Intermolecular Forces:

1. Dipole-Dipole Forces: Attractive forces occuring in polar molecules. Don't exist in nonpolar molecules.

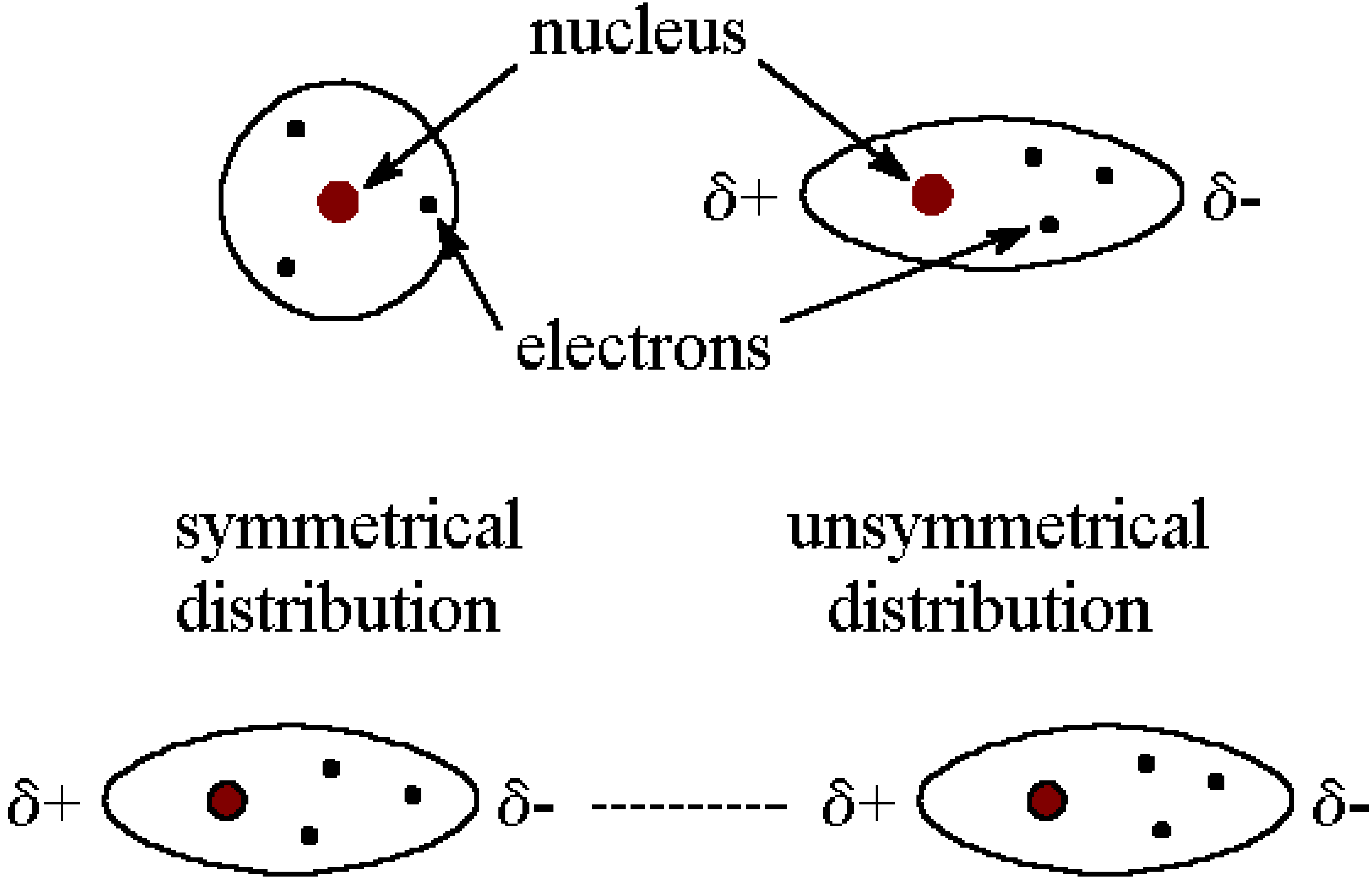
Ex: H-F

Substance	Dipole Moment(D)	Boiling Point(°C)
C_3H_8	0.1	-42
C_2H_6O	1.9	-25
CH_3CN	3.9	82

Intermolecular Forces cont…:

2. Dispersion Forces(London Forces): Attractive forces occuring in nonpolar and polar molecules. Movement of electrons results in a temporary and instantaneous dipole.

Ex: Ar, He, CH_4


nucleus
δ+
δ-
electrons
symmetrical distribution
unsymmetrical distribution
δ+
δ-
δ+
δ-

London Forces increase as the number of electrons and thus the size of the molecule increases.

Substance	Melting Point(°C)
CH_4(smallest)	-182.5
CF_4	-150.0
CCl_4	-23.0
CBr_4	+90.0
CI_4(largest)	+171.0

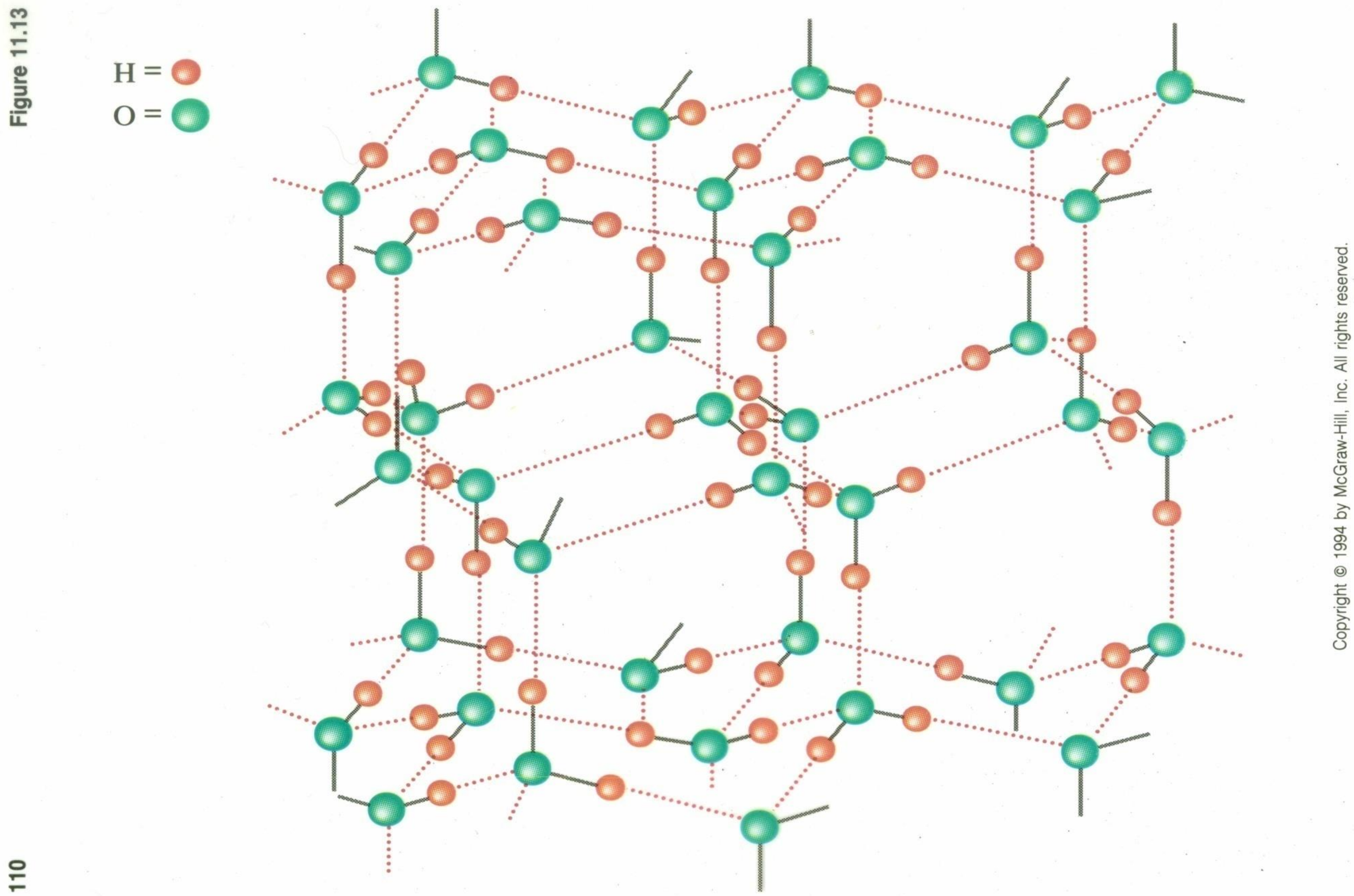
Intermolecular Forces cont…:

As molecule gets bigger(more electrons), London Forces get stronger and more energy needed to separate molecules.

3. Hydrogen Bonding: Attractive force occuring in molecules containing hydrogen atoms directly bonded to a small electronegative atom(N,O, F).

Ex: HF, H_2O

Hydrogen Bonding in Water:



Changes in Physical State:

Phase change is the transformation from one homogeneous phase to another.

Matter exists in three distinct phases (gas, liquid, and solid).

Phases of Matter:

Solids: Molecules, atoms, or ions rigidly held in place and occupying a specific volume.

Liquids: Molecules, atoms, or ions occupy a given volume but not rigidly held in place.

Gases: Molecules, atoms, or ions not held together. Volume varies.

Liquid to Gas – Evaporation:

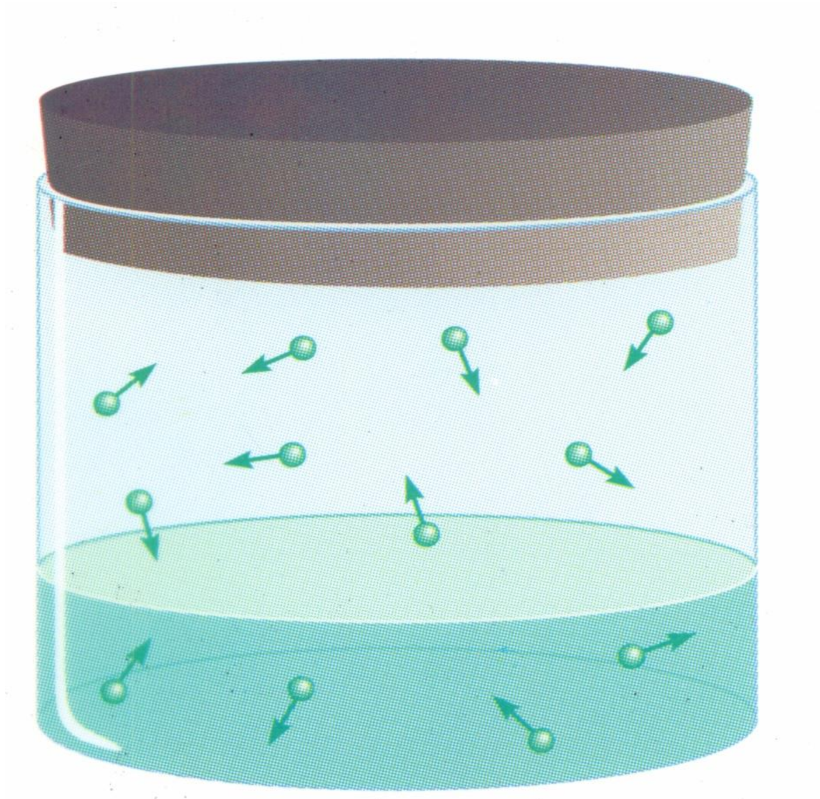
$H_2O(l) \rightarrow H_2O(g)$ ΔH_{vap} = 43.8 kJ/mole at 25°C

ΔH_{vap}: enthalpy of vaporization. The energy required to vaporize one mole of a liquid.

Vapor Pressure:

<u>Vapor Pressure</u>: The pressure of a vapor in equilibrium with its liquid at a given temperature.

$$H_2O(l) \rightleftharpoons H_2O(g)$$



Boiling Point: The temperature at which the vapor pressure of a liquid equals the atmospheric pressure.

normal Boiling Point: The boiling point of a liquid at 1 atmosphere.

Boiling point decreases with external pressure.

Solid to Liquid:

$H_2O(s) \rightarrow H_2O(l)$ ΔH_{fus}= 6.02 kJ/mole

ΔH_{fus}: enthalpy of fusion. The energy required to melt one mole of a solid.

Ex:

How much heat is required to melt 30 kg of ice?

normal Melting or Freezing Point: The temperature at which solid and liquid are in equilibrium at 1 atm.

Solid to Gas:

$$\text{Solid} \rightarrow \text{Gas} \qquad \Delta H_{sub}$$

ΔH_{sub}: enthalpy of sublimation. The energy required to sublime one mole of a solid.

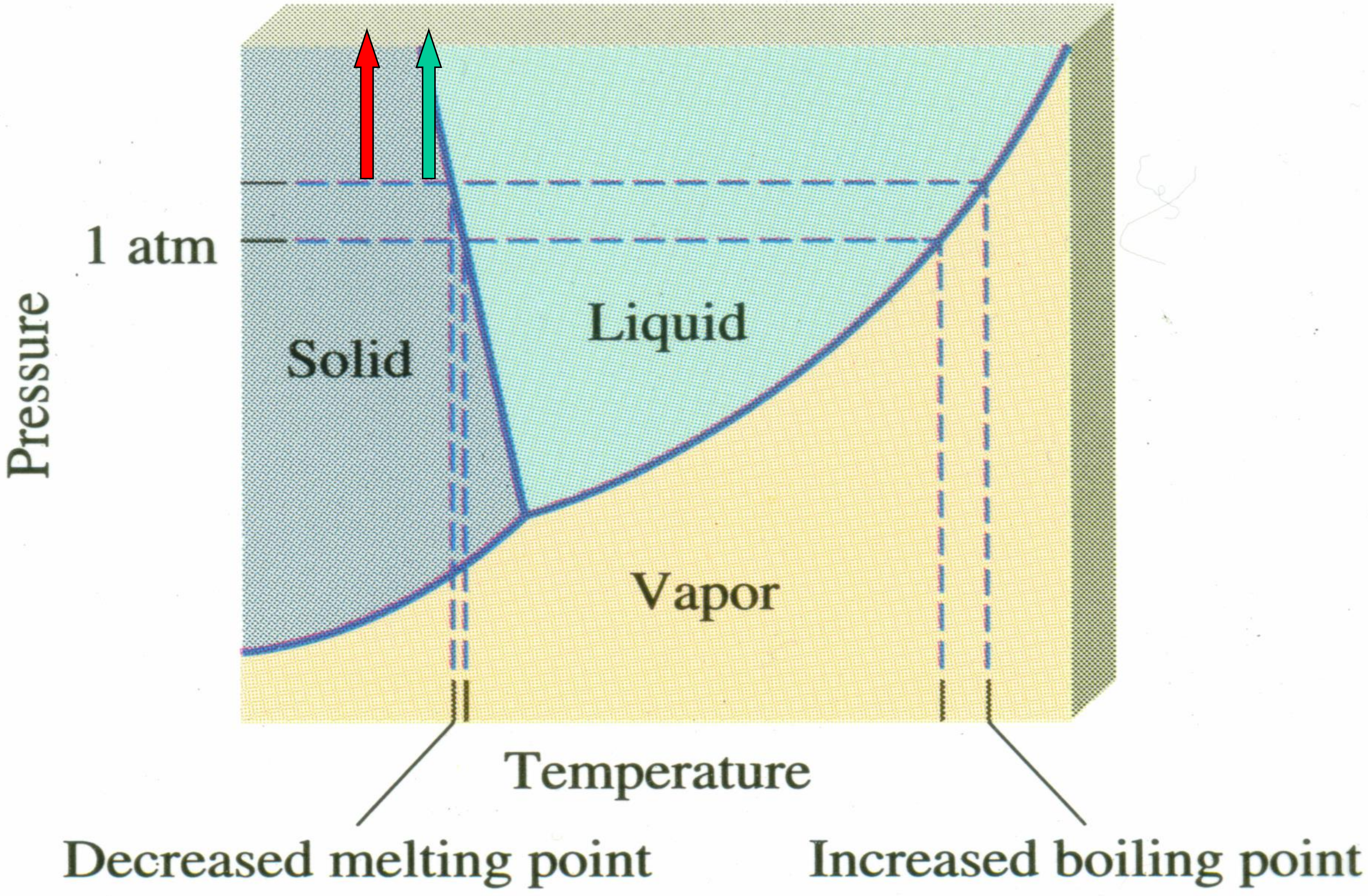
$$\Delta H_{sub} = \Delta H_{fus} + \Delta H_{vap}$$

Phase Diagrams:

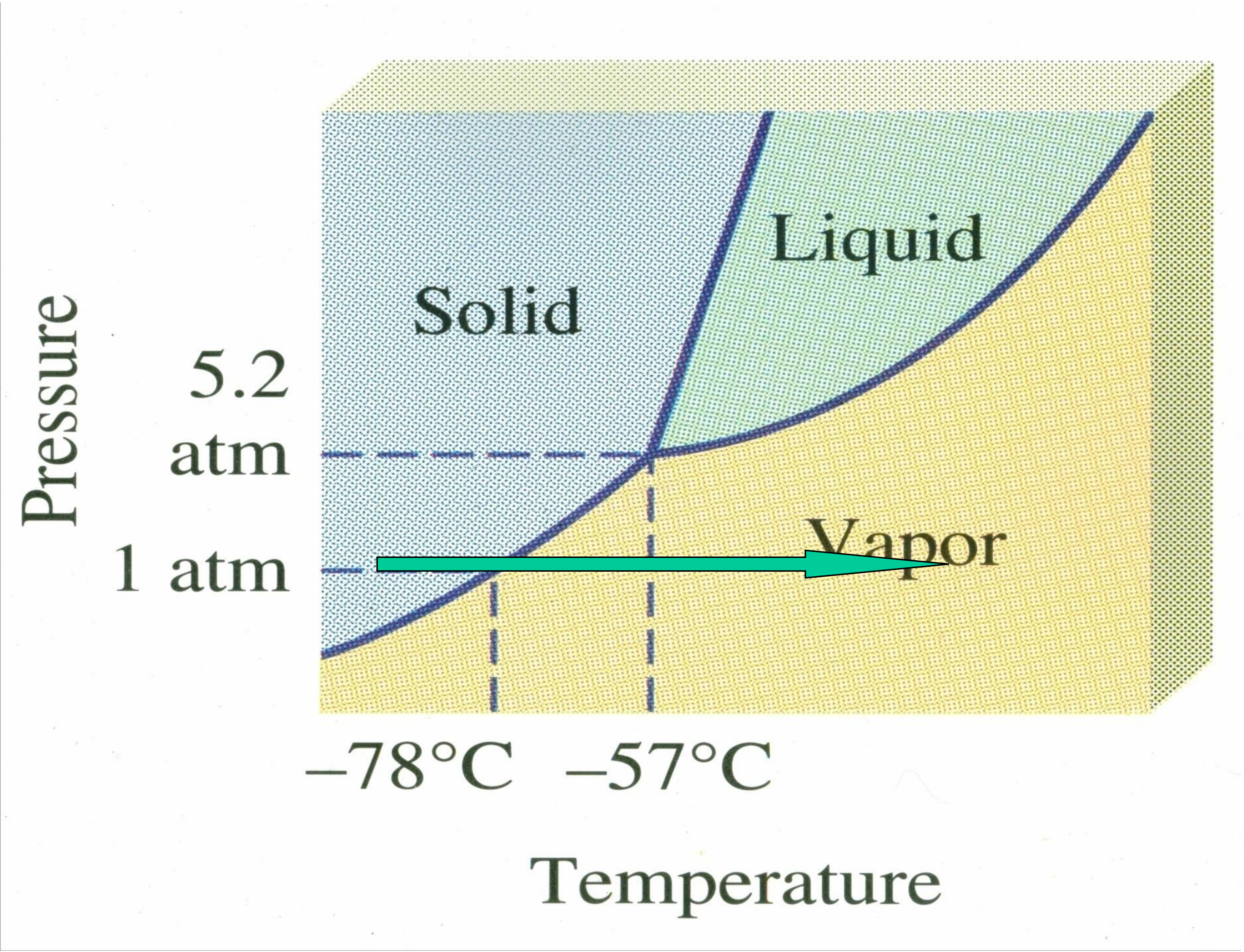
A phase diagram graphically illustrates all the conditions under which all the various phases of a substance can exist.

TP: triple point. Pressure and temperature at which all 3 phases are observed.
CP: critical point. The point beyond which a substance can not be condensed into a liquid.
MP: Normal melting point. Temperature at which solid-liquid are in equilibrium at 1 atm.
BP: Normal boiling point. Temperature at which liquid-gas are in equilibrium at 1 atm.

Phase Diagram for Water:



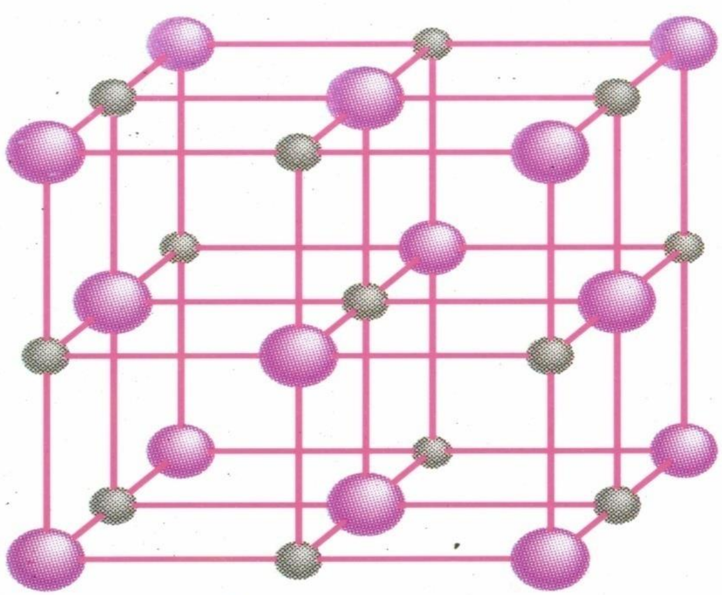
Phase Diagram of Carbon Dioxide:

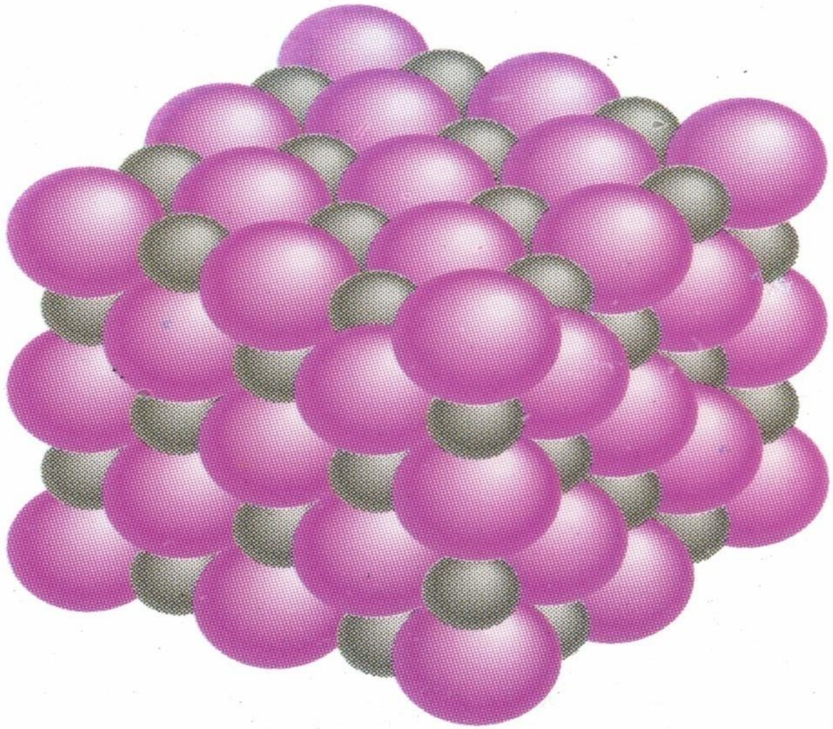


Unit Cells:

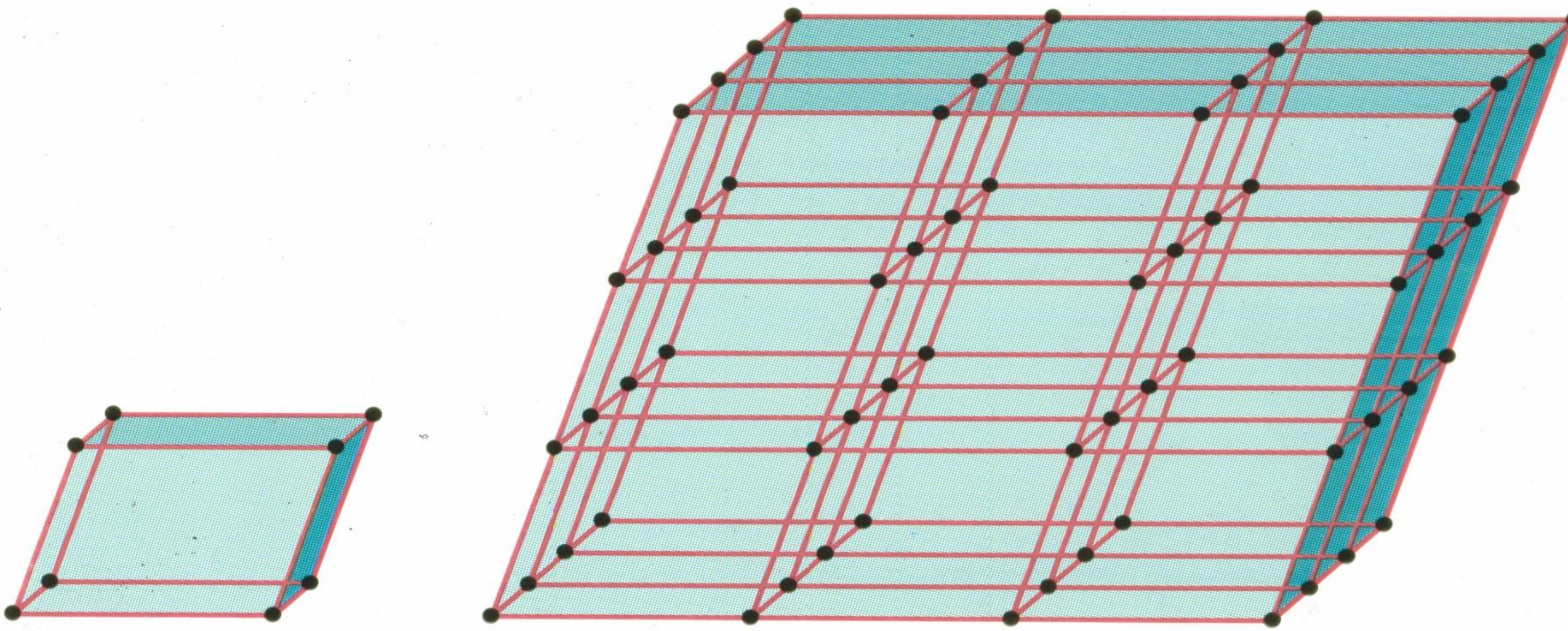
Repeating pattern of atoms and/or ions in a crystal.

Sodium chloride has a repeating pattern of Na^+ and Cl^- ions.





Unit Cells cont…



(a) (b)

Figure 11.15

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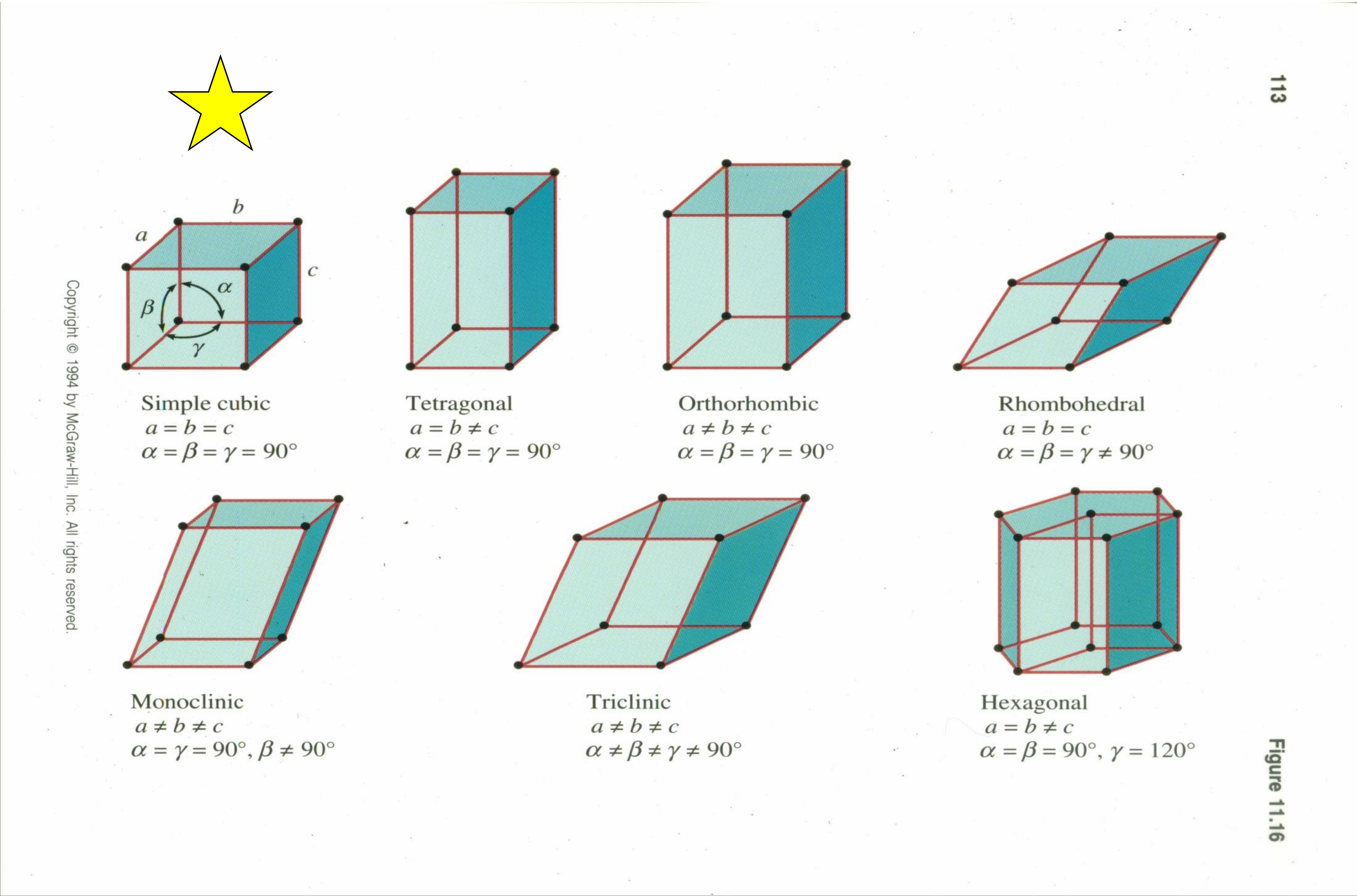
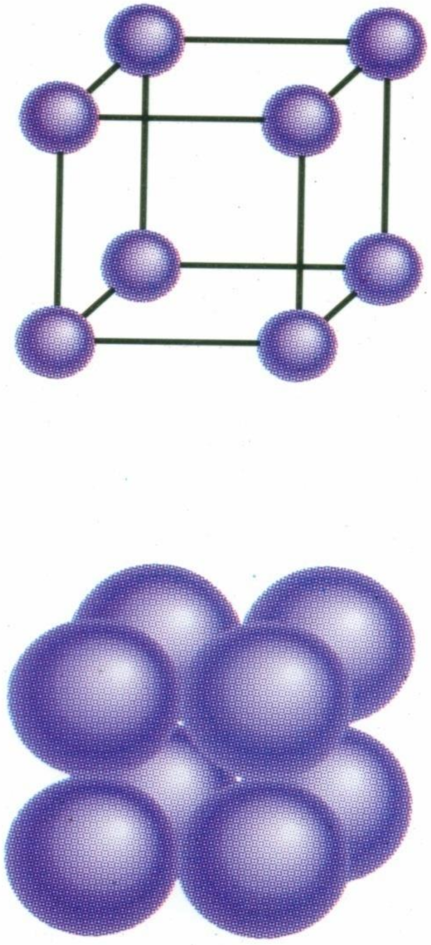
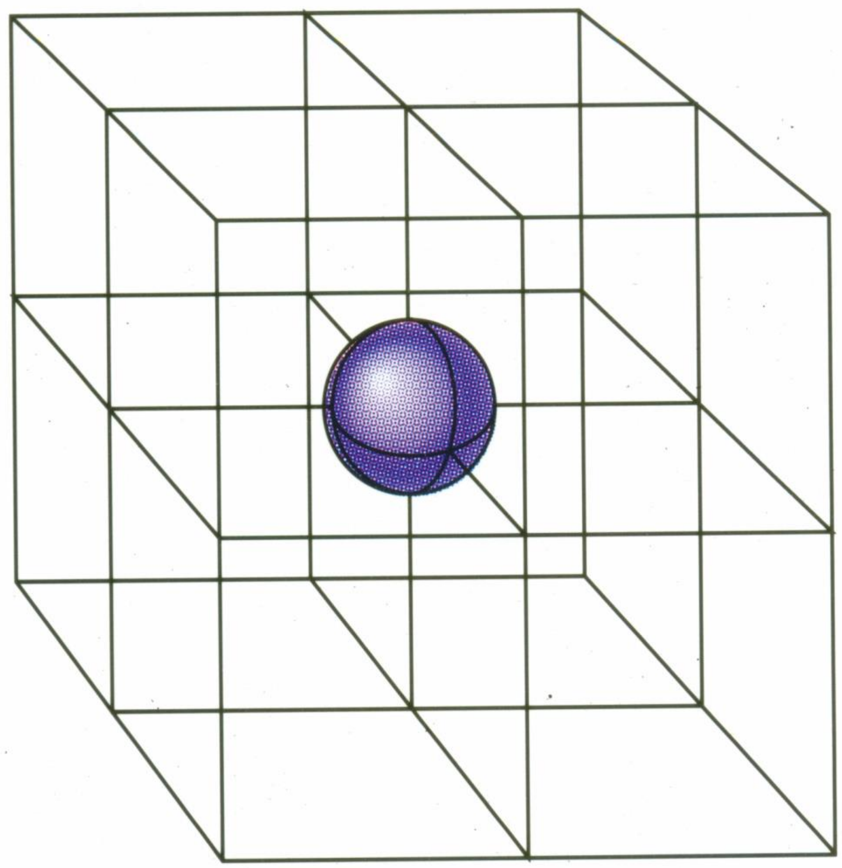
Types of Unit Cells:



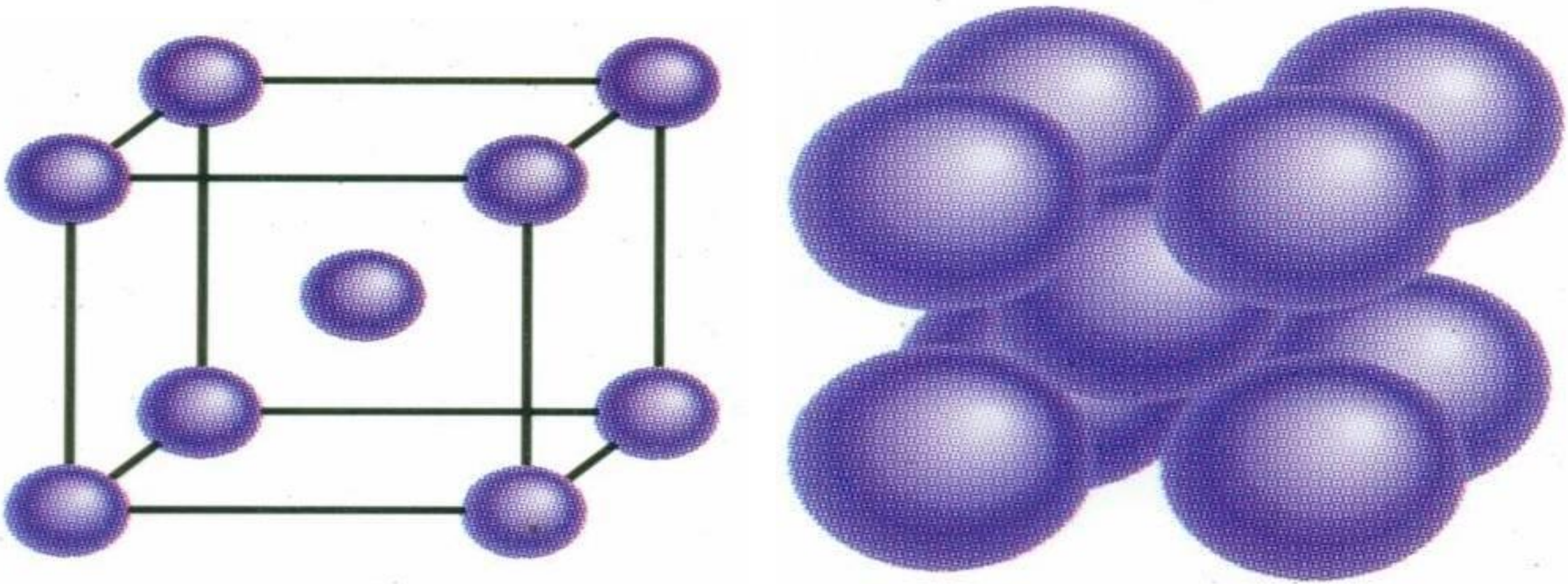
Simple Unit Cell:



Simple cubic

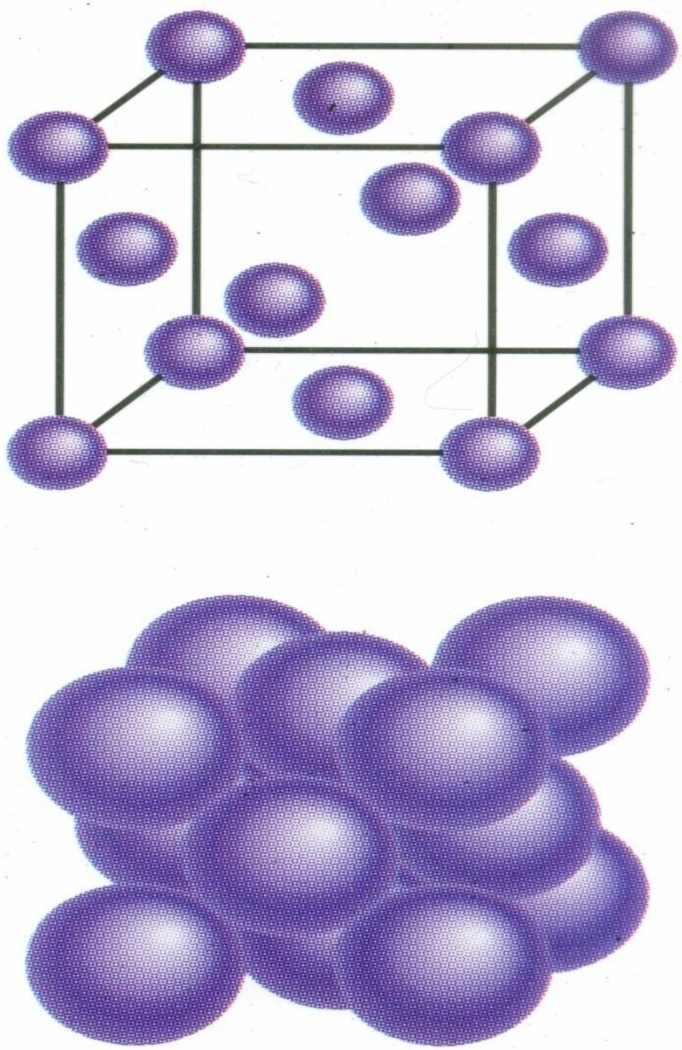


Body-Centered Unit Cell:

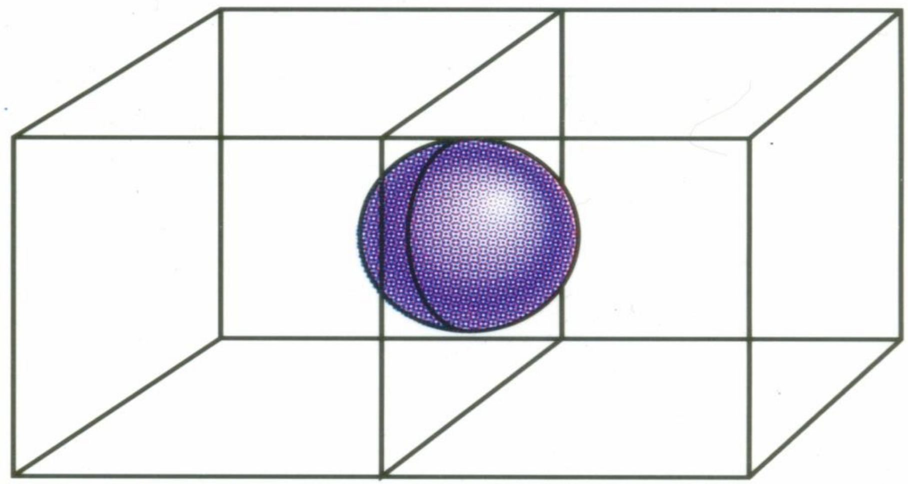


Body–centered cubic

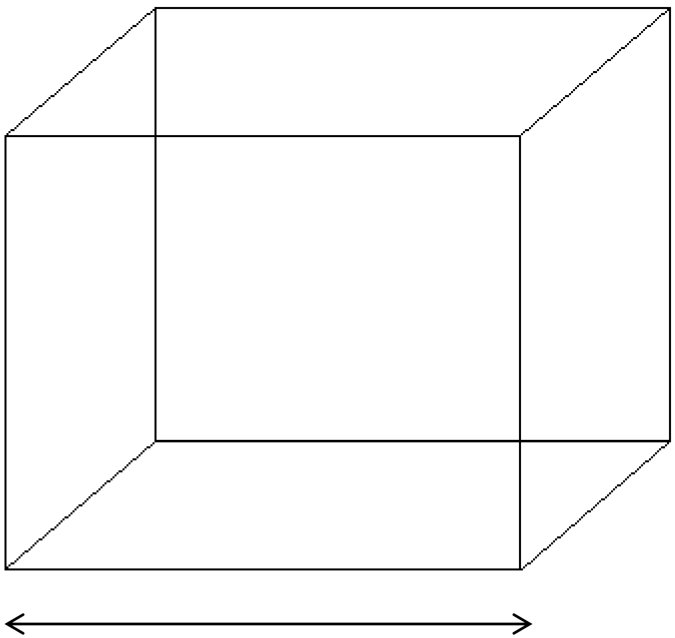
Face-Centered Unit Cell:



Face–centered cubic



Unit Cell Calculations:



length

Volume = $(\text{length})^3$

length → volume

\# atoms → mol atoms → g atoms

} Density g/volume