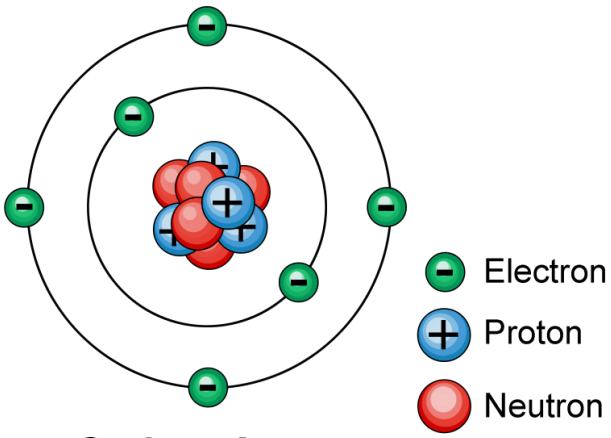
Atoms

An atom is the smallest particle of a chemical element that can exist as that element

The Earth and all substances on it, whether gases, liquids, or solids, are made up of atoms. There are many types of atoms; each type is referred to as a chemical element. Most of the atoms on earth are linked: that is, they are bonded together. Each atom is composed of three smaller particles or **'sub-atomic particles'** called **protons, electrons, and neutrons**. They are arranged in a specific way so that protons and neutrons are huddled together, in what is known as the **'nucleus'**, and are orbited by electrons in **'shells'**. The number of protons and electrons in an atom is always equal, and the number of neutrons generally follows suit. The number of protons dictates the type of atom, and this is known as an **'Element'**.

Diamond is the only gem formed from a single element – Carbon.

Diamond is typically about 99.95 percent carbon. The other 0.05 percent can include one or more trace elements, which are atoms that aren't part of the diamond's essential chemistry. Some trace elements can influence the color or crystal shape. The Carbon Atom has 6 Protons + 6 Neutrons.



Carbon Atom

Crystallography

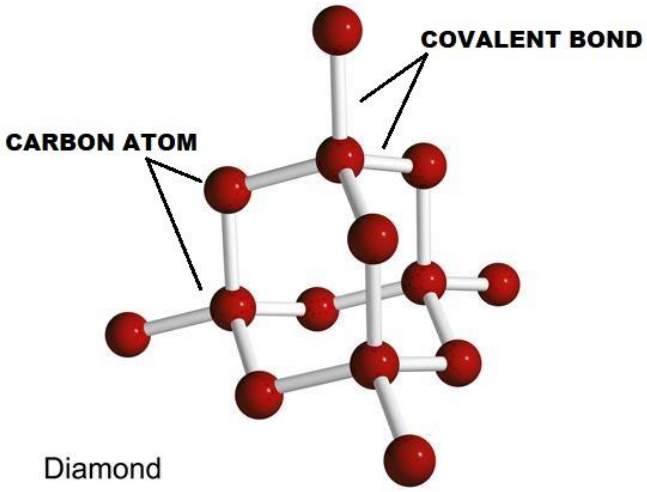
Earth consists of chemical elements made up of atoms. Most of these atoms are in orderly, solid arrangements. Materials with such orderly atomic arrangements are said to be **crystalline** and each different atomic arrangement is called a **crystal structure.**

Crystalline materials are made up of different crystalline pieces that have grown together. When a solid crystal structure is formed, the material is said to crystallize. Solid material grows whenever atoms come close enough to share electrons, to form a stable cluster of atoms. The cluster of atoms may continue to build up a rigid structure with further atoms. Diamonds may occur both in single crystals and also in formless (shapeless) crystalline masses. The word 'crystal' is often used to describe a single crystal solid with plane crystal faces. It is also used to describe pieces of gem material that consist of a single internal crystal structure, even if the external surfaces are irregular or broken. Crystals are divided into seven main systems of symmetry and diamond forms into the most symmetrical of them, the cubic, also called isometric crystal system.

Crystal Structure

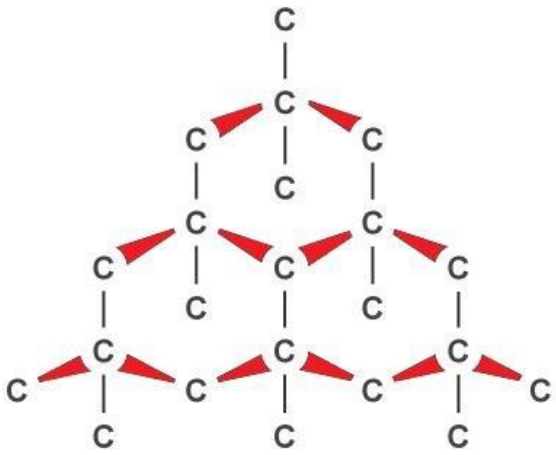
Diamonds form in the **isometric (or cubic)** crystal system
Diamonds are composed of carbon atoms (like graphite in a lead pencil).

A carbon atom has four electrons orbiting in the outer shell. Two carbon atoms can link together by sharing an electron from one, which fills a hole in the shell of the other.

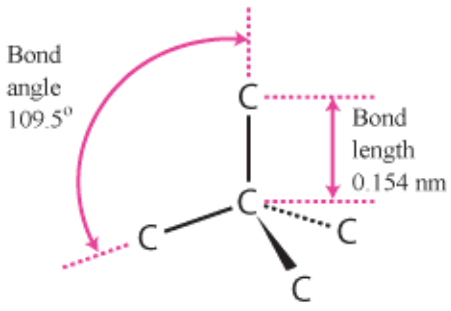


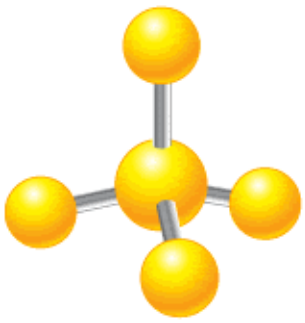
Diamond

As there are 4 electrons and 4 holes to each atom, each atom can link with 4 others; i.e. it has a valency of 4. A carbon atom can share electrons with neighboring carbon atoms to fill its shell to eight. This forms bonds between the atoms. Such bonds are called **covalent bonds** and can hold atoms together so that they form geometrical structures known as atomic crystals. The lattices are always strong and rigid and the resulting substances are hard solids with high melting-points.

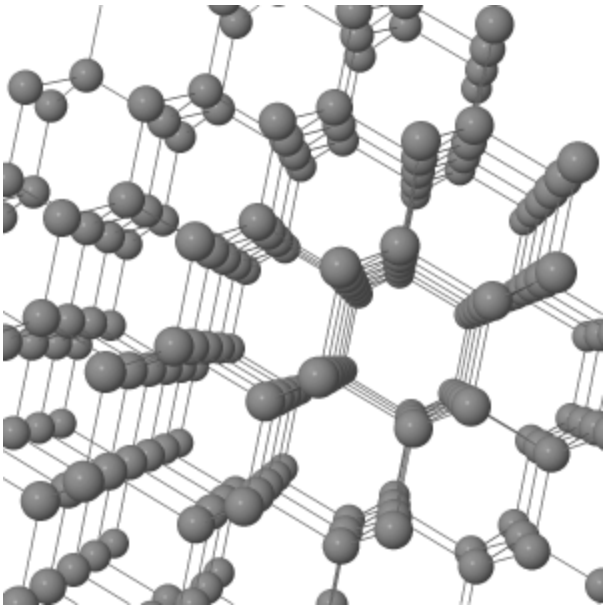


Diamond can be described as a giant saturated molecule of carbon. The 4 bonds to each atom are not, of course, flat, but are always at a **109.5 °** degree angle to each other. This is called the tetrahedral angle.



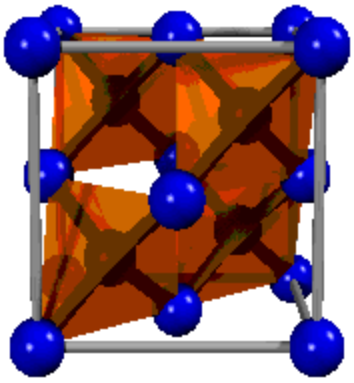


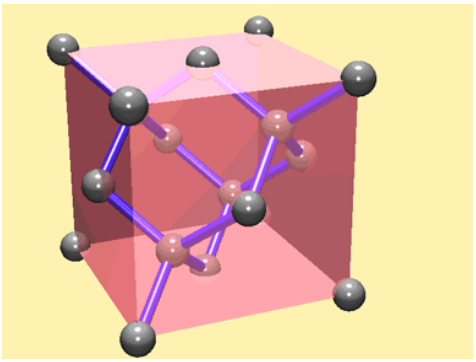
Each carbon atom is joined to four other carbon atoms by covalent bonds, creating a symmetrical, three-dimensional crystal structure in the form of an imaginary tetrahedron. Every bond is the same, 1.544 ångstrom units long.



The puckered hexagonal rings of atoms that result from the structure inside a diamond crystal

The crystal structure of a diamond is made up of a regularly repeating arrangement of carbon atoms joined to four other carbon atoms via the strongest chemical linkage, covalent bonds. Each carbon atom is in a rigid tetrahedral network where it is equidistant from its neighboring carbon atoms. The structural unit of diamond consists of eight atoms, fundamentally arranged in a cube.





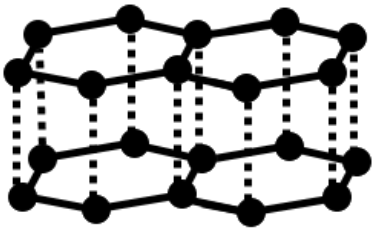
Polymorphism

Carbon is capable of forming many allotropes due to its valency.

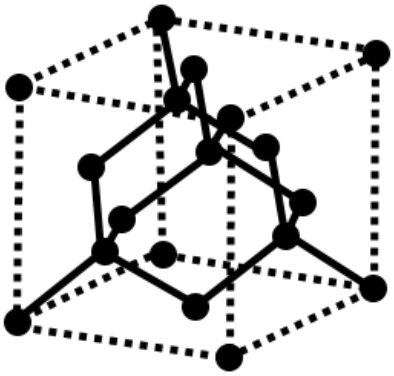
An **allotrope** is a single element that can take the form of different crystal structures. This is better known as polymorphism.

Carbon is a **polymorph**. In the case of the element carbon, it can take the form of a diamond as well as graphite. Both diamond and graphite are made almost entirely of the same element – carbon but are completely different in both physical and optical properties due to their atomic crystal structures and covalent bonding.

Allotropes of carbon

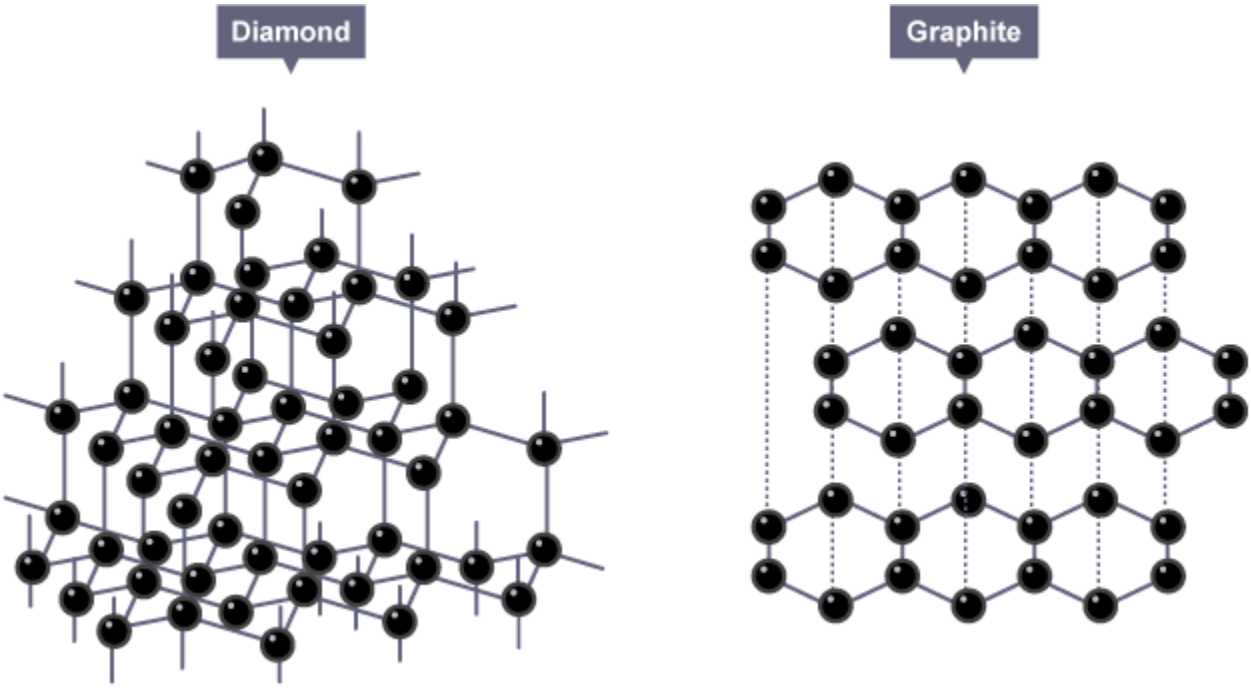


Graphite Structure



Diamond Structure

In graphite, the atoms also form into hexagonal rings, but the rings are flat and in thin plates as shown below. Graphite forms in layers or sheets where the carbon atoms have strong bonds on the same plane or layer, but only weak bonds to the layer above or below. These layers can slide over each other, so graphite is much **softer** than diamond. The carbon atoms in diamonds, on the other hand, have strong bonds in three dimensions.



The most exceptional atomic crystal structure is that of a diamond. The cubic structure of a diamond, with its strong covalent bonds and rigid and regular repeating arrangement, is what makes it stand out from other substances, and is the key to its unique properties:

- **Extreme hardness**
- **High thermal conductivity**
- **Resistance to chemicals**
- **Exceptionally high transparency**

The following chart shows how the properties of diamond compare to graphite.

SUBSTANCE	DIAMOND	GRAPHITE
APPEARANCE	TRANSPARENT	BLACK, GREASY
HARDNESS	EXCEPTIONALLY HARD	SOFT, SLIPPERY
DENSITY	HIGH	LOW
ELECTRICAL CONDUCTIVITY	POOR	EXCELLENT