Carbon 1

Allotropes of carbon:

The phenomena of existence of elements in more than one form which are physically different but chemically identical is known as allotropy. The elements exhibiting this property is said to be allotropic and these different physical state are also called allotropic form or allotropic modification or simply as allotropes.

Allotropic forms of carbon is basically divided into two types:-

1. Crystalline allotropes
2. Amorphous allotropes

1 Crystalline allotropes:

(a) Diamond
(b) Graphite
(c) Fullerene

(a) Diamond:

(i) Diamond is the hardest crystalline allotrope of carbon.
(ii) It is purest form of carbon.
(iii) Its pure form is colourless and transparent to X-ray.
(iv) It's density and refractive index is high.
(v) It is a bad conductor of heat and electricity.

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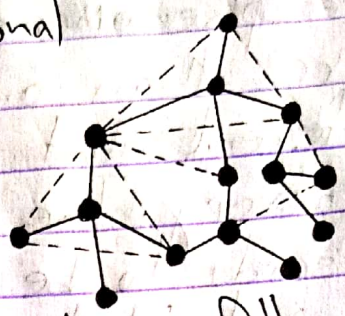
Structure:

It is a big three-dimensional structure in which each carbon atom is covalently bonded to four carbon atoms which lie at the corners of a regular tetrahedron. All carbon atoms in a diamond crystal are bound by sp^3 covalent bonds.



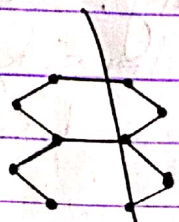
Uses:-

(i) It is used as precious stones in jewellery as a gem because of brilliant shine.
(ii) It is used for grinding and polishing of hard materials as abrassives.
(iii) It is used for cutting glass, metals, etc.

(b) Graphite:

(i) It is the most stable allotrope of carbon.
(ii) It is soft, dark grey substance having metallic lustre.
(iii) It has less specific gravity than diamond.
(iv) It is good conductor of electricity.

Structure:



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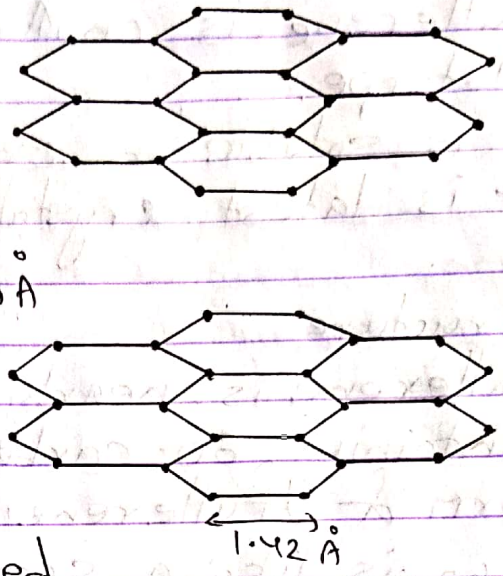
Structure:

Graphite consists of two dimensional layer structures of carbon atoms. In each layer, the carbon atoms are arranged in regular hexagonal rings.



In graphite each carbon atom is bonded to three other neighbouring carbon atoms through trigonal sp^2 covalent bonds and form many hexagonal rings. Each layer is bonded with the adjacent planar layer by weak Van der Waal's force. Each carbon-carbon bond length is hexagonal ring is 1.42 Å and each angle 120°. The successive layers are 3.40 Å apart as shown in figure.

Uses:

(i) As graphite is a good conductor of electricity, it is used for making electrodes in electric furnace.

(ii) It is used for making lead pencil by mixing it with clay.

(iii) It is used for making graphite crucibles that can withstand high temperature.

(iv) It is used as lubricant for high speed machines, as an additive for motor oil.

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(c) Fullerene:

(i) Fullerene is another crystalline form of allotrope.

(ii) It is soluble in organic solvents.

(iii) It is latest crystalline allotrope of carbon.

Structure:

Fullerene is nearly spherical in shape containing 60 carbon atoms and this common form of fullerene is C_{60}. Structure of C_{60} is like a soccer ball which consists of 12 pentagonal and 20 hexagonal faces. Each carbon of C_{60} is sp^2 hybridized and consists of covalent bonds.

Uses:

(i) Fullerene is used as super conductors due to its reasonable electric conductivity.

(ii) They are useful in trapping certain metal ions such as calcium, gold, etc inside the carbon clusters so can be used as sieve.

(iii) It is used to store hydrogen possibly as a fuel tank for fuel cell powered cars.

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2. Amorphous allotropes:

(a) Coal:
It is black solid formed by the carbonization of wood or vegetable matter. Carbonization is the process of conversion of wood or vegetable matter to coal under the influence of high temperature, high pressure and in absence of air.

Uses:
(i) It is used in manufacture of producer gas and water gas.
(ii) It is used as reducing agent in metallurgy.

(b) Coke:
It is the residue of coal obtained after destructive distillation of coal. During this process, volatile organic substances escape out.

Uses:
(i) It is used as fuel.
(ii) It is used as a reducing agent in metallurgy.

(c) Charcoal:
Charcoal is an amorphous form of carbon. It is porous form of carbon produced by the destructive distillation of organic materials like wood, sugar, etc. Organic materials are heated strongly in limited supply of air.

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Uses:

(i) It is used in adsorption phenomena as it adsorps toxic gases.

(ii) It is used for lightening the colour of organic compounds.

(iii) It is used in qualitative analysis of basic radical.

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Properties of carbon monoxide:

1. Reducing action:
Carbon monoxide is reducing agent. It reduces metallic oxide to metal when heated.

$$Fe_2O_3 + 3CO \xrightarrow{600-900^\circ C} 2Fe + 3CO_2$$

$$PbO + CO \xrightarrow{\Delta} Pb + CO_2$$

$$ZnO + CO \xrightarrow{\Delta} Zn + CO_2$$

CO reduces I_2O_5 to Iodine

$$I_2O_5 + 5CO \longrightarrow I_2 + 5CO_2\uparrow$$

2. Reation with metals:-
Carbon monoxide combines with transition metals like nickel, iron, cobalt, etc. under suitable conditions to form addition compounds called metal carbonyls.

$$Ni + 4CO \xrightarrow[\Delta]{80^\circ C} Ni(CO)_4$$

Nickel tetracarbonyl decomposes on heating at 180°C to give pure nickel.

$$Ni(CO)_4 \xrightarrow{180^\circ C} Ni + 4CO(g)$$

3. Reaction with non-metals:
Carbon monoxide reacts with ~~halogens~~ non-metals like halogen to give carbonyl halide

$$CO + Cl_2 \xrightarrow{\text{sunlight}} COCl_2 \text{ (carbonylchloride)}$$

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Uses of CO:

(i) Combustion of carbon monoxide is an exothermic reaction. Therefore, it is used as a fuel in the form of water gas or producer gas.

(ii) It is used in the metallurgy for the purification of nickel by Mond's process.

(iii) It is used for the manufacture of phosgene gas used in dye industry.

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