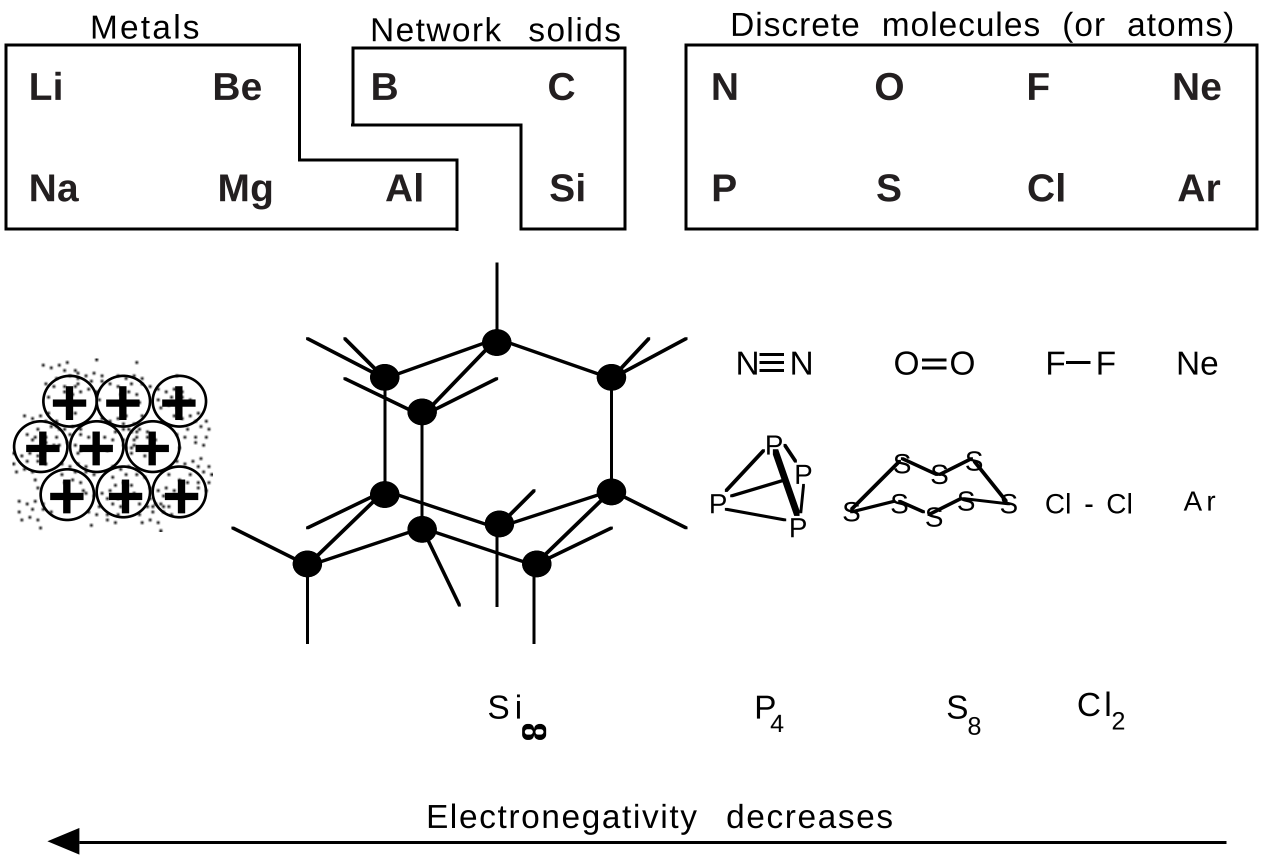
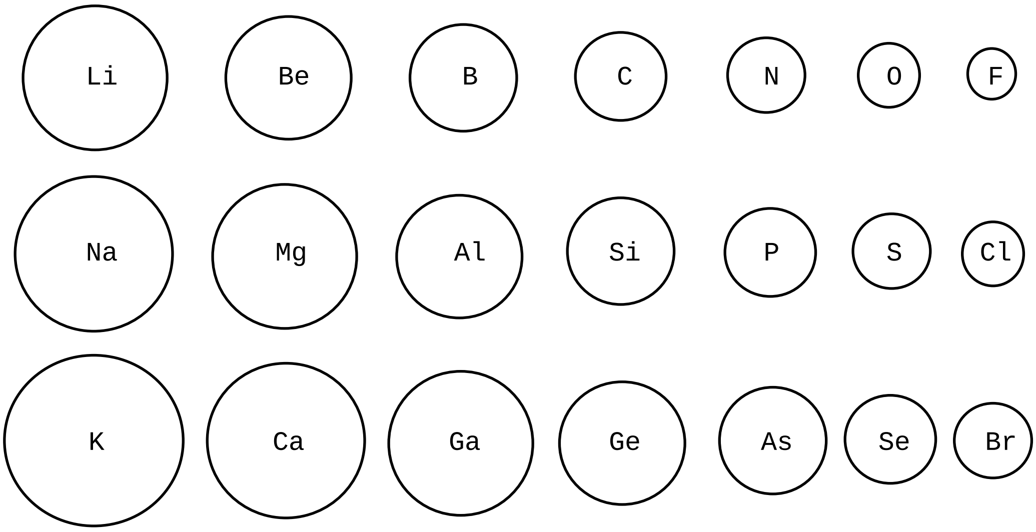
Properties of the First 20 Elements

In 1869 Mendeleev constructed the first periodic table. He arranged the known elements in order of increasing atomic masses. He arranged the elements in series to show the periodic recurrence in properties. He left gaps for elements yet to be discovered.

Structures are largely determined by the valency and electronegativity.



ATOMIC SIZE



The atomic size decreases across a period (L->R) due to increase in nuclear charge pulling the electron clouds closer to the nucleus.

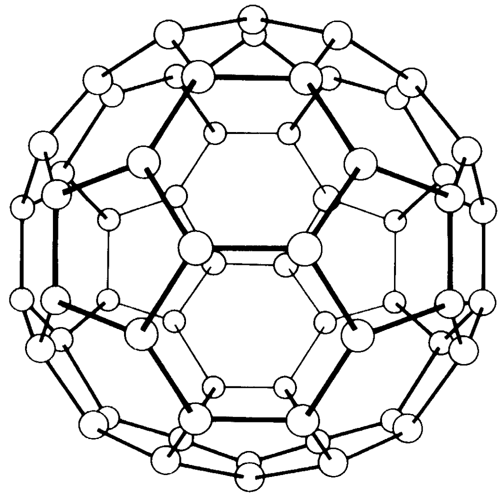
The atomic size increases down a group (T->B) due to the electrons entering energy levels increasingly further from the nucleus.

The smaller the atoms the nearer the bonding electrons are to the nucleus and the stronger the bond e.g. C-F is stronger than C-Cl.

Discrete molecules or atoms

Since the electronegativity is high the electrons are confined to covalent bonds so the elements do not conduct electricity. They are non-metals.
The noble (inert) gases, with no unpaired electrons, are monatomic.
Multiple bonding is possible with first row elements only. In a double bond, four electrons in the same area repel. The **small** atoms in the first row have a high electronegativity and are, therefore, able to overcome this repulsion. Their nuclei attract the bonding electrons strongly and hold them in place e.g. O=O (no chains or rings like Sulphur)
The molecules in the solid or liquid states of these elements are held together by weak van der Waals' forces and so melting points and boiling points are very low e.g. Nitrogen M.P. -210 ^{0}C ; B.P. -196 ^{0}C

Fullerenes



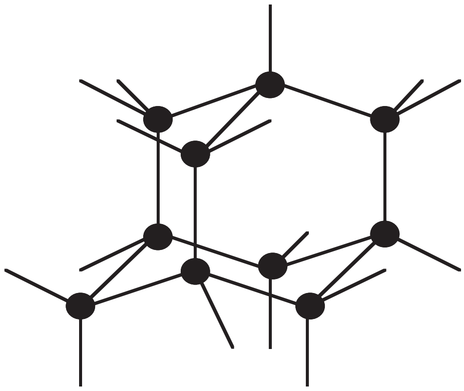
Buckminsterfullerene (C_{60}), a 'ball-shaped' molecule of Carbon, has been produced by passing high voltage sparks across graphite electrodes. The soot obtained is dissolved in Benzene and crystallises to form dark red crystals.

Other fullerenes have been made e.g. C_{70}.

Fullerenes are the subject of current research and applications are being saught notably as a superconductor.

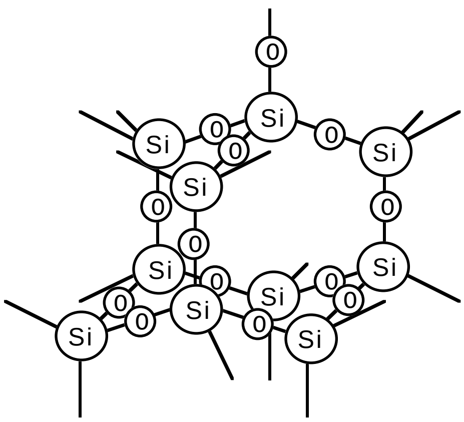
Network Solids

Though the electronegativity is lower, the electrons are still confined to covalent bonds so the elements are non conductors of electricity e.g. Diamond, a form of Carbon, is a hard rigid solid.

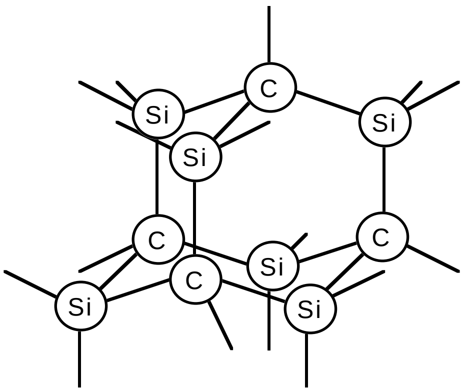


Silicon, with the same structure as Diamond, has a small electrical conductivity rising with temperature. Electrons can be dislodged from the bonds in Silicon by heat or light energy. Silicon is a 'semiconductor'.

Note the similar rigid structure of Silicon dioxide (Quartz) and Silicon carbide (Carborundum).



Silicon dioxide

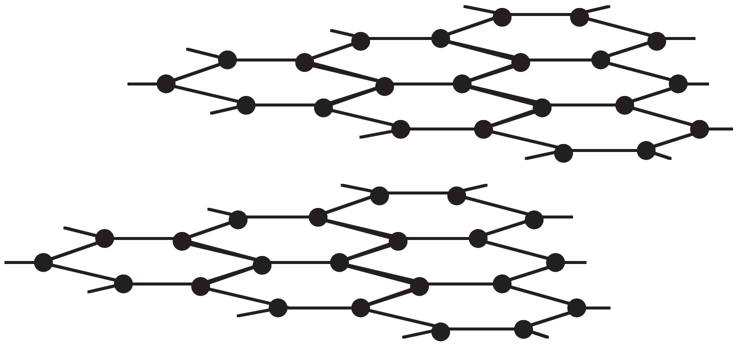


Silicon carbide

The strength of the Si-O and Si-C bonds result in both substances being hard, stable solids. Both are used as abrasives.

Graphite

Another polymorph of Carbon:



Each Carbon atom in Graphite forms only three covalent bonds ; the fourth electron joins a delocalised cloud of electrons which can move across the layers giving Graphite its characteristic electrical conductivity.

The layers, held together by weak van der Waals bonds, can slip and slide giving Graphite a slippery feel and making it a useful lubricant.

Melting and boiling involve breaking down the lattice by breaking the covalent bonds. Covalent bonds are very much stronger than van der Waals bonds so the elements have high melting points and boiling points e.g. Graphite M.P. 3730 ^{0}C ; B.P. 4200 ^{0}C.

Metals

The electronegativity is so low that the electrons are free to leave the atom forming positive ions which are then held together tightly by the free electrons moving between them. Metals are thus clusters of positive ions immersed in a sea of mobile electrons hence the conductivity.

Movement of ions within the electron sea is easy hence melting points are low (Lithium MP 180 ^{0}C). Complete escape, against the pull of the electron sea, is difficult hence boiling points are high (Lithium BP 1330 ^{0}C).

The strength of the metallic bond depends on the ion charge and the number of bonding electrons : the Mg^{2+} ions in solid Magnesium (density 1.74 g cm^{-3}) are much more tightly bonded than the Na^+ ions in solid Sodium (density 0.97 g cm^{-3}) resulting in the higher density of Magnesium.