

Physical Properties of Ionic, Covalent Network and Metallic Solids

	Ionic Solids (Salts)	Covalent Network Solids	Metallic Solids
melting and boiling point	very high to high melting and boiling points: due to strong intramolecular forces of attraction (electrostatic forces of attraction between positive and negative ions) that require a lot of thermal energy to overcome	very high to high melting and boiling points: due to strong intramolecular forces of attraction (covalent bonds) that require a lot of thermal energy to overcome (do not confuse with discrete molecular compounds which have low to moderate melting and boiling points)	very high to moderate: the metallic bond strength can vary due to metal ion charge, ionic radius and number of electrons donated to the "electron soup" that holds the metal ions together, stronger metallic bonds of course require more thermal energy to overcome
crystal structure	highly structured due to lattice arrangement, lattice arrangement is a result of minimum energy considerations that maximize attractions between ions of opposite charge while minimizing repulsions between ions of like charge, anomalies are rare	highly structured due to lattice arrangement, lattice arrangement is a result of covalent bonding geometry producing a three dimensional network giving a very strong crystal structure with few anomalies	moderate degree of structure usually not visible to the eye, the metallic bond does not require a specific geometry, crystal packing arrangements (i.e. body centered cubic, hexagonal close packed and cubic close packed) are merely ways of packing ions together, crystal packing is prone to anomalies
response to physical stress or strain	may shatter: once the crystal lattice is disturbed, the ionic bonds will break if the ions are dislocated may cleave: the crystal lattice could fracture along a plane of ions, thus breaking ionic bonds along a flat face	may shatter: once the crystal lattice is disturbed, the covalent bond breaks may cleave: the crystal lattice could fracture along a plane of atoms, thus breaking covalent bonds along a flat face	malleable and ductile: will bend and stretch, <u>metal ions</u> can slide past each other without interrupting the metallic bond (the electrons move very fast and freely throughout the metal)



continued

solubility	<p>variable solubility in water and other <u>polar solvents</u>: electrostatic interaction between regions of partial charge on solvent molecules and the charge on ions can be sufficient to overcome the lattice energy of the ionic crystal, in water the dissolving process is called solvation or hydration,</p> <p>lattice energy > hydration energy insoluble ionic compound</p> <p>hydration energy > lattice energy soluble ionic compound</p>	<p>insoluble: neutral atoms in the crystal have a high latticed energy, there are no solvents that can interact successful with neutral atoms to overcome the high lattice energy, lattice energy must be overcome for dissolving to occur</p> <p>(lattice energy is associated with the force of attraction that holds a crystal together in a crystal lattice)</p>	<p>insoluble: free moving electrons are not soluble in any normal solvent (i.e. electrons cannot be hydrated), therefore metals cannot dissolve even though metal ions could be hydrated</p> <p>many metals are soluble in mercury metal: mercury metal can accommodate free moving electrons thus allowing metals to dissolve</p>
electrical conductivity	<p>solid crystals are non-conductive: electrons and ions are locked in place, no free moving charged particles, therefore no conduction</p> <p>molten (liquid) state are conductive: positive and negative ions are able to move, free moving charged particles allow for conduction (note: electrons are still locked into the ions)</p> <p>ionic solutions are conductive: free moving positive and negative ions in solution are able to carry a current</p>	<p>three dimensional network solids are non-conductive: electrons are localized in covalent bonds, no free moving charged particles, therefore no conduction</p> <p>two dimensional network solids (graphite) are conductive within a plane but none conductive between planes: electronic resonance within a plane allows for the movement of electrons through a plane, free moving charged particles, therefore conductive</p>	<p>conductive in solid and liquid state: free moving electrons traveling in the empty valence orbitals of the metal ions provide excellent conductivity</p>
molecular size	macromolecule: unspecified large size	macromolecule: unspecified large size	macromolecule: unspecified large size
examples	NaCl, LiF,	diamond (C _n), quartz (SiO ₄), LiN, Si, SiC	gold, silver, iron, steel alloys