INTRODUCTION

Carbon and silicon are two important elements of group IV-A of the periodic table. They have four electrons in their valence shell.

- Carbon is non metal
- Silicon is a metalloid.

OCCURRENCE OF CARBON:

Carbon is 0.08% of earth's crust; half of it (0.04%) is in the form of carbonates. It is sixteenth most abundant element in the earth crust.

FORMS OF CARBON:

In the Free State carbon occurs in the following forms.

1. **CRYSTALLINE FORMS:**
   a) Diamond b) Graphite c) Bucky Balls
2. **AMORPHOUS FORMS:**
   a) Lamp Black b) Wood Charcoal c) Coal
   d) Animal charcoal e) Gas carbon.

ALLOTROPY

Definition:

"The existence of the same element in two or more different forms having same chemical properties but different physical properties is known as Allotropy."

The different in the same state are referred to as allotropic modification or allotropes.

CRYSTALLINE ALLOTROPES OF CARBON

1. DIAMOND:

Diamond is one of the crystalline allotropic forms of carbon. It is found mainly in South Africa, Brazil, Australia and India.

Properties:

- In pure state, diamond is transparent and bright.
- It is the hardest natural substance known.
- Its density is about 3.51 g/cm^3.
- It has a very high refractive index 2.54 due to which it acquires great brilliance.
- It is a bad conductor of electricity.
- It has a high melting point of about 3500°C.
- Diamond may be of blue, green, yellow, red or black in color.
- Black color diamonds are called bort or carbando which are of inferior qualities and are used for cutting glasses and for drilling rocks other diamonds are used as gems and precious stones.

2. GRAPHITE:

Graphite occurs naturally as "PLUMBAGO" an opaque black solid. It is found in Siberia, Canada and in Srilanka.

Properties:

- Graphite is of dark grey color crystalline solid with dull metallic luster.

- It is soft and greasy to feel.
- It is less dense than diamond and has density 2.2g/cm^3.
- It is good conductor of electricity and is used in the preparation of electrodes.
- It leaves black mark on paper, so it is used in the manufacturing of lead pencils.
- Graphite is also used as black pigment in paints and also as neutron moderator in nuclear reactors.
- It has a very high melting point about 3000°C.
- Sometimes graphite is mixed with oil to form a high temperature lubricant.

3. BUCKY BALLS (BUCKMINSTER FULLERENE)

In 1985, a new type of allotropic forms of carbon was discovered by the vaporized graphite by two English researchers who named it Bucky Balls.

Properties

- It has been found that in bucky balls, carbon atoms are about 60 forming C_{60} molecules because the mass spectrum peaks correspond to cluster of carbon atoms as molecules of 60 carbon atoms which form a ball like foot ball or soccer ball with highly symmetrical structure.
- Unlike diamond and graphite, bucky balls can be dissolved in organic solvents.
- Bucky balls are used as semi conductors and lubricant.

AMORPHOUS FORMS OF CARBON

1. COAL

The anaerobic decay of buried trees and plants under the earth's surface at high temperature and pressure gradually and over ages converting them into CH_4, CO_2 and water vapours leaving behind a material containing high percentage of carbon called "Coal". Following are the various stages of formation of coal.

a) **Peat:** 59.9%C, light soft brown spongy material cheap fuel, energy value = 18700 KJ/Kg
b) **Lignite:** 61.8% C, hard, cheap fuel having energy value = 20900 KJ/Kg
c) **Sub- Bituminous Coal:** 80%C, used in power generating station.
d) **Bituminous Coal:**78.7%C, its destructive distillation gives coke, coal gas and coal tar.
e) **Anthracite Coal:** 91%C, hardest, driest coal, black, burns without smoke, energy value = 32600 KJ/Kg

2. COKE

Coke is produced by bituminous coal to very high temperature about 1300°C in the absence of air to remove all the volatile constituents present in coal. This process is called Destructive Distillation.

- It is used as fuel and also as reducing agent in the extraction of metals especially ion.
- Coke burns in air with no smoke leaves very little residue.

3. CHARCOAL

"The residue left after heating to high temperature organic substances like wood, nut shell, bones, sugar etc in the absence of air is called charcoal."

a) Wood Charcoal:

It is the most common charcoal prepared by burning wood in the limited supply of air. It contains impurities such as sulphur. It is mainly used as domestic fuel.

b) Animal Charcoal:

It is produced when animal bones and refuse are heated in the limited supply of air. It contains high percentage of calcium phosphate as impurity. It is used in sugar industry to remove brown colors of cane sugar and also decolorized petroleum jelly.

c) Sugar Charcoal:

It is formed by dehydration of carbohydrates by concentration H_2SO_4.

d) Activated Charcoal:

It is the charcoal that has been thoroughly treated and cleaned by heating with super heated steam. It has more adsorbing poisonous gases and in sugar mills for decolorizing sugar juices and sugar cane.

4. CARBON BLACK: (SOOT)

It is prepared by heating methane to high temperature in limited supply of air. It is used in black shoe polishes, printer's ink, type- writing papers and in rubber tyer industry as filler to increase the strength hardness and elastic of rubber.

CHEMICAL PROPERTIES OF CARBON

Chemically carbon is not very reactive element. All the allotropes of carbon have similar chemical properties.

1. Combustion:

i. $C + O_2 \xrightarrow{\text{excess air}} CO_2$ $\quad \Delta H = -394kJ/mol$

ii. $C + O_2 \xrightarrow[\text{Of Air}]{\text{Limited Supply}} CO$

2. Combination Reaction:

i. $C + 2H_2 \xrightarrow{\Delta} CH_4$

ii. $C + 2S \xrightarrow{\Delta} CS_2$

iii. $2C + Ca \xrightarrow{\Delta} CaC_2$

iv. $C + 4Al \longrightarrow Al_4C_3$

3. As Reducing Agent:

Carbon is a powerful reducing agent because it has greater affinity for oxygen. It reduces many oxides. This reduction occurs at very high temperature to form CO_2 and CO gas

For Example:

i. $Fe_2O_3 + 3C \xrightarrow{\Delta} 2Fe + 3CO$

ii. $2ZnO + C \xrightarrow{\Delta} 2Zn + CO_2$

iii. $2PbO + C \xrightarrow{\Delta} 2Pb + CO_2$

iv. $2CuO + C \xrightarrow{\Delta} 2Cu + CO_2$

v. $H_2O + C \xrightarrow{\Delta} CO + H_2$ (Water gas)

vi. $CO_2 + C \xrightarrow{\Delta} 2CO$

4. Reaction With Strong Oxidizing Agent:

Carbon reacts with strong oxidizing agent like hot and concentrated nitric acid and concentrated sulphuric acid and gets oxidized and liberated CO_2 gas.

i. $C + 4HNO_3 \xrightarrow[\text{conc.}]{\text{hot}} CO_2 + 4NO_2 + 2H_2O$

ii. $C + 2H_2SO_4 \xrightarrow[\text{conc.}]{\text{hot}} CO_2 + 4SO_2 + 2H_2O$

SILICA SiO_2

Silica occurs naturally in thre main crystalline forms namely quartz, tridymite and crystobalite. The most common of three is quartz.

Preparation:

1. It is prepared by heating silicon in air or oxygen.

   $Si + O_2 \xrightarrow{\text{strong heating}} SiO_2$

2. It can also be prepared by in hydrated form as a gelatinous precipitate by warming sodium silicate (Na_2SiO_3) with conc. HCl solution.

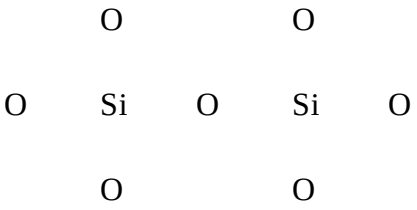
   $Na_2SiO_3 + 2HCl \xrightarrow{\text{warm}} SiO_2.H_2O + 2NaCl$

Properties:

1. Because of its structure SiO_2 is non volatile and hard.
2. Its melting point is about 1500°C.
3. When cooled, it forms glass like solid known as fused silica (also called quartz glass) which has very low co efficient of expansion and hence is heated resistant.

Structure:

Silica (SiO_2) exists in a colorless crystalline form when pure. It is a macromolecular compound with silicon and oxygen atoms linked together covalently in tetrahedral units.



Uses:

1. Sand (SiO_2) is widely used in making cement, concrete, glass and refractory silica bricks.
2. Fused silica (quartz glass) is used in making optical lenses and prisms, heat resisting articles.
3. Large quartz crystals are used in the manufacture of lenses of optical instruments.
4. Powered quartz is used in the making of silicon carbide (SiC), Silicon tetra flouride (SiF_4), Sodium Silicate Na_2SiO_3 and silica bricks.
5. Keiselguhr (SiO_2) absorbs liquids readily and is used as absorbent of nitroglycerine (explosive) in the manufacturing of dynamite.
6. It is also used in medicines for making dry antiseptic dressing.

SODIUM SILICATE

Preparation:

Sodium silicate is prepared by heating a mixture of silica and sodium carbonate.

$$SiO_2 + Na_2CO_3 \xrightarrow{\Delta} Na_2SiO_3 + CO_2$$

Properties:

i. It is glass like solid.
ii. Its melting point is 1090°C
iii. It dissolved in hot water forming thick syrup like liquid called water glass.

Uses:

It is used for:

i. Fire proofing wood and textiles.
ii. Soap making.

SILICA GEL

Preparation:

When an acid is mixed in aqueous solution of sodium silicate (water glass), a gel ($SiO_2.H_2O$) is formed. When dehydrated by heating a hard porous mass is left which is called silica gel.

Properties:

- It is hard transparent solid.
  It absorbs moisture and other volatile substances on heating the vapors are lost and can be recovered.

Uses:

Silica gel is used as:

i. Drying agent in medicines small bags of silica gel are kept in medicines packing to prevent the medicines being spoiled by water vapors in the atmosphere.
ii. It is also used to recover valuable vapors from industrial effluents and in the refining of petroleum.