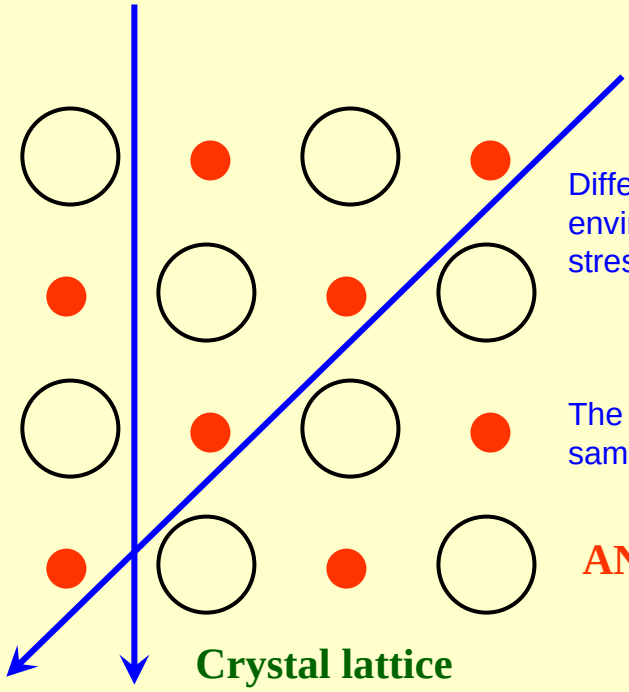
Zumdahl *Chapter 10*

Liquids and Solids

GASES	SOLIDS
• Fluid	• Dense
• Compressible	• Incompressible
• Have low density	• Anisotropic
• Completely fill container	
• Isotropic	



Different atomic environments of the stress vectors.

The response is not the same in all directions!

ANISOTROPY

REVEALING FACTS

$H_2O\ (s) \longrightarrow H_2O\ (l)$ $\quad \Delta H°_{fus} = +\ 6.02$ kJ/mol

$H_2O\ (l) \longrightarrow H_2O\ (g)$ $\quad \Delta H°_{vap} = +\ 40.7$ kJ/mol

GAS

$d_{H2O\ (g)} = 3.26 \times 10^{-4}$ g/cm^3 at 1.00 atm and 400°C

$= 0.157$ g/cm^3 at 242 atm and 400°C

Appreciable change

LIQUID

$d_{H2O\ (l)} = 0.997$ g/cm^3 at 1.00 atm and 25°C

$= 1.05$ g/cm^3 at 1065 atm and 25°C

Almost no change

Liquids and solids show many similarities: $d_{H2O\ (l)} = 0.9971$ g/cm^3; $d_{H2O\ (s)} = 0.9168$ g/cm^3

GENERALLY: **the volume of a solid increases by ~ 4% upon melting.**

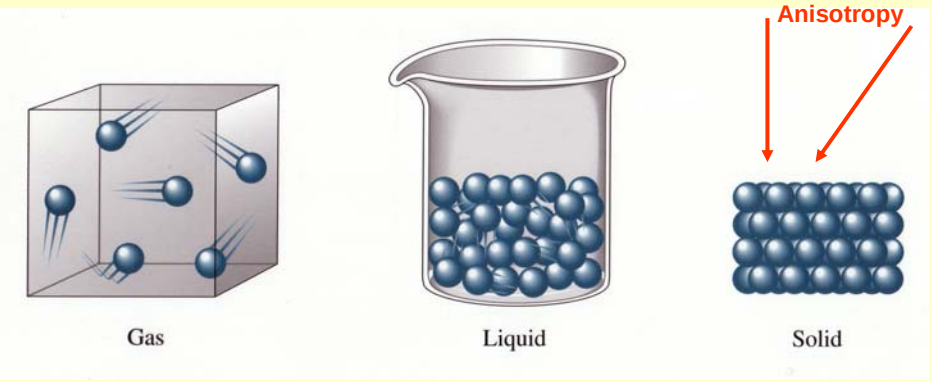
LIQUIDS

Like SOLIDS

- dense
- incompressible

Like GASES

- fluid
- isotropic



GASES

- Weak (or no) intermolecular forces
- Molecules are in constant random motion
- Chaos

LIQUIDS

INTERMEDIATE

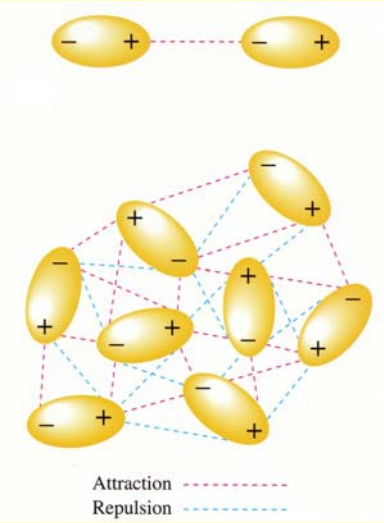
- Large holes between the partilces
- thermal motion
- ***But,*** a large extent of packing

SOLIDS

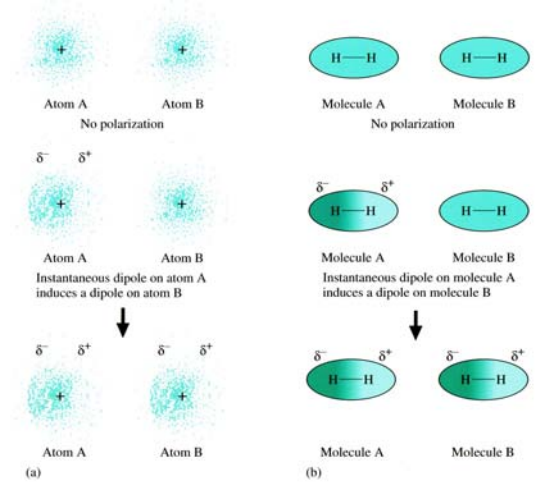
- Strong intermolecular forces
- Particles occupy well-defined locations in the ***crystal lattice***
- Complete order

1. Intermolecular forces

- Ion-ion
- Ion-dipole
- Dipole-dipole



Instantaneous dipole-Instantaneous dipole



2. Structure and types of solids

Broadest classification: { Crystalline solids
Amorphous solids

❖ **Crystalline solids**

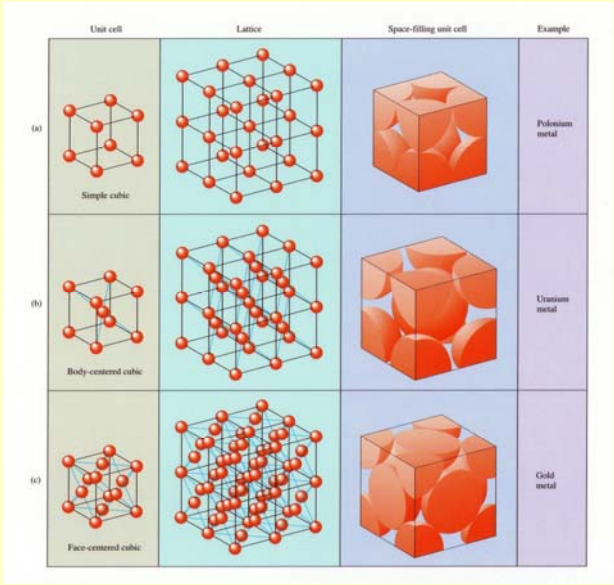
Under the microscope: crystals with characteristic shapes, well-defined faces an edges.

Particles: occupy well-defined positions in the crystal lattice ≡ a three-dimensional system of points in arrays, designating the positions of the particles.

Simple cubic:
1 particle/unit cell

Body-centered cubic:
2 particles/unit cell

Face-centered cubic:
4 particles/unit cell



Extended structure ≡ a series of repeating **unit cells** that share faces in the interior of the lattice.

❖ **Amorphous solids**

Intermediary between solids and liquids.
Examples: glass, rubber, plastics

Solids
Amorphous solids
Liquids
Real gases
Ideal Gases

Structure of solids is determined by **X-ray diffraction.**

Types of crystalline solids

➢ **Ionic solids:** entities are +ve*ly* and –ve*ly* charged **ions.**
Salts are ionic solids.

Working definition: *a solid that conducts the electric current when melted.*

➢ **Molecular solids:** entities are **molecules** (*examples:* sucrose, ice, organic solids…)

➢ **Atomic solids:** entities at the lattice points are **atoms.**

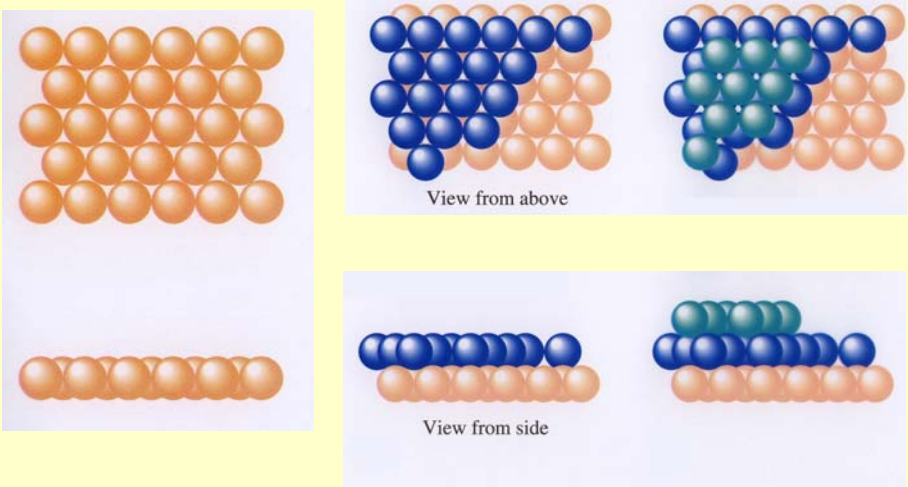
Examples: carbon (diamond, graphite and carbon nanotubes are ***network atomic solids***),
boron, silicon and **all** metals.
The *fullerenes* (C_{60}) are ***molecular*** solids.

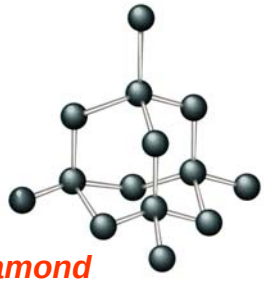
Subgroups of Atomic Solids

Metallic	Network	Group 8A
Delocalized, nondirectional covalent bonding Close packing	Strongly directional covalent bonds that lead to giant molecules	Atoms attracted by *London dispersion forces.*

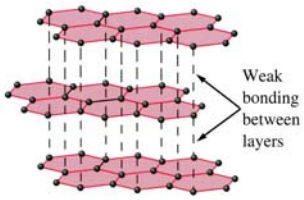
See Table 10.3 for a summary.
See Table 10.7 for a more comprehensive summary.

Metals: layers of atoms in a closed packed arrangement

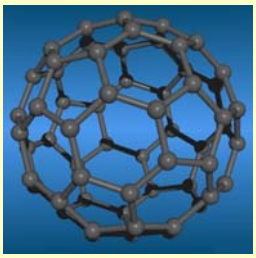




Diamond

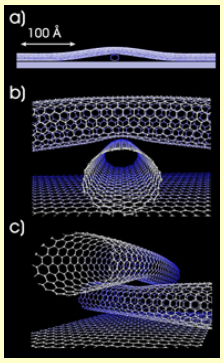


Graphite



Fullerene C_{60}

See Chemical impact boxes pp. 66 and 84.



Carbon nanotubes