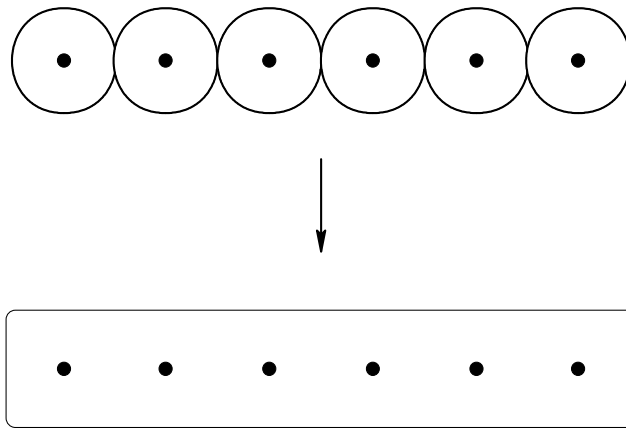


Types and Physical Properties of Solids

- ✓ Substances that are solids at room temperature usually fall into one of the following categories:
 - Metals
 - Ionic Solids
 - Molecular Solids
 - Network Solids
 - Amorphous Solids

Metals

- Highly conductive of heat and electricity.
- Orbitals of valence electrons on individual atoms combine to produce electron bands extending over the entire metal structure.



- Delocalization and mobility of electrons in such bands accounts for conductivity.
- The metal structure consists of an orderly array of nuclei in a sea of electrons.
- Metal structures are built up by close packing of spherical atoms.

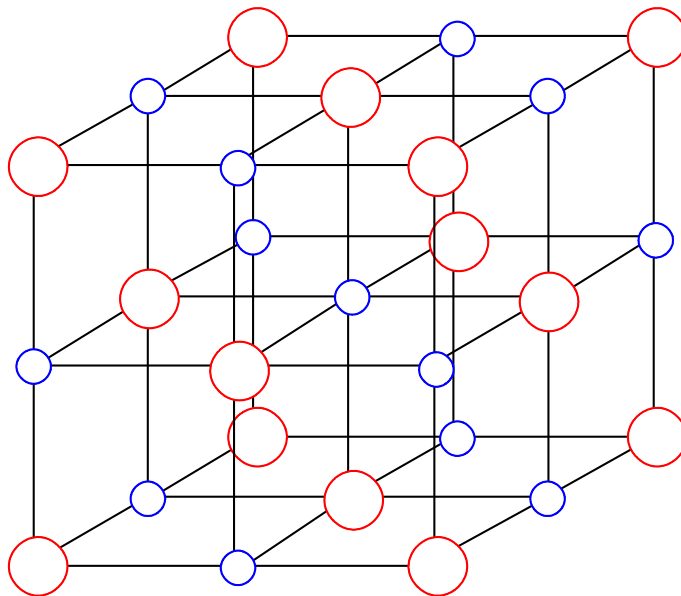
Physical Properties of Metals

- Metallic structure is typically stable over a wide range of temperatures.
- As the number of valence electrons increases, metallic bonding tends to be stronger, resulting in typically high m.p. and b.p.
 - Alkali metals, with only one ns^1 electron to contribute to bonding have unusually low m.p. and b.p.
 - Most metals have a long liquid range.
 - ⇒ Gallium has the longest liquid range of any known substance:
m.p. = 29.78 °C b.p. \approx 2400 °C

Metal	m.p. °C	b.p. °C	Metal	m.p. °C	b.p. °C
Li	180	1326	Be	1278	2970
Na	97.5	889	Mg	649	1090
K	63.4	757	Ca	839	1484
Rb	38.8	679	Sr	769	1384
Cs	28.7	690	Ba	725	1640

Ionic Compounds

- Non-conductive, hard, crystalline, solids, composed of electrically equivalent numbers of cations and anions in an orderly, three-dimensional crystal lattice.



Cl^-



Na^+

- Lattice energy increases with ion charge and decreases with ion separation.

Physical Properties of Ionic Compounds

- M.p. and b.p. tend to increase with lattice strength.
- Liquid ranges tend to be long, but somewhat shorter than for metals.

Compound	U° kJ·mol	m.p. °C	b.p. °C
NaCl	786.8	801	1413
NaBr	751.8	747	1390
NaI	703	661	1304
MgO	3795	2852	3600
CaO	3414	2614	2850

Molecular Compounds

- Held together by intermolecular forces: London dispersion, dipole-dipole, hydrogen bonding.
- M.p. and b.p. typically lower than other solids.
 - B.p. rarely above 400 °C.
- Relatively short liquid ranges.

Network Solids

- Network solids consist of infinite arrays of covalently bonded atoms. (No individual molecules.)
- Among the hardest substances known.
- Typically very high m.p. and b.p.
- Examples include both elements and compounds.

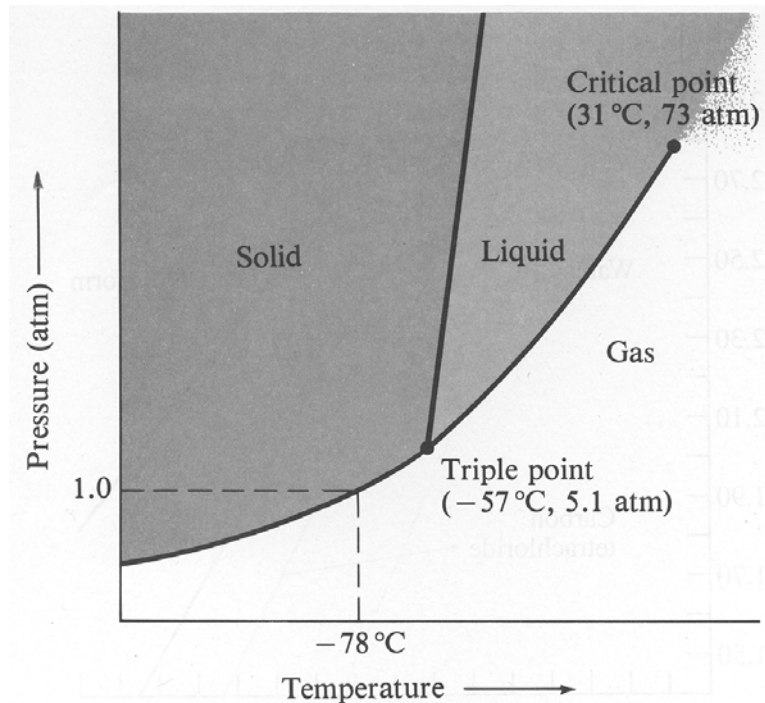
Solid	m.p. (°C)	b.p. (°C)
C (graphite)	>4000	>4200
C (diamond)	>4000	>4200
SiO ₂ (quartz)	1670	2230
SiC (silicon carbide)	>2700 (decomp.)	n/a

Amorphous Solids

- ⇒ Glass is the most familiar example of an amorphous solid, but many plastics such as polyethylene and nylon are also amorphous solids.
- ✓ Less ordered structures than crystalline solids.
- ✓ Have short-range order among near-neighbor units, but long-range order is lacking.
- ✓ Tend to break in unpredictable ways.
- ✓ Melting points tend to be similar but somewhat lower than more ordered substances of similar composition.

Phase Diagrams

Phase Diagram for CO₂



- ✓ Only one phase exists for any T - P combination entirely in a phase region.
- ✓ Lines represent T - P combinations where two phases are in equilibrium (phase transitions).
- ✓ The **triple point** is a T - P combination at which all three phases are simultaneously in equilibrium.
- ✓ Critical point is a T - P combination beyond which a gas cannot be liquified with increased pressure.