UPDATED For 2022-23 Boards Exam

SHOBHIT NIRWAN's

DESIGNED

CARBON AND ITS COMPOUNDS

NOTES

Carbon and it's Compounds

- Covalent Bond
  - Examples of Covalent Bonding
    - Formation of Hydrogen molecule
    - formation of Chlorine molecule
    - formation of Oxygen molecule
    - Formation of Nitrogen molecule
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    - formation of Sulphur
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  - Ethanol
  - Ethanoic acid.

Atomic number of Carbon = 6 (K, L)
∴ Its electronic configuration ⇒ 2, 4 → अभी ये stable नहीं है, क्योंकि stable होने के लिए $8e^{\ominus}$ चाहिए होंगे (in outermost shell) but यहाँ 4 ही है → अब या तो ये 4 gain कर लें या 4 lose कर दें।

- It could gain four electrons forming C^{4-} anion, but it would be difficult for the nucleus to hold six protons to hold on to ten electrons.
- It could lose four electrons forming C^{4+} cation, but it would require a large amount of energy to remove four electrons.

[CBSE 2019 2014] दोनों ही case fail होते हुए दिख रहे हैं Guyzz 😔 ; But 😊 अब Carbon गठबंधन करेगा!

Therefore, in order to overcome this problem, Carbon shares its valence electrons with other atoms of carbon or with atoms of other elements. These shared electrons belong to the outermost shells of both atoms and in this way, both atoms attain the nearest noble gas configuration. This type of bonding is called Covalent Bonding.

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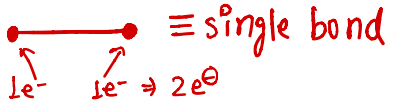
EXAMPLES OF COVALENT BONDING:-

[I] Formation of Hydrogen Molecule (H_2):

H_2, Atomic no. = 1 (K)
Electronic configuration = 1

Need 1 more $e^{\ominus}$ to fill K-shell completely. ∴ two H-atoms share their electrons to form a H_2 molecule, also it will attain nearest noble gas configuration ie of helium.

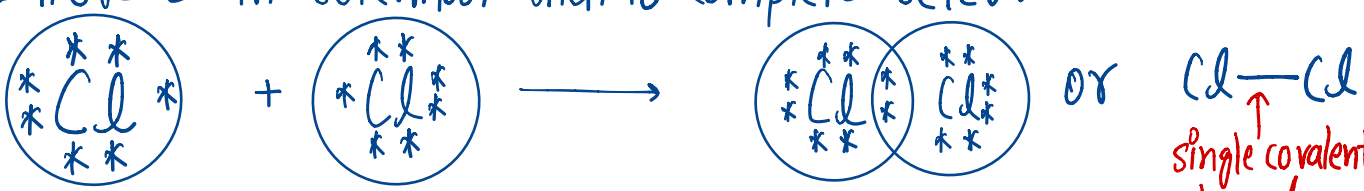
K³B* single bond (because दोनों एक एक $e^{\ominus}$ share करें।)



[II] Formation of Chlorine Molecule (Cl_2):-

Cl_2, Atomic no. = 17
Electronic configuration ⇒ 2, 8, 7 (K, L, M)

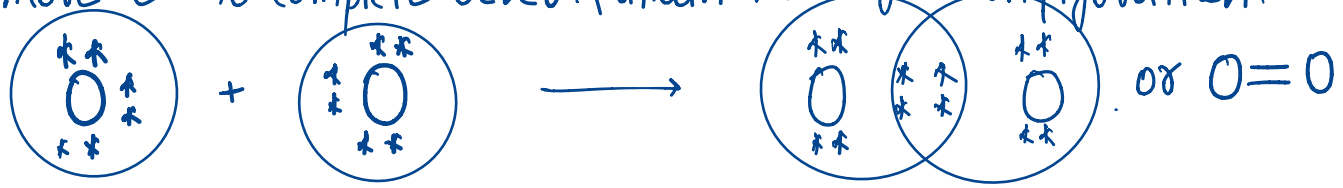
Need 1 more $e^{\ominus}$ in outermost shell to complete octet.



[III] Formation of Oxygen Molecule (O_2) :-

O_8 Atomic number = 8
Electronic Configuration = K L
2, 6

Need 2 more $e^{\ominus}$ to complete octet & attain Noble gas Configuration.



$2e^{\ominus}$ share → single bond (—)
$4e^{\ominus}$ share → double bond (=)
similarly if $6e^{\ominus}$ share ?
↳ triple bond (≡)

[IV] Formation of Nitrogen Molecule (N_2) :-

N_7 Atomic No. = 7
Electronic Configuration = K L
2, 5

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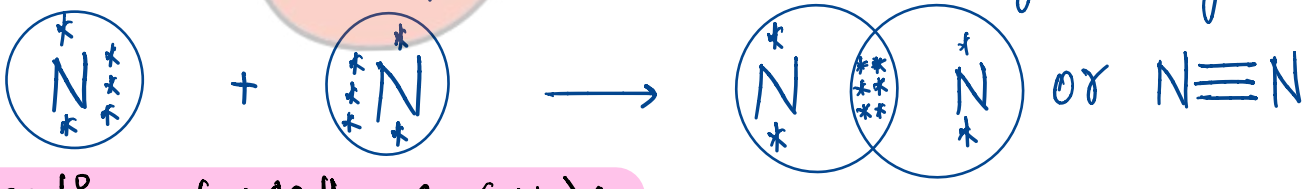
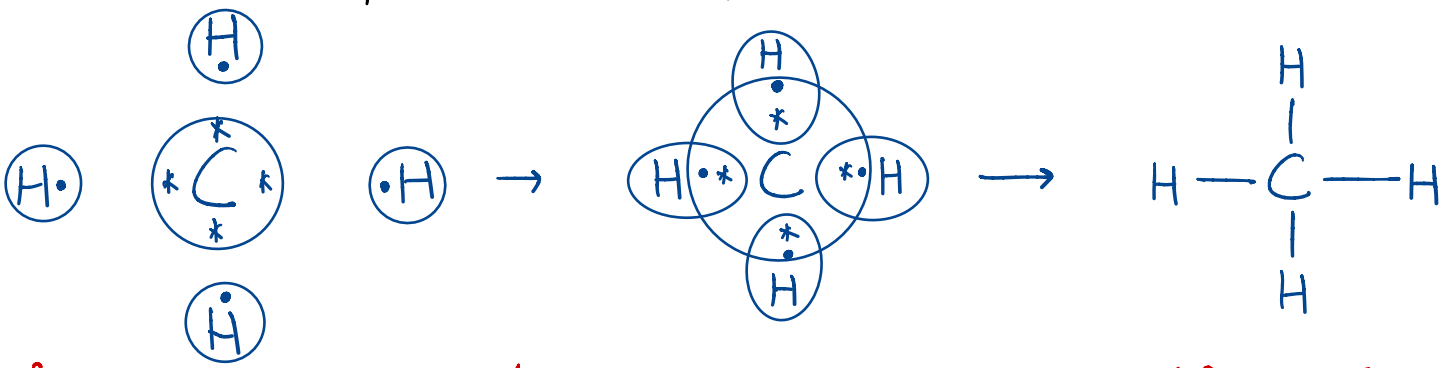
Need 3 more $e^{\ominus}$s to complete octet & achieve noble gas configuration.



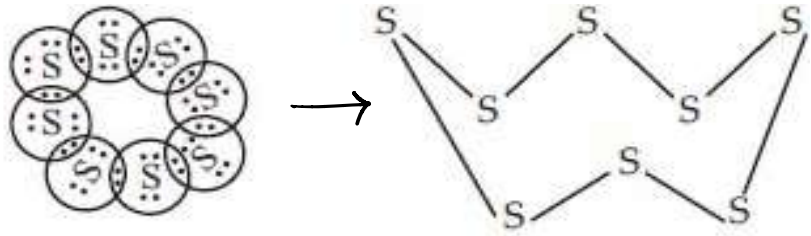
[V] Formation of Methane (CH_4) :



K³B ⇒ Methane also called marsh gas, used as a fuel and is a major component of CNG (Compressed Natural Gas) and Biogas.

चलो अब इन compounds के अपने आप बनाओ :-
→ Ammonia (NH_3)
→ Water (H_2O)
→ Carbon Dioxide (CO_2)

[VI] formation of Sulphur (S_8):-



Ring structure of S_8 molecule

Crown shape of S_8 molecule

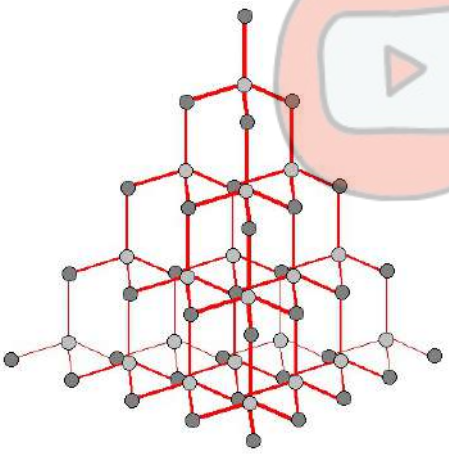
Properties of Covalent Bond: [cbse 2019, 2018]

- Low melting and boiling points (∵ weak inter molecular forces).
- As electrons are shared between atoms and no charged particles are formed in these compounds.

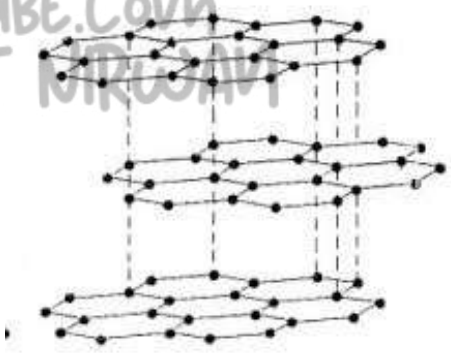
Allotropes of Carbon

↳ Allotropy is the property by which an element exists in more than one form and each form has different physical Properties but identical chemical prop.

DIAMOND



GRAPHITE



graphite

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Property-

- Very Hard
- Non-conductor of Electricity
- Colourless transparent

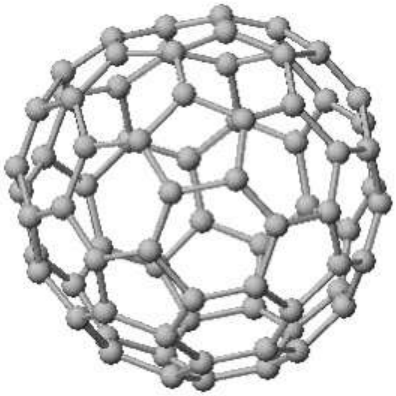
- lighter than diamond, slippery
- Conduct Electricity
- Greyish black, opaque

Uses-

- Used as a cutting instrument
- Making jewellery

- Used as a lubricant
- Used in electric cell
- To make core of pencil.

Fullerenes: Fullerene (C_{60}) was named Bukminster fullerene. The first known fullerene was C_{60} which contains 60 carbon atoms.



K³B ⇒ CARBON के इतने Jalwe क्यू हैं? OR,
What are the factors that enables carbon to form large no. of Compounds?
OR, Versatile Nature of Carbon:- [cbse 2020]

1. CATENATION: Carbon has a self-linking property in which C-atoms links through covalent bonds to form long, straight or branced chains and rings. Carbon shows maximum catenation in the periodic table due to its small size and strong C-C bond.

2. TETRAVALENCY OF CARBON: Carbon has 4 $e^{\ominus}$s in outermost shell. Hence, its valency is four i.e. it is capable of bonding or pairing with four other carbon atoms or with the atoms of some other monovalent elements like hydrogen, halogen (chlorine, bromine) etc.

3. TENDENCY TO FORM MULTIPLE BONDS: Due to its small size carbon has a strong tendency to form multiple bonds (double and triple bonds) by sharing more than on $e^{\ominus}$ pair with its own atoms or with the atoms like Oxygen, nitrogen etc.

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✱ ⇒ Compounds of Carbon are called Organic Compounds.

Hydrocarbons [cbse 2017, 2012]

A compound made of hydrogen and carbon only is called hydrocarbon.
Types of Hydrocarbons -

1. SATURATED: Compounds of carbon which are linked only by single bonds between the carbon atoms.
Types of Saturated hydrocarbons — Alkanes.

2. UNSATURATED: Compounds of carbon having double or triple bonds between their carbon atoms.
Types of Unsatured hydrocarbons - Alkenes, Alkynes.

Now:-

(i) Alkanes: The hydrocarbons in which all the carbon atoms are linked by only single covalent bonds are called alkanes or paraffins.
General formula ⇒ C_nH_{2n+2}

(ii) Alkenes: Those unsaturated hydrocarbons which have atleast one double bond alongwith single bonds are called alkenes or Olefins.
General formula ⇒ C_nH_{2n} $[n>1]$

(iii) Alkynes: Those unsaturated hydrocarbons which have one or more triple bonds

alongwith the single bonds are called alkynes.
General formula: C_nH_{2n-2} $[n>1]$

* here $[n>1]$ i.e minimum no. of carbon for double or triple bond must be two.
↳ सिर्फ एक carbon से double/triple bond कैसे लाओगे!

IUPAC Nomenclature of Hydrocarbons (नामकरण)

↳ नामकरण करने के लिए :- PREFIX + SUFFIX → बस यही करना है!

→ Prefix is based on number of carbon atoms in the chain.

#RattaMaaroLo :

		Prefix
C_1	→	Meth
C_2	→	Eth
C_3	→	Prop
C_4	→	But
C_5	→	Pent
C_6	→	Hex

→ Suffix is based on if hydrocarbon is alkane, alkene, alkyne.

#RattaMaaroLo :

		Suffix
Alkane	→	ane
Alkene	→	ene
Alkyne	→	yne

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Method : ○ Suffix तो आराम से total no. of carbon से निकल जाएगा।
○ कौनसा hydrocarbon है ये पता चलेगा कि वो जो तुम्हें compound दिया है वो कौनसी formulae से बना है (like C_nH_{2n+2}, C_nH_{2n}, C_nH_{2n-2})

eg : C_2H_4 — Carbon → 2 ∴ "Eth" is prefix
If we put n=2 in C_nH_{2n} we get C_2H_4 → ∴ its alkene → ∴ "ene" is suffix.
∴ Name → Prefix + Suffix → Ethene

C_5H_{12} — Prefix → "Pent"
Suffix → "ane" [∵ put n=5 in C_nH_{2n+2} to get C_5H_{12}] → Pentane

$CH_3(H_2CH_3$ — (पहले clup-up कर के simplify कर लो।)
≡ C_3H_8
↳ Now, Prefix → "prop"
Suffix → "ane" → propane

C_3H_4 — Prefix → "Prop"
Suffix → "yne" → Propyne

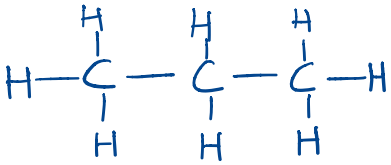
→ [cbse 2015]

HOW TO DRAW STRUCTURE OF SATURATED AND UNSATURATED COMPOUNDS:

(i) Connect all the carbon atoms together with single bond.
(ii) After that use the hydrogen atoms to satisfy the remaining valencies of carbon (as we know, carbon forms 4 bonds due to its 4 valency).
(iii) If number of available H-atoms are less than what is required, satisfy remaining valency by using double or triple bond.

↳ Trick ⇒ पहले ही जाँच लो कि Alkane, alkene या Alkyne है → formulae से!
तो फिर पहले ही तुम्हे पता होगा की double, triple या कौनसा Bond होगा।

eg (i) C_3H_8 ⇒ Name → Propane
↳ all single bonds. ∴ Simple ऊपर वाले steps follow करो



(ii) C_2H_4 → Ethene
↳ 1 double bond

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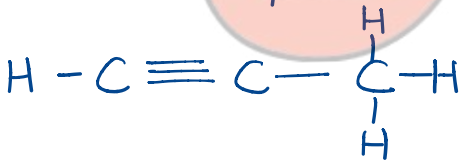
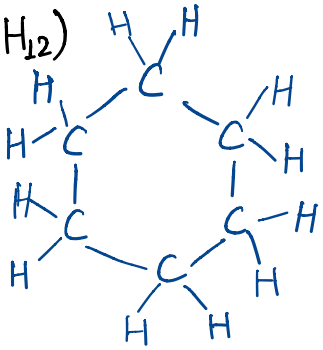
(iii) C_3H_4 → Propyne
↳ 1 Triple bond.

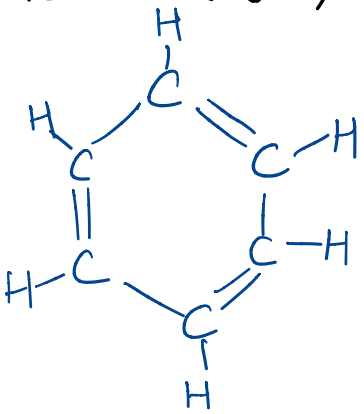


← [Triple bond दोनो में से किसी भी जगह लगा सकते थे, बस Triple bond और Hydrogen लगाते हुए एक बात ध्यान रखना कि Carbon के 4 से ज्यादा Bond ना बन जाए।]

(iv) Cyclohexane (C_6H_{12}) [cbse 2018]



** (v) Benzene (C_6H_6) (Ratt lo)



Functional Groups

↳ An atom or group of atom that makes a carbon compound reactive and decides its chemical property is called a functional group.
↳ [cbse 2016]

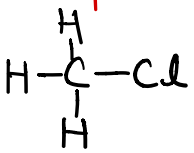
for Nomenclature: If functional group is present in the compound, it is indicated in the name of the compound with either a prefix or suffix (given on next page)

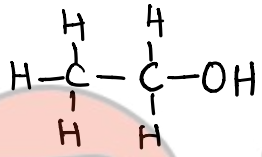
Hetero atom	Functional group	Formula of functional group	Prefix/Suffix
Cl/Br	Halo- (Chloro/bromo)	—Cl, —Br (substitutes for hydrogen atom)	Prefix – Chloro, Bromo
Oxygen	1. Alcohol	—OH	suffix – ol
	2. Aldehyde		suffix – al
	3. Ketone		suffix – one
	4. Carboxylic acid		suffix – oic acid

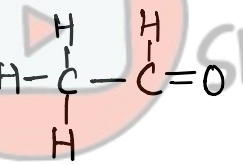
→ [cbse 2014]

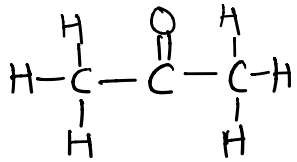
∴ for nomenclature do → Prefix + Hydrocarbon
or, Hydrocarbon + Suffix

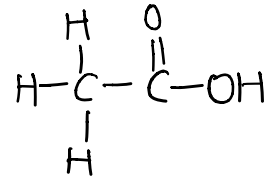
In suffix case, delete the final 'e' and add the appropriate suffix.

eg CH_3Cl or  ⟹ Prefix + Hydrocarbon
⇒ Chloroethane

CH_3CH_2OH or  ⟹ Hydrocarbon + suffix (but delete 'e')
Ethane $\xrightarrow[-e]{+ol}$ Ethanol

CH_3CHO or  ⟹ Hydrocarbon + suffix
Ethane $\xrightarrow[-e]{+al}$ Ethanal

CH_3COCH_3 or  ⇒ Propane $\xrightarrow[-e]{+one}$ Propanone

CH_3COOH or  ⇒ Ethane $\xrightarrow[-e]{+oic\ acid}$ Ethanoic acid

Homologous Series [cbse 2017, 2013]

↳ A homologous series is a group of organic compounds having similar structure and chemical property in which successive compound group differ by $-CH_2$ group.
eg:- CH_4, C_2H_6, C_3H_8 ----

Characteristics:
- All members are represented by same General formula
- 2 adjacent members differ by $-CH_2$ group.
- 2 adjacent members differ by mol. masses of 14u.
- All shows similar chemical properties. (but not physical)

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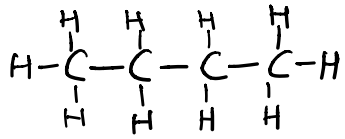
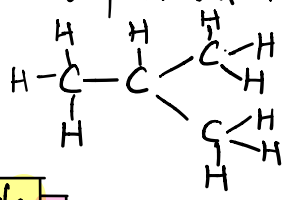
STRUCTURAL ISOMERISM

↳ Compounds with identical molecular formula but different structures

eg  &  → Both C_4H_{10} but connectivity अलग है ∴ they both are Isomers.

Some Important Carbon Compounds

[I] Ethanol (CH_3CH_2OH):

- Liquid, soluble in water
- Commonly called alcohol and is active ingredient
- As it is a good solvent, it is used in medicines such as tincture iodine, cough syrups and many tonics.
- Preparation — Obtained by fermentation of molasses which are obtained from sugarcane juice

[II] Ethanoic Acid (CH_3COOH):

- Commonly called acetic acid.
- 5-8% solution of acetic acid in water is called vinegar which is used as presentation in pickle.
- Melting point 290 K, so freezes during winter.
- Carboxylic acid are weak acids.

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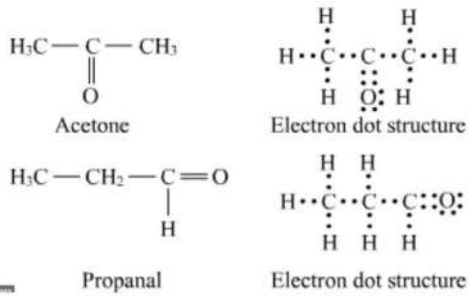
⇒ Some Important Lallu Problems:

CBSE 2013 (b) Draw two possible isomers of the compound with molecular formula C_3H_6O and write their names.

ans →



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K3B

- Frozen acetic acid (CH_3COOH) is also called glacial acetic acid.
- DENATURED ALCOHOL: Consumption of Alcohol in large quantity is not good for health. It tends to slow metabolic processes and depress the central nervous system which in turn results in lack of coordination, drowsiness etc. Therefore, in order to stop misuse of alcohol, it is made unfit for drinking by adding poisonous substances like methanol, pyridine etc and coloured substances likes dyes. Such alcohol is called denatured alcohol.

KHATAM

—– Chemical Properties of Carbon Compounds —–

1. <u>COMBUSTION</u>: A chemical reaction in which heat and light are given out is called combustion.

   - **Combustion of Carbon:**
     $C(s) + O2(g) \rightarrow CO2(g) + Heat + Light$
   - **Combustion of Hydrocarbon:**
     $CH4(g) + O2(g) \rightarrow CO2(g) + H20(g) + Heat + Light$
   - **Combustion of Alcohol:**
     $CH3CH2OH\ (g) + O2(g) \rightarrow CO2(g) + H20(g) + Heat + Light$

   <u>The Nature of Flame:</u>

- Saturated hydrocarbon such as, methane, ethane burn with clear b/w flame in the presence of sufficient oxygen.
- Saturated hydrocarbon in the presence of Limited amount of oxygen give sooty Flame
- Unsaturated hydrocarbon such as ethene, ethyne etc. burn with yellow flame with lots of black smoke
- Kerosene when burnt in the presence of sufficient oxygen gives clear between flame.
- Some hydrocarbons like benzene, naphthalene etc. burn with sooty flame.
- Coal and Petroleum on burning produce mainly CO2, CO, Oxides of Nitrogen and sulphur. The oxides of Nitrogen and sulphur cause air pollution.

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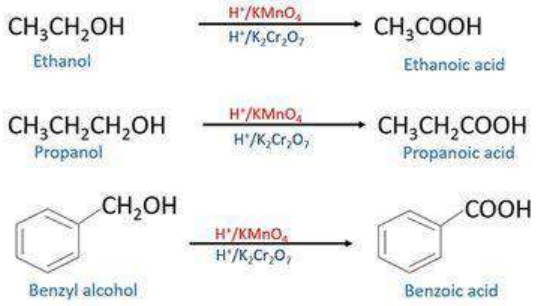
2. <u>OXIDATION</u>: Carbon compounds can be easily oxidised on combustion.

$$2C(s) + O2(g) \longrightarrow 2CO(g)$$
Limited — Carbon Monoxide

$$C(s) + O2(g) \longrightarrow CO2(g)$$
Excess — Carbon Monoxide

*Different amount of oxygen gives different products.

Oxidation of Alcohol: (CBSE 2020)

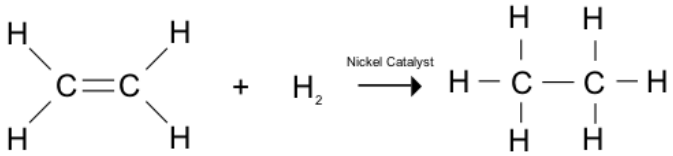


*Both Alkaline KMnO4 and acidified K2Cr2O7 act as oxidising Agents (substance that supplyoxygen for oxidation)

3. <u>ADDITION REACTION:</u>

Unsaturated hydrocarbon add hydrogen in the presence of catalyst such as palladium or Nickel to give saturated hydrocarbons.
**Catalysts are the substances that cause a reaction to occur at a different rate, without being used up in the reaction.*

Hydrogenation Reaction: This reaction is used in the hydrogenation of Vegetable oil Vegetable oil generally have long unsaturated carbon chains while animal fats have saturated carbon chain.
Animal fats generally contain saturated fatly acid which are harmful for health.



4. SUBSTITUTION REACTION:
It is a single replacement chemical reaction during which one functional group in chemical compounds is replaced by another functional groups.

$$CH3OH + HBr \longrightarrow CH3Br + H2O$$

$$CH4 + Cl2 \xrightarrow{hv} CH3Cl + HCl$$

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5. Reactions of Ethanol:
i. Reaction with sodium:

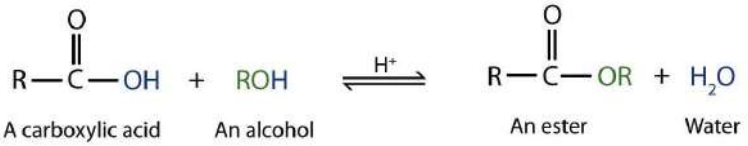
$$2Na + 2CH3CH2OH \longrightarrow \underset{\text{(sodium ethoxide)}}{2CH3CH2O\text{-}Na^{+}} + H2$$

ii. Reaction to give unsaturated hydrocarbons:

$$CH3\text{-}CH2\text{-}OH \xrightarrow[H2S04]{\text{Hot conc.}} CH2 = CH2 + H20$$

*Hot conc. H2SO4 act as dehydrating Agent(which removes water)

6. Reactions of Ethanoic Acid:
i. Esterification Reaction: Reaction of Acid and alcohol girs ester. Esters are sweet smelling substances used in making perfumes and as flavouring agents.



ii. Saponification Reaction: Reaction used in preparation of soaps.
Ester + base —> Alcohol + Carboxylic Acid

$$CH3COOC2H5 \xrightarrow{NaOH} \underset{\text{(alcohol)}}{C2H5OH} + \underset{\text{(sodium acetate)}}{CH3COONa}$$

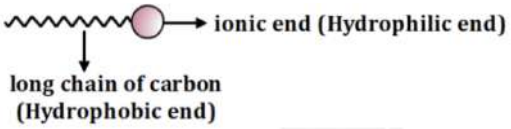
$$NaOH + CH3COOH \longrightarrow CH3COONa + H2O$$

ii. Reaction with Carbonates and Hydrogen Carbonates:

$$2CH_3COOH - Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$$
$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$$

—— Soaps and Detergents ——

- Soaps are sodium or potassium salts of long chain carboxylic acids. The ionic - end of soap dissolve in water the carbon chain dissolves in oil.



- Detergents are generally ammonium or sulphonates salts of long chain carboxylic acid.
- Cleaning Action of Soap:
  - Most of the dirt is oily in nature and oil does not dissolve in water
  - The soap molecule form the structure called Micelles
  - In Micelles one end is towards the oils droplet and other end which is ionic faces outside.
  - Soap in the form of a micelle in the centre of the micelles
  - The micelles stay in the solution as a colloid and will not come together to precipitate due to ion ion Repulsion.
  - Soap micelles are large enough to scatter light; Hence soap solution appears cloudy.

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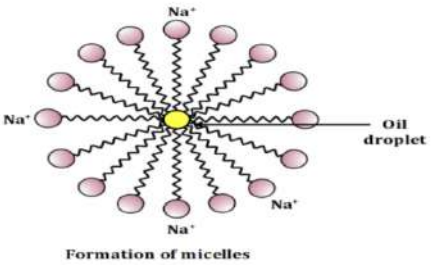
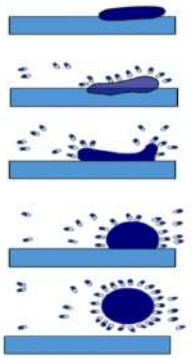


Formation of micelles



- Hardness of Water
  - Hard water means, water having a very high a mineral content like calcium and Magnesium salts soap molecule react with the salts of calcium and magnesium and for precipitate also known as sum.
  - Soft water (which do not contain calcium and Magnesium salts are) do not form sum with soap.
  - Detergents are generally ammonium or sulphonates salts of long chain carboxylic acid. The charged ends of these compounds do not form insoluble precipitates with Hardwater, thus they remain effective in Hard water.

LP: Why detergents are better cleansing agents than soaps?
Ans- The charged ends of detergents do not form insoluble precipitates with calcium and magnesium ion in Hard water, while when soaps are used for washing clothes with hardwater, it react with the calcium and magnesium ions of hardwater to form an insoluble precipitate called scum; therefore detergents are better cleansing agents than soaps, because they can be used even with hard water.

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-- PREVIOUS YEAR QUESTIONS --

1 MARK QUESTIONS (INCLUDING MCQs)

Q1. What is the difference in the molecular formula of any two consecutive members of a homologous series of organic compounds? [CBSE 2008]
A.1 The molecular formula of any two consecutive members of homologous series differ by CH_2 units.

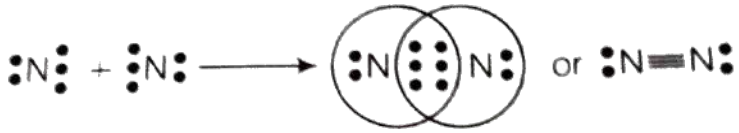
Q2. Write the molecular formula of the 2nd and 3rd member of the homologous series where the first member is ethyne. [CBSE 2017]
A.2 The molecular formula of the 2nd and 3rd members of a homologous series where the first member is ethyne (C2H2) is formed by adding -CH2 -:
2nd member of alkyne series = propyne (C3H4) CH3-CH2-C≡CH
3rd member of alkyne series = butyne (C4H6) CH3-CH2-C≡CH

Q3. Write the name and formula of the 2nd member of the series of carbon compounds whose general formula is CnH2n. [CBSE 2012]
A.3 C3H6------> Formula
H2C=CH-CH3------> Structure
Propene is the second member of the series whose general formula is CnH2n.

Q4. Write the molecular formula of the 2nd and the 3rd member of the homologous series whose first member is methane. [CBSE 2017]
A.4 2nd member - Ethane C2H6
3rd member - Propane C3H8

Q5. Which element exhibits the property of catenation to maximum extent and why? [CBSE 2016]
A.5 Carbon exhibits the property of catenation due to it's strong C-C bond.

Q6. Draw the electron dot structure of Nitrogen molecule. [CBSE 2012,2013]
A.6 This is the electron dot structure of nitrogen molecule.



7. Ethane, with the molecular formula C2H has
a). 6 covalent bonds
b). 7 covalent bonds
c). 8 covalent bonds
d). 9 covalent bonds
A.7 b). 7 covalent bonds

3 MARKS QUESTIONS

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Q8. State the reason why carbon can neither form C^{4+} cations nor C^{4-} anions but forms covalent compounds. Also, state reasons to explain why covalent compounds:
(i) are bad conductors of electricity?
(ii) have low melting and boiling points? [CBSE Compt. 2017, CBSE 2019]
A.8 The atomic number of Carbon is 6 with an electronic configuration of 2, 4. Hence, carbon has 4 electrons in its valence shell. Carbon can lose or gain 4 electrons in order to gain stability. It cannot gain four electrons as carbon atom having 6 protons is very small to handle 10 electrons and it cannot donate electrons as it needs a lot of energy to do so. Hence, it cannot form C^{4+} anion or C^{4-} anion and thus forms a covalent bond.
1. Covalent compounds are formed by sharing of electrons. They don't have a free electron that is required for electricity transfer (electricity is the flow of free electrons), thus they are bad conductors.
2. Covalent compounds have low melting and boiling points because they have weak intermolecular forces between bonds. Hence, less energy/temperature is needed to break the bonds.

Q9. Give reasons for the following:
(i) Element carbon forms compounds mainly by covalent bonding.
(ii) Diamond has a high melting point.
(ii) Graphite is a good conductor of electricity. [CBSE 2011]
A.9 (i) It is because carbon has four valence electrons, it cannot gain or lose four electrons because high energy is needed. It can only share four electrons.
(ii) It is due to strong covalent bonds and compact structure of diamond.
(iii) It is due to presence of free electrons in graphite because each carbon is linked to three more carbon atoms.

Q10. Carbon a member of group 14, forms a large number of carbon compounds estimated to be about three million. Why is this property not exhibited by other elements of this group?
[CBSE 2020]
A.10 This property of carbon is known as catenation which is exhibited only carbon atom not by other elements of this group.
Due to the small size of carbon atoms , stability of carbon atoms and ability to form strong bonds , carbon gives rise to a large number of compounds linked to each other.

Q11. (a) Why are most carbon compounds poor conductors of electricity?
(b)Write the name and structure of a saturated compound in which the carbon atoms are arranged in a ring. Give the number of single bonds present in this compound.
[CBSE 2018]
A.11 a) Electricity is conducted by moving electrons. But carbon forms covalent bonds by sharing electrons. Hence, it does not have free electrons.
(b) Cyclohexane is a saturated compound in which carbon atoms are arranged in a ring. 6 single bonds present in this compound.

5 MARKS QUESTIONS
Q12. (a) Explain why carbon forms covalent bond? Give two reasons for carbon forming large number of compounds.
(b) Explain the formation of ammonia molecules.

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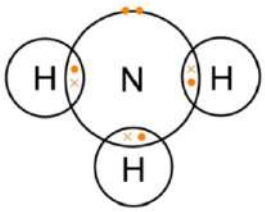
A.12 (a). The atomic number of Carbon is 6 with an electronic configuration of 2, 4. Hence, carbon has 4 electrons in its valence shell. Carbon can lose or gain 4 electrons in order to gain stability. It cannot gain four electrons as a carbon atom having 6 protons is very small to handle 10 electrons and it cannot donate electrons as it needs a lot of energy to do so. Hence, it cannot form C4+ anion or C4- anion and thus forms a covalent bond.
(b). Ammonia (NH_3) is made up of one atom of nitrogen and three atoms of hydrogen
Atomic number of N = 7
Electronic configuration = 2, 5
Atomic number of H = 1
Electronic configuration = 1
So hydrogen needs more electron to complete its duplet and nitrogen needs three more electrons to complete its octet. Hence three hydrogen atoms will combine with nitrogen to form ammonia.



ASSERTION AND REASONING QUESTIONS
Rule : Assertion is labelled as (A) and the Reason is labelled as (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below :
(a) Both (A) and (R) are true and (R) is the correct explanation of the assertion (A).
(b) Both (A) and (R) are true, but (R) is not the correct explanation of the assertion (A).
(c) (A) is true, but (R) is false.
(d) (A) is false, but (R) is true

Q13. Assertion: Carbon has ability to form long carbon chains.
Reason : Carbon has unique property of ability to chain and branched chains called catenation.
A.13 (a) Both assertion (A) and reason (R) are correct and reason is the correct explanation of assertion.

Q14. Assertion: Second number of alkane is ethane (C_2H_6).
Reason : It is obtained from general formula C_nH_{2n+2}.
A.14 (a) Both assertion (A) and reason (R) are correct and reason is the correct explanation of assertion.

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