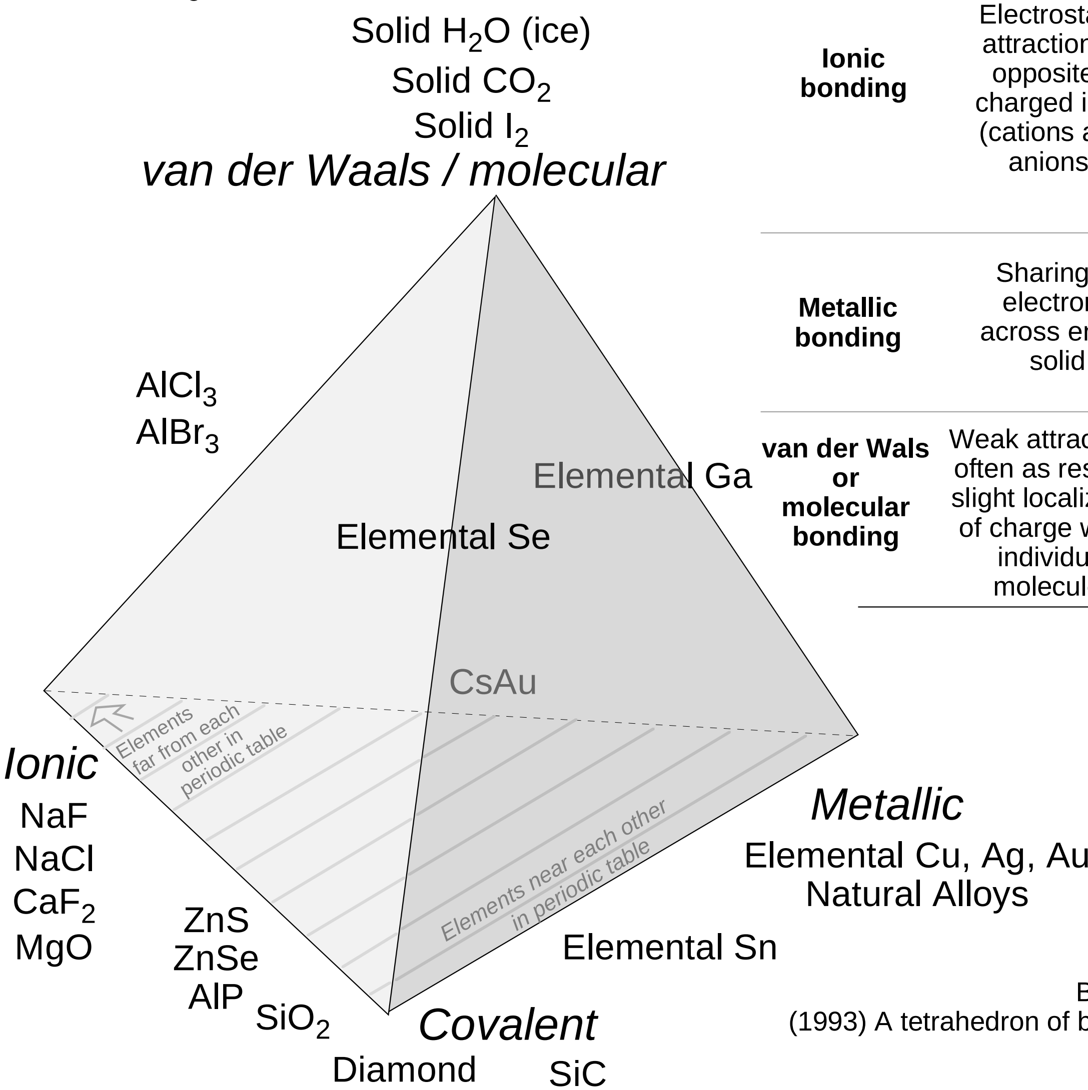
Chemical Bonding

Atoms and molecules bond by four mechanisms. These mechanisms are differentiated by the behavior of valence electrons, and they result in different physical properties, as shown in the table at the right.

	Nature of bond	*Behavior of valence electrons*	*Conductivity of electricity*	*Melting point and hardness*
Covalent bonding	Sharing of electrons between pairs of atoms (in a sense, overlap of atoms)	Valence electrons are constrained in pairs between pairs of atoms.	Little conductivity in either solid or liquid state	Very high melting points; very hard (Diamond: T_m = 4440°C; Mohs hardness = 10)
Ionic bonding	Electrostatic attraction of oppositely charged ions (cations and anions)	Valence electrons are constrained around each atom, some of which have gained electrons and thus have positive charge (and so are anions), and some of which have lost electrons and so have positive charge (and so are cations).	Little conductivity in solid state, but conducts when molten (i.e., as a liquid, where ions are free to move).	Melting points ≥500°C. (2825°C for MgO; 1418°C for CaF_2; 801°C for NaCl; hardness = 6, 4, & 2, respectively)
Metallic bonding	Sharing of electrons across entire solid	Valence electrons flow freely from atom to atom in all directions, so that the electrons are part of the entire solid, not of one atom.	Conducts electricity in both solid and liquid state	Broad range of melting points (-39°C for Hg; 1085°C for Cu; 3200°C for W) malleable
van der Wals or molecular bonding	Weak attractions, often as result of slight localization of charge within individual molecules	Valence electrons are constrained to one group of atoms, which in some cases constitute a molecule.	Little conductivity in either solid or liquid state	Very low melting points (0°C for H_2O)

The degrees of conductivity and melting points in the two rightmost columns above can be seen as results of the behaviors of electrons and natures of bonds, respectively.



The seeming discreteness of this table conceals the fact that most substances have bonding intermediate between these ideal end-members. The tetrahedron at left attempts to represent those intermediate conditions.

Both the table and the figure are based on M. Liang (1993) A tetrahedron of bonding: *Education in Chemistry,* v. 30, p. 160-163.