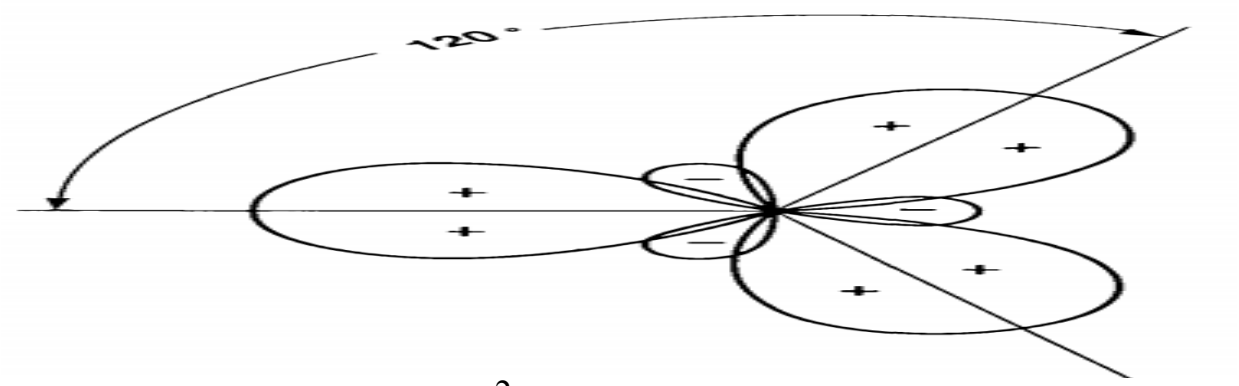
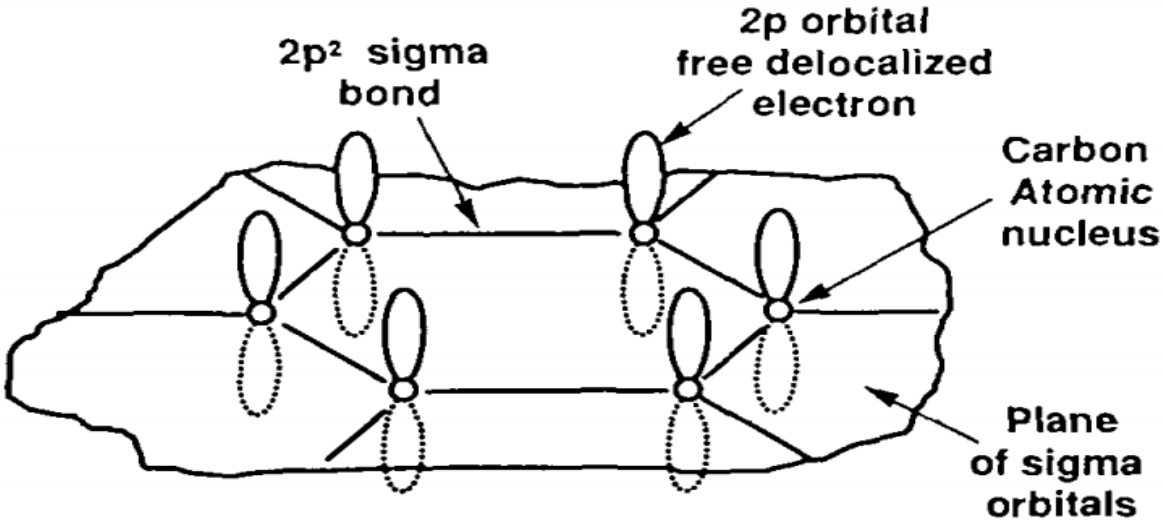
These orbitals form a regular triangular shape when we connect a straight line between their ends, and the angles between the adjacent sides are equal and the value of each is (120°), and the fourth orbital is perpendicular to the plane of the three orbitals,[R. Saito, 1998] [Pratish Mahtani, 2010].



sp^2 hybrid orbitals

Each hybridized carbon atom bonds with three other hybridized carbon atoms to form a hexagonal structure within parallel planes.

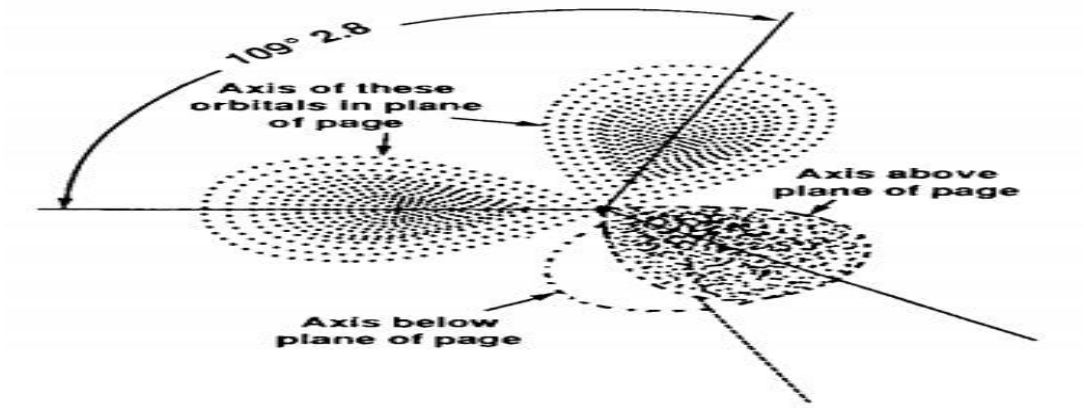
The un hybridized (π) orbitals are perpendicular to these planes, as in



sp^2 hybrid orbitals

3 - $2sp^3$ hybridization : The s orbital overlaps with the (p) orbital compounds through the transfer of one electron from the (2s) orbital to the (2p) orbital, thus four hybrid atomic orbitals are generated, each containing a single electron.

These orbitals create a regular tetrahedral shape when we connect a straight line between their ends, and the angles between the adjacent sides are equal and the value of each is $109^o.28$ as in the figure.

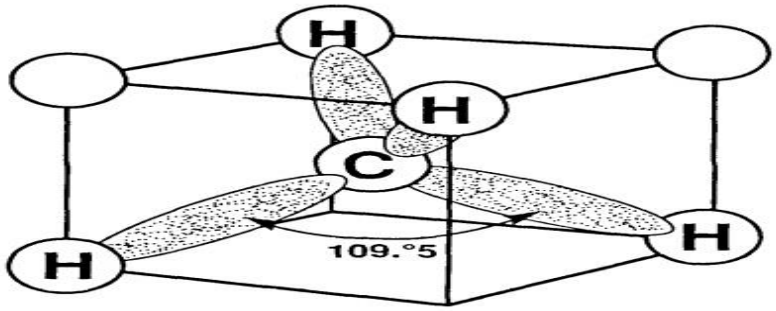


Sp^3 hybrid orbitals

Name of the Molecule	Carbon
Molecular Formula	C
Hybridization Type	sp, sp^2, sp^3
Bond Angle	109.5°, 120°, 180°
Geometry	Linear, Trigonal Planar, Tetrahedral

Types of Hybridization in Carbon

This arrangement enables the atom to form four (σ) covalent bonds with four neighboring atoms [Alekse v N. Kolmogorov, 2004].



Sp^3 hybrid orbitals

11 -Crystalline Forms of Carbon:

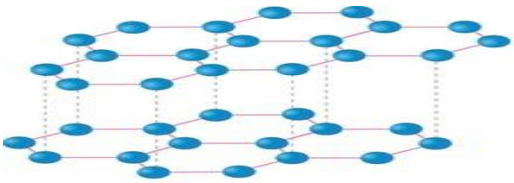
The existence of multiple forms of carbon results from the multiple possibilities of the carbon atom's bonding with the atoms adjacent to it (2sp, 2sp2, and 2sp3), which in turn gives different properties and characteristics to each form. The following are some of the crystalline forms of carbon (**Diamond , Graphite , Fullerenes)** .



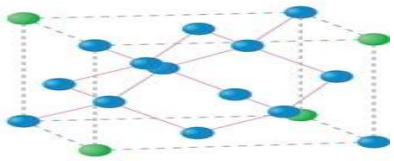
A – **Diamond:**
Diamond is the crystalline form of carbon in which each carbon atom is covalently bonded to four other carbon atoms in a tetrahedral arrangement, forming a rigid, three-dimensional crystal lattice called the diamond cubic structure. This strong, stable covalent structure is the reason diamond is the hardest natural substance, known for its use in cutting tools and as a gemstone.
The amorphous carbons, when heated under pressure, crystallized first into graphite at 450 to 600°C and then into diamond at 1120 to 2000° C.

B – Graphite :

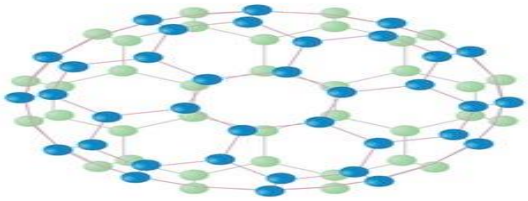
Graphite is a crystalline allotrope (form) of the element carbon. where carbon atoms are arranged in stacked layers of hexagonal rings called graphene. These layers are held together by weak van der Waals forces, allowing them to slide easily and making graphite soft and slippery, a property useful for lubrication. In contrast, strong covalent bonds within the layers give graphite its strength and electrical conductivity.
It consists of many stacked layers of graphene, typically in excess of hundreds of layers. Graphite occurs naturally and is the most stable form of carbon under standard conditions .It combines the properties of both carbon and graphite, making it useful in various industrial applications due to its high thermal and electrical conductivity, lubricating properties, and chemical resistance.



Graphite



Diamond



Fullerenes

C – fullerenes :

fullerenes an allotrope of carbon whose molecules consist of carbon atoms connected by single and double bonds so as to form a closed or partially closed mesh, with fused rings of five to six atoms. The molecules may have hollow sphere- and ellipsoid-like forms, tubes, or other shapes.

fullerenes are a crystalline allotropic form of carbon, featuring hollow, cage-like structures composed of carbon atoms arranged in hexagonal and pentagonal rings. The most famous fullerene is C60 , or buckminsterfullerene, which resembles a soccer ball and forms face-centered cubic (fcc) crystals when solid.