atoms & hence, minimum 2 carbon atoms are needed for the same.

Methene does not exist in nature.

Put n=2,

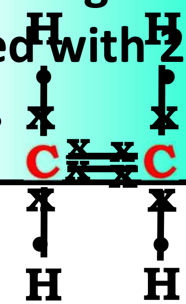
$C_2H_{2(2)}$

C_2H_4



Out of 4 valence electrons of carbon, 2 e-s are shared. So the remaining 2 e-s are shared with 2 H atoms each.

Electron cross dot structure



Ethene

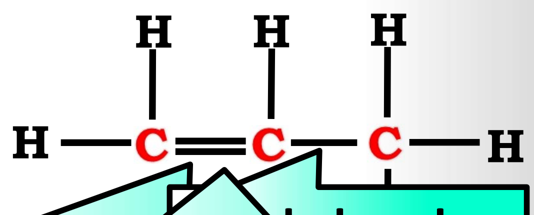
ALKENE

General formula : C_nH_{2n}

Put n=3,

$C_3H_{2(3)}$

C_3H_6



There ... betw...

...le bond

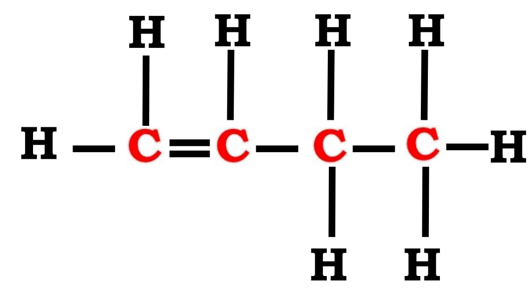
Attach H atoms to C atoms only after checking the valency of C

Propene

Put n=4,

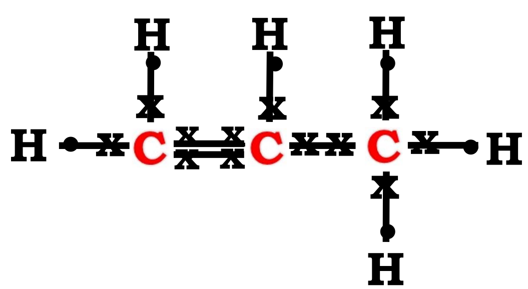
$C_4H_{2(4)}$

C_4H_8



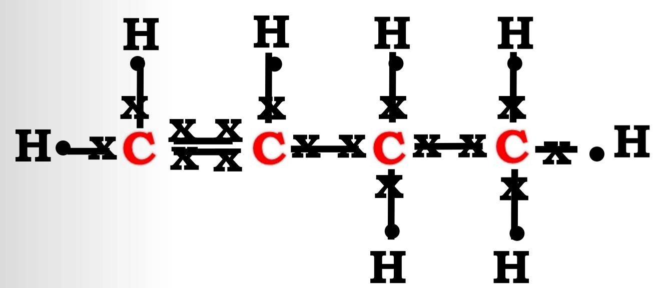
Butene

Electron cross dot structure



Propene

Electron cross dot structure

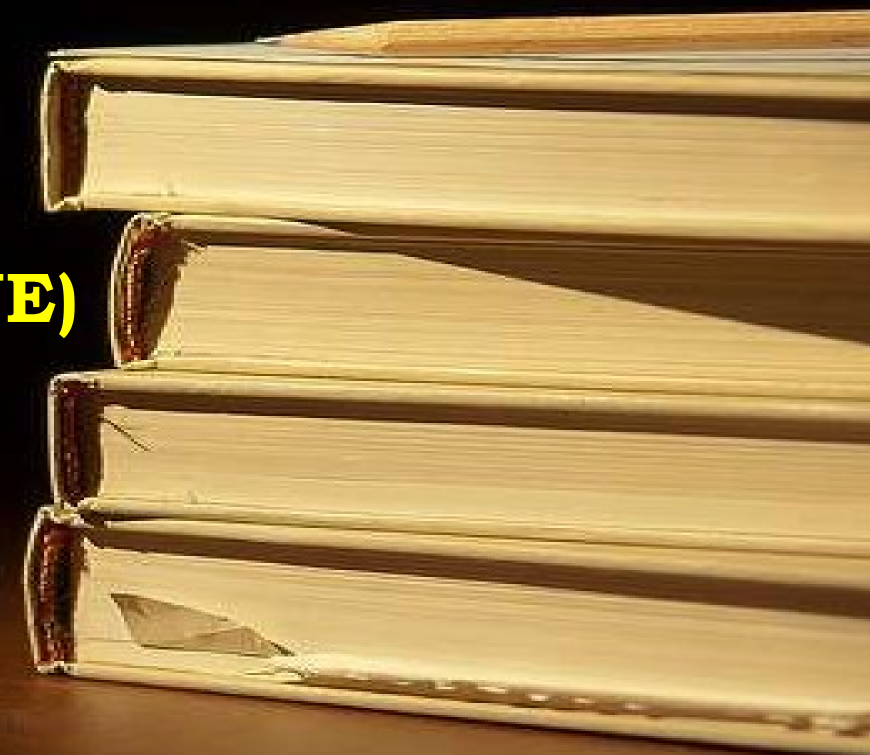


Butene

CARBON AND ITS COMPOUNDS

- **Unsaturated hydrocarbons (Alkyne) C_nH_{2n-2}**

UNSATURATED HYDROCARBONS(ALKYNE)
C_nH_{2n-2}



ALKYNE

General formula : C_nH_{2n-2}

Like alkenes, we cannot substitute n=1 for alkynes, as they contain triple bond. for a triple bond to exist, 2 carbon atoms are needed. Hence substitution starts with n=2.

Methyne does not exist in nature.

Put n=2,

$C_2H_{2(2)-2}$

C_2H_{4-2}

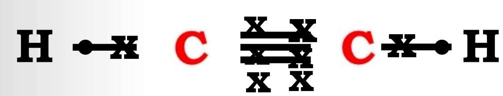
C_2H_2

$H-C\equiv C-H$

Since th

After sharing 3 valence electrons each carbon shares 1 e- with one H atom

Electron cross dot structure



Ethyne

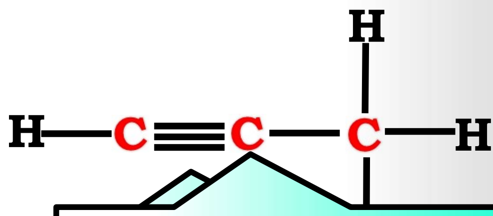
ALKYNE **General formula :** C_nH_{2n-2}

Put n=3,

$C_3H_{2(3)-2}$

C_3H_{6-2}

C_3H_4



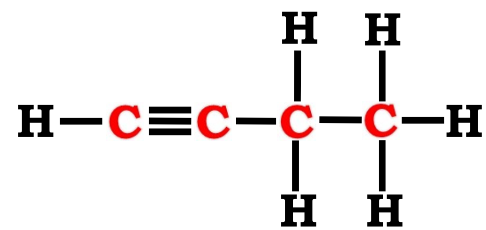
Nothing is attached to this carbon as all 4 valence e-s are shared already.

Put n=4,

$C_4H_{2(4)-2}$

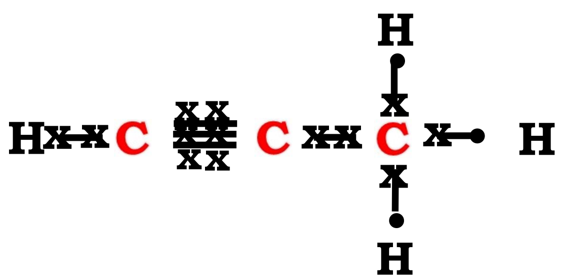
C_4H_{8-2}

C_4H_6



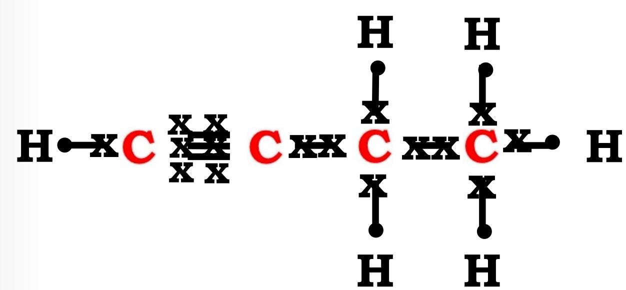
Butyne

Electron cross dot structure



Propyne

Electron cross dot structure



Butyne

CARBON AND ITS COMPOUNDS

- **Exercise**

GOLDEN RULES

If hydrogen atoms is "2 MORE" than double the number of carbon atoms → ALKANES

If hydrogen atoms is "EXACTLY EQUAL" to double the number of carbon atoms → ALKENES

If hydrogen atoms is "2 LESS" than double the number of carbon atoms → ALKYNES

Q. 1 Give the formula for ethane and write the number of covalent bonds present in it.

Solution: Ethane is an alkane with general formula C_nH_{2n+2} it contains 2 carbon atoms.

C_nH_{2n+2}

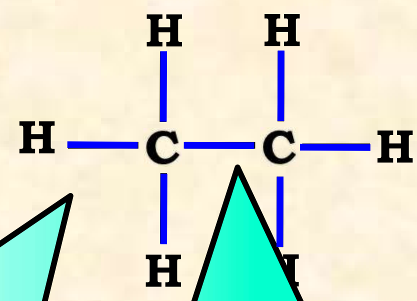
Put n=2,

$C_2H_{2(2)+2}$

C_2H_{4+2}

C_2H_6

Structure of ethane is



carbon atoms

Out of 4 valence electrons carbon has shared 1 e- So the remaining 3 e-s will be shared with 3H atoms .

∴ Formula of ethane is (C_2H_6)

∴ Number of covalent bonds present in ethane are 7

Q. 2 Give the general formula for alkynes and identify which of the following is an alkyne.

CH_4, C_2H_6, C_2H_2, C_3H_4, C_2H_4

Solution:

General f ula of alkynes C_nH_2

$\therefore$ **C_2H are alkynes.**

CH_4, C_2H_6 are alkanes with gene formula C_nH_{2n+2} (n = 1 & n = 2)

C_2H_4 is an alkene with general formula C_nH_{2n} (n = 2)

Q. 3 Give the general formula for alkenes and identify which of the following is an alkene.

C_2H_6, C_2H_4, C_2H_2, C_3H_4, C_3H_6

Solution:

General formula of alkenes (C_nH_{2n})

$\therefore$ **C_2H_4, C_3H_6 are alkenes.**

C_2H_4, C_3H_6 are alkenes with general formula C_nH_{2n} (n = 2 & n = 3)

ith general formula

Q. 4 Give the general formula for alkanes and identify which of the following is an alkane.

CH_4, C_3H_8, C_2H_2, C_3H_6, C_2H_6

Solution:

General f ula of alka is $(C_nH$)

$\therefore$ CH_4, C_2H_6 & C_3H_8 are alkanes.

CH_4, C_2H_6, C_3H_8 are a
formula C_nH_{2n+2} (n

C_2H_2 is an alkyne
C_nH_{2n-2} (n = 2)

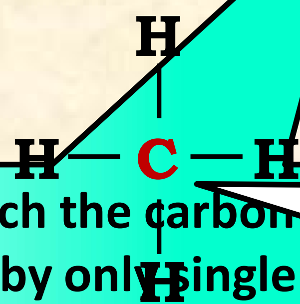
C_3H_6 is an alkene with general formula C_nH_{2n} (n = 3)

Q. 5 Which of the following compounds is saturated?

CH_4, C_2H_4

Solution:

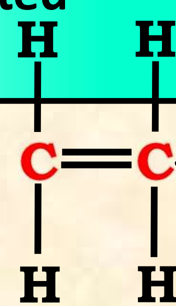
Structure of methane (CH_4) is



A hydrocarbon in which the carbon atoms are connected by only single bonds are called a saturated hydrocarbons.

Connected by only single bonds.

Structure of ethene (C_2H_4) is



Carbon atoms are connected by double bonds. Therefore it is a unsaturated hydrocarbon.

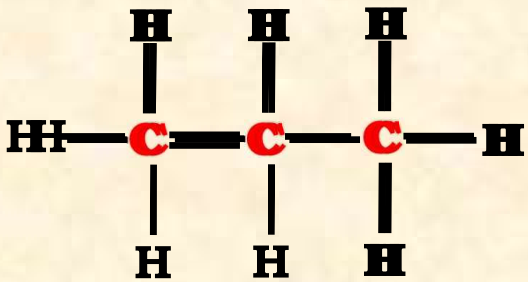
∴ CH_4 is a saturated hydrocarbon.

Q. 6 Which of the following compounds can have a double bond?

C_3H_8, C_3H_6

Solution:

C_3H_6 is an alkene with general formula C_nH_{2n}. Alkenes are unsaturated hydrocarbons (connected by double bonds).

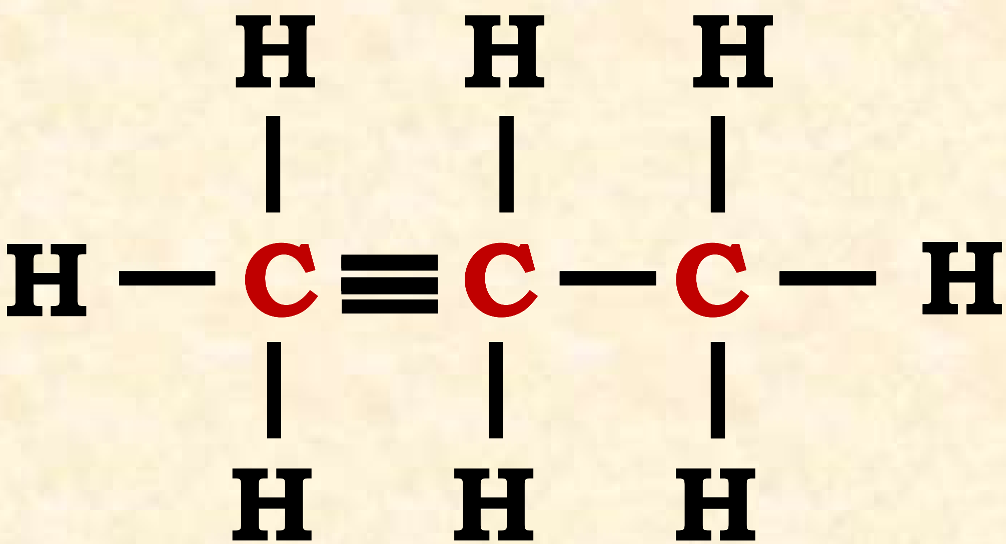


$\therefore$ **C_3H_6 has a double bond.**

Q. 7 A hydrocarbon molecule has 3 carbon atoms. Write down its molecular formula, structural formula if it is an: ALKANE, ALKENE, ALKYNE.

Solution:

Alkyne (C_3H_4) Propyne



Q. 8 Home work

A hydrocarbon molecule has 7 carbon atoms. Write down its molecular formula and structural formula if it is an:

Solution:

1) **ALKANE**

2) **ALKENE**

3) **ALKYNE**

CARBON AND ITS COMPOUNDS

- **Closed chain hydrocarbons**
- **Alkyl group**

Hydrocarbons

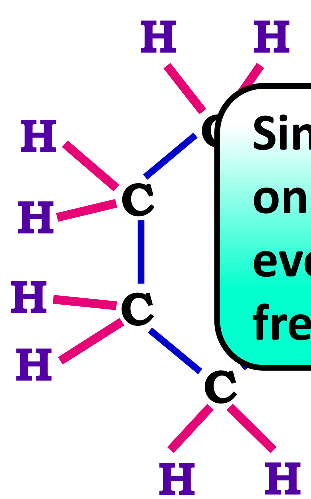
Open chain Hydrocarbons

Closed-chain/ring cyclic hydrocarbon

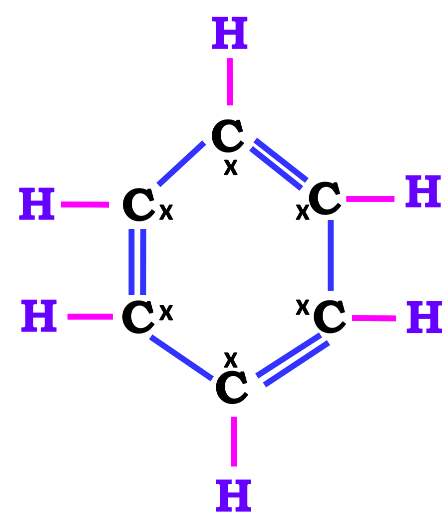
Example

1. Cyclohexane (C_6H_{12})

2. Benzene (C_6H_6)



Since every carbon has only three bonds hence every carbon has one free valence electron



Let us study the 1st ten members of the alkane family

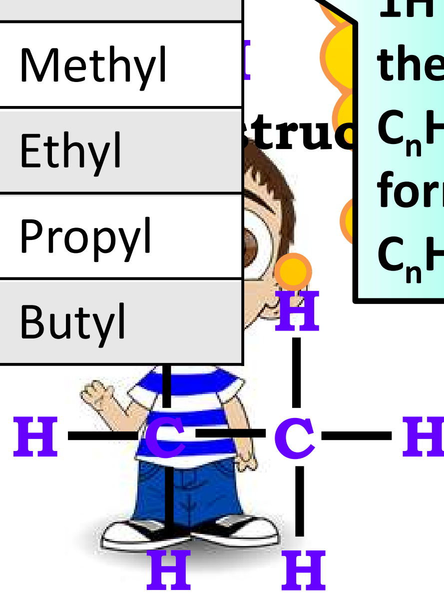
CH_4	Methane
C_2H_6	Ethane
C_3H_8	Propane
C_4H_{10}	Butane
C_5H_{12}	Pentane
C_6H_{14}	Hexane
C_7H_{16}	Heptane
C_8H_{18}	Octane
C_9H_{20}	Nonane
$C_{10}H_{22}$	Decane

Alkanes — Alkyl group - R

General formula C_nH_{2n+2}	Name of the compound	General formula C_nH_{2n+1}	Name of the alkyl group
CH_4	Methane	- CH_3	Methyl
C_2H_6	Ethane	- C_2H_5	Ethyl
C_3H_8	Propane	- C_3H_7	Propyl
C_4H_{10}	Butane	- C_4H_9	Butyl

When 1 H

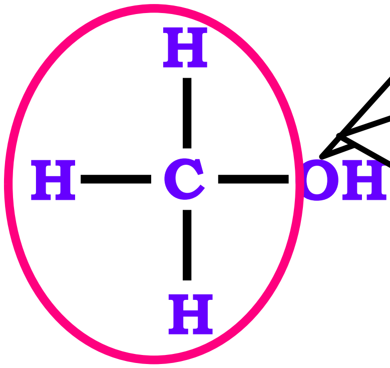
General formula of alkane is C_nH_{2n+2} .Since alkyl group has 1H atom less as compared to the corresponding alkane, C_nH_{2n+2-1} .So the general formula for alkyl group is C_nH_{2n+1}



On removal of 1H atom from C_2H_6 i.e. ethane, we get - C_2H_5 i.e. ethyl group.

Alcohol

$R-OH$



In organic chemistry, OH group represents a group of ompounds called ALCOHOLS

Methyl alcohol
CH_3OH

Similarly

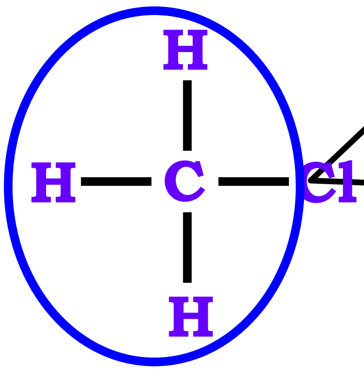
C_2H_5OH	Ethyl alcohol
C_3H_7OH	Propyl alcohol
C_4H_9OH	Butyl alcohol

ALKYL GROUP - R

General formula	Name of the alkyl group
$- CH_3$	Methyl
$- C_2H_5$	Ethyl
$- C_3H_7$	Propyl
$- C_4H_9$	Butyl

Chloride

R — Cl



On removal of 1H atom from Carbon bec unstable.

Let us consider methyl group

Methyl chloride
CH_3Cl

Similarly

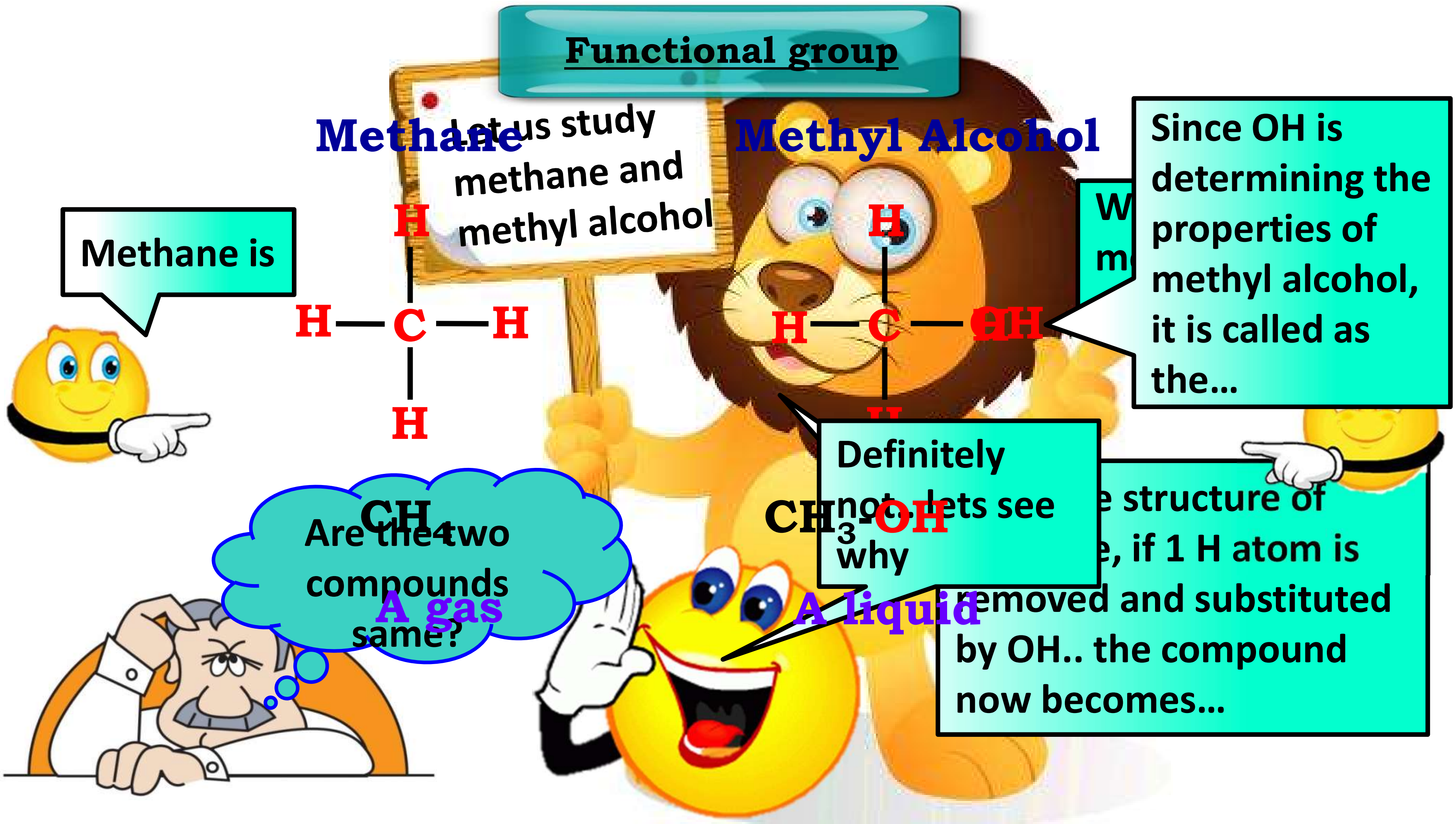
C_2H_5Cl	Ethyl chloride
C_3H_7Cl	Propyl chloride
C_4H_9Cl	Butyl chloride

ALKYL GROUP - R

General formula	Name of the alkyl group
- CH_3	Methyl
- C_2H_5	Ethyl
- C_3H_7	Propyl
- C_4H_9	Butyl

CARBON AND ITS COMPOUNDS

- Functional group



Functional group
Let us study methane and methyl alcohol
Methane
Methyl Alcohol
Methane is
H
H — C — H
H
H
H — C — OH
CH4
CH3-OH
A gas
A liquid
Are the two compounds same?
Definitely not.. lets see why
Since OH is determining the properties of methyl alcohol, it is called as the...
removed and substituted by OH.. the compound now becomes...

Functional group in organic compounds

The atom or group of atoms present in the molecule which determines characteristic property of organic compounds is called the FUNCTIONAL GROUP.

Functional group

COMPOUND	GEN FORMULA R = C_nH_{2n+1}	FUNCTIONAL GROUP	EXAMPLES
ALCOHOLS	R - OH	-OH	CH_3OH Methyl Alcohol C_2H_5OH Ethyl Alcohol
CARBOXYLIC ACID	R-COOH	O ‖ – C – OH	CH_3COOH Acetic acid
ALDEHYDES	R –CHO	H |	CH_3CHO Acetaldehyde
KETONES	O ‖ R – C – R’	‖ – C –	CH_3COCH_3 Acetone/ Dimethyl Ketone

R and R’ both can be same or different alkyl group

CARBON AND ITS COMPOUNDS

- **Introduction to IUPAC & rules**

Nomenclature of organic compounds

The latest and widely accepted system for giving systematic names to organic compounds is – IUPAC system.

International Union of Pure and Applied Chemistry System

All organic compounds are considered as derivatives of saturated hydrocarbons – ALKANES.

Derived (obtained) from

TERMINOLOGY USED IN NOM E -

ROOT – NATURE OF BASIC CARB ON.

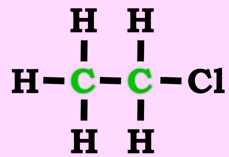
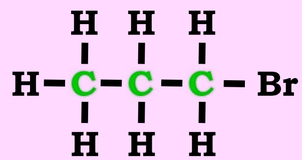
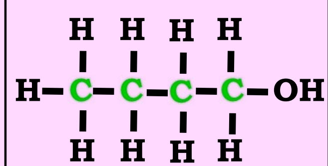
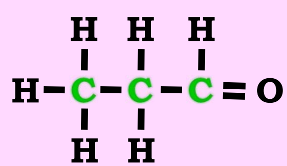
PREFIX – PHRASE BEFORE.

SUFFIX – PHRASE AFTER.

Terminology used in nomenclature

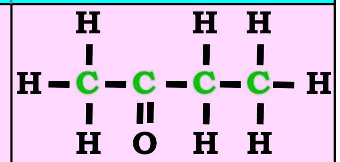
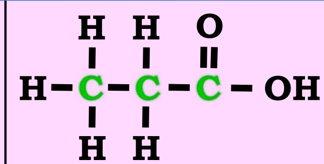
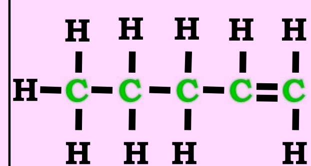
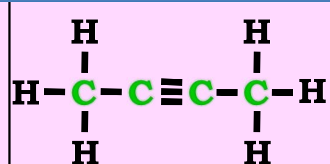
ROOT – indicates the nature and no. of carbon atoms in the basic carbon skeleton.

Chain length	Root word
Bond with 1 C atom	Meth –
Bond with 2 C atoms	Eth –
Bond with 3 C atoms	Prop –
Bond with 4 C atoms	But –
Bond with 5 C atoms	Pent –
Bond with 6 C atoms	Hex –
Bond with 7 C atoms	Hept –
Bond with 8 C atoms	Oct –

Functional group	*Prefix/suffix*	*IUPAC Name*	*Example*
1. Halogen	**Prefix-chloro, bromo, etc.**	**Haloalkane**	 **Chloroethane**  **Bromopropane**
2. Alcohol	**Suffix-ol**	**Alkanol**	 **Butanol**
3. Aldehyde	**Suffix-al**	**Alkanal**	 **Propanal**

Alk will be replaced

C = 1 Meth	**C = 2 Eth**
C = 3 Prop	**C = 4 But**
C = 5 Pent	**C = 6 Hex**
C = 7 Hept	**C = 8 Oct**
C = 9 Non	**C = 10 Dec**

Functional group	*Prefix/suffix*	*IUPAC Name*	*Example*
4. Ketone	**Suffix-one**	**Alkanone**	 **Butanone**
5. Carboxylic acid	**Suffix-oic acid**	**Alkanoic acid**	 **Propanoic acid**
6. Double bond	**Suffix- ene**	**Alkene**	 **Pentene**
7. Triple bond	**Suffix- yne**	**Alkyne**	 **Butyne**

Alk will be replaced

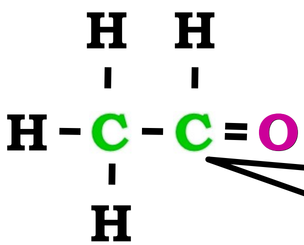
C = 1 Meth	**C = 2 Eth**
C = 3 Prop	**C = 4 But**
C = 5 Pent	**C = 6 Hex**
C = 7 Hept	**C = 8 Oct**
C = 9 Non	**C = 10 Dec**

CARBON AND ITS COMPOUNDS

- **Some examples of IUPAC**
- **Isomerism**

Spot the O or the halo

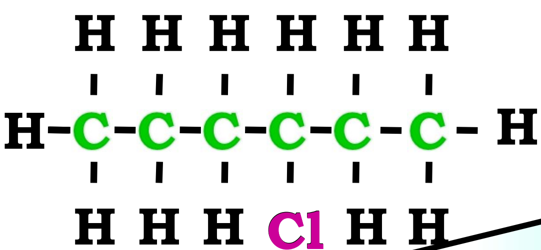
Give the IUPAC name



Ethanal

Parent hydrocarbon ethane
Functional group aldehyde
Suffix al
IUPAC name

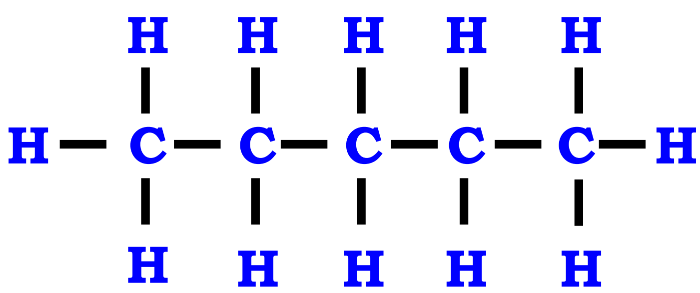
Parent hydrocarbon propane
Functional group alkyne
Suffix yne
IUPAC name propyne

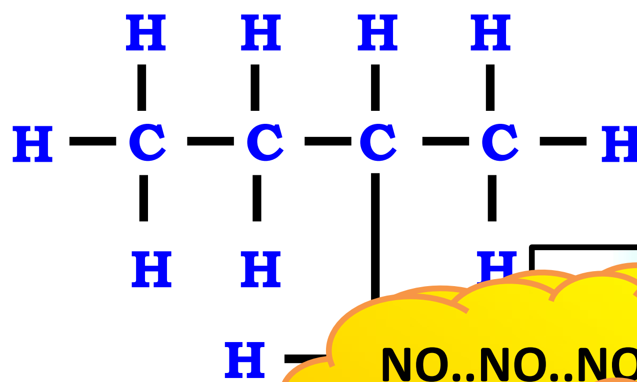


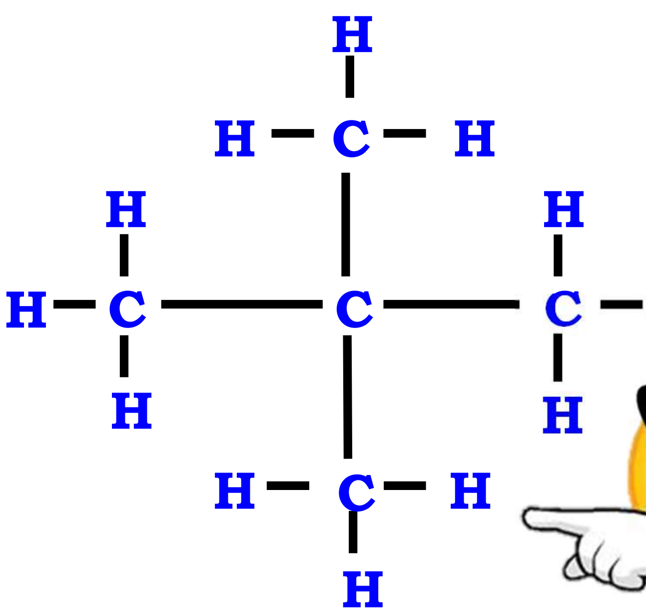
Chlorohexane

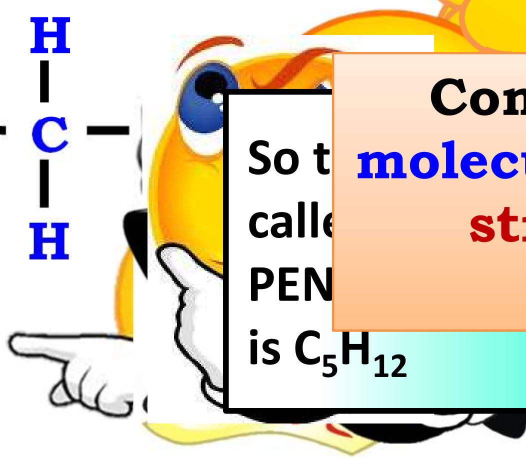
Parent hydrocarbon hexane
Functional group halo
Prefix chloro
IUPAC name Chlorohexane

Amazing property of hydrocarbons









operty is

NO..NO..NO..

What

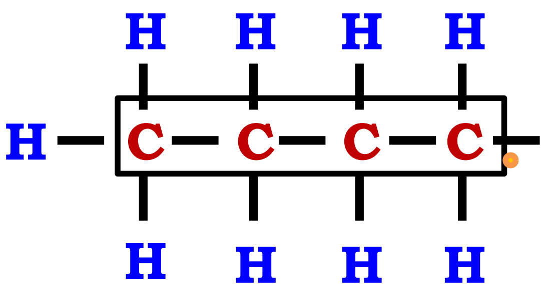
co pounds

So t
calle
PEN
is C_5H_{12}

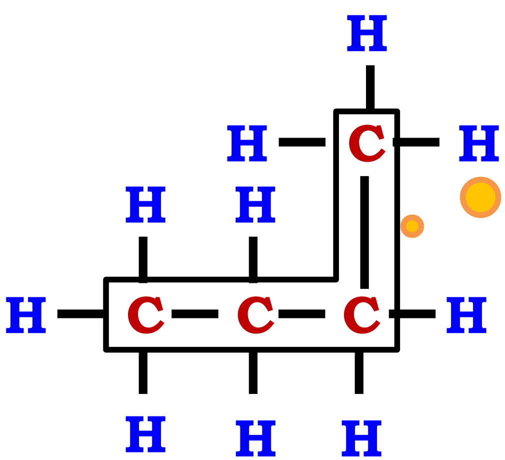
Compounds with identical molecular formula but different structures are called as ISOMERS.

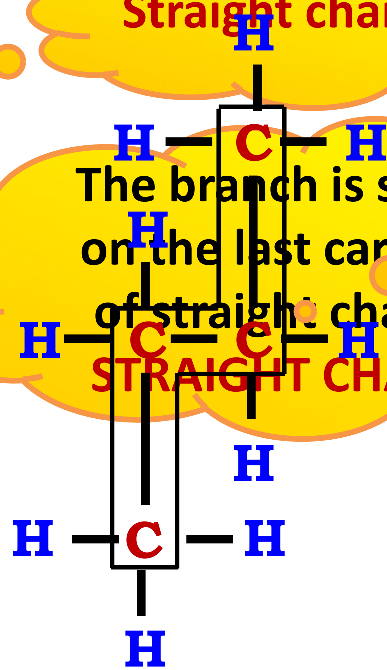

Branches are never
On the first and last
carbon

Identify which structure is a branched chain



Straight chain

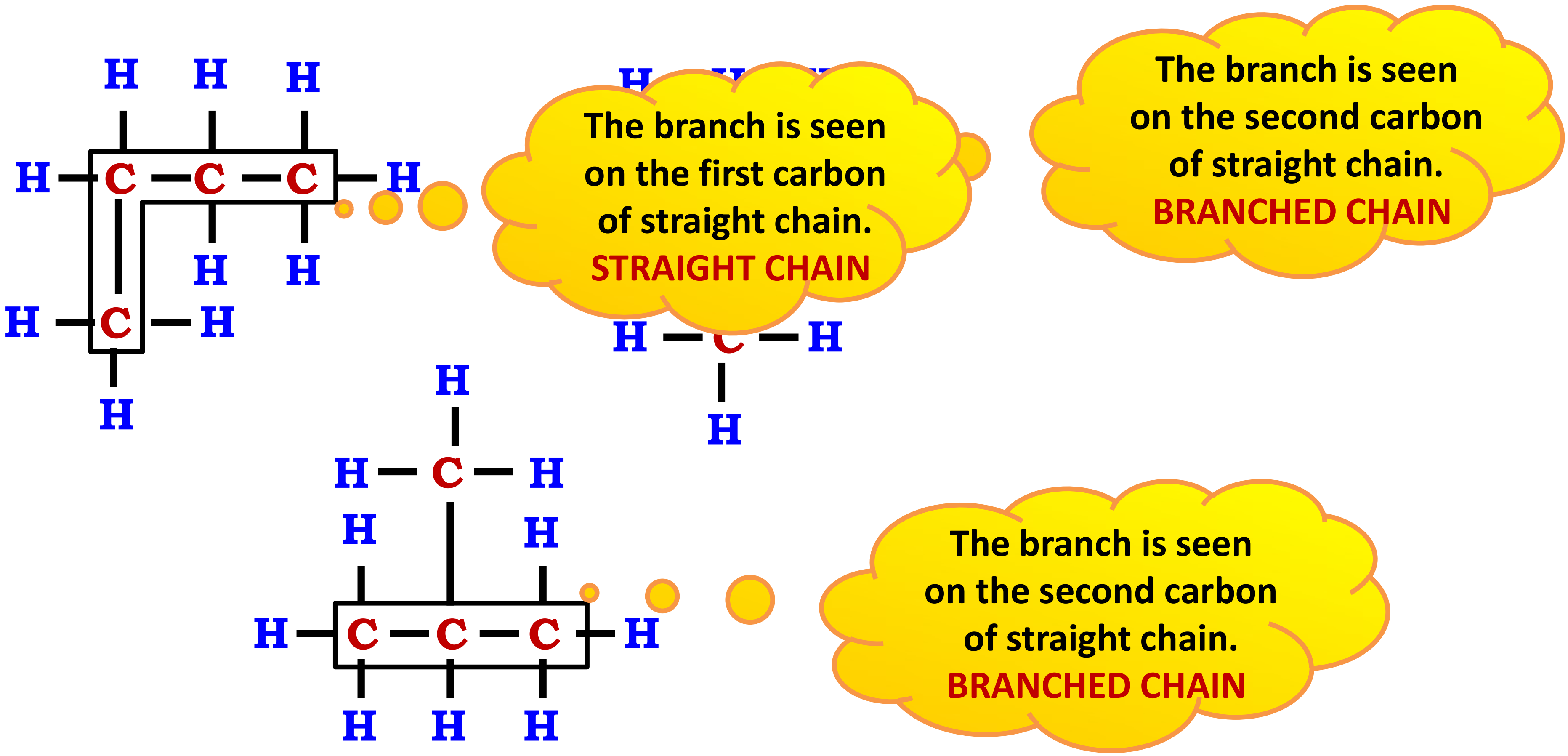




The branch is seen
on the last carbon
of straight chain.
STRAIGHT CHAIN

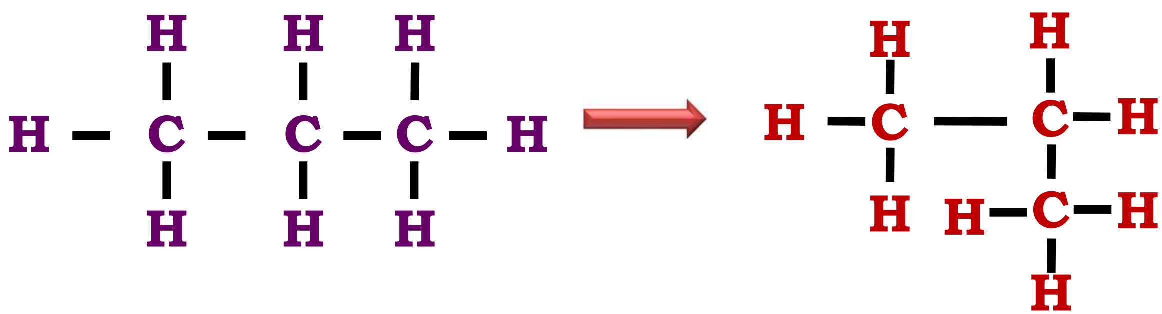
The branch is seen
on the first and last carbon
of straight chain.
STRAIGHT CHAIN

Identify which structure is a branched chain



Structure isomers of propane

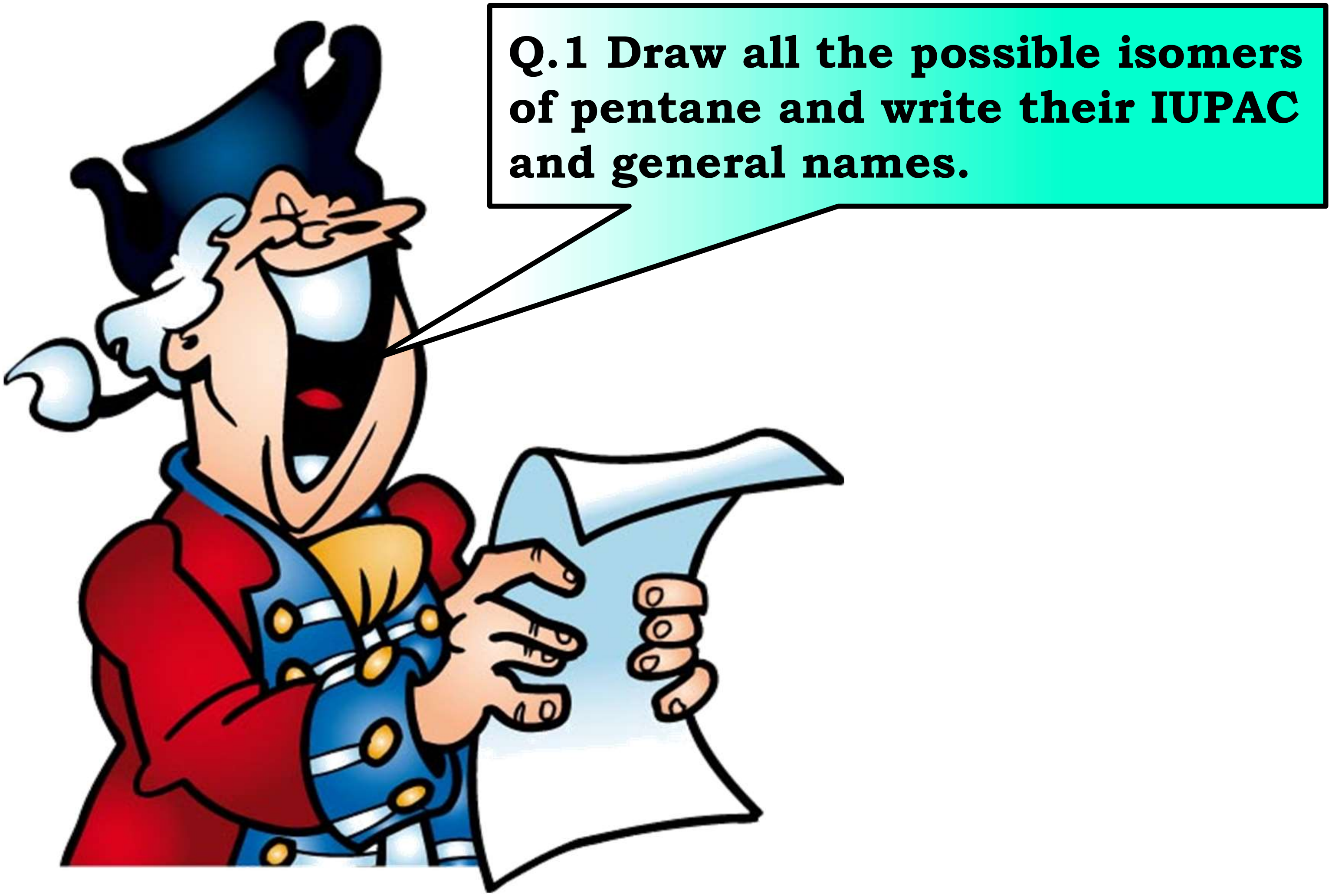
(i)



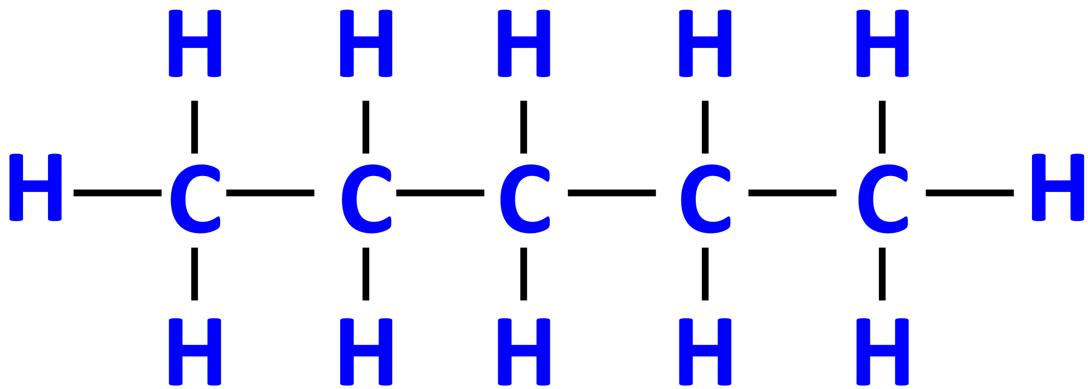
Same structure → No Isomers

CARBON AND ITS COMPOUNDS

- **Isomerism**


Q.1 Draw all the possible isomers of pentane and write their IUPAC and general names.

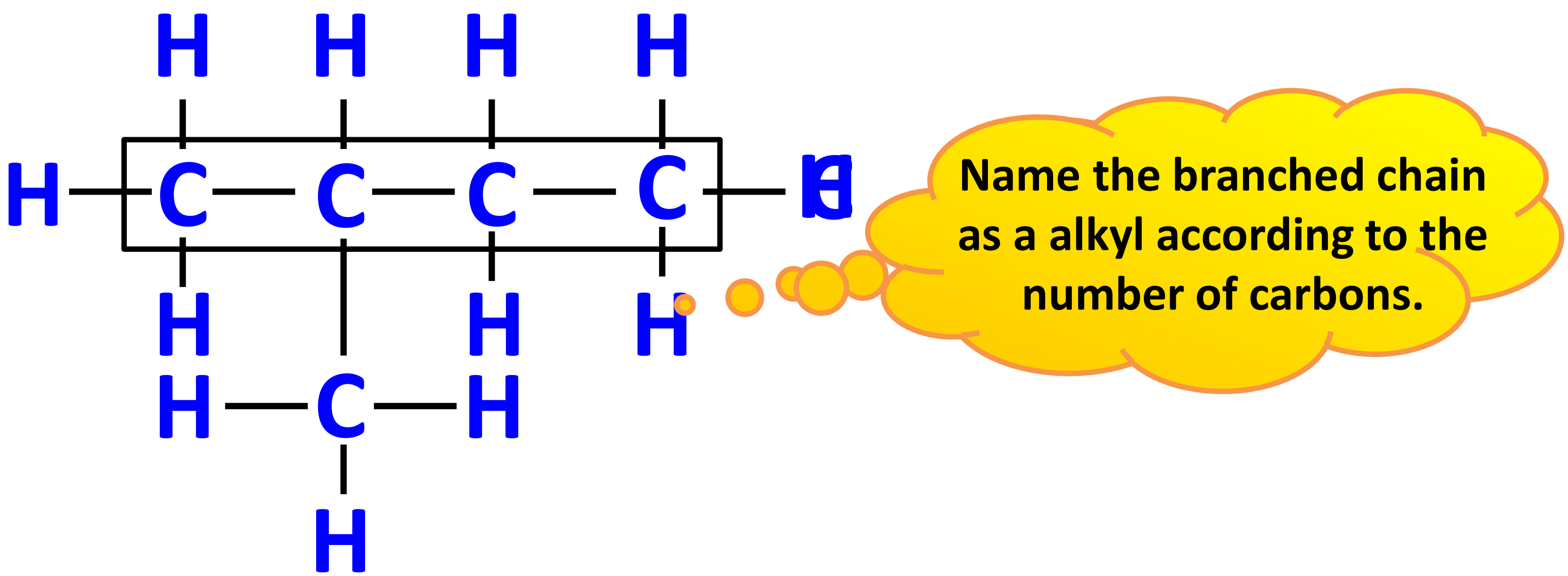
1.



General name: n-pentane

IUPAC name: Pentane

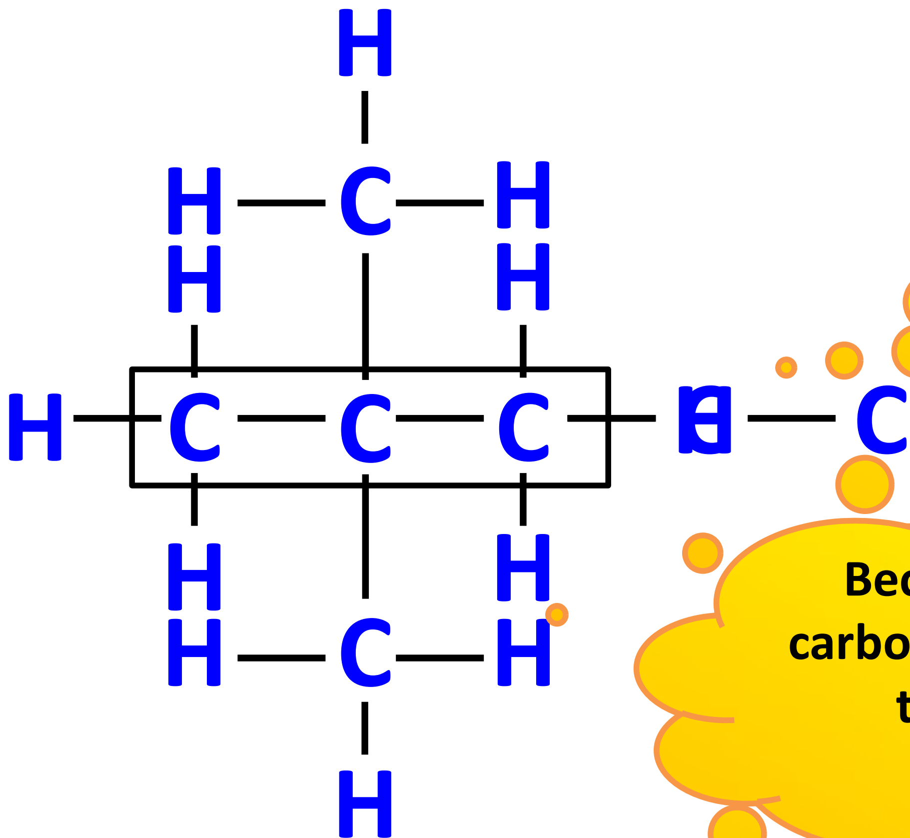
2.



General name: Iso-pentane

IUPAC name: methylbutane

3.



Name the branched chain as a alkyl according to the number of carbons.

Because there are three carbons in the straight chain, the name becomes dimethypropane

General name: Neo-pentane

IUPAC name: dimethyl propane

<u>IUPAC rules for nomenclature of carbon compounds</u>

1. **The IUPAC name of compound is obtained by writing the name of alkyl group just before the name of the parent hydrocarbon.**

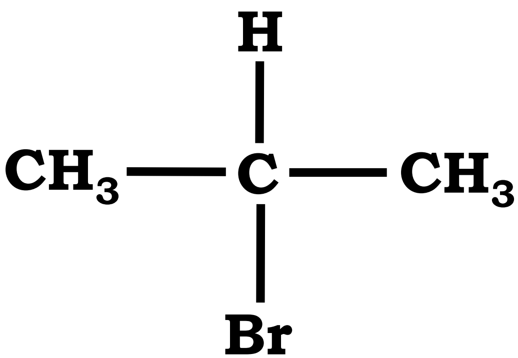
$$\begin{array}{c} CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH_2}} - CH_3 \end{array}$$

methylpropane

CARBON AND ITS COMPOUNDS

- **Some more examples**

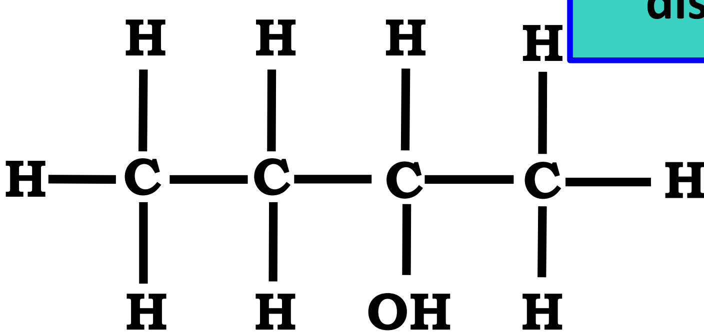
Example :



Let us now solve a few examples for IUPAC nomenclature using the rules discussed earlier

LONGEST CARBON CHAIN - 3
PARENT ALKANE - Propane
FUNCTIONAL GROUP - Halo
PREFIX - bromo

bromopropane



CARBON CHAIN - 4
PARENT ALKANE - Butane
FUNCTIONAL GROUP - Alcohol
SUFFIX - ol

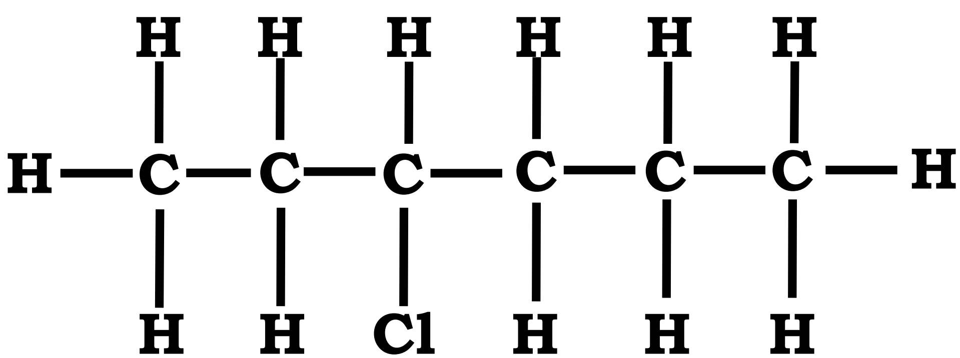
butanol

Example :

$CH_3\,CH_2\,CH = CH_2$

LONGEST CARBON CHAIN - 4
PARENT ALKANE - Butane
FUNCTIONAL GROUP - alkene (=)
SUFFIX - ene

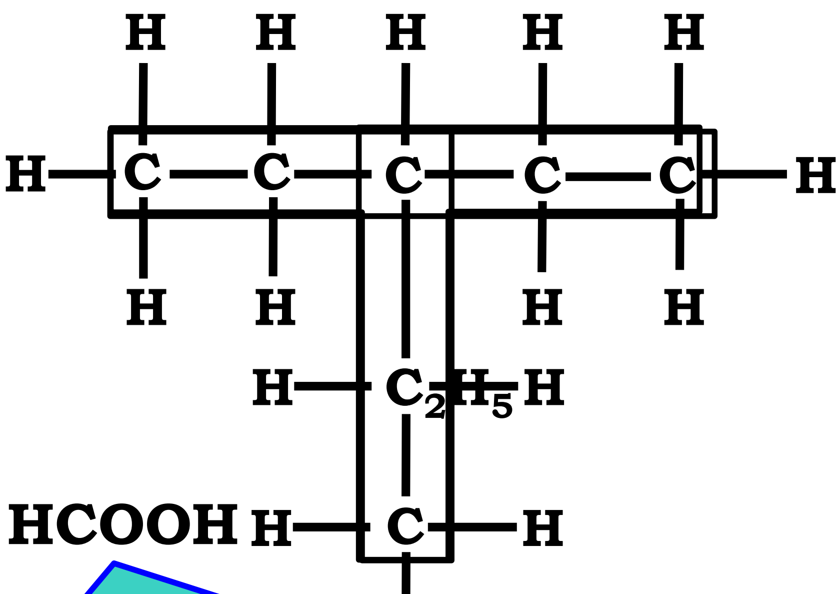
butane



LONGEST CARBON CHAIN - 6
PARENT ALKANE - hexane
FUNCTIONAL GROUP - Halo
PREFIX - chloro

chlorohexane

Example :



HCOOH

Since there is only 1 carbon atom in the structure, we don't mention the position.

LONGEST CARBON CHAIN - 5
PARENT ALKANE - pentane
FUNCTIONAL GROUP - alkyl
SUFFIX - ethyl

ethylpentane

LONGEST CARBON CHAIN - 1
PARENT ALKANE - methane
FUNCTIONAL GROUP - Carboxylic acid
SUFFIX - oic acid

methanoic acid

Give the IUPAC names of :

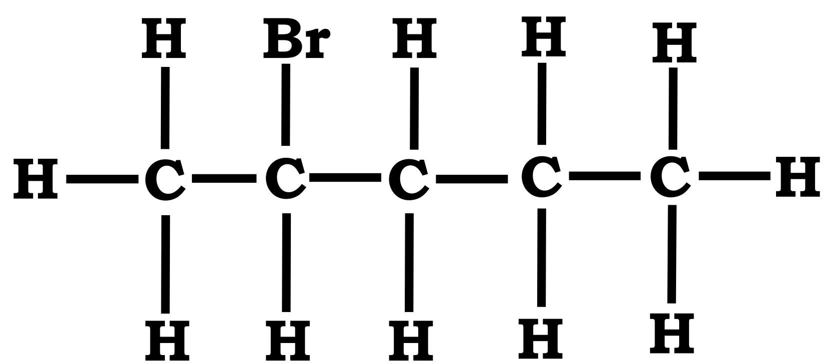
1) CH_3COOH

Ans. ethanoic acid

2) $CH_3\ CH_2\ CH = CH\ CH_2\ CH_3$

Ans. hexene

3)



Ans. bromopentane

CARBON AND ITS COMPOUNDS

- **Homologous series**

C_nH_{2n+2}

Alkane

Values of 'n'	Molecular formula	Name	Molecular Mass	Difference mass
n = 1	CH_4	Methane	?	

Sum of the atomic masses

C_nH_{2n+2}

Alkane

Values of 'n'	Molecular formula	Name	Molecular Weight	Difference in weight
n = 1	CH_4	Methane	16	30 – 16 =14
n = 2	C_2H_6	Ethane	30	
n = 3	C_3H_8	Propane	44	58 – 44 =14
n = 4	C_4H_{10}	Butane	58	

– CH_2 –

Calculate the difference in weight between 2 consecutive (one after another)

– CH_2 –

The molecular weight of consecutive members always differs by 14 units

Consecutive members differ by (– CH2 –) group i.e. methylene group. Let us take the example of methane and ethane

Molecular mass of CH_4
= (12 x 1) + (1 x 4)
= 12 + 4
= 16

Alcohols

Let us study one more example

A group of organic compounds hav group –OH

General representation of Alcohol is R-OH

General formula is $C_nH_{2n+1}OH$

Name	Molecular formula	
Methyl alcohol	CH_3OH	These differ by
Ethyl alcohol	C_2H_5OH	– CH_2 units
Propyl alcohol	C_3H_7OH	These differ by
Butyl alcohol	C_4H_9OH	– CH_2 units

Homologous series

Yes

group – OH

mula is $C_nH_{2n+1}OH$

NAME	MOLECULAR FORMULA
Methyl alcohol	CH_3OH
Ethyl alcohol	C_2H_5OH
Propyl alcohol	C_3H_7OH
Butyl alcohol	C_4H_9OH

What is the functional group?

What is the general formula?

The physical & chemical properties of the compounds show a gradual change.

Can we call this as a group of compounds?

A ... f ...rganic compounds containing **same functional group**,

... represented by the **same general formula**

...ore or less show **similar trends in their properties**

Characteristics of homologous series

1) All the members have **same general formula.**
2) They have **same functional group.**
3) They have **similar chemical properties**
4) **Physical properties** like melting point, boiling point, density, show a **gradual change** with increase in the molecular formula.
5) **Consecutive members** of the series **differ by – CH_2 – group** (methylene group) and their **molecular weight** differs by **14 units.**

Write the molecular formulae of the third and fifth members of homologous series of carbon compounds represented by the general formula C_nH_{2n-2}.

Since methyne does not exist

This is the general formula of alkyne

Solution:

The third member will have four carbons similarly fifth member will have six carbons.

∴ Substituting the values in C_nH_{2n-2} the third member will be butyne C_4H_6 and fifth member will be hexyne C_6H_{10}.

Which of the following belong to the same homologous series ?

C_3H_8 C_3H_6 C_4H_8 C_4H_6

Solu n:

The members of the same homologous series will

homologous series and they

ference of CH_2.

a C_nH_{2n-2}

C_3H_8 is an alkane with general formula C_nH_{2n+2} (n = 3).

CARBON AND ITS COMPOUNDS

- **Combustion reaction**

Chemical properties of carbon compounds

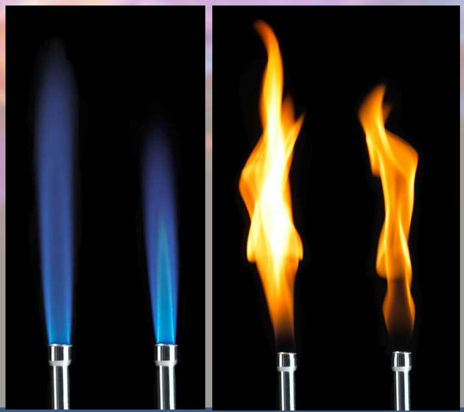
Combustion

- **Most carbon compounds also release a large amount of heat and light on burning.**

$$CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O + \text{Heat \& light}$$

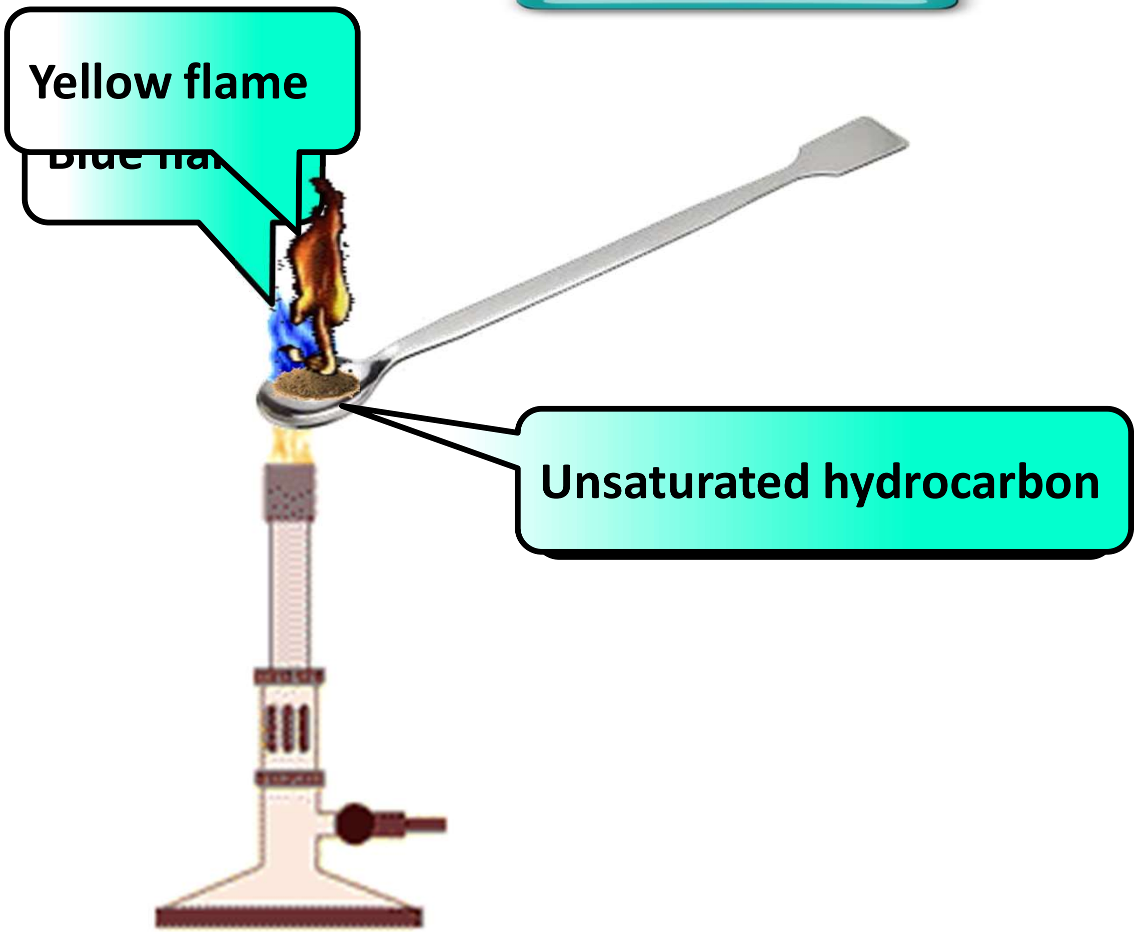
$$CH_3CH_2OH + 3\,O_2 \longrightarrow 2\,CO_2 + 3\,H_2O + \text{Heat \& light}$$

Oxidising flame (Saturated Hydrocarbon)



Reducing flame (Unsaturated Hydrocarbon)

Combustion

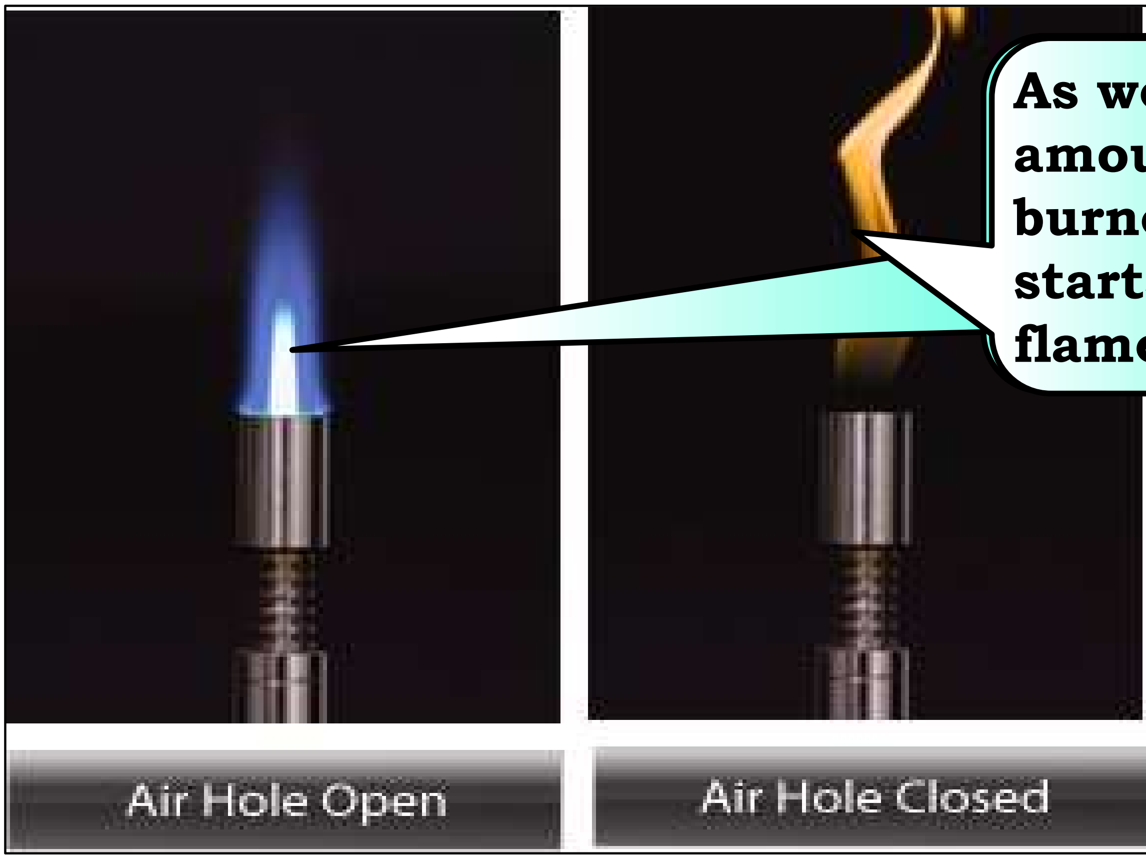


Differences between saturated and unsaturated hydrocarbons

- **COMPLETE**
  - BLUE FLAME
  - CLEAN FLAME
  - NO SOOTY DEPOSIT

- **INCOMPLETE**
  - YELLOW FLAME
  - BLACK SMOKE
  - SOOTY DEPOSIT

Reason for incomplete combustion



As we go on reducing the amount of air going into burner, the gas in burner starts burning with a sooty flame.

Reason for incomplete combustion

The unburnt carbon particles get stuck to the bottom of cooking vessels resulting in the blackening of bottom of vessels.

CARBON AND ITS COMPOUNDS

- **Reasons for flame**
- **Formation of coal**

Why do substances burn with or without a flame?

Because a flame is only produce when gaseous substances burn.

When wood or coal is ignited , the volatile substances present vapourise and burn with flame in the beginning.

Evaporating rapidly

Formation of coal

sedimen
was
s of sedi

er plants that grew
got buried in
oil.

ted
nous

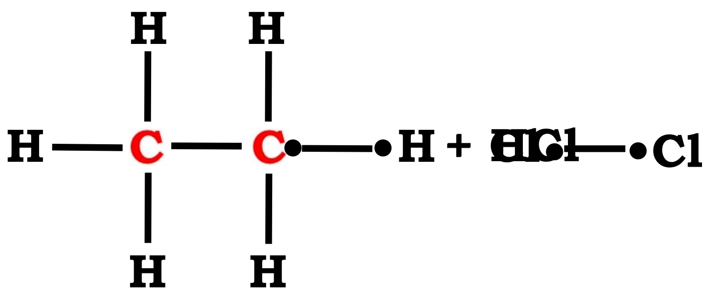
Even further compression resulted in the formation of anthracite.

CARBON AND ITS COMPOUNDS

- **Addition reaction**
- **substitution reaction**

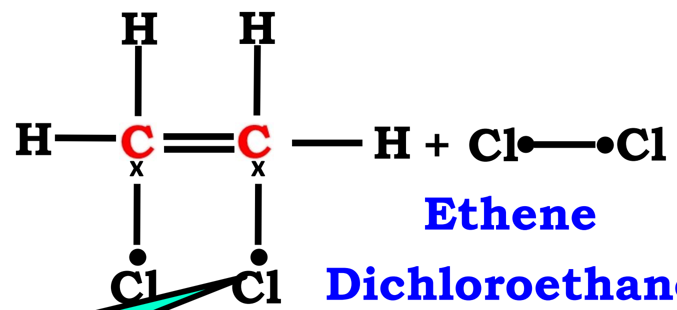
Reason for addition and substitution reaction

SATURATED HYDROCARBON

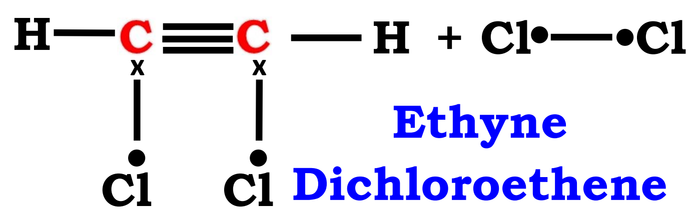


Ethane
Monochloroethane

UNSATURATED HYDROCARBON



Ethene
Dichloroethane

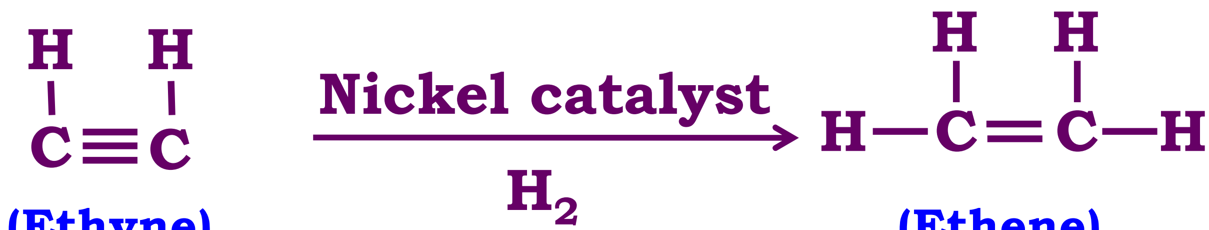


Ethyne
Dichloroethene

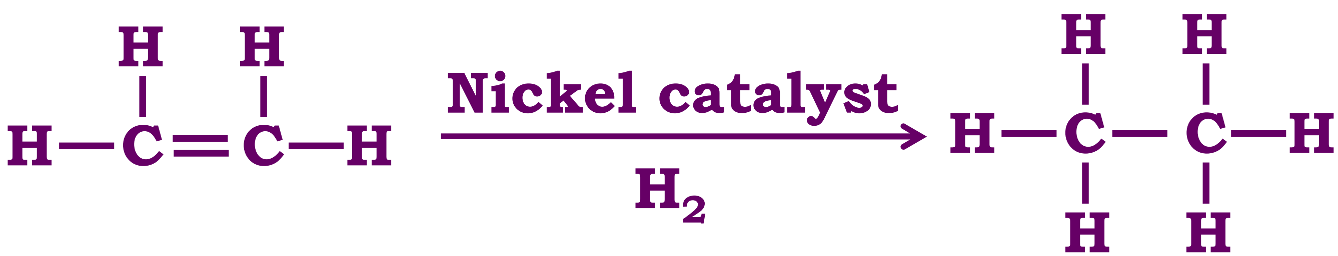
Unsaturated hydrocarbons undergo addition reactions. They contain double & triple bonds (C=H &C≡H) which are weaker and easier to break.

Addition Reaction

The addition of hydrogen to an unsaturated hydrocarbon to obtain a saturated hydrocarbon is called hydrogenation.



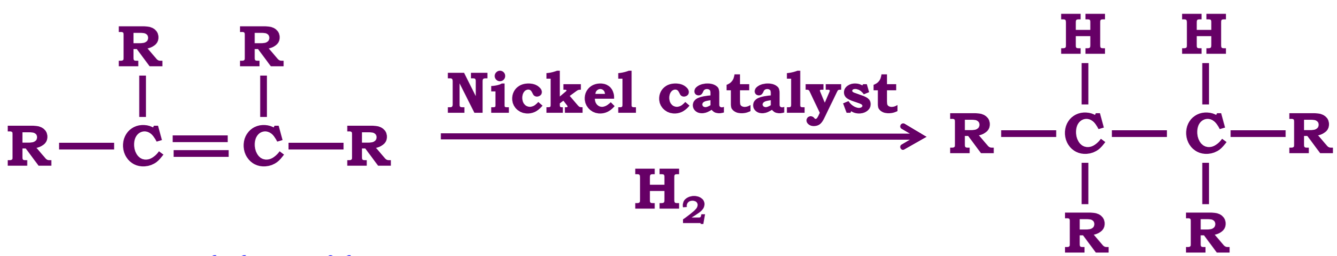
(Ethyne) (Ethene)



(Ethene) (Ethane)

Addition Reaction

The process of hydrogenation has an important industrial application: it is used to prepare vegetable ghee from a vegetable oils



Vegetable oil

Unsaturated fat

Liquid state

Vegetable ghee

Saturated fat

Solid state

Substitution Reaction

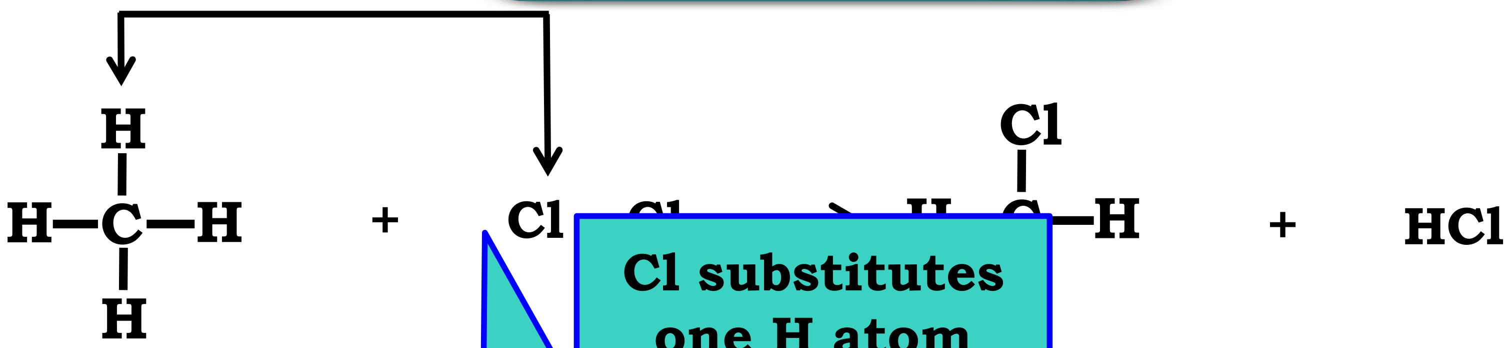
Saturated hydrocarbons undergo substitution reaction in presence of sunlight.

$$CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3Cl + HCl$$

(Methane) (Methyl chloride)

The replacement of hydrogen atom with a halogen in an organic compound is called halogenation.

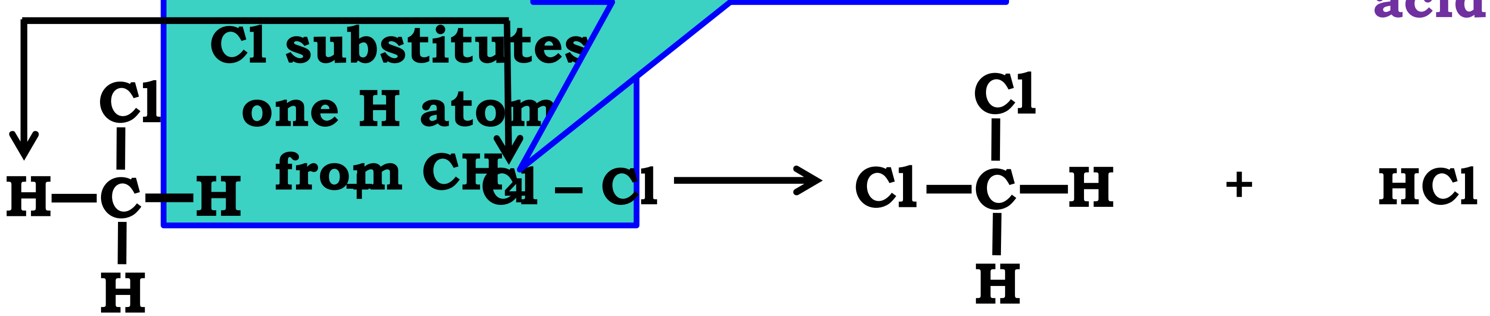
Reaction with halogens



Methane ... hloride Hydrochloric acid

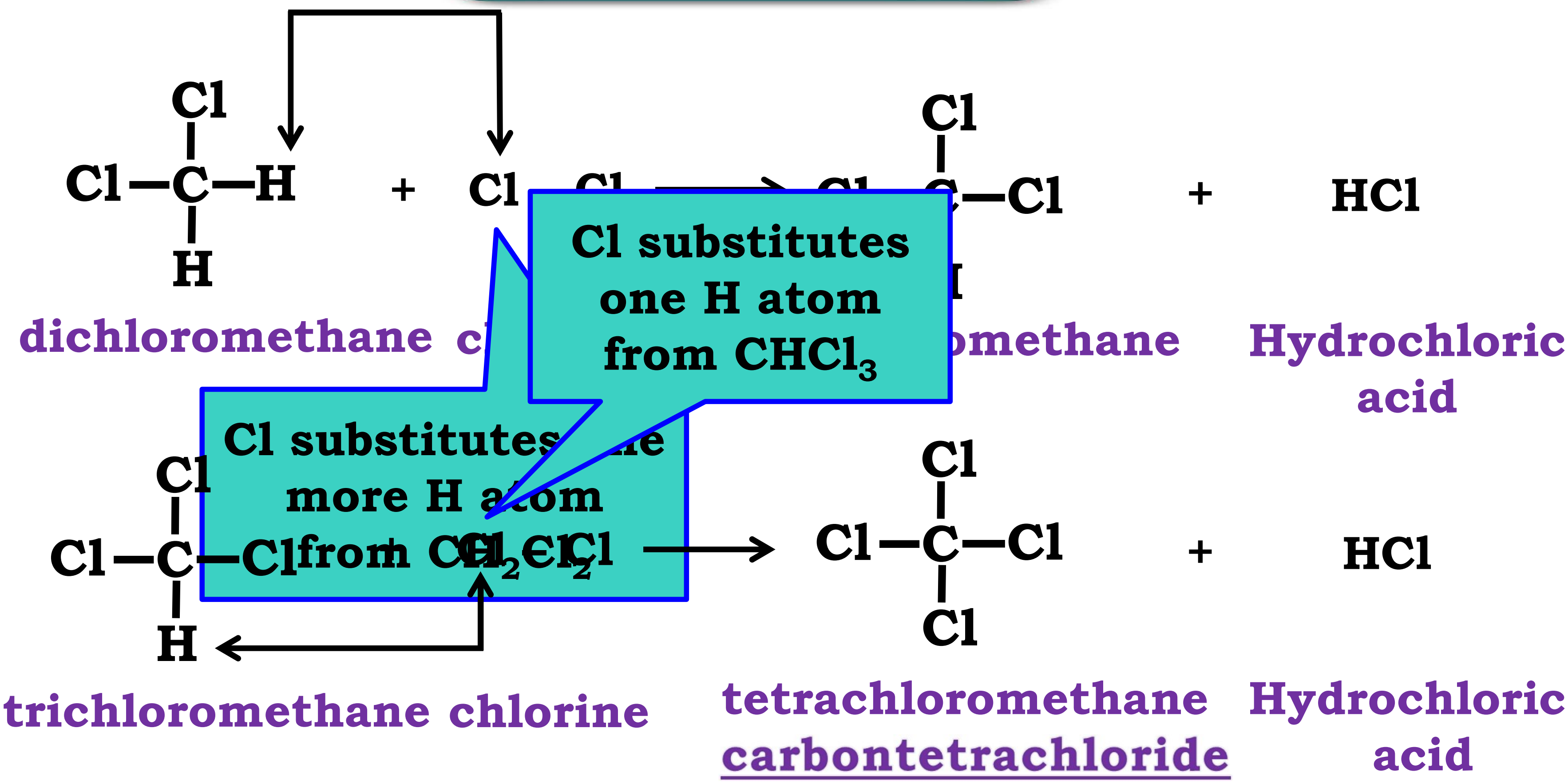
Cl substitutes one H atom from CH_3Cl

Cl substitutes one H atom from CH



Methylchloride chlorine dichloromethane Hydrochloric acid

Reaction with halogens



CARBON AND ITS COMPOUNDS

- **Importance of carbon compounds**
- **Ethanol, Ethanoic Acid**

Some Important Carbon Compounds

Ethanol

- Liquid at room temperature.
- Commonly called alcohol.
- Active ingredient of all alcoholic drinks.
- Because it is good solvent, it is also used in medicines such as tincture iodine, cough syrups, and many tonics.
- Soluble in water in all proportions.

Reactions of Ethanol

i) Reaction with sodium

$$\underset{\text{(Sodium)}}{2Na} + \underset{\text{(Ethanol)}}{2CH_3CH_2OH} \longrightarrow \underset{\text{(Sodium ethoxide)}}{2CH_3CH_2O^-Na^+} + H_2$$

ii) Reaction to give unsaturated hydrocarbon :

(Dehydration of ethanol)

$$\underset{\text{(Ethanol)}}{CH_3CH_2OH} \xrightarrow[H_2SO_4]{\text{Hot conc.}} \underset{\text{(Ethene)}}{CH_2=CH_2} + H_2O$$

Oxidation

Carbon compounds can be easily oxidised on combustion. In addition to this complete oxidation, we have reactions in which alchohols are converted to carboxylic acids.

$$\underset{\text{(Ethanol)}}{CH_3\text{-}CH_2OH} \xrightarrow[\text{Or acidified } K_2Cr_2O_7 \text{ + Heat}]{\text{Alkaline } KMnO_4 \text{ + Heat}} \underset{\text{Ethanoic acid}}{CH_3COOH}$$

Oxidising agent

Properties of Ethanoic Acid

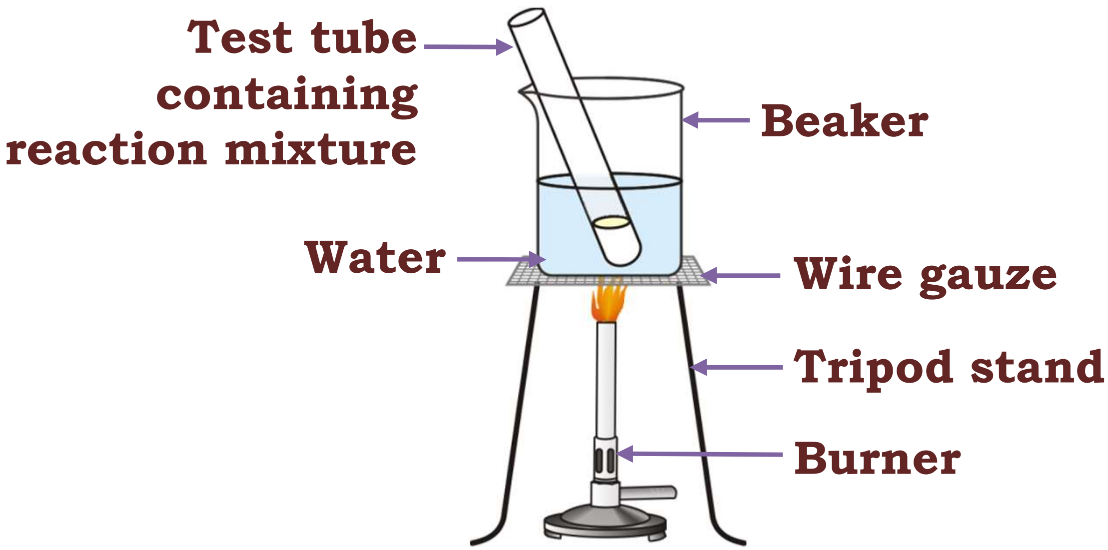
- ❖ Commonly called acetic acid
- ❖ Belongs to a group of acids called carboxylic acids.
- ❖ 5 – 8% solution of acetic acid in water is called vinegar.
- ❖ Used widely as a preservative in pickles.
- ❖ Its melting point is 290 K
- ❖ Frozen acetic acid is called glacial acetic acid.

Reactions of ethanoic acid :

i) Esterification reaction : Acid + Alcohol $\longrightarrow$ Ester

$$\underset{\text{(Ethanoic acid)}}{CH_3\,COOH} + \underset{\text{(Ethanol)}}{CH_3\,CH_2OH} \xrightarrow{\text{(Acid)}} \underset{\text{(Ester)}}{CH_3\,\overset{}{\underset{\underset{O}{\|}}{C}} - O - CH_2\,CH_3}$$

Formation of Ester :



CARBON AND ITS COMPOUNDS

- **Saponification**

Saponification (Preparation of soap) :

Reaction with carbonates & hydrogen carbonates:

$$2\,CH_3COOH + Na_2CO_3 \xrightarrow{NaOH} 2\,CH_3COONa + H_2O + CO_2$$

(Ethanoic acid) (Sodium carbonate) (Sodium ethanoate)

$$CH_3COOH + NaHCO_3 \xrightarrow{NaOH} CH_3COONa + H_2O + CO_2$$

(Ethanoic acid) (Sodium hydrogen carbonate) (Sodium ethanoate)

Saponification (Preparation of soap) :

Ester + Alkali ⟶ Alcohol + Sodium salt of carboxylic acid

i) Hydrolysis of ester

The reaction takes places in two steps.
i) Hydrolysis of ester
ii) Reaction of acid with

OH + CH_3COOH
nol) (Sodium acetate)

The water present in NaOH is used for the hydrolysis of ester.
The H^+ ion and OH^- ion is added to the ester.

CH_3COONa + H_2O
(Sodium hydroxide) (Ethanol) (Sodium ethanoate)

Saponification (Preparation of soap) :

SAPONIFICATION

$$CH_3\,COOC_2H_5 + NaOH \longrightarrow CH_3COONa + CH_3CH_2OH$$

(Ethyl acetate) (Ester) → (Sodium acetate) (Ethanol)

SAPONIFICATION

Vegetable oil + NaOH ⟶ soaps + glycerol

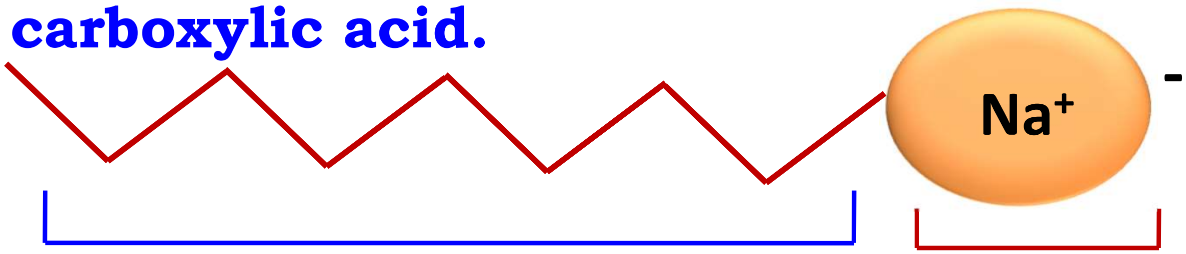
soaps: $(C_{17}H_{35}COONa)$ OR $(C_{15}H_{31}COONa)$

CARBON AND ITS COMPOUNDS

- **Soaps and detergents**

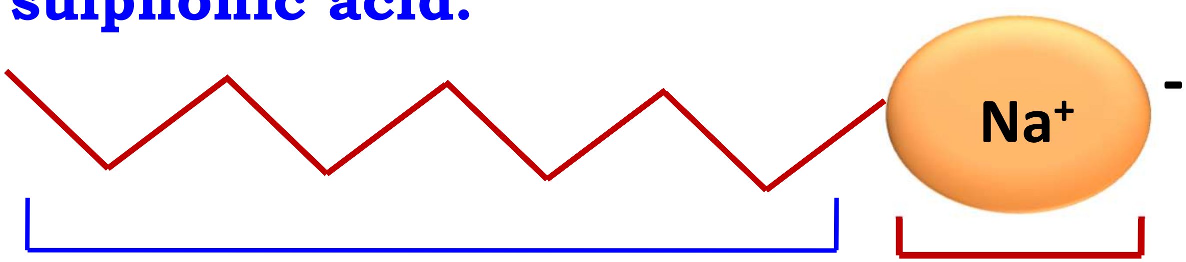
Soaps and Detergents

A soap is the sodium salt or potassium salt of a long chain carboxylic acid.



Hydrocarbon chain $C_{17}H_{35}$ **Ionic end (COO^-Na^+)**

A detergent is the sodium salt of a long chain benzene sulphonic acid.



Hydrocarbon chain $C_{12}H_{25}$ C_6H_4 $(SO_4^-Na^+)$

Action of detergents in hard water and soft water

Soaps

Soft water

- Lathers easily
- No scum formed

Hard Water (Ca^{2+} or Mg^{2+})

- Does not lather easily
- Reacts with Ca^{2+} and Mg^{2+} ions to form insoluble precipitate called scum.

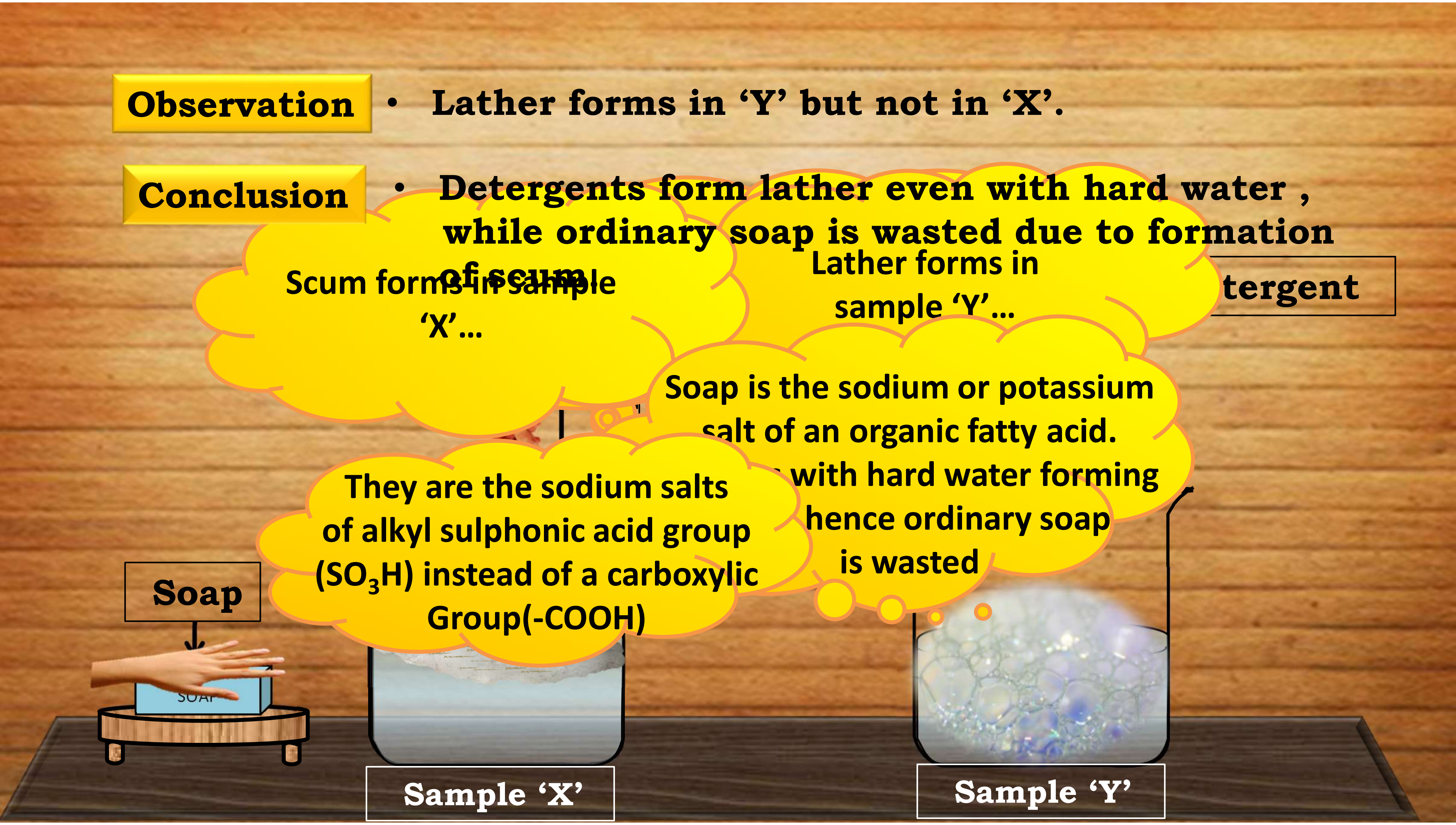
Detergents

Soft water

- Lathers easily
- No scum formed

Hard Water (Ca^{2+} or Mg^{2+})

- Lathers easily
- No scum formed

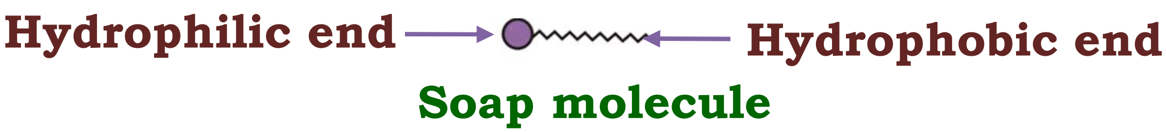

Observation
• Lather forms in 'Y' but not in 'X'.
Conclusion
• Detergents form lather even with hard water , while ordinary soap is wasted due to formation of scum.
Scum forms in sample 'X'…
Lather forms in sample 'Y'…
Soap is the sodium or potassium salt of an organic fatty acid.
with hard water forming
hence ordinary soap is wasted
They are the sodium salts of alkyl sulphonic acid group (SO_3H) instead of a carboxylic Group(-COOH)
Soap
SOAP
Sample 'X'
Sample 'Y'

Differences between soaps and Detergents

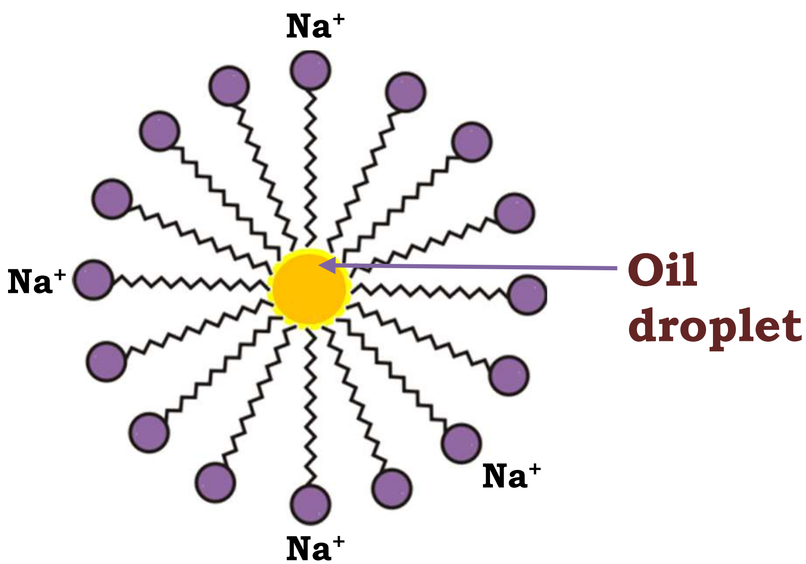
SOAPS	DETERGENTS
1. Biodegradable	1. Non-biodegradable
2. Not suitable for washing in hard water	2. Suitable for washing in hard water
3. Relatively weak cleansing action	3. Strong cleansing action

Soaps and Detergents :

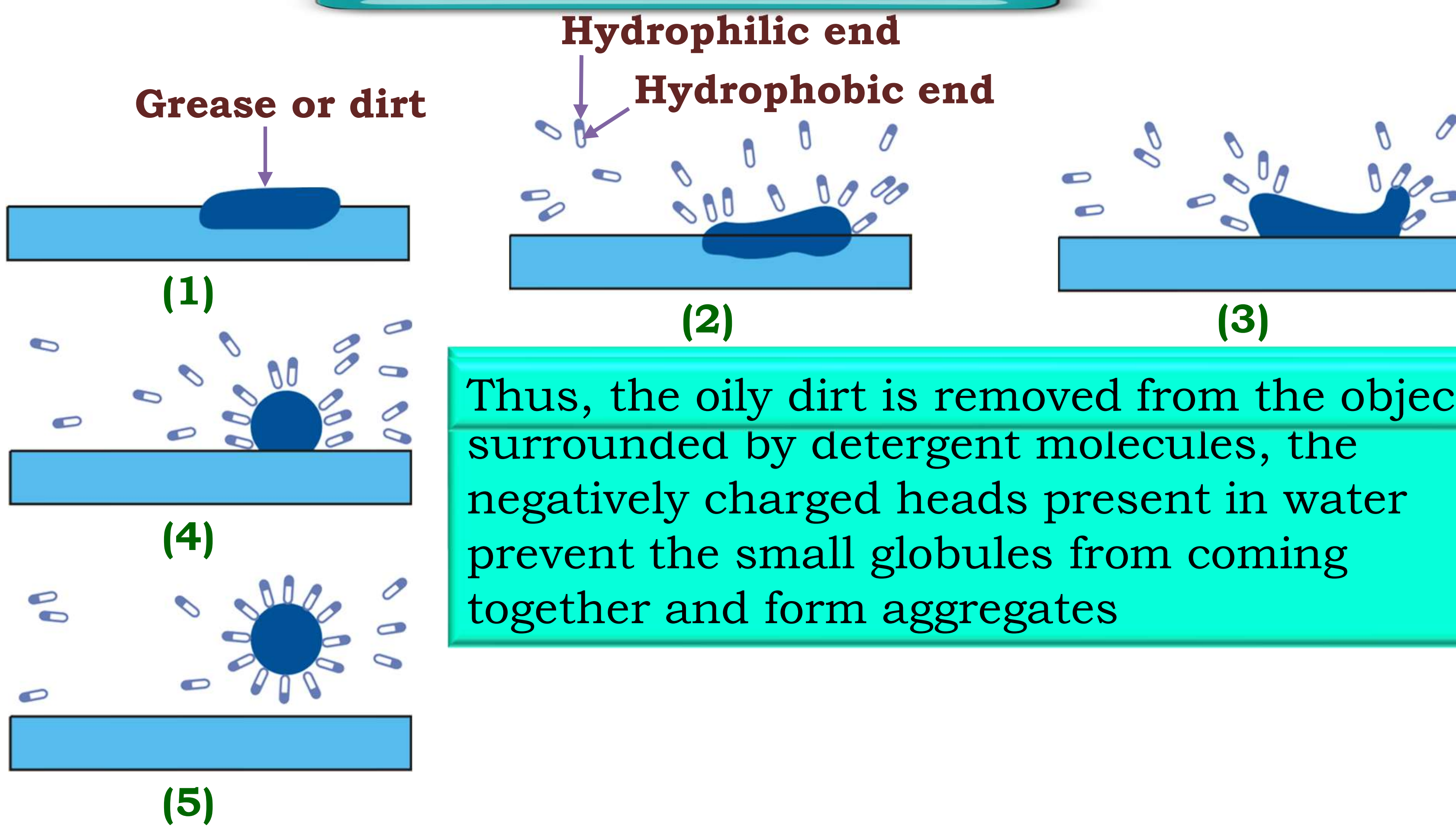
Micelles :



Formation of micelles :



Effect of soap in cleaning



Thus, the oily dirt is removed from the object surrounded by detergent molecules, the negatively charged heads present in water prevent the small globules from coming together and form aggregates

Thank You