# Allotropes of Carbon

**Allotropes** are different molecular or crystalline forms of the same element, resulting in different physical properties.

**Carbon** is an example of an element that exists as different allotropes. Each carbon atom has an outermost electron shell with 4 electrons. This means that each carbon atom needs to gain **4 more electrons** to gain a full outer shell of electrons through covalent bond. They form different **macromolecular structures**:

1- Diamond

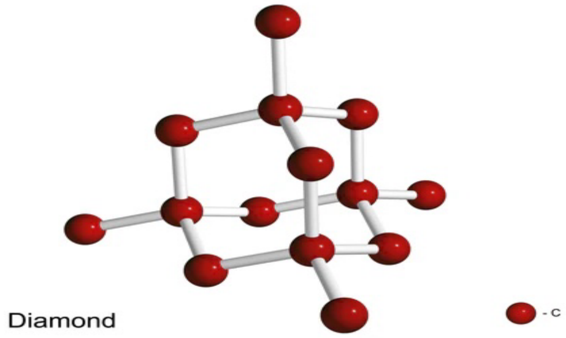
2- Graphite

3- Fullerenes



## 1- Diamond

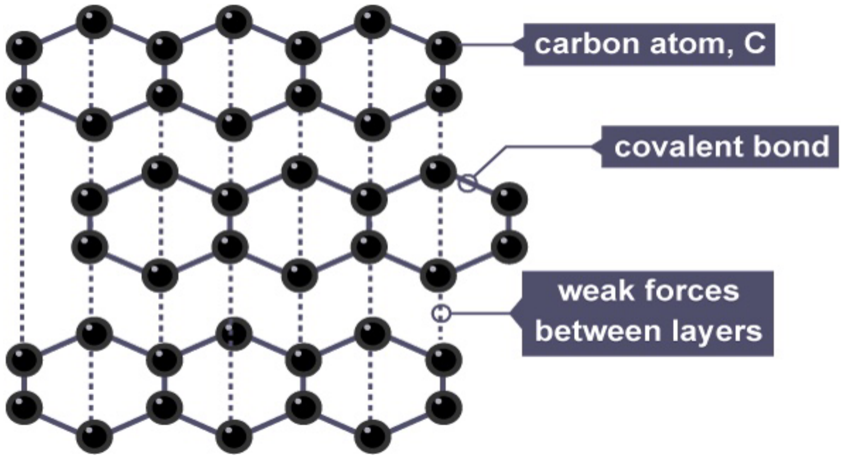
- **Four covalent bonds with four other carbon atoms.** In diamond, each carbon shares electrons with four other carbon atoms. This means that each carbon atom forms a single covalent bond with four other carbon atoms.
- **Hard substance due to its strong covalent bonds.** The strong covalent bonds in diamond means that it is very difficult to break. It is actually known to be the hardest naturally occurring substance found on Earth.
- **High melting and boiling point.** The covalent bonds in diamond are very strong, therefore a large amount of energy is needed to break them.
- **Good conductor of heat.** Diamond is a good thermal conductor because of the strong covalent bonds it consists of. This means that when you heat the diamond, the vibrations of thermal energy are rapidly transferred through the substance.
- **Insolubility in both water and in organic solvents.** Diamond does not dissolve in any solvent. This is because the attraction between the carbon atoms in diamond by covalent bonds is a lot stronger than the attraction that could occur between the solvent molecules and carbon atoms in diamond.
- **Poor conductor of electricity.** Diamond cannot conduct electric because the outer electrons found in each carbon atom are fixated between the atoms in covalent bonds. This means there are no free electrons that can move around and carry charge.

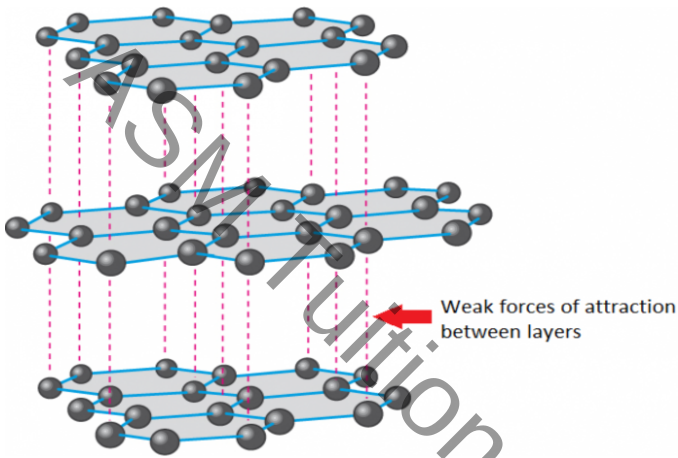





## 2- Graphite

- **Three covalent bonds with three other carbon atoms:** In graphite, each carbon shares electrons with three other carbon atoms. This means that each carbon atom has one outer electron that is not involved in a covalent bond. This 'fourth' electron becomes delocalised and is free to move around.
- **Sheets of hexagons:**In graphite, the carbon atoms are arranged into sheets which means that graphite has a layer structure. The sheets are arranged into layers and the layers are joined together by weak intermolecular forces called **'van Der Waals forces'.**
- **Soft slippery substance:** Unlike diamond, graphite is arranged in layers and sheets of carbon atoms. The layers in graphite can easily slide over each other because there are weak intermolecular forces holding them together. Due to its slippery nature, graphite act be used in pencils and as a dry lubricant.
- **High melting and boiling point:** The covalent bonds in graphite are very strong, therefore a large amount of energy is needed to break them.
- **Insolubility in both water and in organic solvents:**Graphite does not dissolve in any solvent. This is because the attraction between the carbon atoms in graphite by covalent bonds is a stronger than the attraction that could occur between the solvent molecules and carbon atoms in graphite.
- **Good conductor of electricity:** Graphite can conduct electricity because it contains delocalised electrons which are free to move between the sheets of carbon atoms and carry charge.
- **Low density because the distance between the layers is large:**As the layers in graphite are held together by weak intermolecular forces, the layers are far apart.



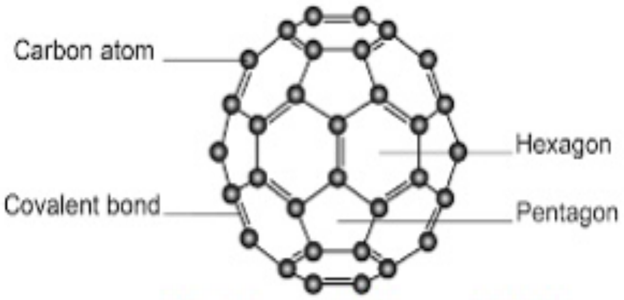






## 3- Buckminsterfullerene

- **Buckminsterfullerene (C60) consists of tiny hollow spheres of covalently bonded carbon atoms:** These spheres can measure as little as 0.1 and 100nm. Buckminsterfullerene is therefore an example of a carbon nanoparticle.
- **Each carbon atom is bonded to 3 other carbons:** The covalently bonded carbon atoms form rings in the shape of a hexagon or a pentagon. In total, the carbon atoms in buckminsterfullerene are arranged at the corners of 20 hexagons and 12 pentagons.
- **Low melting and boiling ing point:** It directly turns into a gas from its solid state without becoming a liquid first. This is due to the very weak Van de Wall forces between individual buckminsterfullerene molecules.
- **Soft material:** Again this is due to the very weak Van de Wall forces between individual buckminsterfullerene molecules and the little energy required to overcome them.
- **Conduct electricity:** Due to the presence of delocalized electrons. Extent of delocalisation is less than in graphite so its electrical conductivity is worse.
- **Lubricant**: it is a great lubricant

- **Great catalyst due to large surface area.:** fullerenes have large surface area that's why it is useful in industrial catalyst




Structure of Fullerene(C60)