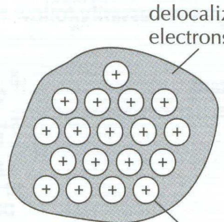
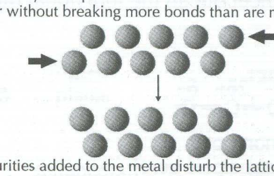
Metallic bonding and physical properties related to bonding type

METALLIC BONDING

The valence electrons in metals become detached from the individual atoms so that metals consist of a close packed lattice of positive ions in a sea of delocalized electrons. A metallic bond is the attraction that two neighbouring positive ions have for the delocalized electrons between them. Metals are malleable, that is, they can be bent and reshaped under pressure. They are also ductile, which means they can be drawn out into a wire.



Metals are malleable and ductile because the close-packed layers of positive ions can slide over each other without breaking more bonds than are made.



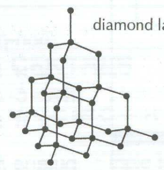
Impurities added to the metal disturb the lattice and so make the metal less malleable and ductile. This is why alloys are harder than the pure metals they are made from.

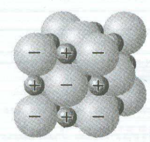
TYPE OF BONDING AND PHYSICAL PROPERTIES

Melting and boiling points

When a liquid turns into a gas the attractive forces between the particles are completely broken so boiling point is a good indication of the strength of intermolecular forces. When solids melt the crystal structure is broken down, but there are still some attractive forces between the particles. Melting points are affected by impurities. These weaken the structure and result in lower melting points.

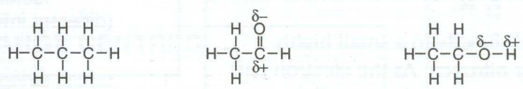
Covalent macromolecular structures have extremely high melting and boiling points. Metals and ionic compounds also tend to have relatively high boiling points due to ionic attractions. Hydrogen bonds are in the order of $\frac{1}{10}$th the strength of a covalent bond whereas van der Waals' forces are in the order of less than $\frac{1}{100}$ of a covalent bond. The weaker the attractive forces the more volatile the substance.





Diamond (melting point over 4000 °C)
All bonds in the macromolecular structure covalent

Sodium chloride (melting point 801 °C)
Ions held strongly in ionic lattice



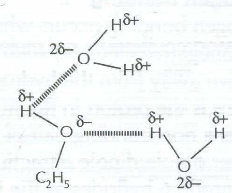
Compound	propane	ethanal	ethanol
M_r	44	44	46
M. pt / °C	–42.2	20.8	78.5
Polarity	non-polar	polar	polar
Bonding type	van der Waals'	dipole:dipole	hydrogen bonding

Solubility

'Like tends to dissolve like'. Polar substances tend to dissolve in polar solvents, such as water, whereas non-polar substances tend to dissolve in non-polar solvents, such as heptane or tetrachloromethane. Organic molecules often contain a polar head and a non-polar carbon chain tail. As the non-polar carbon chain length increases in an homologous series the molecules become less soluble in water. Ethanol itself is a good solvent for other substances as it contains both polar and non-polar ends.

CH_3OH
C_2H_5OH
C_3H_7OH
C_4H_9OH

decreasing solubility in water ↓

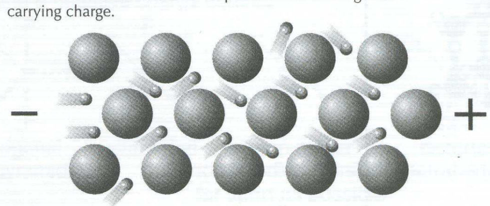


Ethanol is completely miscible with water as it can hydrogen-bond to water molecules.

Conductivity

For conductivity to occur the substance must possess electrons or ions that are free to move. Metals (and graphite) contain delocalized electrons and are excellent conductors. Molten ionic salts also conduct electricity, but are chemically decomposed in the process. Where all the electrons are held in fixed positions, such as diamond or in simple molecules, no electrical conductivity occurs.

When a potential gradient is applied to the metal, the delocalized electrons can move towards the positive end of the gradient carrying charge.



When an ionic compound melts, the ions are free to move to oppositely charged electrodes. Note: in molten ionic compounds it is the ions that carry the charge, not free electrons.