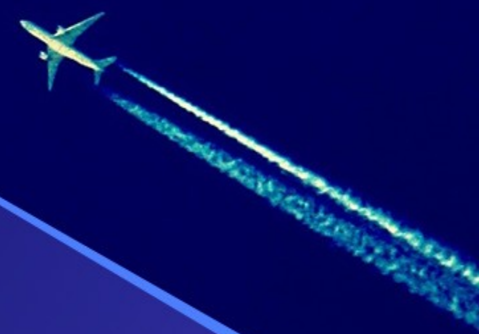

UNIT-11
THE P-BLOCK ELEMENTS

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P-BLOCK ELEMENTS

- The elements in which the last electron enters the p-orbitals of their valence shell are called P-block elements.
- It consists of group 13 to 18 except He.
- The valence shell configuration of these elements is $ns^2\ np^{1-6}$.
- The maximum oxidation state shown by a P-block element is equal to the total number of valence electrons
- (i.e., the sum of s and p electrons).

ANOMALOUS BEHAVIOUR OF FIRST MEMBER OF A GROUP

- The first member in each group differ from that of the other elements in their respective groups.
- The anomalous behaviour of the first member in each group is due to
- The very small size of the atoms
- High Ionisation energies
- High electronegativities
- Absence of vacant d orbitals.

INERT PAIR EFFECT

- It is the reluctance of s-electrons to participate in chemical bonding.
- It is commonly seen in the elements of groups 13, 14 & 15.
- Down the group, due to the poor shielding effect of inner d and f orbitals, the effective nuclear charge is greater, which holds the s-electrons tightly.
- So they cannot participate in bonding.
- Due to the above reason, TlCl is more stable than $TlCl_3$.
- Lead mainly forms $PbCl_2$ than $PbCl_4$.
- Tl^{+} is stabler than Tl^{3+} and Pb^{2+} is stabler than Pb^{4+}

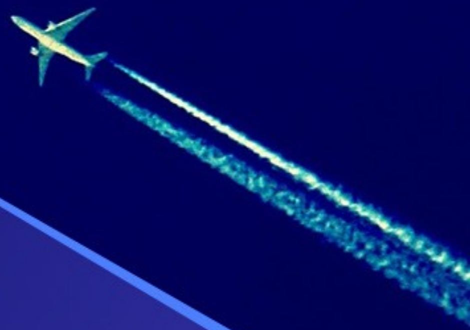
GROUP 13 ELEMENTS:
THE BORON FAMILY

GROUP 13 ELEMENTS

- It includes Boron, Aluminium, Gallium, Indium and Thallium.
- Boron is a typical non metal.
- Al is a metal.
- Ga, In and Tl are almost metallic in character.
- Boron mainly occurs as orthoboric acid (H_3BO_3), borax ($Na_2B_4O_7.10H_2O$) and Kernite ($Na_2B_4O_7.4H_2O$).
- The two isotopic forms of Boron are ^{10}B and ^{11}B.

GROUP 13 ELEMENTS

- Aluminium is the most abundant metal and the third most abundant element in the earth's crust.
- Bauxite ($Al_2O_3.2H_2O$) and Cryolite (Na_3AlF_6) are the important minerals of aluminium.
- Ga, In and Tl are less abundant elements in nature.



ATOMIC PROPERTIES

ELECTRONIC CONFIGURATION

- The outer electronic configuration of these elements is $ns^2 np^1$.
- Boron and Aluminium have noble gas core.
- Ga and In have noble gas plus 10 d electrons.
- Thallium has noble gas plus 14 f electrons plus 10 d electron cores.

ATOMIC RADII

- On moving down the group, atomic radius increases.
- Atomic radius of Ga is less than that of Al.
- This is due to the presence of completely filled d orbitals in Ga.
- The presence of 10 d electrons offers only very poor shielding effect for the outer electrons.
- Consequently, the atomic radius of gallium (135 pm) is less than that of Al (143 pm).

IONISATION ENTHALPY

- Ionisation enthalpy does not decrease smoothly down the group.
- This is due to the poor shielding effect of the completely filled inner d and f electrons.

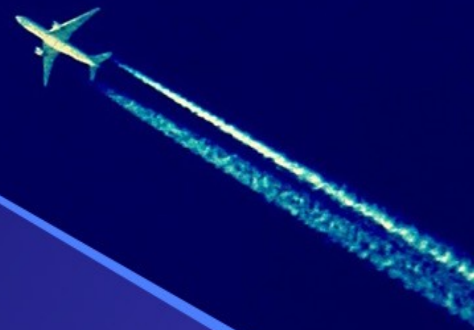
ELECTRONEGATIVITY

- Down the group, electronegativity first decreases from B to Al and then increases marginally.
- This is because of the variation in atomic size of the elements.

PHYSICAL PROPERTIES

- Boron is non metallic in nature.
- It is extremely hard and black coloured solid.
- It exists in many allotropic forms.
- Due to very strong crystalline lattice, boron has unusually high melting point.
- The other members of this group are soft metals.
- They have low melting point and high electrical conductivity.
- Ga with very low melting point (303 K) could exist in liquid state during summer.
- Its boiling point is very high. (2676 K).
- Therefore, it is used in high temperature thermometers.

CHEMICAL PROPERTIES



REACTIVITY TOWARDS AIR

- Boron is unreactive in crystalline form.
- Aluminium forms a very thin oxide layer on the surface which protects the metal from further attack.
- Amorphous boron and Al metal on heating in air form B_2O_3 and Al_2O_3 respectively.
- With dinitrogen at high temperature they form nitrides.

$$4E + 3O_2 \longrightarrow 2E_2O_3$$

$$2E + 3N_2 \longrightarrow 2EN \qquad (E = \text{Element})$$

REACTIVITY TOWARDS ACIDS AND ALKALIES

- Boron does not react with acids and alkalies even at moderate temperature.
- Al dissolves in mineral acids and aqueous alkalies.
- Al shows amphoteric character.
- Al dissolves in dilute HCl and liberates dihydrogen.

$$2Al + 6HCl \longrightarrow 2Al_3 + +6Cl^- + 3H_2$$

- Conc. HNO_3 renders Al passive by forming a protective oxide layer on the surface.
- Al also reacts with aqueous alkalie and liberates dihydrogen.

$$2Al + 2NaOH + 6H_2O \longrightarrow \underset{\text{Sodium tetrahydroxo aluminate (III)}}{2NaAl(OH)_4} + 3H_2$$

REACTIVITY TOWARDS HALOGENS

- **Group 13 elements react with halogens to form trihalides except (TlI_3)**

$$2E + 3X_2 \longrightarrow 2EX_3 \qquad (E = F, Cl, Br, I)$$

IMPORTANT TRENDS AND ANOMALOUS PROPERTIES OF BORON

- They are covalent in nature.
- They are hydrolysed in water.
- The monomeric trihalides are electron deficient.
- Therefore, they are strong Lewis acids.
- Boron trifluoride easily react with Lewis bases such as NH_3 to complete octet around Boron.

$$F_3B + :NH_3 \longrightarrow F_3B \leftarrow NH_3$$

- It is due to the absence of d orbitals that the maximum covalency is 4.

Boron is unstable to form BF_6^{3-} ion. Explain.

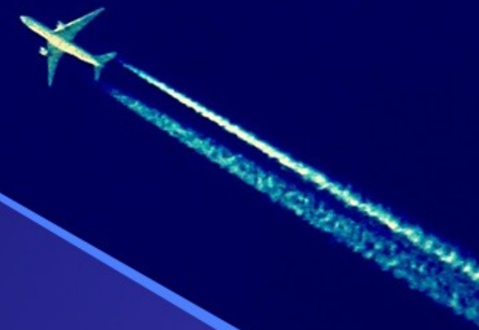
- Due to non-availability of d orbitals, boron is unable to expand its octet.
- Therefore, the maximum covalency of boron cannot exceed 4.

Why is boric acid considered as a weak acid?

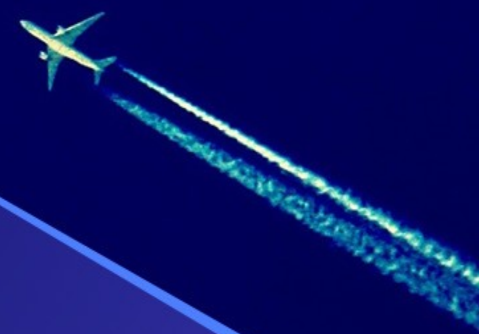
- Because it is not able to release H^+ ions on its own.
- It receives OH^- ions from water molecule to complete its octet and in turn releases H^+ ions.

White fumes appear around the bottle of anhydrous $AlCl_3$.Give reason.

- Anhydrous aluminium chloride is partially hydrolysed with atmospheric moisture to liberate HCl gas.
- Moist HCl appears white in colour.



SOME IMPORTANT COMPOUNDS OF BORON



1. BORAX [$Na_2B_4O_7.10H_2O$]

2. ORTHOBORIC ACID [H_3BO_3]

3. DIBORANE [B_2H_6]

BORAX [$Na_2B_4O_7.10H_2O$]

BORAX [$Na_2B_4O_7.10H_2O$]

- Borax is a white crystalline solid of formula $Na_2B_4O_7.10H_2O$.
- Borax dissolves in water to give NaOH and orthoboric acid.

$$Na_2B_4O_7 + 7\ H_2O \longrightarrow 2\ NaOH + 4\ H_3BO_3$$

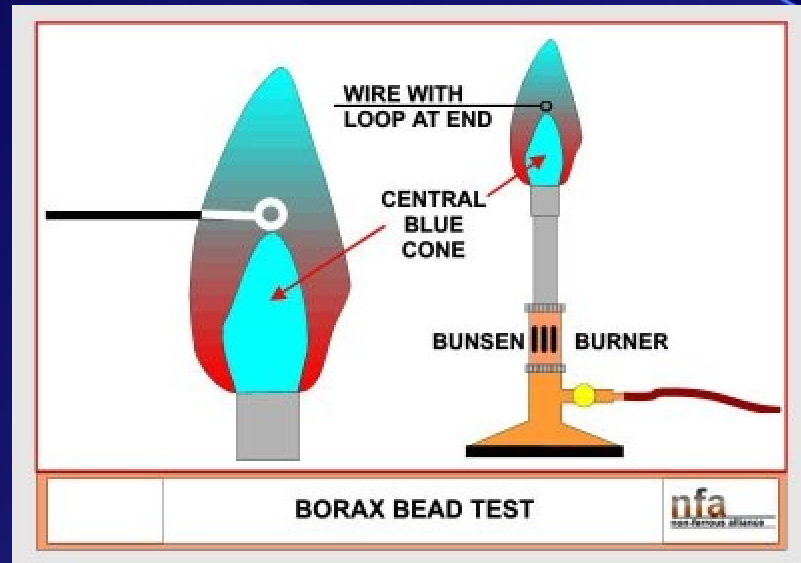
- On heating, borax first loses water molecules and swells up.
- On further heating, it turns into a transparent liquid.
- It solidifies into glass like material known as borax bead.

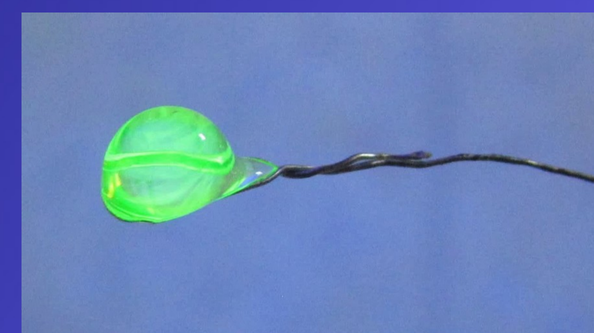
$$Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} 2\ NaBO_2 + B_2O_3$$

Sod. Meta borate + Boric anhydride

BORAX BEAD TEST

- The meta borates of many transition metals have characteristic colours.
- Therefore borax bead test can be used to identify them in the laboratory.
- The bead test sometimes called the borax bead or blister test is an analytical method used to test for the presence of certain metals.
- Boric anhydride is non-volatile.
- When it reacts with coloured metallic salt, a characteristic coloured bead of metal meta borate is formed.


WIRE WITH
LOOP AT END
CENTRAL
BLUE
CONE
BUNSEN
BURNER
BORAX BEAD TEST
nfa



WHAT IS BORAX BEAD TEST?

- On heating, Borax melts into a clear liquid.
- Later, it solidifies into a transparent glass-like bead.
- The glass bead is commonly known as borax bead.
- It is employed in qualitative analysis for the detection of Transition Metals.
- Whenever a coloured salt-containing transition metal cations is heated with a borax bead on a platinum wire, it forms metal meta borates.
- This test is called the borax bead test or Blister Test.

ORTHOBORIC ACID [H_3BO_3]

ORTHOBORIC ACID

- It is a white crystalline solid, with soapy touch.
- It is sparingly soluble in water but highly soluble in hot water.

PREPARATION

- It is prepared by adding conc. HCl to a concentrated aqueous solution of borax.

$$Na_2B_4O_7 + 7HCl + 5H_2O \longrightarrow 2NaCl + 4H_3BO_3$$

PROPERTIES

- Orthoboric acid on heating above 370K forms metaboric acid, (HBO_2)
- This on further heating gives boric oxide, B_2O_3 .

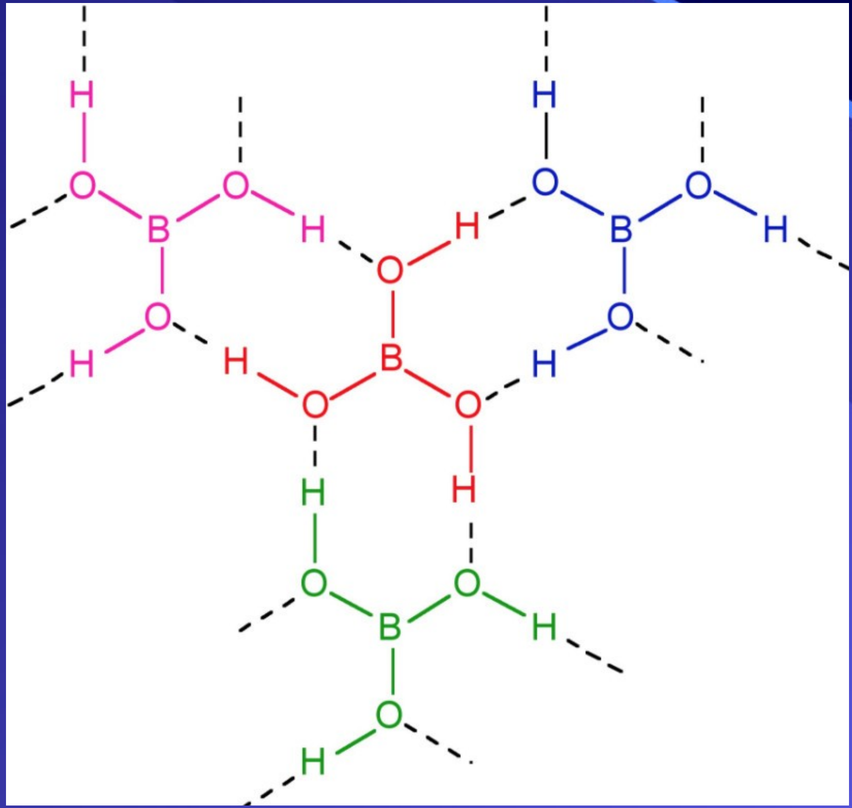
$$H_3BO_3 \xrightarrow{\Delta} HBO_2 \xrightarrow{\Delta} B_2O_3$$

- Boric acid is a weak monobasic acid.
- It is not a protonic acid.
- It acts as a Lewis acid by accepting electrons from a hydroxyl ion.

$$B(OH)_3 + 2\,H{-}OH \longrightarrow [B(OH)_4]^- + H_3O^+$$

STRUCTURE

- Orthoboric acid has a layer structure.
- It has planar BO_3 units which are joined by hydrogen bonds.



DIBORANE [B_2H_6]

- **The simplest boron hydride known is Diborane.**

- Diborane is prepared by treating boron trifluoride with $LiAlH_4$ in diethyl ether.

$$4\,BF_3 + 3\,LiAlH_4 \longrightarrow 2B_2H_6 + 3\,LiF + 3\,AlF_3$$

- In the laboratory, diborane is prepared by the reaction of Iodine with sodium borohydride.

$$2NaBH_4 + I_2 \longrightarrow B_2H_6 + 2NaI + H_2$$

- On an industrial scale, diborane is prepared by the reaction of BF_3 with sodium hydride.

$$2BF_3 + 6NaH \longrightarrow B_2H_6 + 6\,NaF$$

PROPERTIES

- Diborane is a colourless, highly toxic gas with a boiling point of 180 K.
- Diborane catches fire spontaneously upon exposure to air.
- It burns in oxygen releasing an enormous amount of energy.

$$B_2H_6 + 3\ O_2 \longrightarrow B_2O_3 + 3\ H_2O \qquad \Delta H = -1976\ kJ/mol$$

- Diborane is readily hydrolysed by water to give boric acid.

$$B_2H_6 + 6\ H_2O \longrightarrow 2\ B(OH)_3 + 6\ H_2$$

- Diborane undergo cleavage reactions with Lewis base to give borane adduct.

$$B_2H_6 + 2\ NMe_3 \longrightarrow 2\ BH_3.NMe_3$$

$$B_2H_6 + 2\ CO \longrightarrow 2\ BH_3.CO$$

- Diborane reacts with ammonia to give different products under different conditions.

$$B_2H_6 + \text{Excess } NH_3 \xrightarrow{\text{Low Temp}} B_2H_6.2NH_3$$

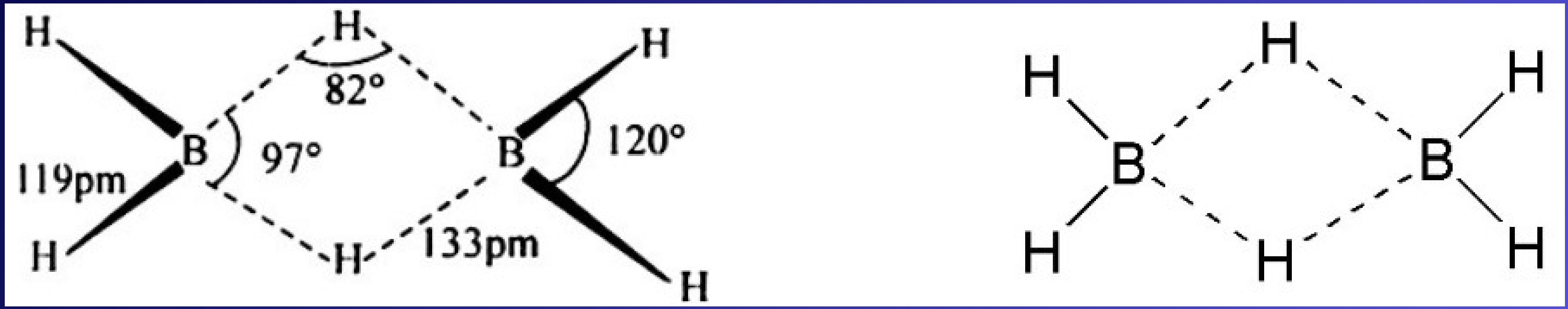
$$B_2H_6 + \text{Excess } NH_3 \xrightarrow{\text{HighTemp}} (BN)_X$$

$$B_2H_6 + 6\ NH_3 \xrightarrow{\text{HighTemp}} 2\ B_3N_3H_6 + 12\ H_2$$

STRUCTURE OF DIBORANE

- In Diborane, Boron atom is sp^3 hybridized.
- All the six hydrogen atoms are not similar.
- Four are terminal hydrogen atoms and two are bridged.
- The four terminal hydrogen atoms and the two boron atoms lie in one plane.
- The bridged hydrogen atoms lie one above and one below this plane.
- The four terminal B—H bonds are regular two centre-two electron bonds.

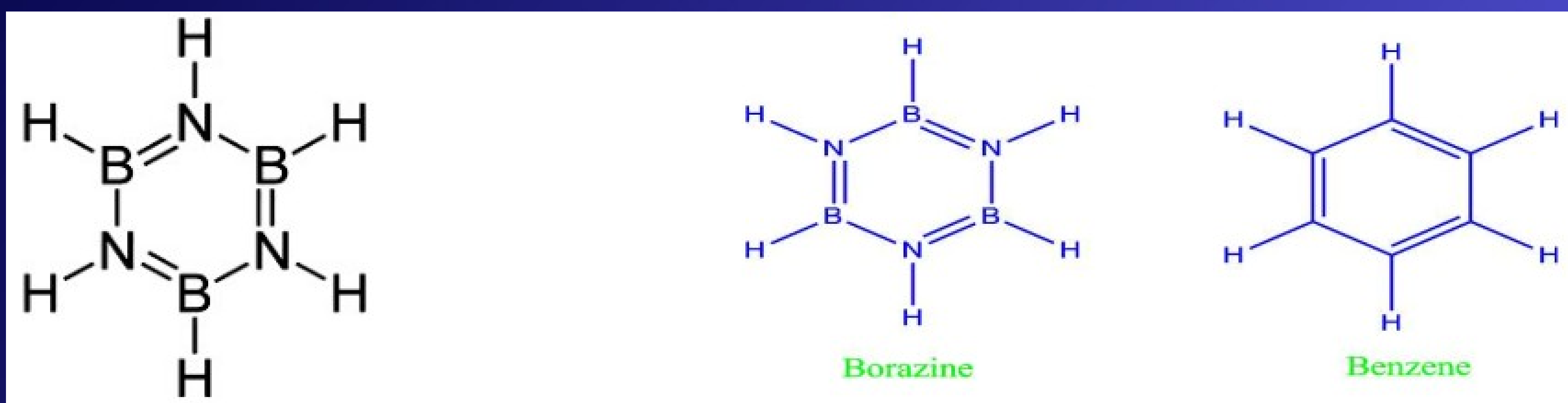
- The four terminal B—H bonds are regular two centre-two electron bonds.
- The two bridge (B—H—B) bonds are three centre two electron bonds.
- These bonds are called banana bond.
- Diborane has only 12 electrons.
- Three from each boron and six from the hydrogen atoms.
- Thus, it is an electron deficient compound.



BORAZINE OR INORGANIC BENZENE

Borazine is also known as Inorganic benzene.

Its structure is similar to benzene with alternate BH and NH groups.



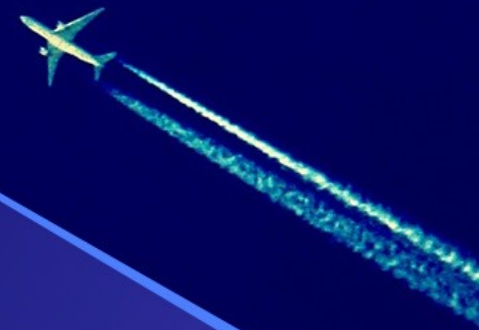
- Borazine is called “inorganic benzene” because the compound is isoelectronic and isostructural with benzene.
- It is a colourless liquid with aromatic smell.
- Borazine is said to be aromatic because the number of pi electrons obeys 4n+2 rule and the B-N bond lengths are all equal.

USES OF BORON AND THEIR COMPOUNDS

- Boron fibres are used in making bullet proof vest.
- It is used in light composite material for air craft.
- Metal borides are used in nuclear industry as protective shields and control rods.
- Borax and boric acid is used in the manufacture of heat resistant glasses, glass wool and fibre glass.
- Borax is also used as a flux for soldering metals.
- Borax is used as a constituent of medicinal soaps.
- An aqueous solution of orthoboric acid is generally used as a mild antiseptic.

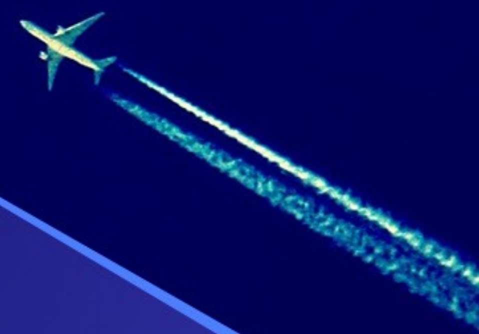
USES OF ALUMINIUM AND THEIR COMPOUNDS

- Aluminium is a bright silvery white metal with high tensile strength.
- It has high electrical and thermal conductivity.
- Aluminium forms alloys with Cu, Mn, Mg, Si and Zn.
- Al and its alloys are used for packing, utensil making, construction of aeroplane and in transportation industry.



GROUP 14 ELEMENTS: THE CARBON FAMILY

ATOMIC PROPERTIES



ELECTRONIC CONFIGURATION

- **The valence shell electronic configuration of these elements is ns^2np^2 .**
- **The inner core of the electronic configuration of elements in this group also differs.**

COVALENT RADIUS

- There is a considerable increase in covalent radius from Carbon to Silicon.
- From Silicon to Lead, a small increase in radius is observed.
- This is due to the presence of completely filled d and f orbitals in heavier members.

IONISATION ENTHALPY

- The first ionisation enthalpy of group 14 elements is higher than the corresponding members of group 13.
- In general, the ionisation enthalpy decreases down the group.
- A small decrease in ionisation enthalpy is observed from Si to Sn.
- A slight increase in ionisation enthalpy is observed from Sn to Pb.
- This is due to poor shielding effect of intervening d and f orbitals and increase in size of the atom.

ELECTRONEGATIVITY

- Due to small size, the elements of this group are slightly more electronegative than group 13 elements.
- The electronegativity values for elements from Si to Pb are almost the same.

PHYSICAL PROPERTIES

- All the group 14 elements are solids.
- Carbon and Silicon are non-metals.
- Germanium is a metalloid.
- Tin and Lead are soft metals with low melting points.
- Melting points and boiling points of group 14 elements are much higher than those of corresponding elements of group 13.

CHEMICAL PROPERTIES

REACTIVITY TOWARDS OXYGEN

- All the members of the group 14 when heated in oxygen form oxides.
- There are mainly two types of oxides
- i.e., monoxide and dioxide of formula MO and MO_2 respectively.
- SiO exists at high temperature.
- Oxides in higher oxidation states of elements are generally more acidic than those in lower oxidation states.

- **The dioxides, CO_2 , SiO_2 , and GeO_2 are acidic.**
- **SnO_2 and PbO_2 are amphoteric in nature.**
- **Among monoxides, CO is neutral.**
- **GeO is acidic.**
- **SnO and PbO are amphoteric.**

REACTIVITY TOWARDS WATER

- **Carbon, Silicon and Germanium are not affected by water.**
- **Tin decomposes steam to form dioxide and dihydrogen gas.**

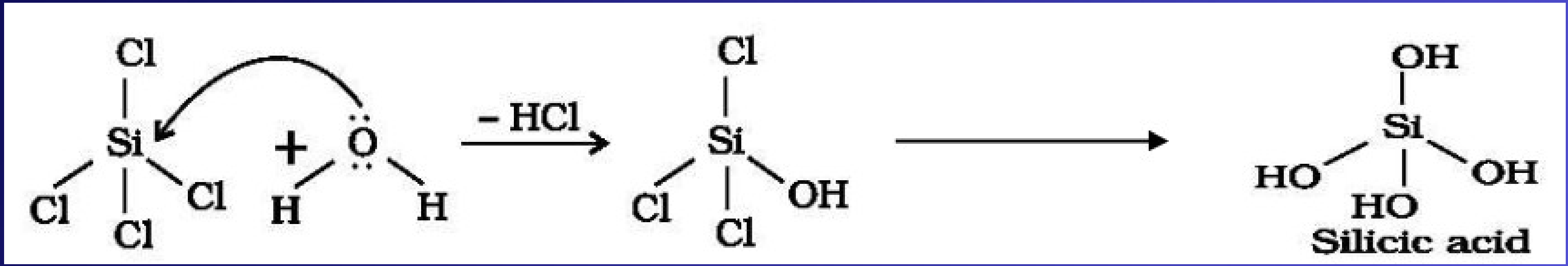
$$Sn + 2H_2O \longrightarrow SnO_2 + 2H_2$$

- **Lead is unaffected by water because of a protective oxide film formation.**

REACTIVITY TOWARDS HALOGEN

- The elements of group 14 can form dihalides of formula MX_2 and MX_4 .
- Except carbon, all other members react directly with halogens under suitable conditions to form halides.
- Most of the MX_4 are covalent in nature.
- Heavier members Ge to Pb are able to make halides of formula MX_2 .

- Except Ccl_4, other tetrachlorides are easily hydrolysed by water.
- This is because the central atom can accommodate the lone pair of electrons from oxygen atom of water molecule in d orbital.
- Eg:- $SiCl_4$ undergoes hydrolysis by initially accepting lone pair of electrons from water molecule in d orbitals of Si, finally leading to the formation of $Si(OH)_4$.



SiF_6^{2-} is known whereas $SiCl_6^{2-}$ is not . Give reasons.

- Six large chloride ions cannot be accommodated around Si^{4+} due to limitation of its size.
- Interaction between lone pair of chloride ion and Si^{4+} is not very strong.

IMPORTANT TRENDS AND ANOMALOUS BEHAVIOUR OF CARBON

- Carbon can accommodate only four pairs of electrons around it.
- The maximum covalency of carbon is four.
- The other members can expand their covalency due to the presence of d orbitals.
- Carbon has the unique ability to form p π —p π multiple bonds with itself and with other atoms of small size and high electronegativity.
- Heavier elements do not form pπ —pπ bonds, because their atomic orbitals are too large and diffuse to have effective overlapping.
- CCl_4 cannot be hydrolysed, but the tetrahalides of other elements can be hydrolysed.

CATENATION

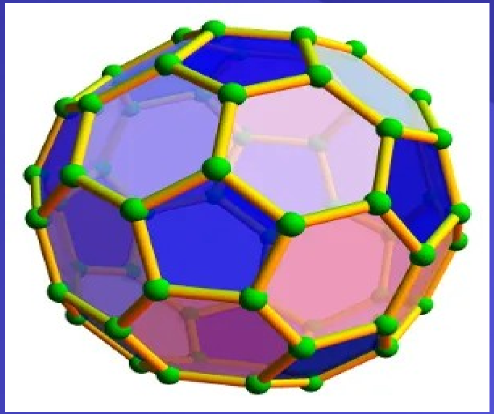
- Carbon atoms have the tendency to link with one another through covalent bonds to form chains and rings.
- This property is called catenation.
- Due to catenation and p π —p π bond formation, carbon is able to show allotropic forms.

ALLOTROPES OF CARBON

- Carbon exhibits three main allotropic forms.
- They are Diamond, Graphite and Fullerenes.

Diamond

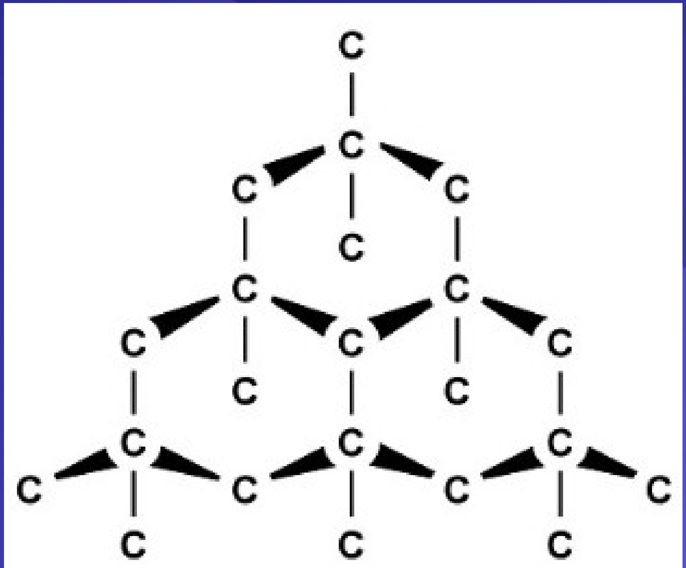
Graphite



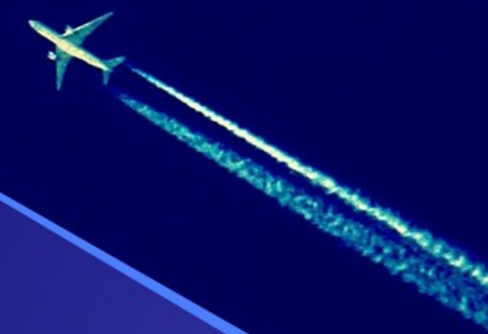
Fullerene

DIAMOND

- It is the purest form of carbon.
- It has a crystalline lattice.
- In diamond, each carbon atom is sp^3 hybridized.
- It is linked tetrahedrally to four other carbon atoms.
- The C—C bond length is 154 pm and bond angle is $109^0 28'$.



- The structure extends in space and produces a rigid three dimensional network of carbon atoms.
- Directional covalent bonds are present throughout the lattice.
- It is very difficult to break extended covalent bonding.
- Therefore, diamond is the hardest substance on the Earth.



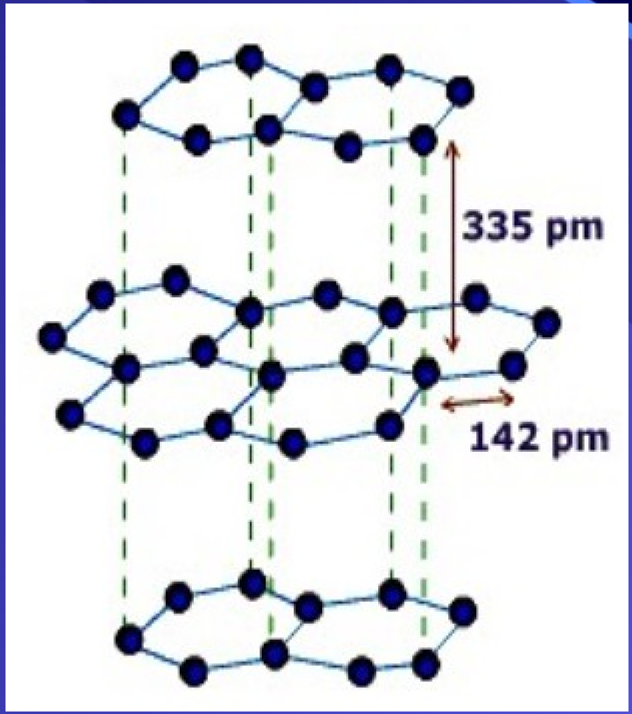
USES

Diamond is used

- for cutting glass.
- as an abrasive for sharpening hard tools.
- in making dyes.
- in the manufacture of tungsten filaments for electric bulbs.
- in making precious gems.
- Surgeons used sharp edged diamonds to remove cataract from eyes.

GRAPHITE

- Graphite is a purest form of carbon.
- Graphite has layered structure.
- Layers are held by Vander Waals forces.
- Distance between two layers is 340 pm.
- Each layer is composed of planar hexagonal rings of carbon atoms.
- The C—C bond length with in the layer is 141.5 pm.



- Each carbon atom in hexagonal rings undergoes sp^2 hybridization.
- It makes three sigma bonds with three neighbouring carbon atoms.
- Fourth electron makes a π bond.
- The electrons are delocalized over the whole sheet.
- Electrons are mobile and therefore graphite conducts electricity.
- In graphite, the successive layers are held together by weak Vander Waals forces.
- As a result, one layer can slip over another.
- This makes graphite soft and a good lubricant.

USES

Graphite is used

- for making electrodes.
- in lead pencils.
- as a lubricant.

NOTE

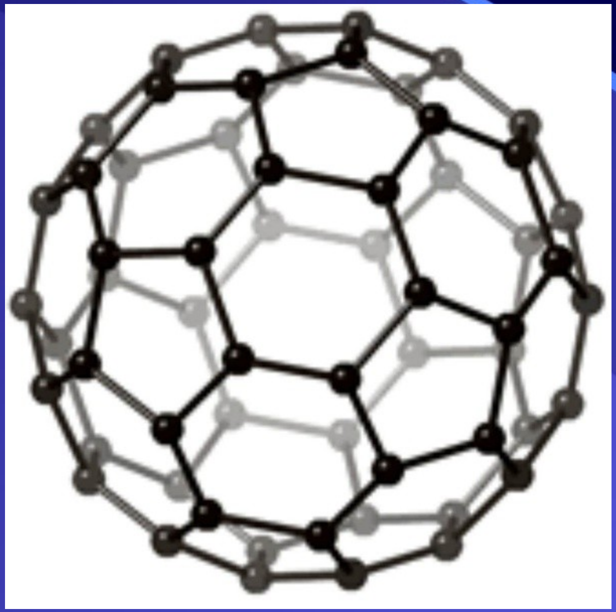
- Graphite can be changed into diamond by applying high pressure and high temperature.
- The diamond thus obtained does not have the gem quality.

FULLERENES

- Fullerenes are newly discovered allotropes of carbon.
- These are cage like spherical molecules of formula C_{60} , C_{70} , C_{76} , C_{84} etc.
- The most commonly known fullerene is C_{60}
- It is named as Buckminster Fullerene.
- Fullerenes are made by the heating of graphite in an electric arc in the presence of inert gas such as He or Ar.
- The sooty material formed consists of C_{60} with smaller amounts of C_{70} and traces of fullerene.
- It consists of even number of carbon atoms up to 350 or above.
- C_{60} molecule has a shape like soccer ball and called Buckminster fullerene.

STRUCTURE OF FULLERENES

- It consist of 20 six membered rings and 12 five membered rings.
- A six membered ring is fused with six or five membered rings.
- A five membered ring can only fuse with six membered rings.
- All the carbon atoms are equal and they undergo sp^2 hybridization.



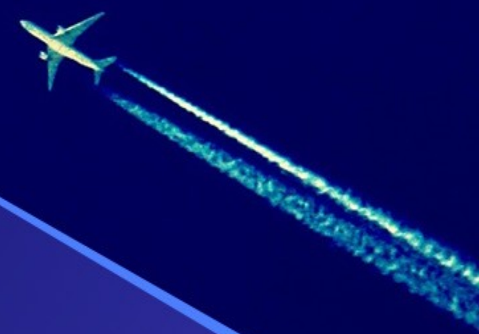
- Each carbon atom forms three sigma bonds with other three carbon atoms.
- The remaining electron at each carbon is delocalized in molecular orbitals.
- It gives aromatic character to the molecule.
- This ball shaped molecule has 60 vertices.
- Each vertices are occupied by one carbon atom.
- It also contains both single and double bonds with C—C distance of 143.5 pm and 138.3pm respectively.
- Spherical fullerenes are also called Bucky balls in short.

USES OF CARBON

- Graphite fibres embedded in plastic material are used in tennis rackets, fishing rods, aircrafts etc.
- Graphite is used for electrodes in batteries.
- Crucibles made from graphite are inert to dilute acids and alkalies.
- Activated charcoal is used in adsorbing poisonous gases.
- Carbon black is used as black pigment, in black ink and as filler in automobile tyres.
- Coke is used as a reducing agent in metallurgy.
- Diamond is a precious stone used in jewellery.

Diamond is covalent, yet it has high melting point. Why?

- Diamond has a three dimensional network structure involving strong C—C bonds, which are very difficult to break and inturn has high melting point.



SOME IMPORTANT COMPOUNDS OF CARBON AND SILICON

OXIDES OF CARBON

CARBON MONOXIDE

- Direct oxidation of carbon in limited supply of oxygen or air.

$$2C + O_2 \longrightarrow 2CO$$

- On a small scale pure CO is prepared by the dehydration of formic acid with conc. H_2SO_4 at 373 K.

$$HCOOH \longrightarrow H_2O + CO$$

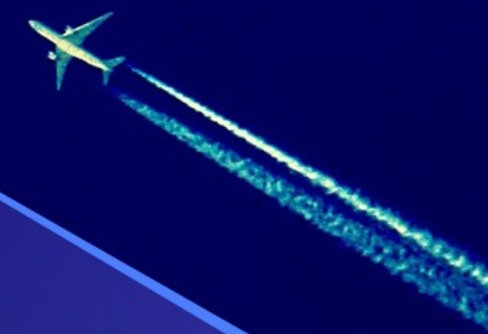
- On a commercial scale, it is prepared by the passage of steam over hot coke.
- The mixture of CO and H_2 thus produced is known as water gas or synthesis gas.

$$C + H_2O \longrightarrow CO + H_2$$

- When air is used instead of steam, a mixture of CO and N_2 is produced.
- A mixture of CO and N_2 is called producer gas.

$$2C + O_2 + 4\,N_2 \longrightarrow 2CO + 4\,N_2$$

PROPERTIES



- CO is a colourless gas and almost insoluble in water.
- CO is highly toxic in nature.
- It reacts with haemoglobin to form a complex carboxy haemoglobin.
- This complex destroys the capacity of haemoglobin to supply oxygen to the body.
- CO burns in air with a pale blue flame to form CO_2 .

$$CO + \frac{1}{2} O_2 \longrightarrow CO_2$$

- CO is a powerful reducing agent.
- It reduces almost all metal oxides other than those of the alkalie and alkaline earth metals, aluminium and a few transition metals.

$$Fe_2O_3 + 3CO \longrightarrow 2\,Fe + 3\,CO_2$$
$$PbO + CO \longrightarrow Pb + CO_2$$
$$ZnO + CO \longrightarrow Zn + CO_2$$

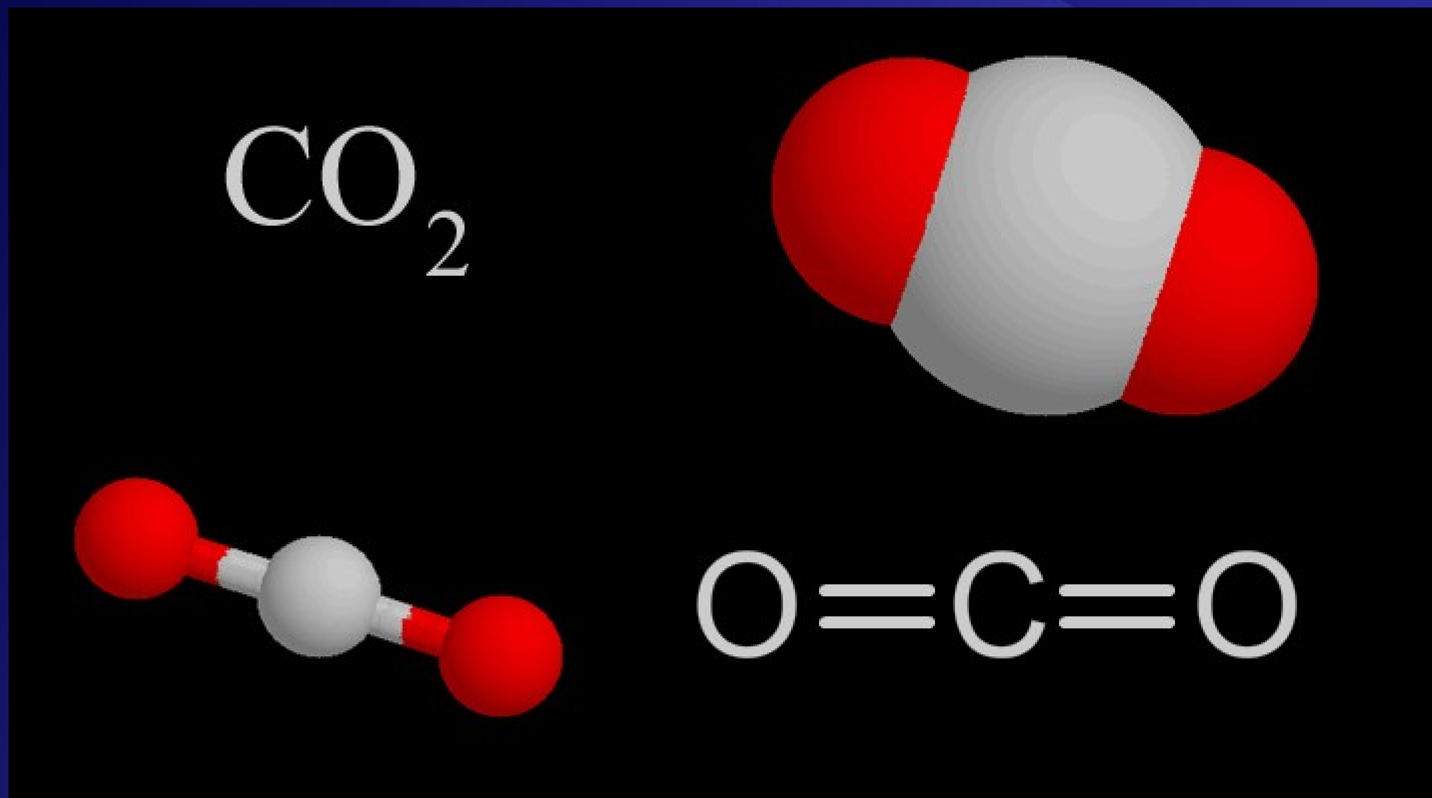
- CO combines with metals like Iron, Nickel, Cobalt etc to form the respective metal carbonyls.

$$Fe + 5\,CO \longrightarrow Fe(CO)_5$$
$$Ni + 4\,CO \longrightarrow Ni(CO)_4$$

USES OF CARBON MONIXIDE

- It is used as an industrial fuel in the form of water gas and producer gas.
- It is used in some metallurgical processes.
- It is used in the manufacture of methanol, synthetic petrol etc.

CARBON DIOXIDE



PREPARATION

- CO_2 is prepared by the complete combustion of carbon and carbon containing fuels in excess of air.

$$C + O_2 \longrightarrow CO_2$$

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2\,H_2O$$

- In the laboratory, it is prepared by the action of dil. HCl on $CaCO_3$.

$$CaCO_3 + 2HCl \rightleftharpoons CaCl_2 + CO_2 + H_2O$$

- On a commercial scale, it is prepared by heating limestone.

$$CaCO_3 \overset{\Delta}{\rightleftharpoons} CaO + CO_2$$

PROPERTIES

- CO_2 is a colourless gas.
- It is slightly soluble in water.
- CO_2 dissolves in water forming carbonic acid, which is a weak dibasic acid.

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

- H_2CO_3 dissociates in two steps

$$H_2CO_3 + H_2O \rightleftharpoons HCO_3^- + H_3O^+$$

$$HCO_3^- + H_2O \rightleftharpoons CO_3^{2-} + H_3O^+$$

- H_2CO_3/HCO_3^- buffer system helps to maintain a pH of blood between 7.26 to 7.42.
- Photosynthesis is the process by which green plants convert atmospheric CO_2 into carbohydrates such as glucose.

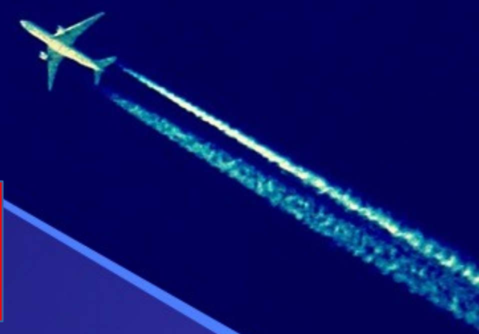
$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{h\upsilon} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

- The increase in carbon dioxide content in the atmosphere may lead to increase in greenhouse effect and thus raise the temperature of the atmosphere.
- Solid carbon dioxide is called dry ice.
- It is obtained by cooling liquid CO_2 under pressure.
- It is a soft snow like substance.

STRUCTURE OF CARBON DIOXIDE

- In CO_2 molecule carbon atom undergoes sp hybridization.
- Two sp hybridized orbitals of carbon overlap with two p orbitals of oxygen atoms to make two sigma bonds.
- The other two electrons of carbon atoms are involved in pπ —pπ bonding with oxygen atom.
- This results in its linear shape with no dipole moment.
- The resonance structures are shown below.

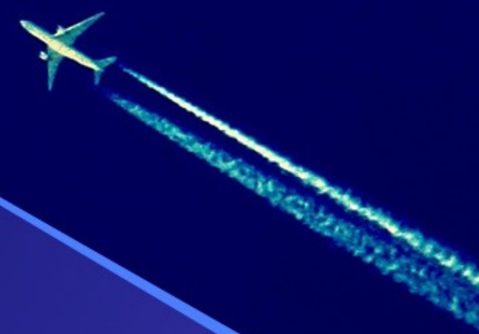
$$\mathrm{O - C \equiv O \quad \leftrightarrow \quad O = C = O \quad \leftrightarrow \quad O \equiv C - O}$$



USES OF CARBON DIOXIDE

- It is used as fire extinguisher.
- It is used in the manufacture of washing soda.
- It is used as a refrigerant in the form of dry ice.
- CO_2 is extensively used to carbonate soft drinks.

OXIDES OF SILICON



SILICON DIOXIDE (SiO_2)

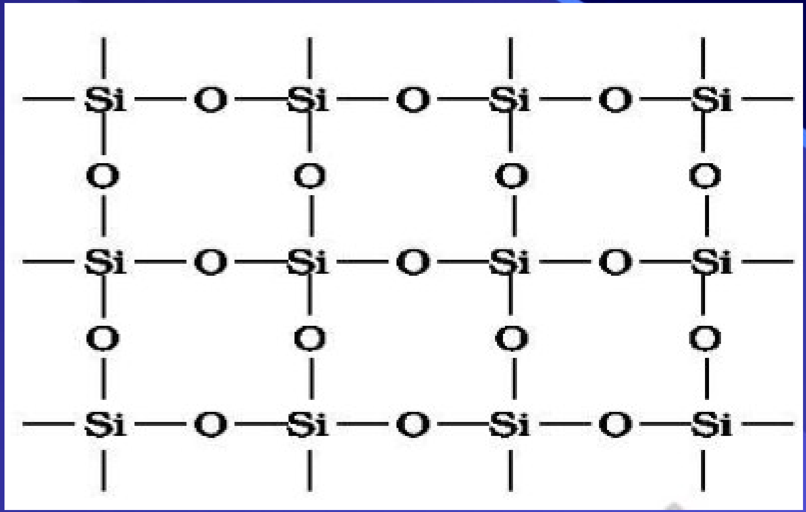
- It commonly known as silica.
- It occurs in several crystallographic forms.
- Quartz, Cristobalite and Tridmite are some of the crystalline forms of Silica.

Quartz

Cristobalite

Tridmite

- SiO_2 is a covalent, three dimensional network solid.
- Each silicon atom is covalently bonded in a tetrahedral manner to four oxygen atoms.
- Each oxygen atom in turn covalently bonded to another silicon atom.
- Each corner is shared with another tetrahedron.



PROPERTIES OF SILICON DIOXIDE (SiO_2)

- Silica is almost non reactive because of very high Si—O bond enthalpy.
- It is attacked by HF and NaOH.

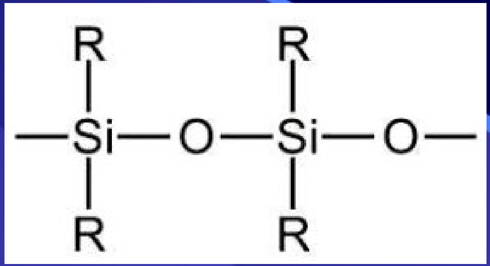
$$SiO_2 + 2NaOH \longrightarrow Na_2SiO_3 + H_2O$$

$$SiO_2 + 4HF \longrightarrow SiF_4 + 2H_2O$$

USES OF SILICON DIOXIDE

- **Quartz is extensively used as a piezoelectric material.**
- **Silica gel is used as a drying agent.**
- **Silica Gel is used as a support for chromatographic materials.**
- **Keiselghur, an amorphous form of silica is used in filtration plants.**

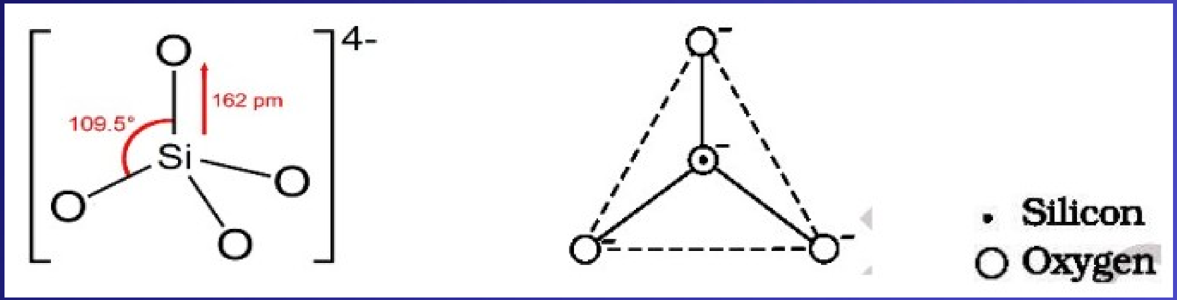
SILICONES



- Silicones are a group of organo silicon polymer.
- It has —$[R_2SiO]$— as a repeating unit.
- The starting materials for the manufacture of silicones are alkyl or aryl substituted silicon chlorides, $R_nSiCl_{(4-n)}$
- where R is alkyl or aryl group.
- Methyl chloride reacts with silicon, in the presence of copper as a catalyst, at 573K temperature, to form various types of methyl substituted chlorosilanes.
- They have the formula $MeSiCl_3$, Me_2SiCl_2 , Me_3SiCl.
- Small amounts of Me_4Si are also formed.

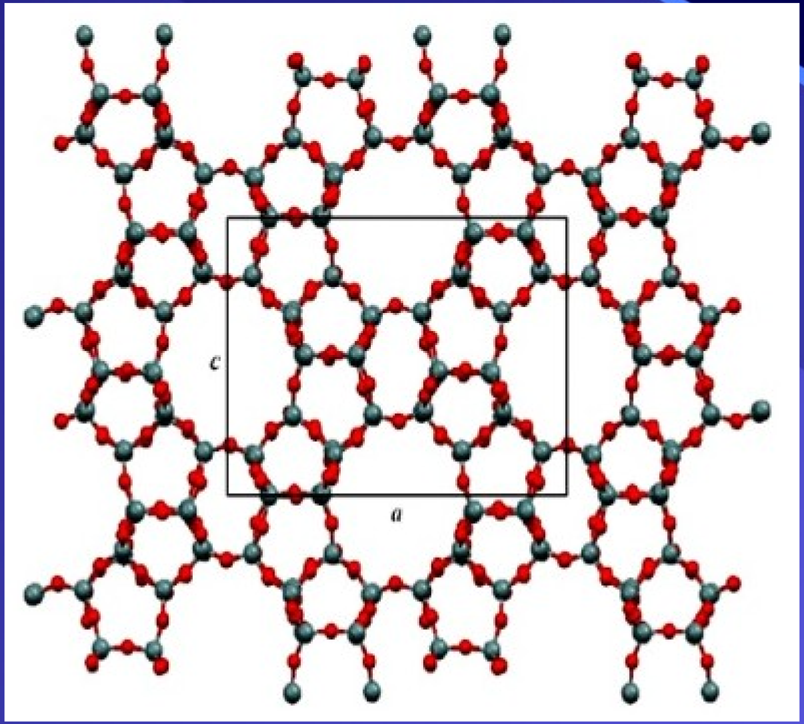
SILICATES

- Silicates are compounds of silicon with oxygen atoms.
- The basic structural unit in silicates is the tetrahedral SiO_4^{4-} ion.
- Silicates are classified as orthosilicates, pyrosilicates, cyclic silicates, chain silicates, sheet silicates and three dimensional silicates.
- Negative charge on silicate structure is neutralized by positively charged metal ions.
- If all the four corners are shared with other tetrahedral units, three dimensional network is formed.



ZEOLITES

- Zeolites are hydrated sodium aluminium silicates.
- Zeolites are widely used as a catalyst in petrochemical industries for cracking of hydrocarbons and isomerisation.
- Eg:- ZSM-5 is used to convert alcohols directly into gasoline.
- Hydrated Zeolites are used as ion exchangers in softening of hard water.




THANK YOU