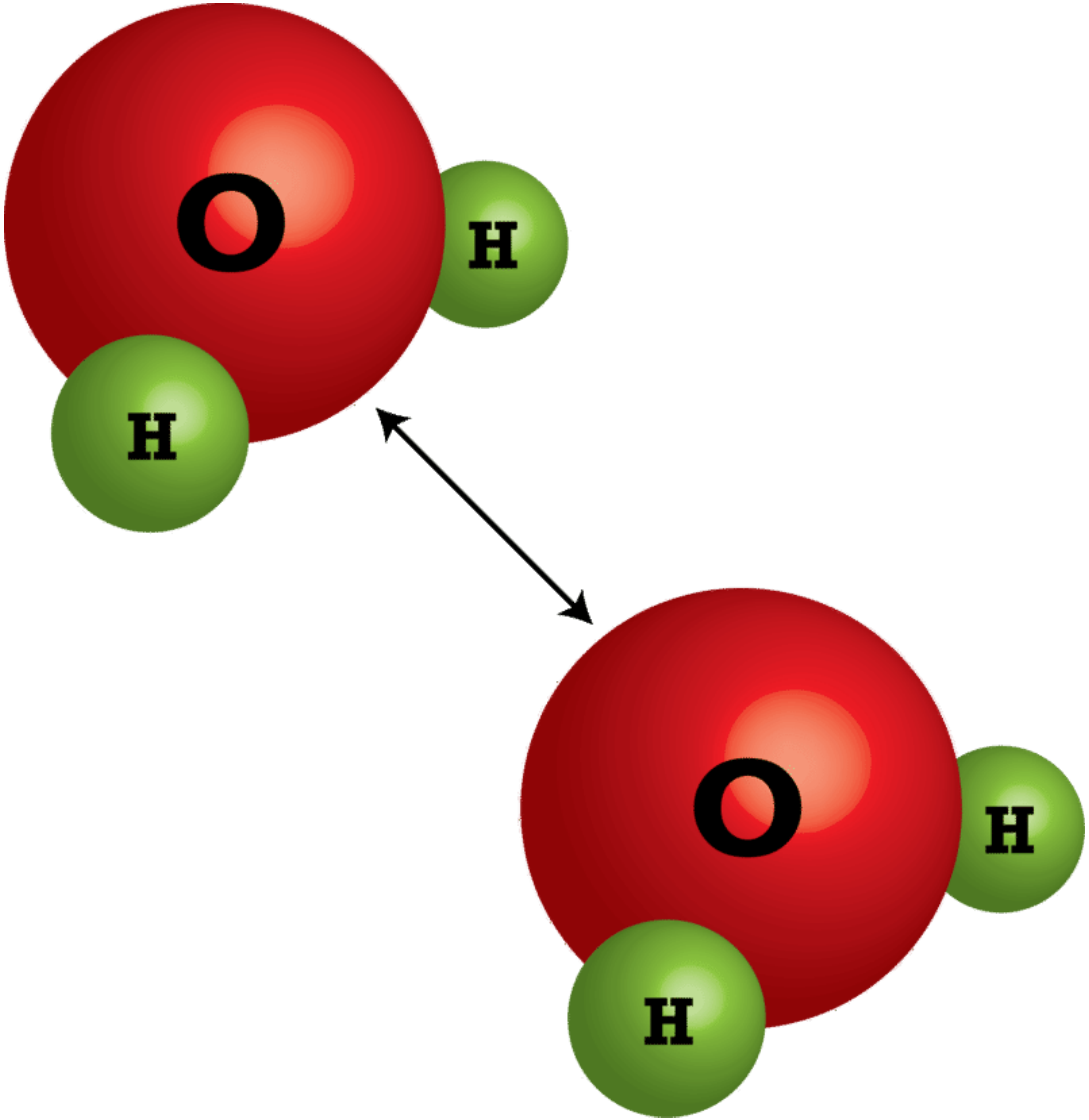


Unit 3

Intermolecular Forces

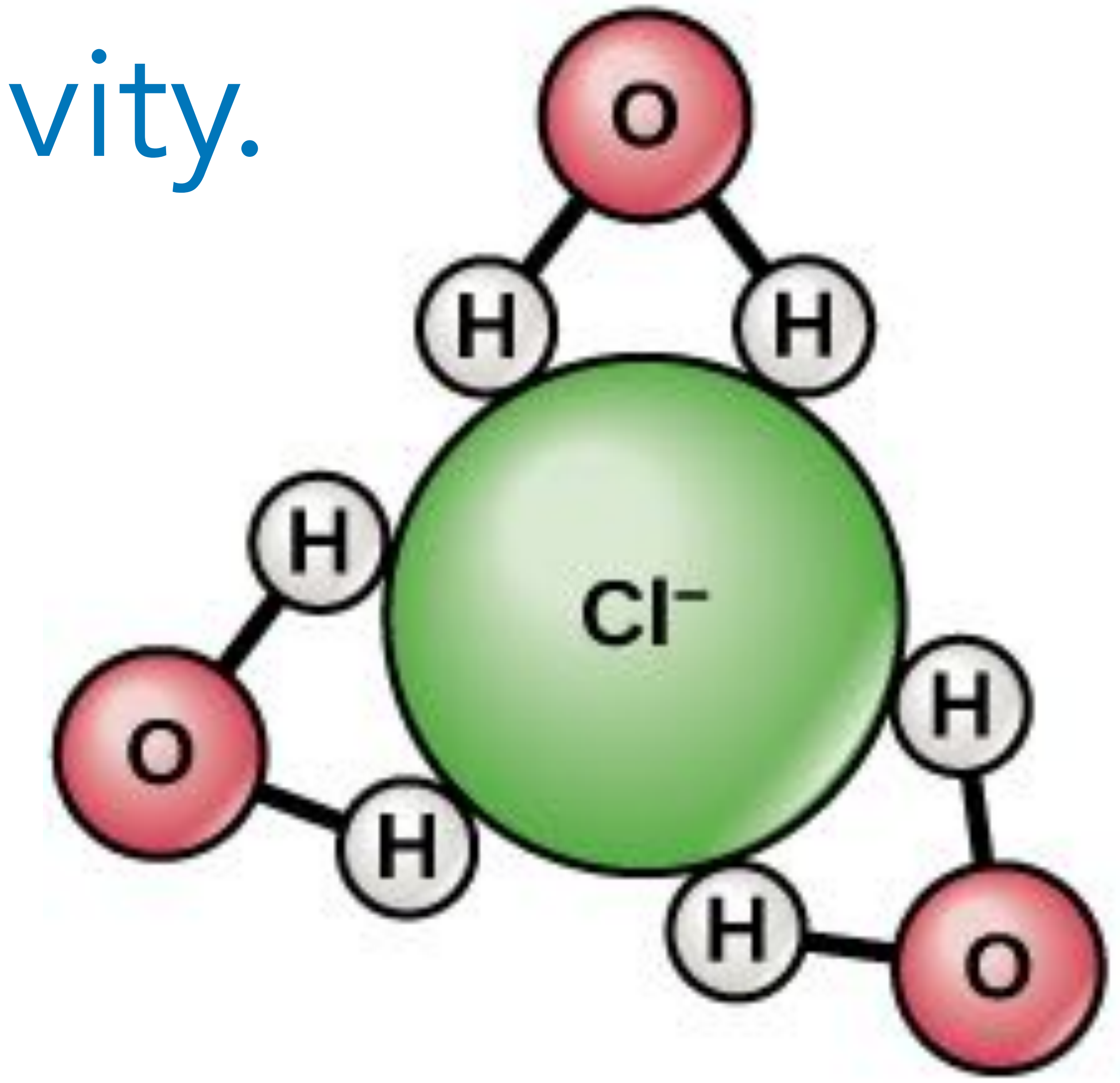
3.2 Properties of Solids

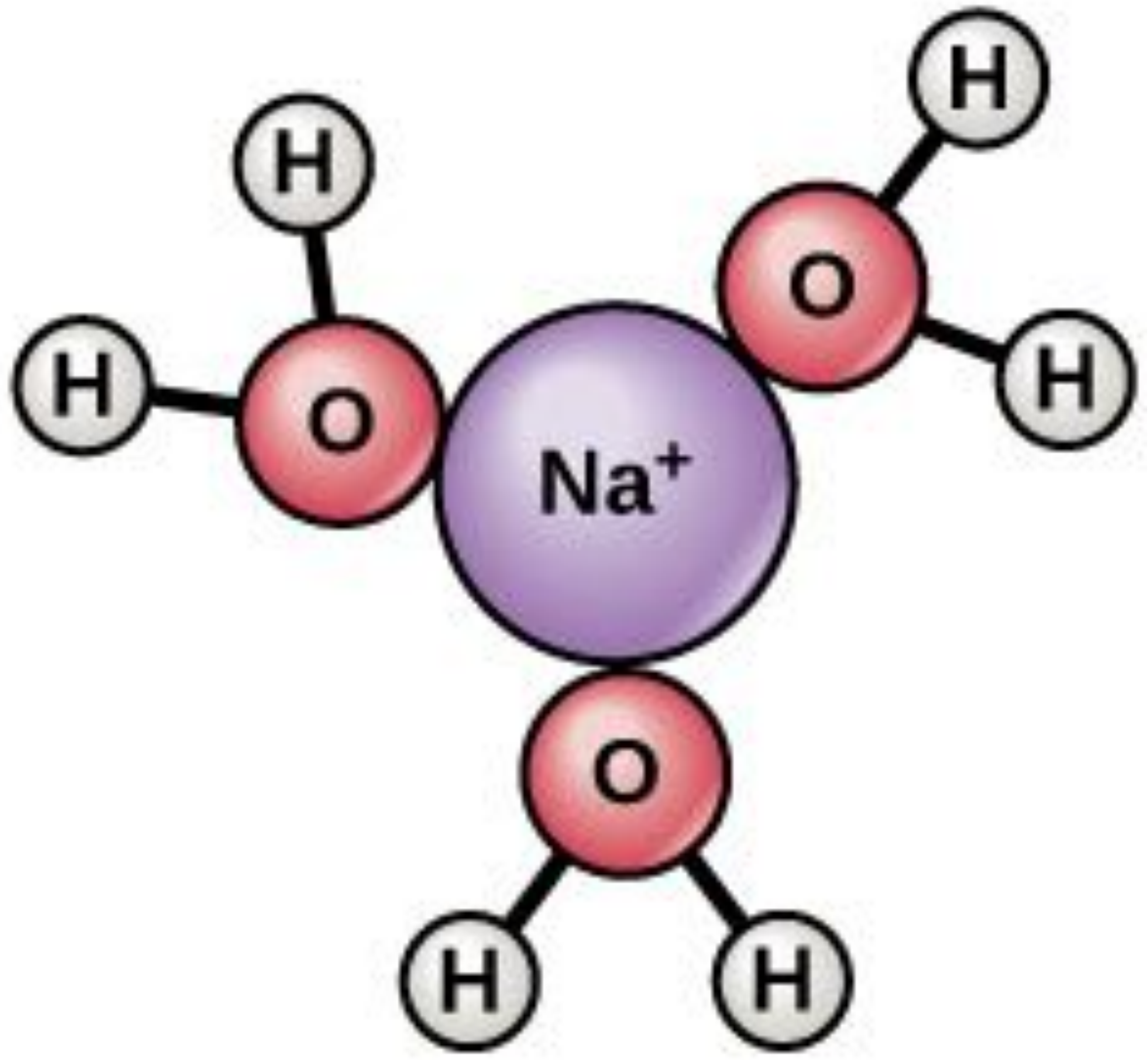
- Heat of Fusion
- Heat of Vaporization
- Vapor Pressure
- Covalent Network Solids

Properties of Ionic Solids

1. Solubility & Conductivity

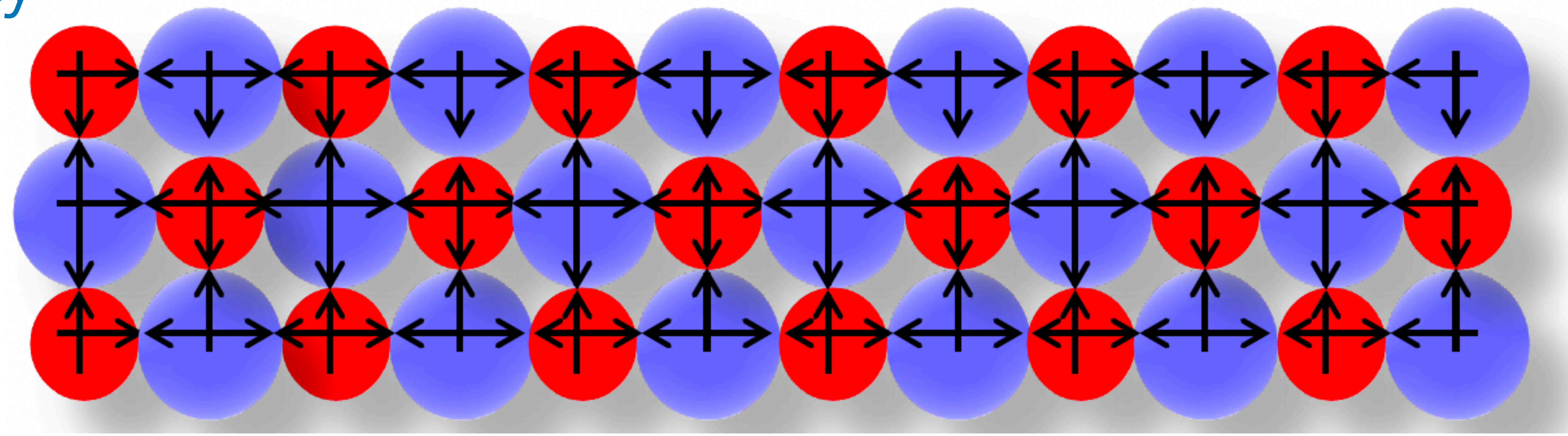
- Most are soluble in polar solvents (i.e. H_2O)
- Conduct electricity **<u>only</u>** when molten or dissolved in a polar solvent (mobile, charged particles).
  - The higher the concentration of ions in a solution, the higher the conductivity.





Properties of Ionic Solids

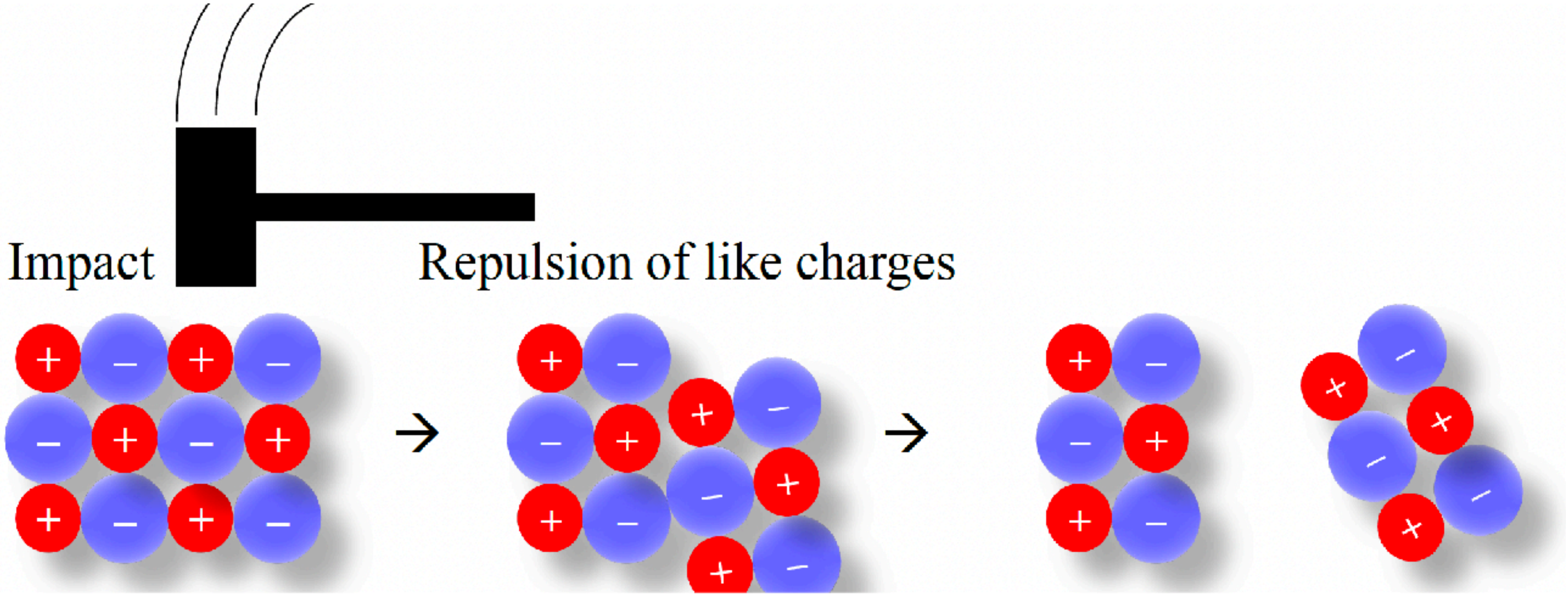
1. **Strong Bonds**
   - Very strong Coulombic forces of attraction
     - High melting points
     - Very hard
     - Low volatility



Properties of Ionic Solids

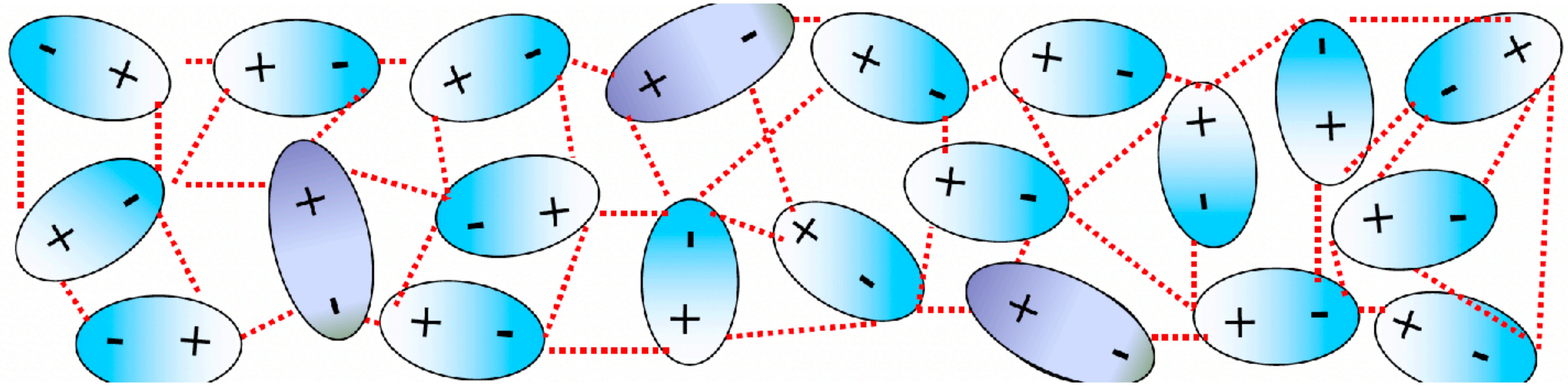
2. Cleave along planes

- Brittle 3D structure
- Ions line up in a repetitive pattern that maximized attractive forces and minimizes repulsive forces.
- Not malleable or ductile.



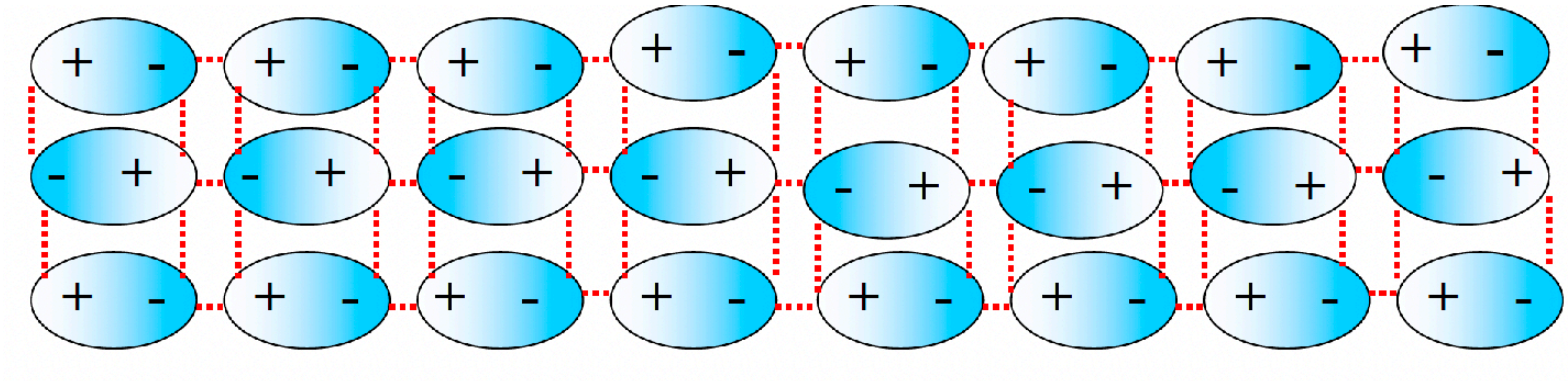
Properties of Molecular Solids

1. **Most molecular solids don't conduct electricity when molten or dissolved in water.**
   - The individual molecules have no net charge, as their valence electrons are tightly held within covalent bonds and lone pairs.
   - Acids are molecules that can ionize and conduct electricity.



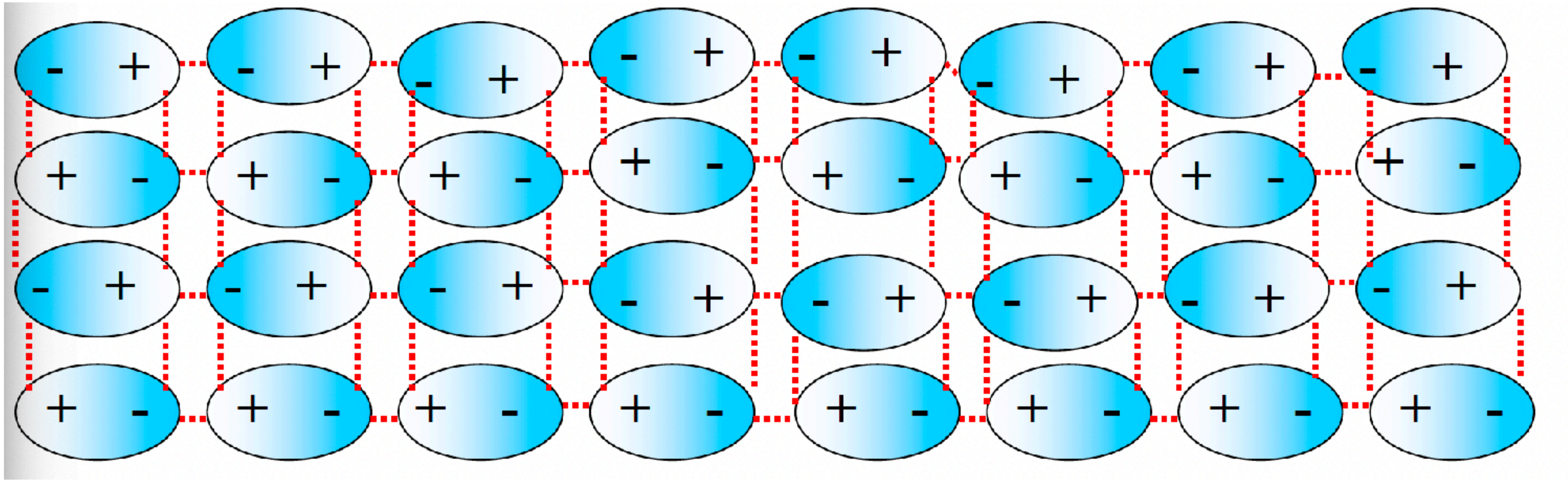
Properties of Molecular Solids

2. **Most molecular solids are held together by intermolecular forces, which are much weaker than ionic or covalent bonds.**
   - They have much higher vapor pressures than ionic solids.
   - They have much lower melting and boiling points than ionic solids.

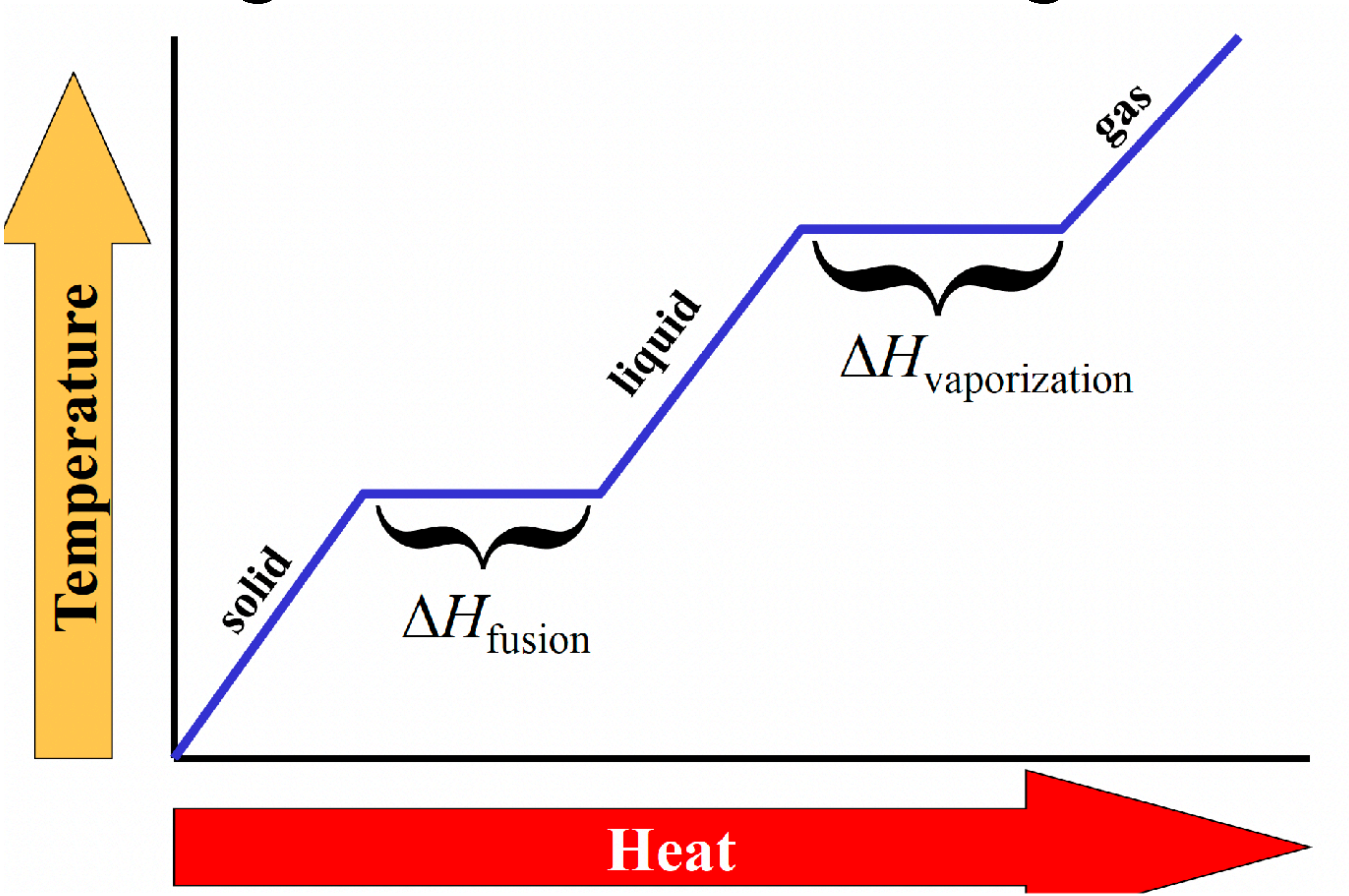


Molecular Solids

In a solid, molecules are held close together in a regular pattern by intermolecular forces that attempt to maximize attractions and minimize repulsions.

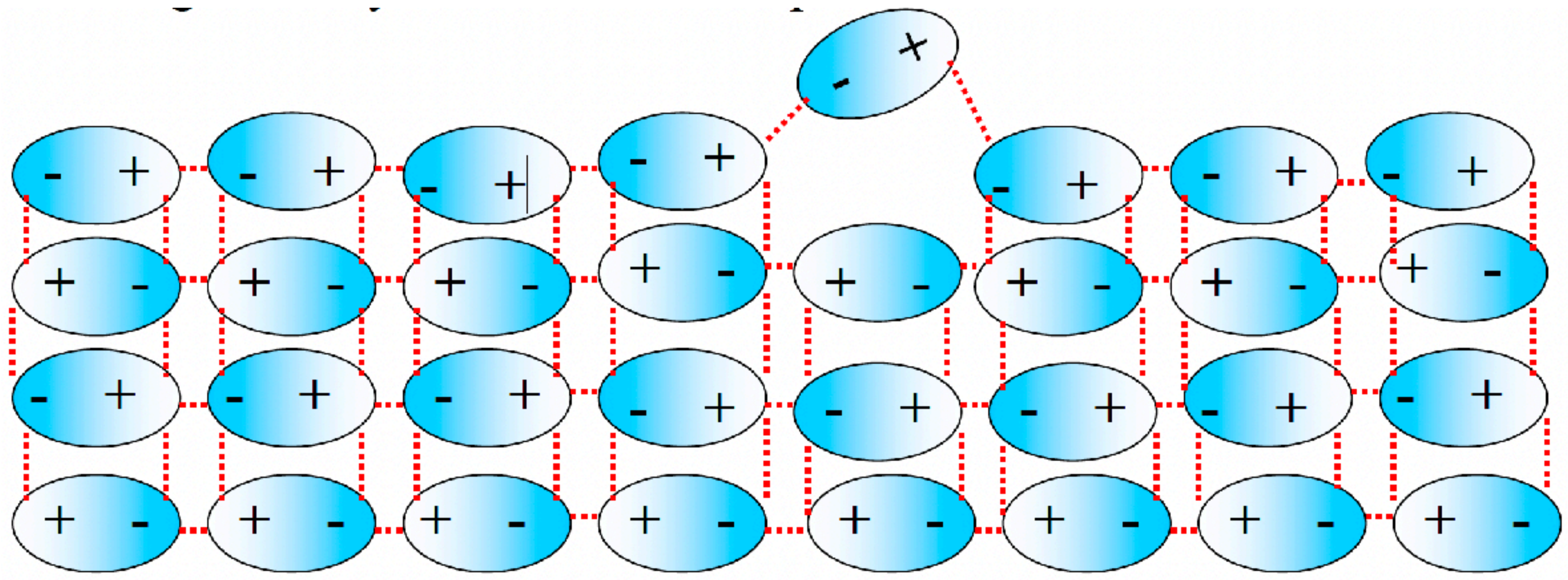


Changes of State: Heating Curve



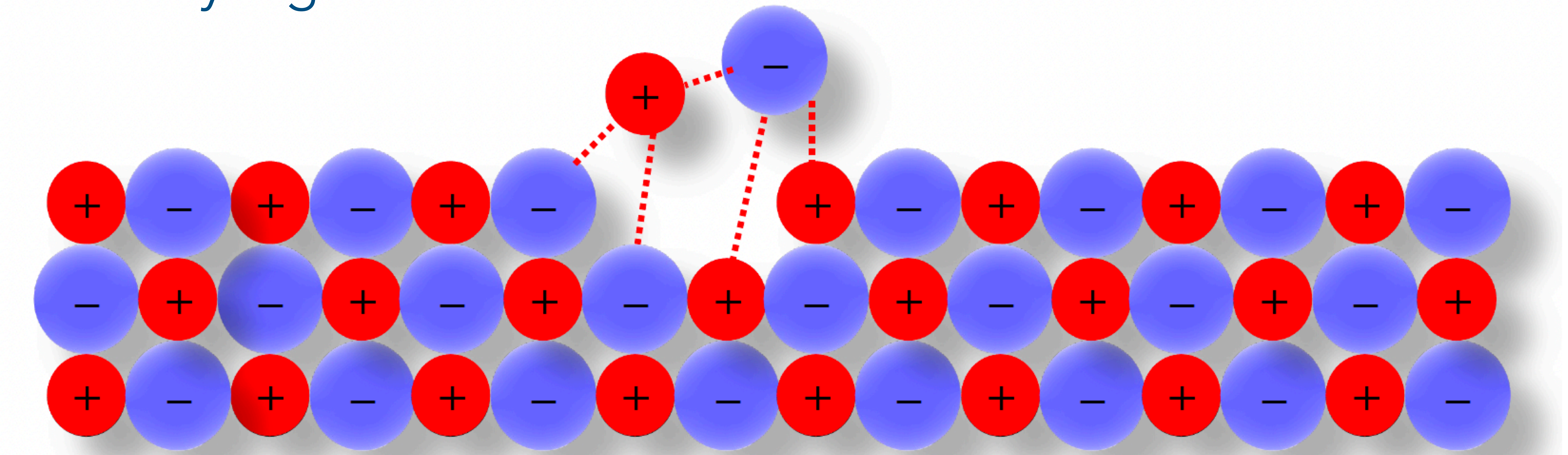
Heat of Fusion (ΔH_{fus})

- ΔH_{fus} - the heat absorbed as 1 mole of a solid liquifies.
- Energy is required to expand/sever intermolecular forces of attraction, as a molecule moves from the solid to the liquid phase.
- This is why molar heat of fusion, ΔH_{fus}, values are always positive.
- Melting is always an endothermic process.



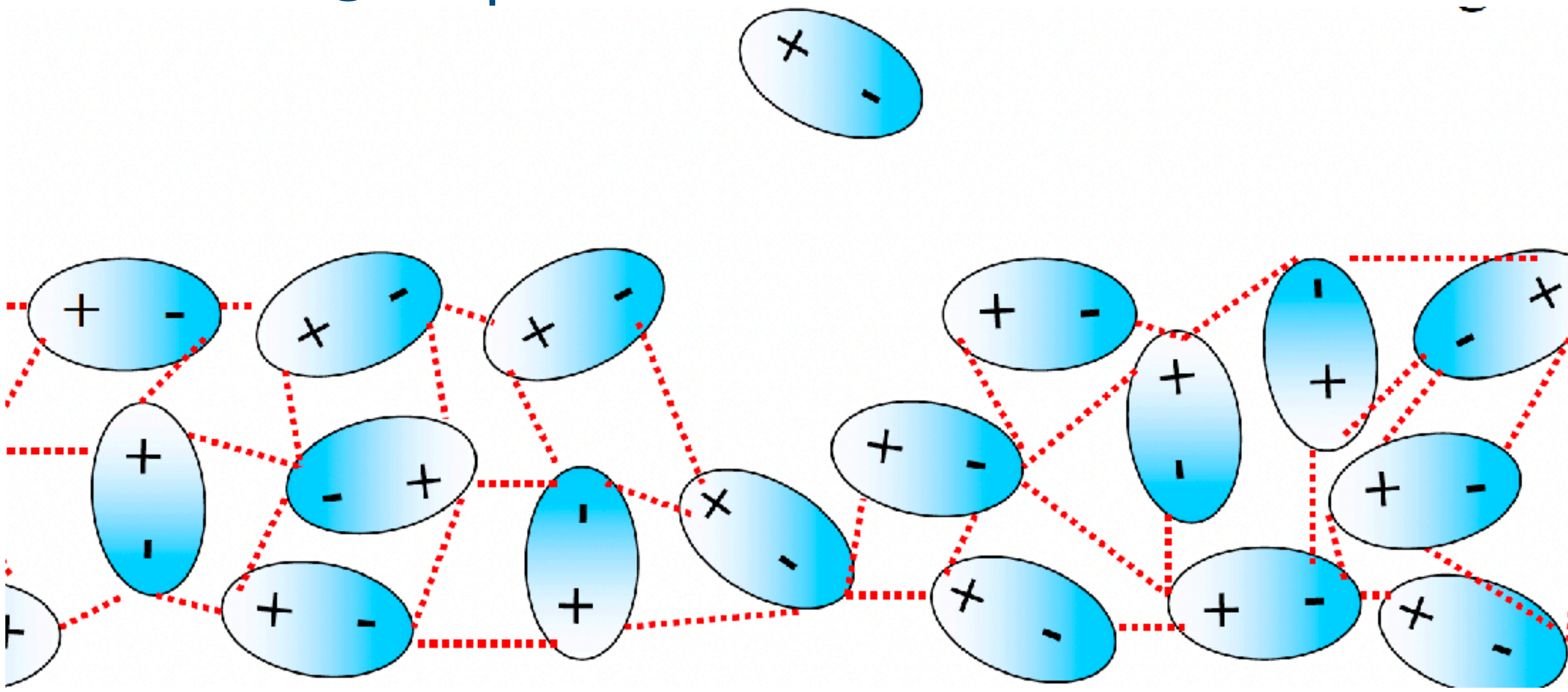
ΔH_{fus} for Ionic Compounds

- As ionic bonds are much stronger than intermolecular forces, the ΔH_{fus} values for ionic compounds are very large.
- The melting and boiling temperatures for ionic compounds are very high.



Heat of Vaporization (ΔH_{vap})

- ΔH_{vap} - the heat absorbed as 1 mole of a liquid becomes gaseous.
- Energy is required to completely overcome (sever) the IMFs as a molecule moves from the liquid to the gas phase.
- Vaporation is always endothermic, so ΔH_{vap} values are positive.
- Ideally, there are no IMFs between gas particles.

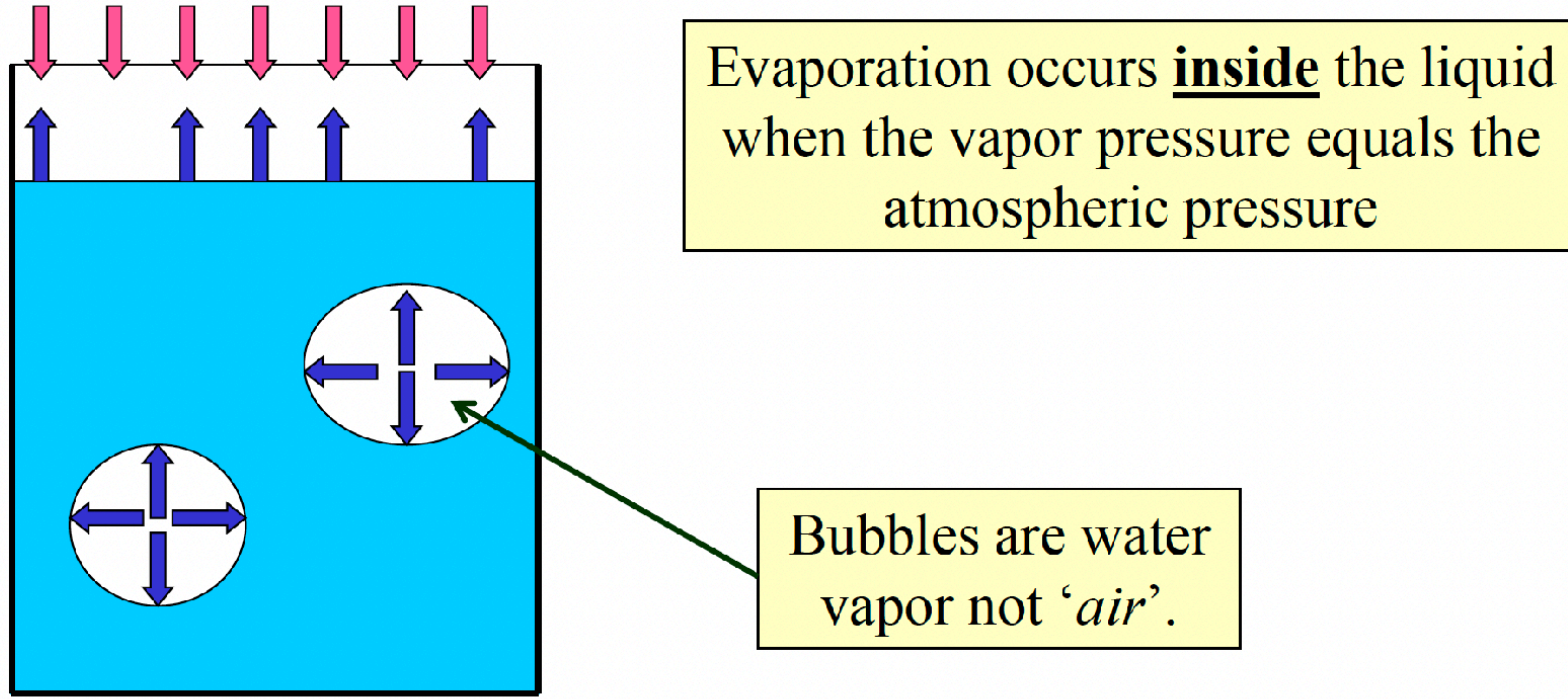


Vapor Pressure

- When molecules leave the surface of a liquid to enter the gas phase, they exert a pressure.
- The vapor pressure exerted depends on the rate of evaporation per unit area of the liquid’s surface.
- Rate of evaporation and vapor pressure increase as temperature increases.
- When two substances are at the same temperature, the rate of evaporation and vapor pressure will be higher in the substance that has weaker IMFs.

Boiling Points

- A liquid boils when its vapor pressure equals the atmospheric pressure.



Boiling Points of Water

Boiling points decrease as elevation increases.

Location	Elevation (meters)	Boiling Point (°C)
Sea Level	0	100
Boulder, Colorado	1655	94
Pa Paz, Bolivia	3600	87
Mt. Everest	8848	70

Boiling Points of Different Liquids

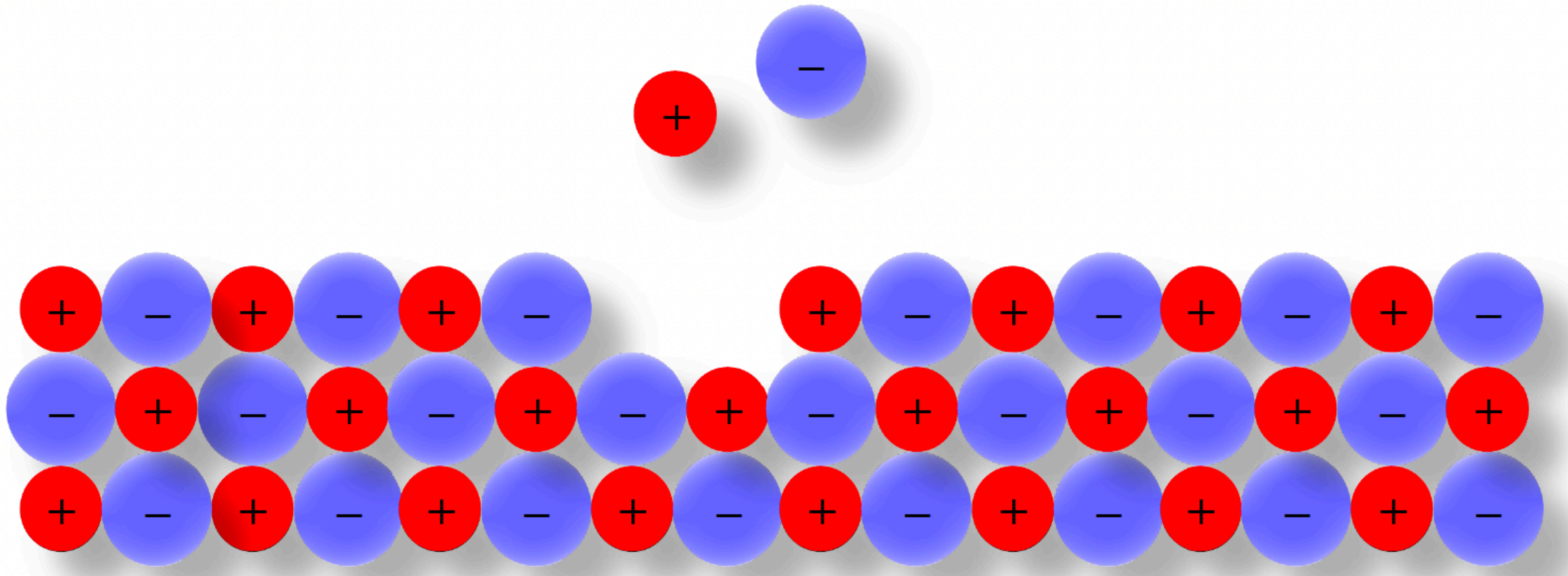
Liquid	IMFs	ΔH_{vap} (kJ/mol)	Boiling Point (°C)
Ar	Dispersion	6.3	-186
CH_4	Dispersion	9.2	-164
C_6H_6 (benzene)	Dispersion	31.0	80.1
H_2O	H-Bonds Dispersion	40.8	100.0

Sublimation

- Solids can evaporate and have a vapor pressure.
- As IMFs are strong in solids, the vapor pressures of solids are normally low.
- Solids with high vapor pressures, have relatively weak IMFs

Vapor Pressures of Ionic Solids

- Ionic compounds have very low vapor pressures and very high boiling points.
  - Strong Coulombic interactions between cations and anions.

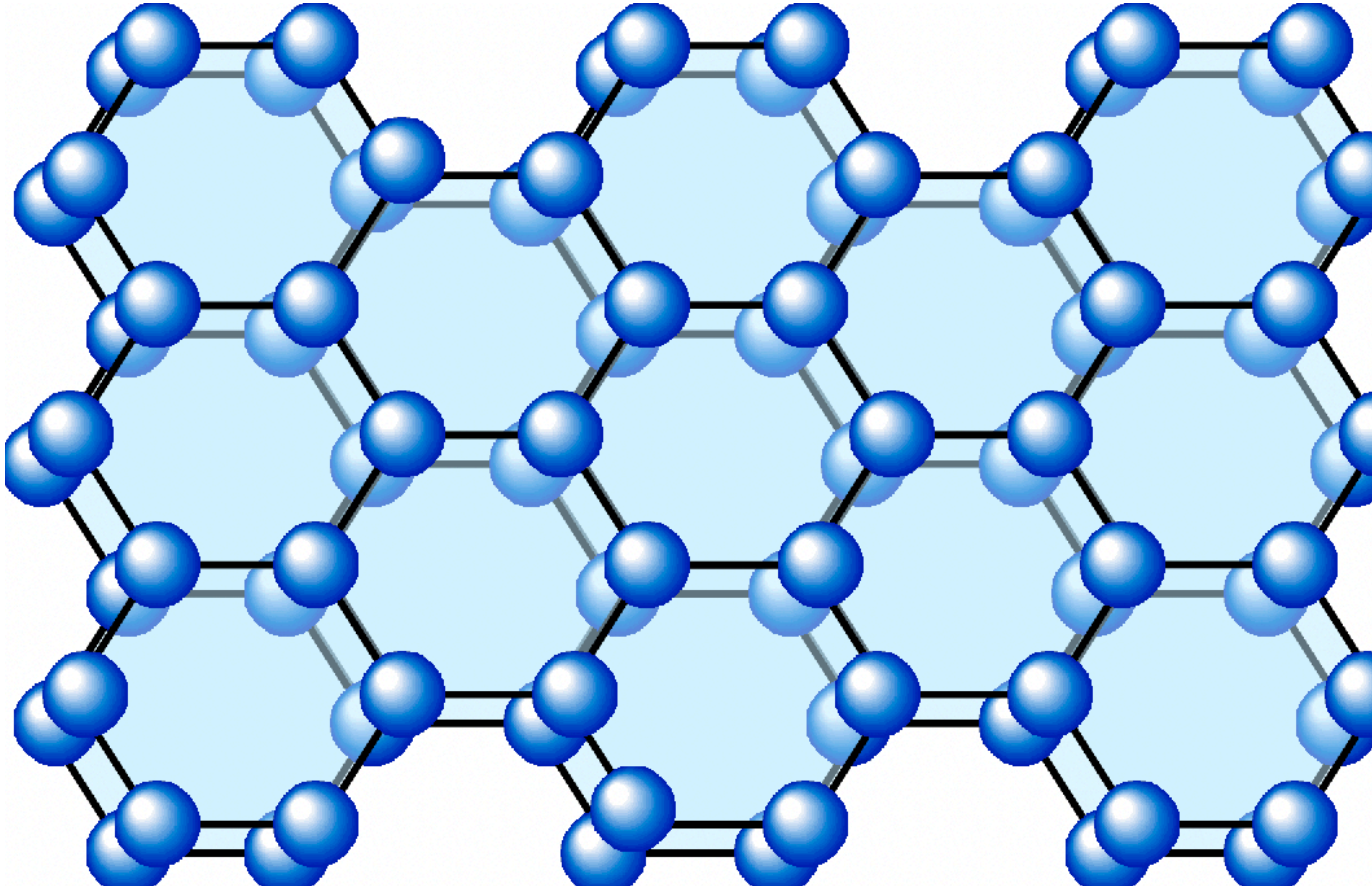


Covalent Network Solids

- Always composed of 1 or 2 nonmetals held together by networks of covalent bonds (i.e. carbon)
- Very high melting points with fixed bond angles.
    - **A diamond is one molecule**
        - many carbon atoms bound together with sp^3 hybrid orbitals.
        - Each carbon makes a single covalent bond with 4 other carbon atoms.
        - Very hard and very high melting point (3550°C)

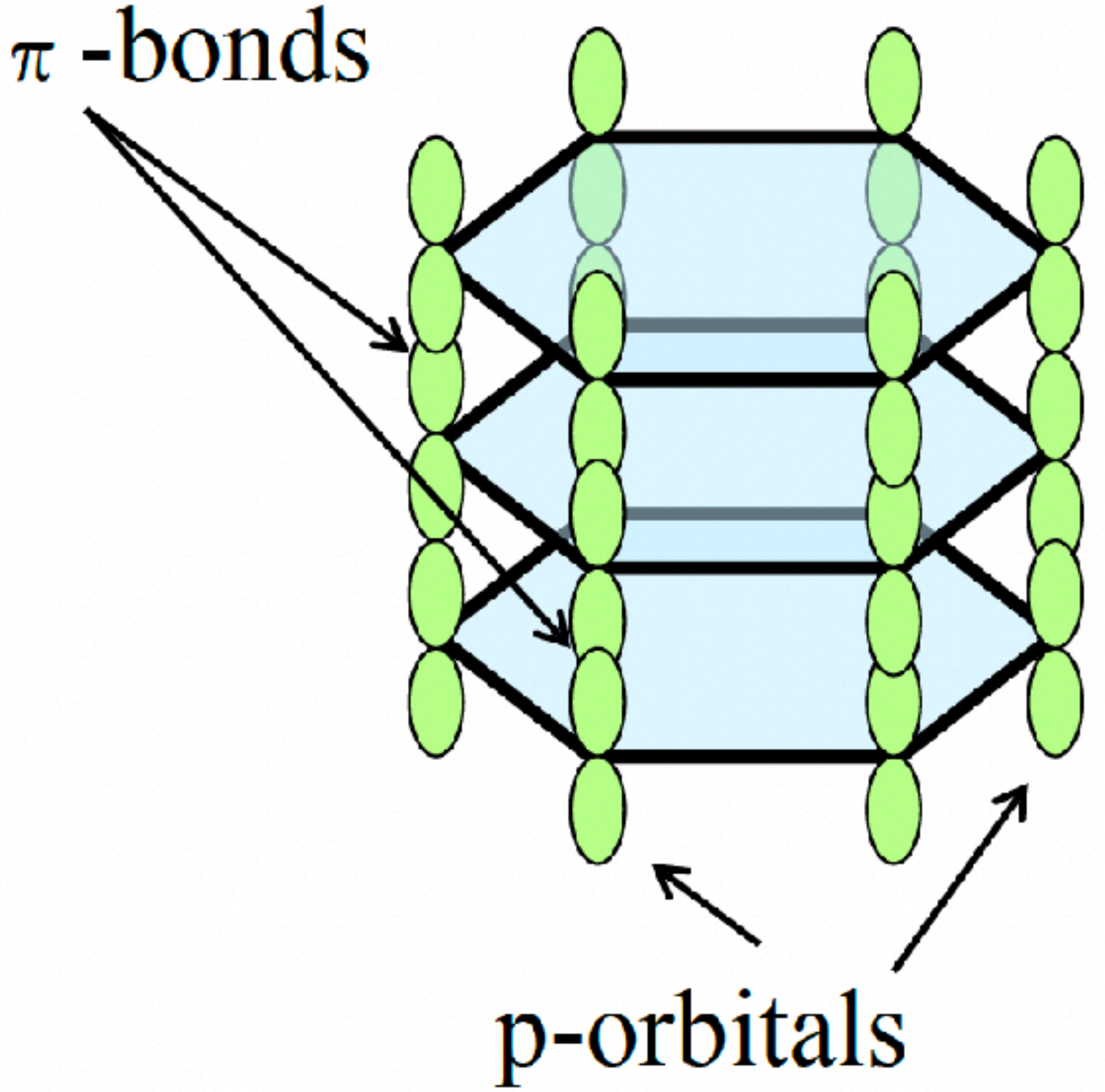
Covalent Network Solids

- **Graphite** - each carbons forms three sp^2 hybrid orbitals that bond with three other carbon atoms.
  - Sheets sit on top of one another (delocalized pi-bonds between sheets.



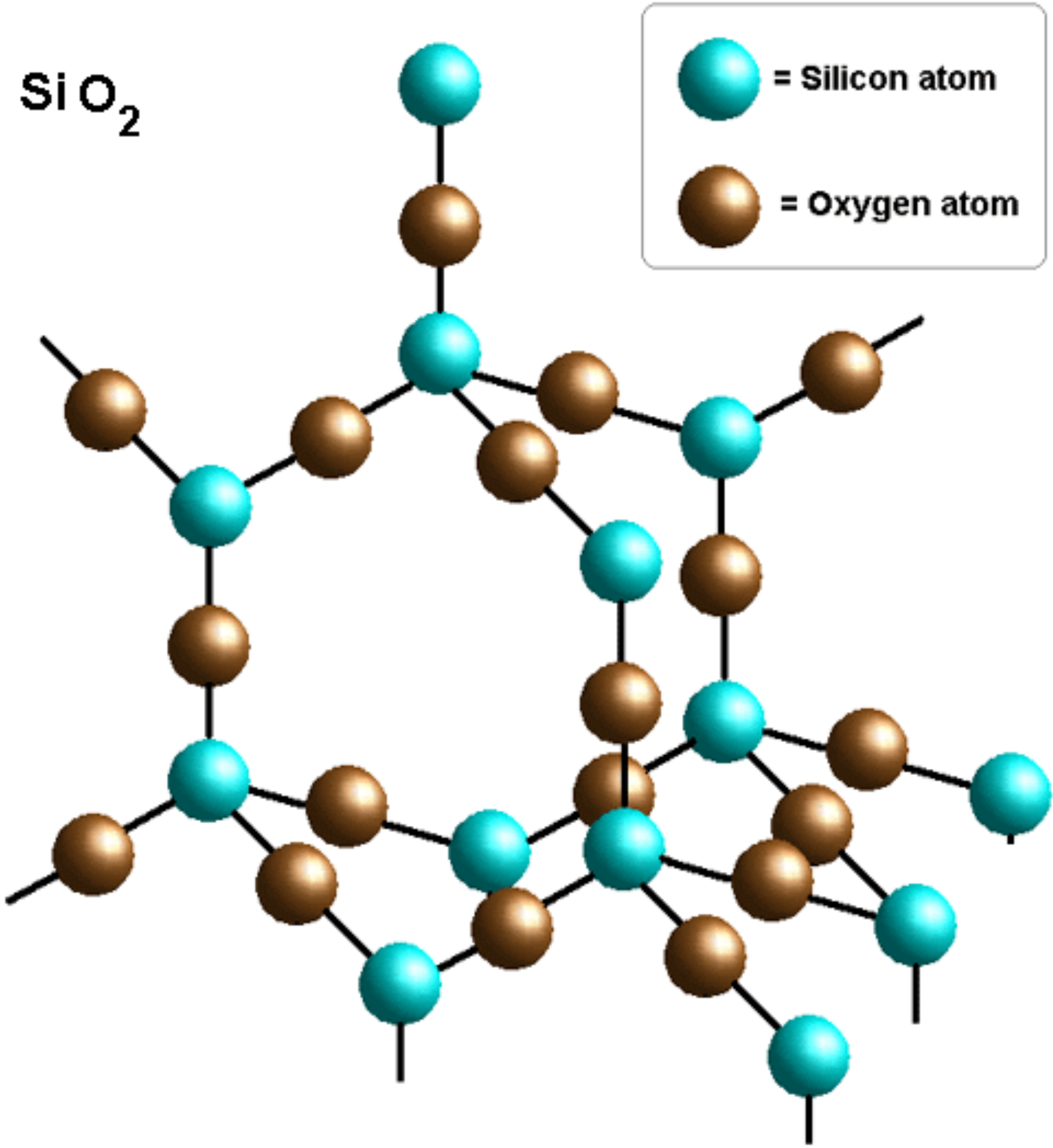
Covalent Network Solids

- **Graphite**
  - Weak pi-bonds and London Dispersion forces allow sheets to slide over one another (pencils)
  - If connected to a battery, electrons will flow.
  - High melting point.



Covalent Network Solids

- **SiO_2 (the empirical formula for Quartz)**
  - Covalent network of SiO_4 tetrahedra
  - Every silicon atom is covalently bonded to 4 oxygen atoms.
  - Every oxygen atom is covalently bonded to 2 silicon atoms.



3.3 Solids, Liquids & Gases

- Properties
- Pressure, Temperature & Kinetic Energy