Giant covalent structures

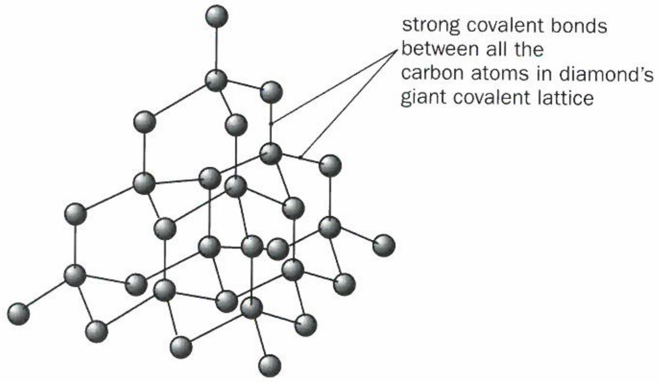
The covalent substances we have seen so far in this chapter have all been made of small molecules made from just a few atoms. However, some substances consist of giant three-dimensional networks of atoms. The atoms are fixed in position by covalent bonds. We call these **giant covalent structures**.

The great variety of life on Earth depends on carbon's ability to form covalent bonds with itself. As the element, carbon atoms bond to millions of other carbon atoms in both diamond and graphite.

Carbon in the form of diamond

Do you know the hardest substance on Earth? Look at the photo opposite: Diamond's hardness makes it a very useful material.

Diamond is made from only carbon atoms. How many covalent bonds can each carbon atom form? Look at the diagram below:



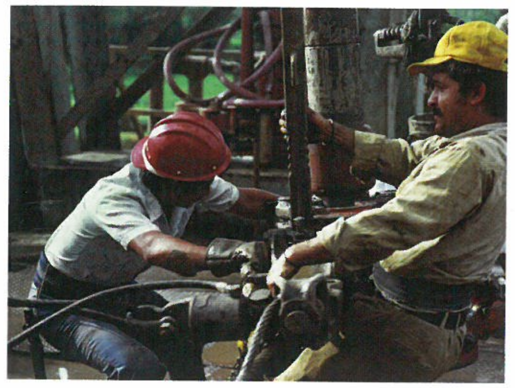
Part of the giant covalent structure of diamond. It is a crystalline solid because of the regular arrangement of atoms within its giant covalent lattice. The element silicon forms a similar giant covalent lattice

Each atom forms four strong covalent bonds with its neighbours. The atoms are arranged in a giant three-dimensional lattice.

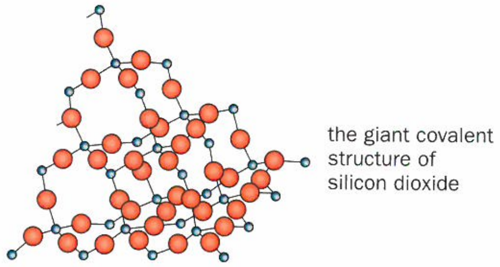
Does diamond have a high or a low melting point? Can you explain why?

Another substance with a giant covalent structure is silica. Its chemical name is silicon dioxide (SiO_2). It melts at over 1600 °C.

Substances with giant covalent structures are ***not soluble in water***. Their particles carry no charge (unlike those in ionic compounds). So polar water molecules are not strongly attracted to them. They can't provide the huge amounts of energy needed to break the structures apart. Substances with giant covalent structures ***don't conduct electricity***. There are no mobile ions or electrons to carry the charge. (Graphite is an exception; see the next page.)



The tip of this drill is lined with industrial diamonds. It is so hard because of its giant structure (the individual bonds between atoms are actually not as strong as those in CO_2!)



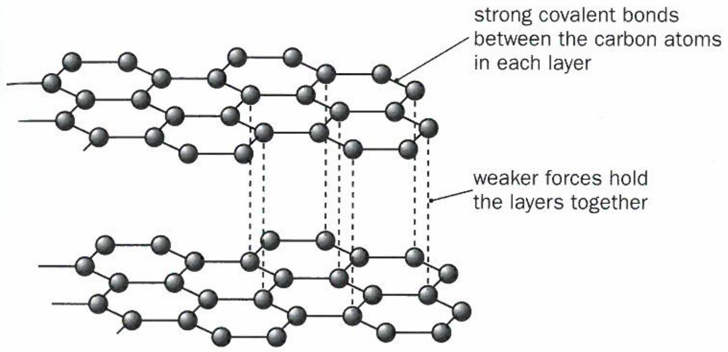
Silicon dioxide (SiO_2) has a giant covalent structure. Its melting point is above 1600 °C, it is insoluble in water and other solvents, and does not conduct electricity. SiO_2 is the main component in quartz sand and is found in many rocks

Properties of giant covalent substances:
1. **They have high melting points.**
2. **They are insoluble in water.**
3. **They do not conduct electricity (graphite is the exception).**

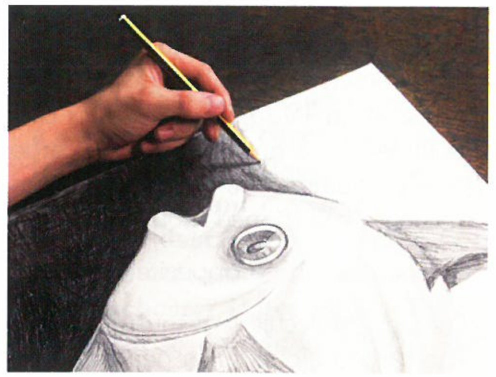
Carbon in the form of graphite

Another form of carbon is the crystalline solid, graphite. Diamond and graphite are **allotropes** of carbon. Allotropes are different forms of the same element. The carbon atoms in graphite are also held together in a giant covalent lattice. However, some of its properties are very different from a typical giant covalent substance, such as diamond or silicon dioxide.

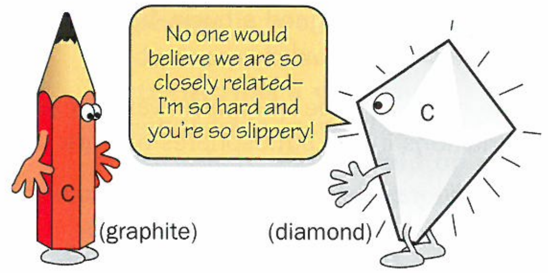
If you touch a lump of graphite, it feels smooth and slippery. Your pencil contains graphite. As you move it across your paper it flakes off, leaving a trail of carbon atoms. Look at the diagram below:



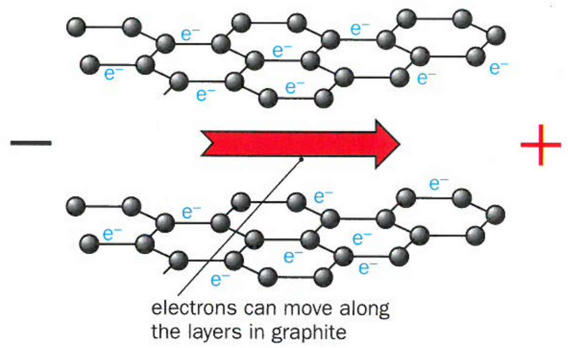
Part of the giant covalent structure of graphite



Graphite (mixed with clay) is used in pencil 'leads'

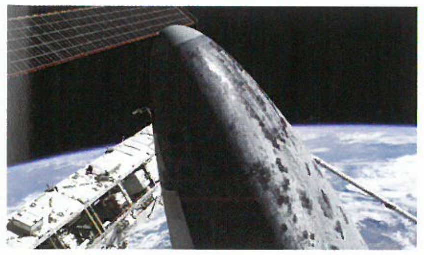


How many carbon atoms are joined to each other by strong covalent bonds? Is this the usual number of bonds? The fourth electron from each carbon atom is found anywhere along the layers. They are **delocalised electrons**, so they are no longer associated with any one carbon atom (see page 78). These electrons help to hold the layers together by weak forces. Therefore the layers can slide over each other easily. Does this explain graphite's use in pencils?



Did you know that graphite is the only non-metallic element that conducts electricity well? The electrons holding the layers together are only held loosely to the carbon atoms. They can drift along the layers in graphite, making it a good conductor of electricity (and heat). Do you think that graphite conducts better along its layers or across them?

Graphite does not melt when you heat it. At over 3000 °C it turns directly into a gas. We say it **sublimes**. Why does it take a lot of energy for graphite to sublime? Look at the photos of some other uses of graphite: Which properties of graphite do they depend on?



The tiles on the nose cone of the space shuttle contained graphite

Lubricant oils sometimes contain graphite. It can also be used as a powder on moving parts in machinery