Cohesion of metals

Localized vs. delocalizable electrons

Electrons are considered to belong to an atom, which might share some of them specifically with another atom through a covalent bond.
If it is true for the electrons of the inner layers, which are said to be localized, it isn't always true for the electrons of the valence layers.
However, this is not always true, especially for metals:

- They have low ionization energies, which means their valence electrons are loosely bound to the nucleus.
- They also have a large atomic radius, which means their outer orbitals tend to overlap with those of other atoms.

Electrons of these outer layers are therefore susceptible to move from one atom to another: they are delocalizable.

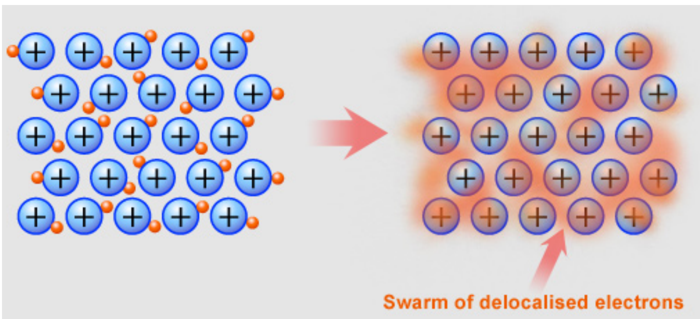
HL Note: ***Metallic atoms, especially those of the d-block usually have from 1 to 3 delocalizable atoms.***

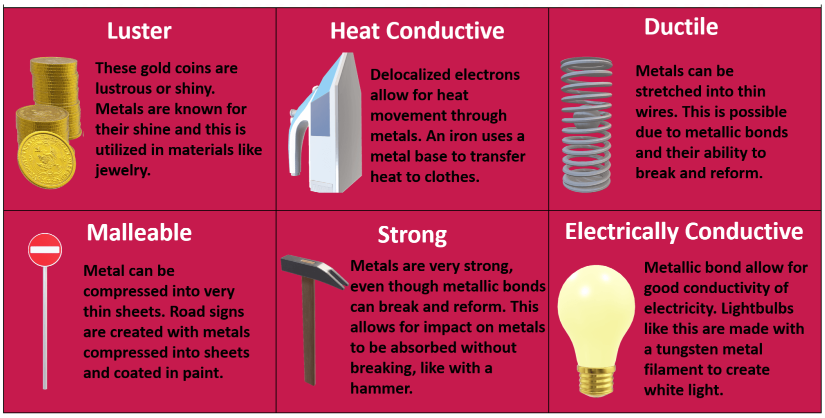
Metallic bonding through a sea of electrons

Metallic atoms have a high electropositivity: they naturally tend to lose or donate their valence electrons.

Note: Electropositivity is not exactly the opposite of electronegativity. If one focuses on the capacity to lose/donate electrons, the other focuses on the capacity to gain/attract electrons.

By forming a regular arrangement of positive nuclei, in which the valence layer of an atom overlaps with those of the neighbouring atoms, the electropositivity of the metallic atoms is favored: their delocalizable electrons become delocalized: they do not belong to the atom anymore, but spread over many atoms, thus forming a sea of constantly moving electrons, but constantly attracted by a nucleus and shared by all atoms of the lattice.





This "sea of electrons" forms a metallic bond, keeping the positive nuclei together. This stabilises the lattice, leading to the known macroscopic physical properties of metals: strength, hardness, high melting and boiling points.
The constant movement of delocalized electrons explains several other properties of metals:

- Delocalized electrons being electrically charged, it is their movement throughout the whole lattice that explains the electrical conductivity of a metal.
- The mobile electrons transfer kinetic energy very efficiently, which explains why metals conduct heat well.
- Metal ions can slide past each other without breaking the lattice, because the delocalized electrons constantly adjust to maintain the lattice cohesion. This explains why metals are malleable and ductile.
- Electrons can absorb and re-emit light by jumping from one energy level to another. Delocalized electrons can do it anywhere in the lattice, giving metals their characteristic shine.