Allotropy:

- The existence of same element in different physical forms is called allotropy.
- Allotrops of an element have similar chemical properties, but different physical properties.
- Allotropic forms may differ in
  1) Crystal structure
  2) Arrangment of atoms
  3) Atomicity
- Carbon has two types of allotropic forms
  1) Crystalline (a) Diamond (b) Graphite
  2) Amorphous (Microcrystalline) coal, coke, charcoal, animal charcoal. Lamp black, carbon black, petroleum coke, gas carbon, sugar charcoal.

Diamond:

Diamonds are measured in carats.

One carat = 0.2 g = 200 mg

- In India, Kohinoor & pitt diamonds are available. Kohinoor is 186 carats & pitt is 136.25 carats.
- Heaviest known diamond in the world is cullinan. It has 3026 carats (S.Africa)

Properites:

- Diamond is the hardest known substance
- It glitters because its refractive index is high i.e., 2.45.
- It has highest m.p. than any other element i.e., 4200 K.
- Diamonds are insulators i.e., bad conductors of electricity.
- It is transparent to light & x-rays.
- It is insoluble in any solvent.
- It is the purest crystalline form of C.
- It is inert form of carbon.
- It is stable upto 1500^0C. On heating invaccum above 1500^0C, it changes to graphite. [1500 –800^0C]

Structure:

- In diamond, C is sp^3 hybridised. Each C is tetrahedrally bonded to four other carbons by strong sigma bonds.
- C – C bondlength is 1.54 A^0.
- C – $\hat{C}$ – C bond angle is 109^0.
- It is three dimensional gaint polymeric

- It is the hardest with highest m.p. because of its polymeric structure.
- It is bad conductor as all the four valence electrons are utilised in bonding & number of electrons is left free.

Uses:

- In jewellary as precious stones.
- In cutting tools.
- As abrasives.

Graphite:

- It is also known as black lead or plumbago.
- It is thermo dynamically more stable. It is good conductor of heat & electricity because each C is left with one free electron.
- It's melting point is very high i.e., around 3500^0C.

Preparation of artificial graphite:

- Graphite is artificially prepared by Acheson's process. Coke is heated with silica above 3500^0C in an electric furnace.
- The SiC is formed & it decomposes to give graphite on further heating

$$SiO_2 + 3C_{(coke)} \rightarrow SiC + 2CO$$

$$SiC(\text{carborundum}) \xrightarrow{\Delta} Si + C_{graphite}$$

Structure of graphite:

- C is sp^2 hybridized. Each C is bonded to three other carbons by strong σ bonds. The fourth valence electron of all carbon atoms together will form a delocalised π-electron cloud which is responsible for the conducting nature of graphite.
- Graphite consists of hexagonal rings.
- It has layer lattice structure.
- The layers are bound by Vanderwall forces.
- The distance between the layers is 3.35 A^0.
- C – C bondlength is 1.42 A^0.
- High meting point of graphite is due to its to two dimensional polymeric sturcture.
- $C-\hat{C}-C$ bond angle is 120^0.
- The soft & slippery nature of graphite is due to layer lattice structure.

Uses:

Used in lead pencils (consists graphite & clay).

- As dry lubricant.
- In making electrodes.
- As moderator in nuclear reactors.
- In painting stoves.
- In electroplating & electrotyping.

Silica (SiO_2)

- Silica is more abundant in the nature in the form of silicates. Mainly in the form of aluminium silicate.
- SiO_2 exhibits allotropy.

  (1) **Crystalline forms:** Quartz, trydimite , Crystobalite

  At low temperature, α form & at high temperature β form of each crystalline exists. Pure quartz is colourless & impure quartz is coloured

  (2) **Amorphous Forms:** Agate, Jaspar, Onyx are the amorphous forms of silica.
- Sand stone consists of sand particles & iron oxide.
- Flint silica consists of both Quartz & amorphous forms.
- Kiesulguhr silica consists of minute sea organisms.

Preparation of silica:

(1) By burning of Si in O_2

$$Si + O_2 \rightarrow SiO_2$$

(2) By hydrolysis of $SiCl_4$ or SiF_4.

$$SiCl_4 + 4H_2O \rightarrow H_4SiO_4 + 4HCl$$

$$3SiF_4 + 4H_2O \rightarrow H_4SiO_4 + 2H_2SiF_6 \text{(orthosilicic acid)}$$

$$H_4SiO_4 \rightarrow SiO_2 + 2H_2O.$$

- Silica is insoluble in water
- Silica is soluble only in HF among all the acids

Chemical properties:

1) **With HF:** It reacts with HF to give SiF_4.

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

2) **With coke:** on heating silica with coke, SiC or carborundum is formed. SiC is very hard substance

$SiO_2 + 3C \rightarrow SiC + 2CO$

3) Acidic nature:

- SiO_2 is slightly acidic in nature.

$\therefore$ It reacts with bases, basic oxides and basic carbonates to give corresponding silicates.

$SiO_2 + Na_2O \rightarrow Na_2SiO_3$

$SiO_2 + CaO \rightarrow CaSiO_3$

$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$

$SiO_2 + Na_2CO_3 \rightarrow Na_2SiO_3 + CO_2$

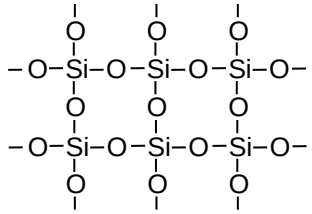
$SiO_2 + CaCO_3 \rightarrow CaSiO_3 + CO_2$

Action of Heat :

- On heating, one form changes to another form & above 1700^0C all the forms change into liquid state.
- Quartz is the purest form of silica.

Structure of silica:

- In SiO_2, each Si is tetrahedrally bonded to four oxygen atoms.
- Though Si is bonded to four 'O's, the formula is SiO_2 because those four 'O's are inturn shared by other silicons.
- It is 3-dimensional giant polymer resembling diamond.
- But, SiO_2 is soft with low m.p. when compared to diamond because Si – O – Si bonds are weak.



There is no direct Si – Si Bond

Uses of Silica :

- As building material .
- Quartz glass is used to prepare glass to work with u, v radiation.
- In the preparation of sand bricks used for lining of furnaces.
- Coloured quartz is used in making lenses, optical instruments.
- As acid flux in metallurgy.

Fuel gases:

- Fuels burn in air & produce heat energy.
- Calorific value can be expressed as the heat energy released per gram.
- Calorific value is also expressed as kJ/m^3 for gaseous fuels.
- Out of solid, liquid & gaseous fuels, the gaseous fuels are more advantageous because of

  a) High calorific value. b) No ash & no smoke.

  c) Easy to transport.

Producer gas:

- It is the mixture of CO(33%) + N_2(64%).

Manufacture:

- It is manufactured in a furnace named as gas producer by the incomplete combustion of coal.
- The furnace is filled with coal & air is sent into it through its bottom.
- Some of the coal is burnt to give CO_2, which rises up through hot beds of coal & gets reduced to CO.

  $C + O_2 \rightarrow CO_2$

  $CO_2 + C \rightarrow 2CO$
- Through the exit at the top, producer gas is collected.
- Its calorific value is very low because N_2 is non-combustible.
- It should be used on the spot to avoid loss of heat.

Uses:

- As fuel in steel & glass industries
- As fuel in gas engines.
- As fuel in the manufacture of ammonia

Water gas:

- It is the mixture of CO & H_2 in 1 : 1 ratio by volume. It is also known as blue gas as both components burn with blue flame.
- It is also called synthesis gas.

Manufacture:

- By passing steam over white hot coke water gas is prepared.

$$C + H_2O \xrightarrow{>1000^0 C} CO + H_2 - \text{heat}$$

- The above reaction is endothermic & hence the coke becomes cold after some time. If steam is passed over cold coke, unwanted reaction occurs.
  $C + 2H_2O \rightarrow CO_2 + 2H_2$
- To maintain required temperature air is supplied for sometime. Thus, steam & air are supplied alternately over coke to produce water gas.
- Water gas has high calorific value.

Uses:

- As fuel in various industries.
- In the manufacture of ammonia by Haber's process.

Semiwater Gas: (Thin producer gas)

- It is the mixture CO, H_2 & N_2($CO + H_2 + N_2$)
- The order of their volumes in semiwater gas.
  $N_2 > CO > H_2$
  55%, 25%, 10%
- Semi-water gas is obtained by passing steam & air simultaneously over white hot coke.
- Its calorific value is less than that of water gas.

Uses:

- As fuel in steel industry.
- In internal combustion engines.

Carburetted water gas:

- It is mixture of water gas & hydro carbons.
- The order of volumes of various gases in the carbureted water gas : $H_2 > CO >$ Saturated hydrocarbons > Unsaturated hydrocarbons
- Its calorific value is very high.
- It is also used as industrial fuel.
- For the above fuel gases, the order of calorific values is

  Carburetted water gas > water gas > semi water gas > producer gas.