12.

3 topics to consider

1. forces in solids & liquids
2. properties
3. phase diagrams

Liquids

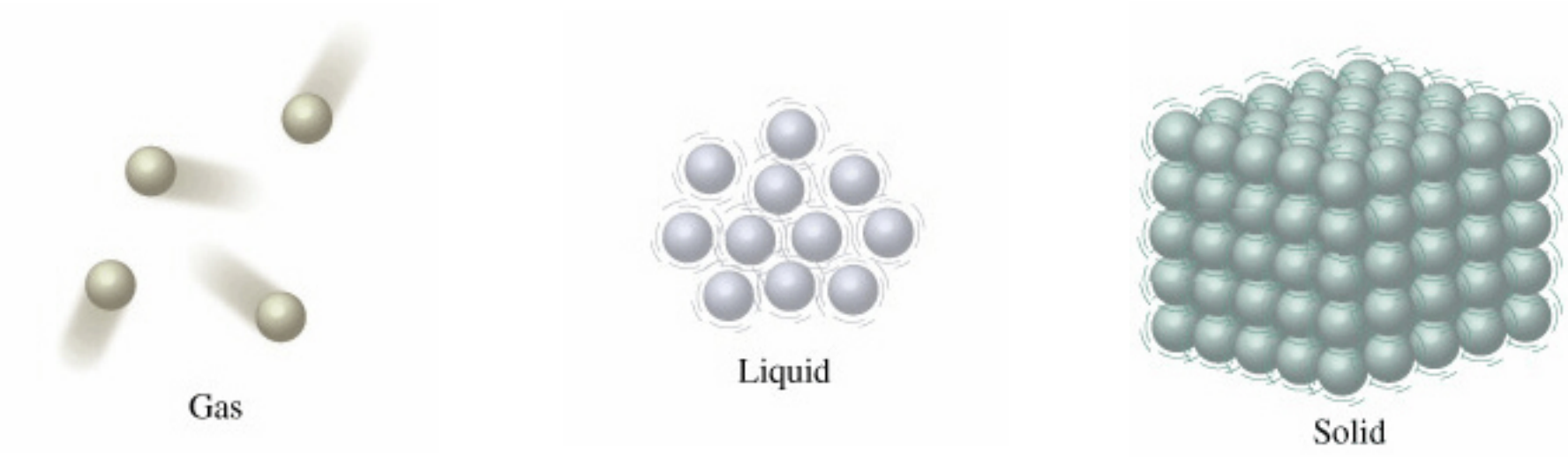
1. What forces hold solids and liquids together?

Liquids

GENERAL PROPERTIES

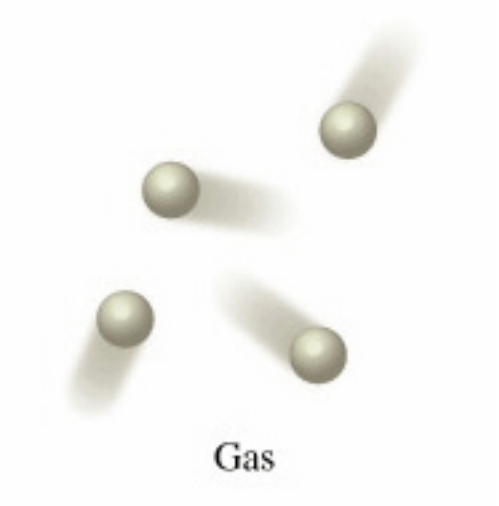
Distance between particles

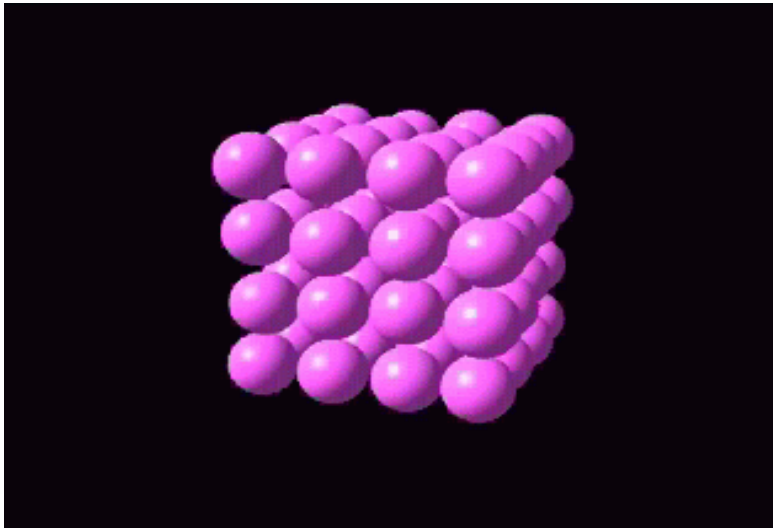
Liquids



g 6 l by 8 P or 9T
l 6 s by further 9T

Liquids





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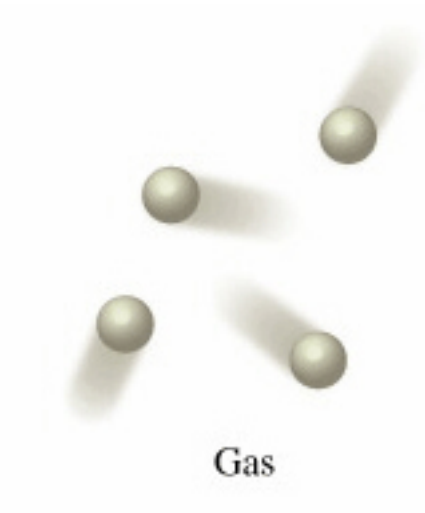
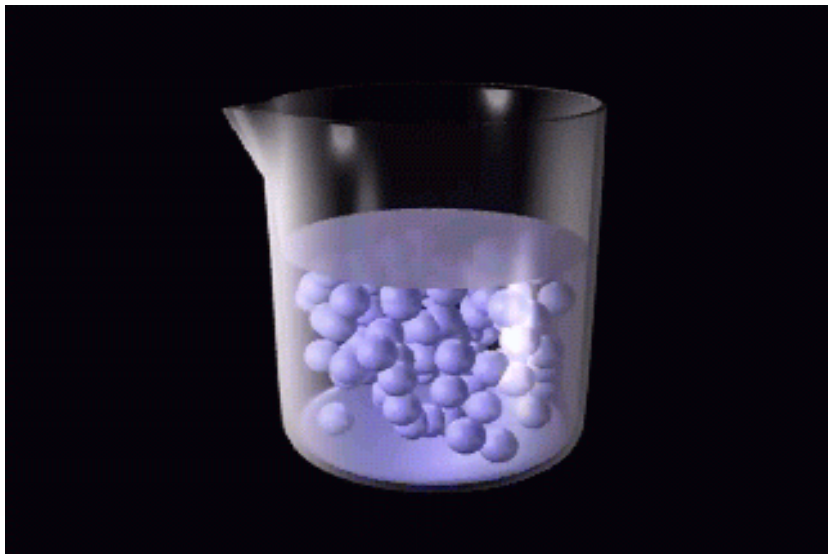
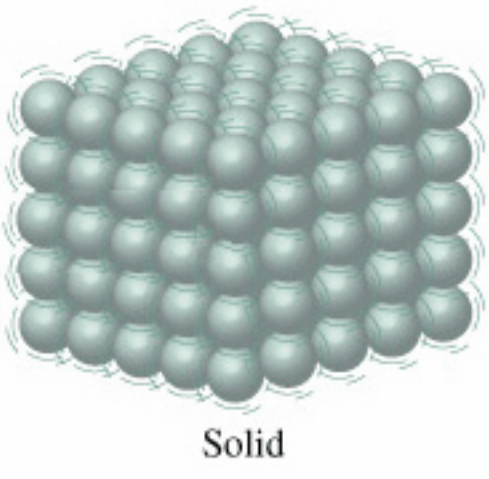
Liquids







g 6 l by 8 P or 9T
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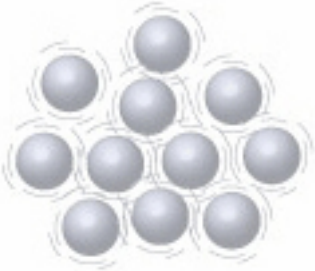
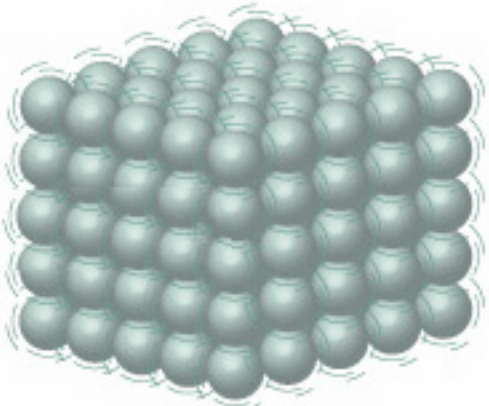
Liquids



Liquid

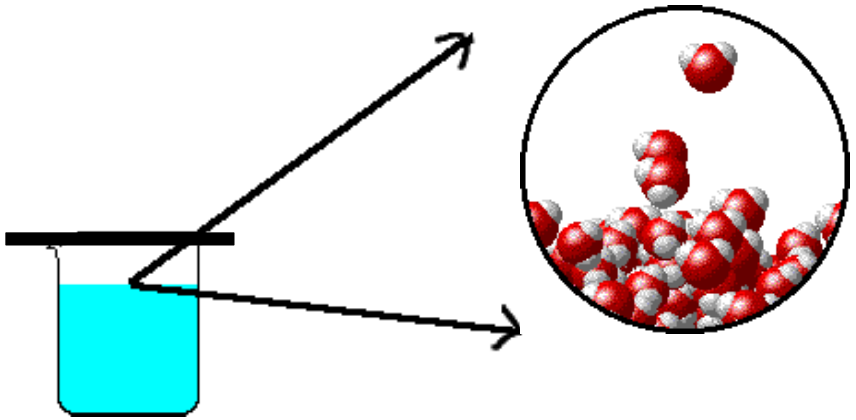


Solid

g 6 l by 8 P or 9T
l 6 s by further 9T

Liquids

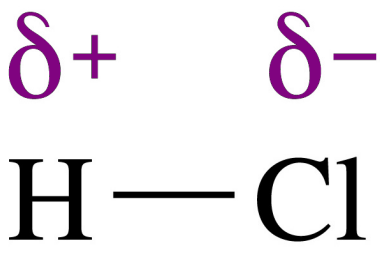
Intermolecular forces
hold molecules together



Liquids

4 types of intermolecular forces

1. Dipole-dipole forces due to EN differences found in polar molecules



Liquids

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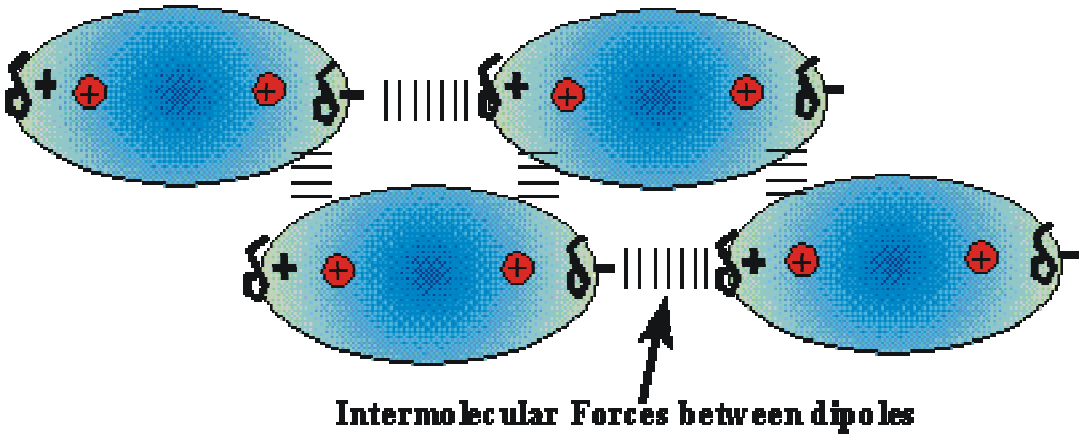


Liquids

4 types of intermolecular forces

1. **Dipole-dipole forces due to EN differences found in polar molecules**

Liquids

4 types of intermolecular forces

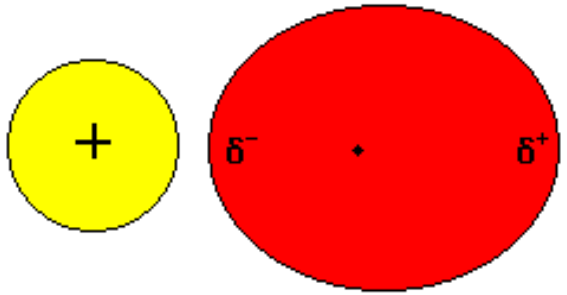
2. Ion-dipole forces between polar molecules and ions

Na^+ ------ H_2O

Liquids

4 types of intermolecular forces

2. Ion-dipole forces between polar molecules and ions



Liquids

4 types of intermolecular forces

3. Dispersion forces
- induced temporary dipoles

Between ions and nonpolar molecules

Between nonpolar and nonpolar molecules

Liquids

4 types of intermolecular forces

3. Dispersion forces
- induced temporary dipoles

Collectively call 1 and 3 *Van der Waals* forces

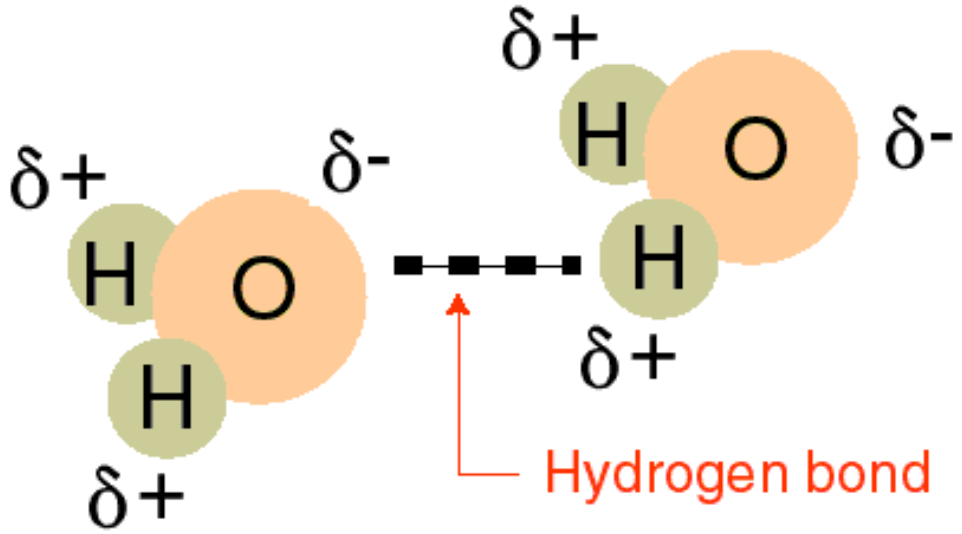
Between ions and nonpolar molecules

Between nonpolar and nonpolar molecules

Liquids

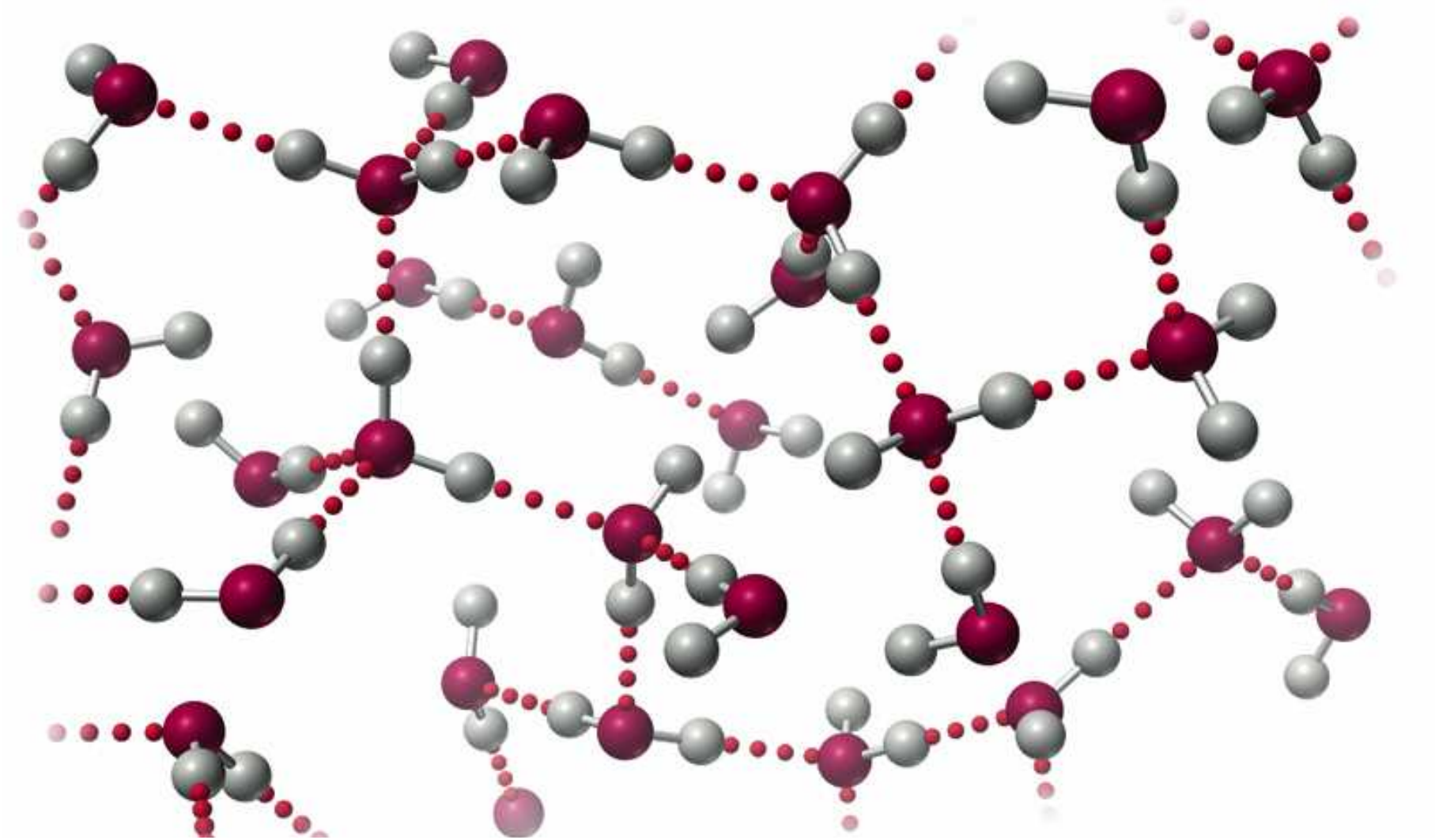
4 types of intermolecular forces

4. Hydrogen bonds
strong dipole-dipole forces



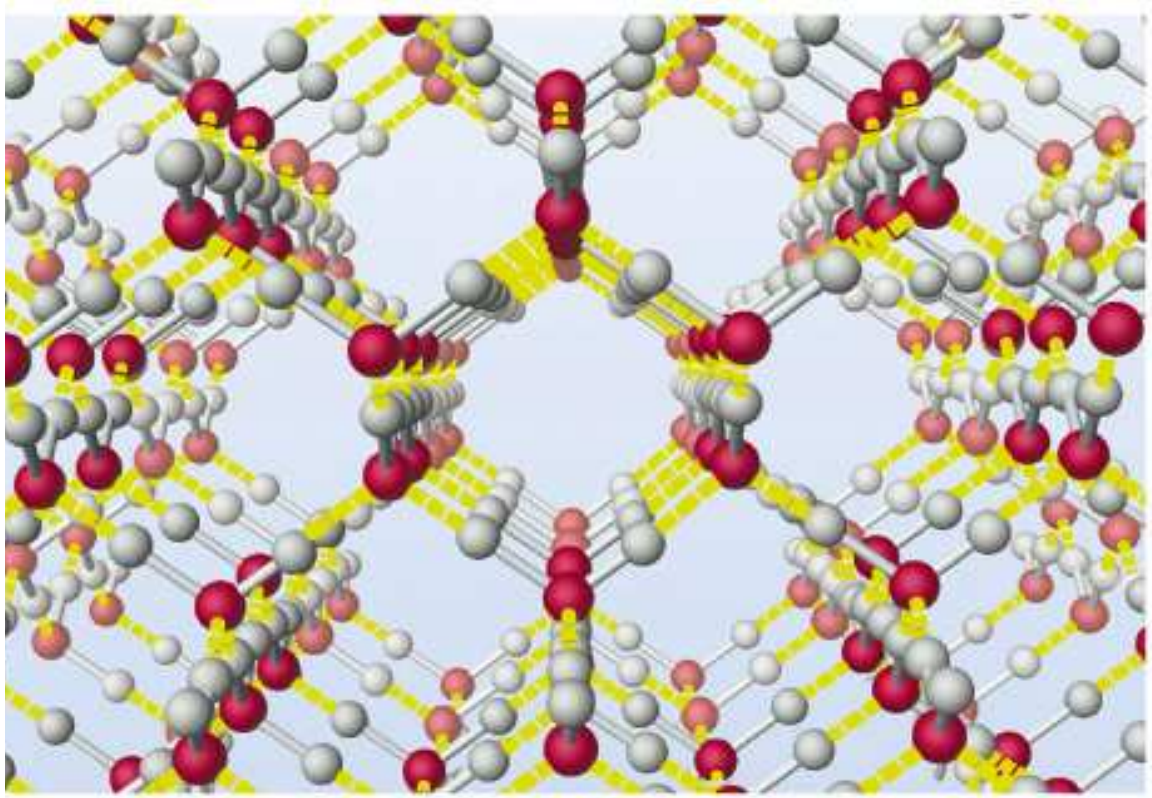
Liquids

Hydrogen bonds in water



Liquids

Hydrogen bonds in ice

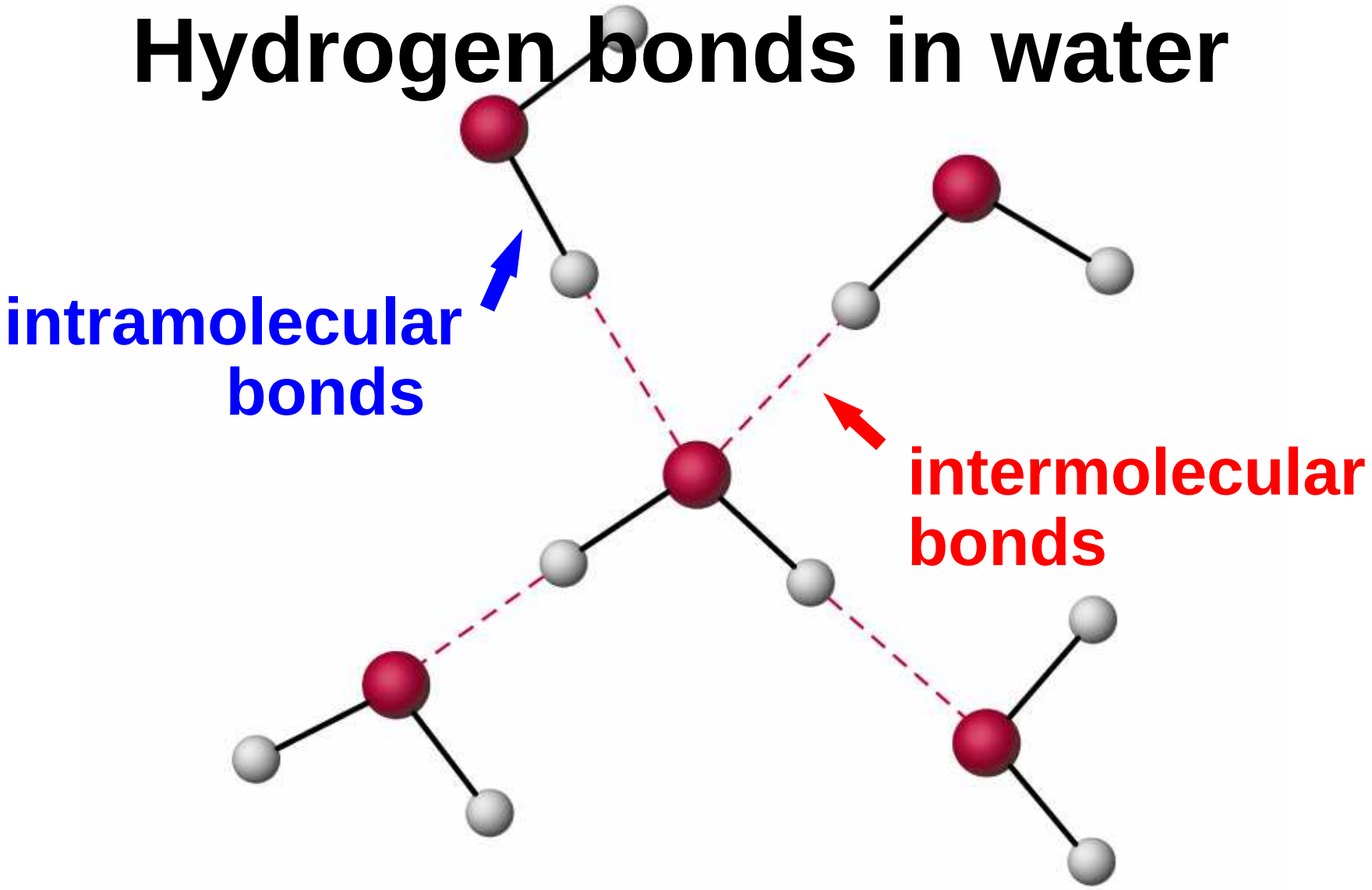


(a)

(b)

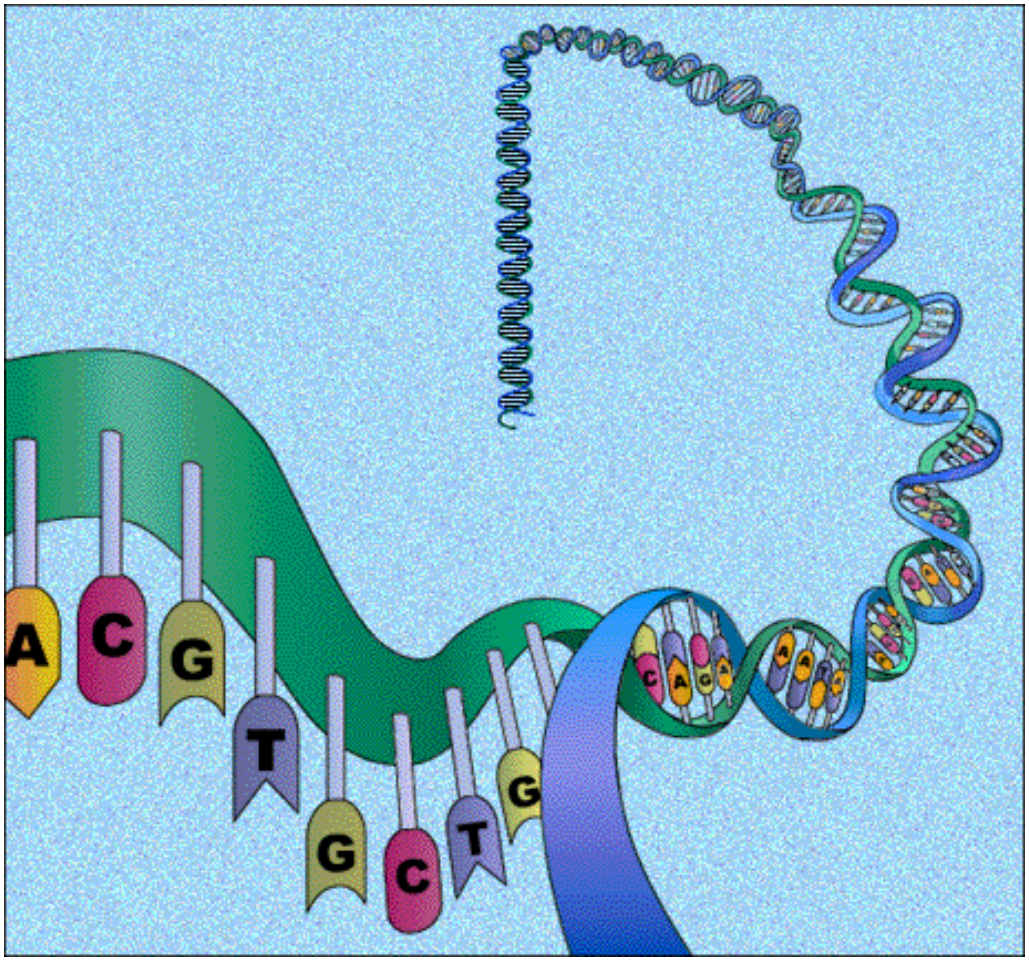
Liquids

Hydrogen bonds in water



Liquids

Hydrogen bonds DNA



Liquids & Solids

2. Properties of solids and liquids?

Compared to solids, liquids are free to move around at random, but still touch

Since the particles are still close, liquids have densities similar to solids

Since the particles can move, liquids take on the shape of the container they are in

The forces that hold a liquid together result in several properties .....

Viscosity resistance to flow

Surface Tension attraction of molecules at a surface

Vapor Pressure ability for molecules to escape from the surface of a liquid

Boiling Point when vapor pressure equals atmospheric pressure

PROPERTIES

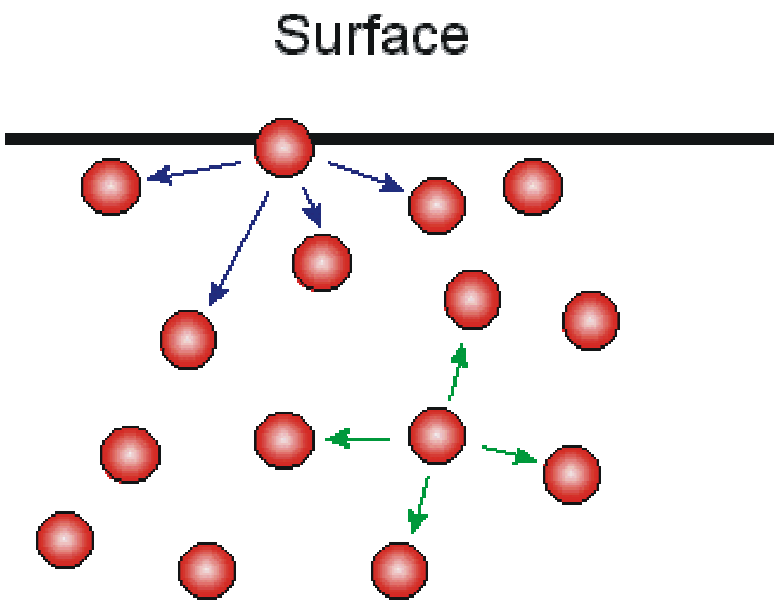
Viscosity resistance to flow

More intermolecular bonds
6 high viscosity

PROPERTIES

Surface tension

measures elastic force in surface of a liquid



PROPERTIES

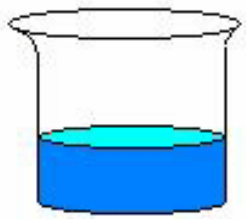
Vapor Pressure

pressure of a vapor over a liquid

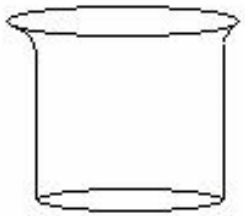
l 6 g vaporization (evaporation)
g 6 l condensation

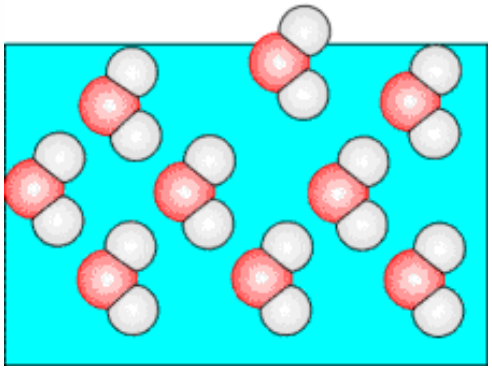
In closed container: equilibrium

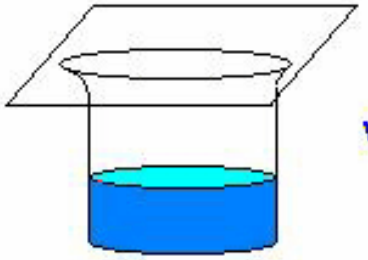
Liquids



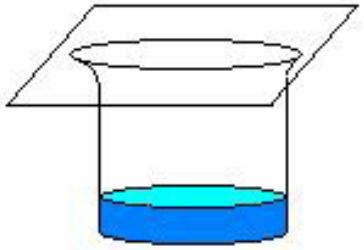
Without a cover





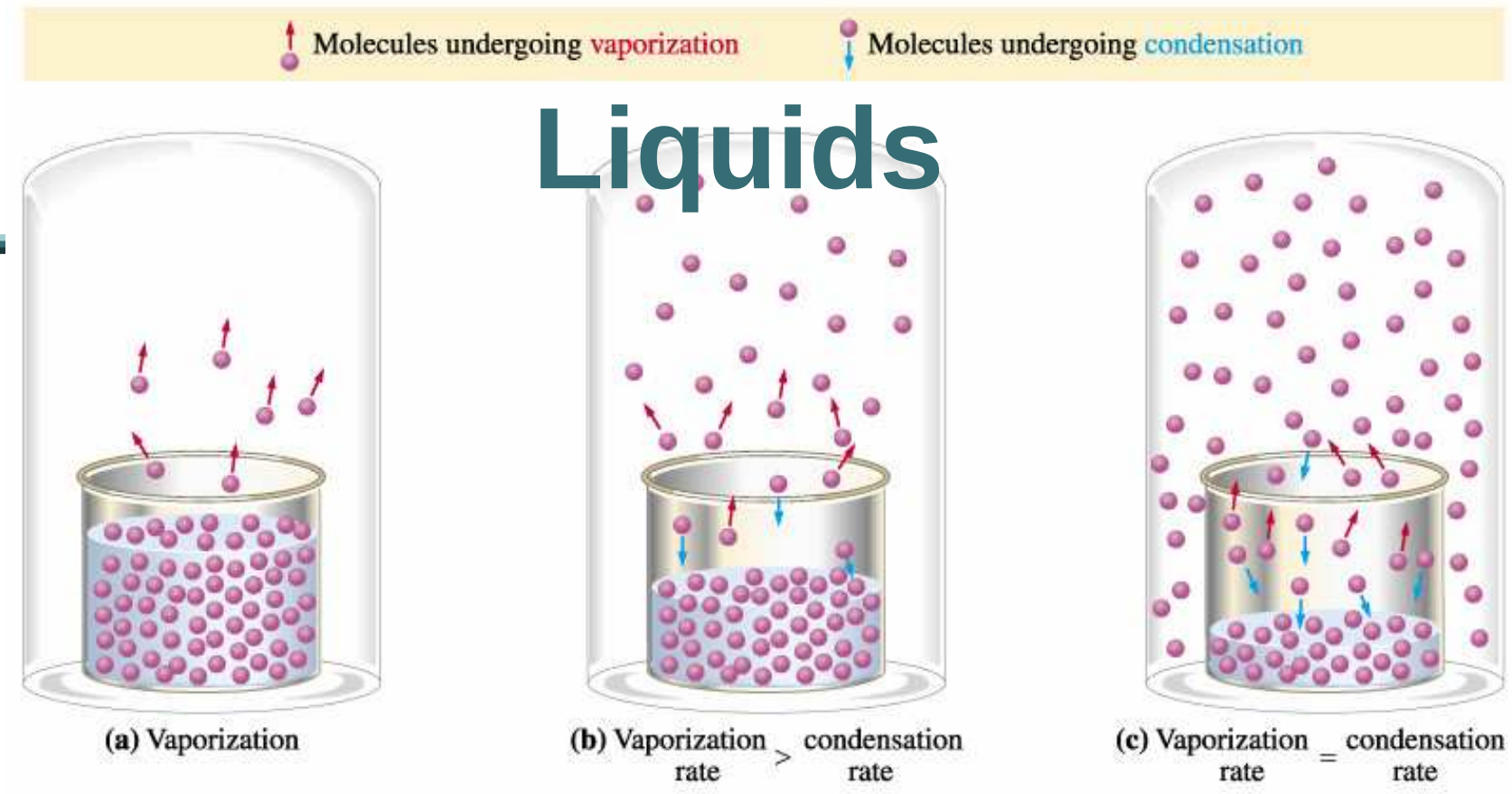


With a cover



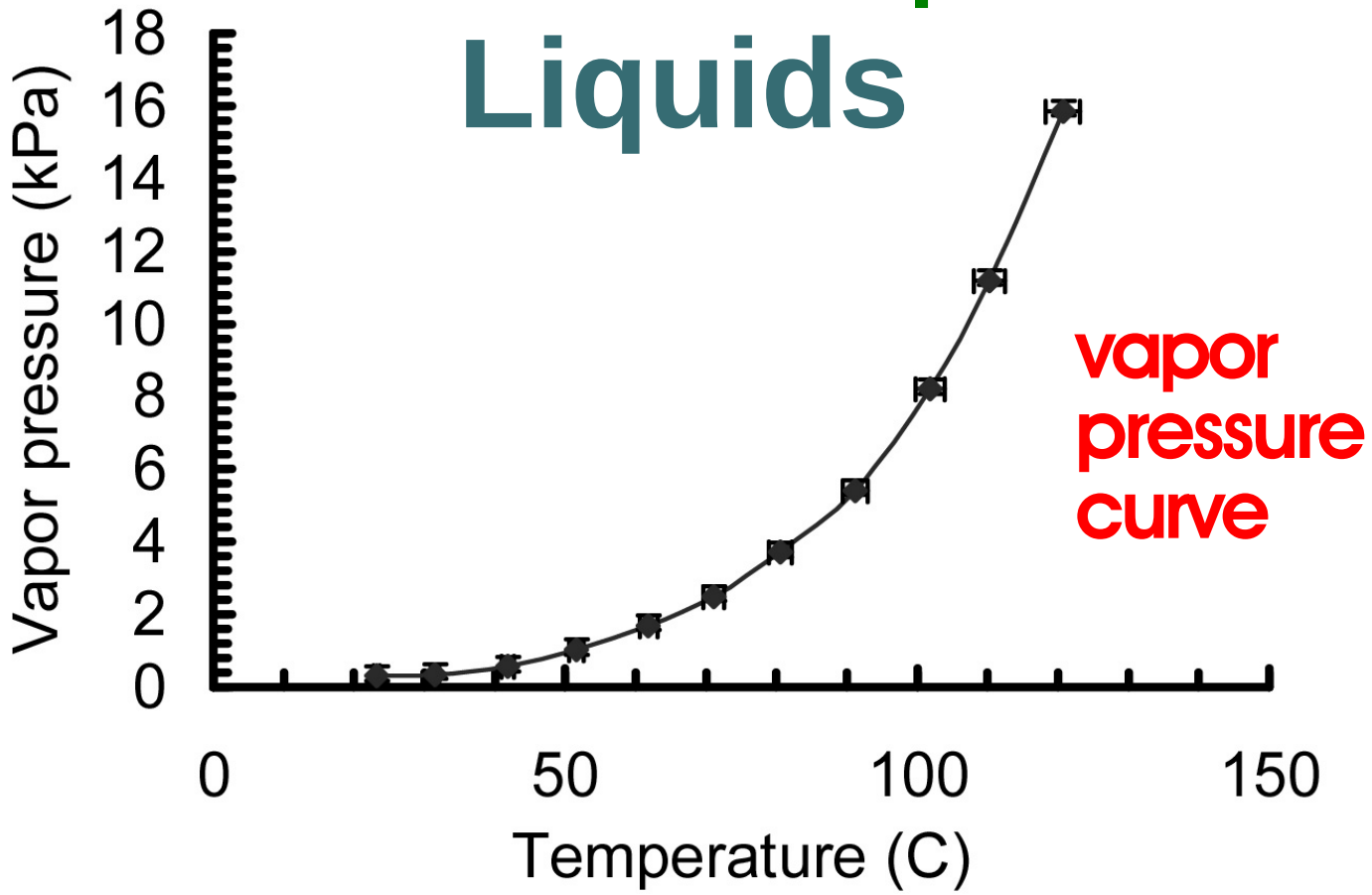
The vapor pressure at equilibrium is the "equilibrium vapor pressure".

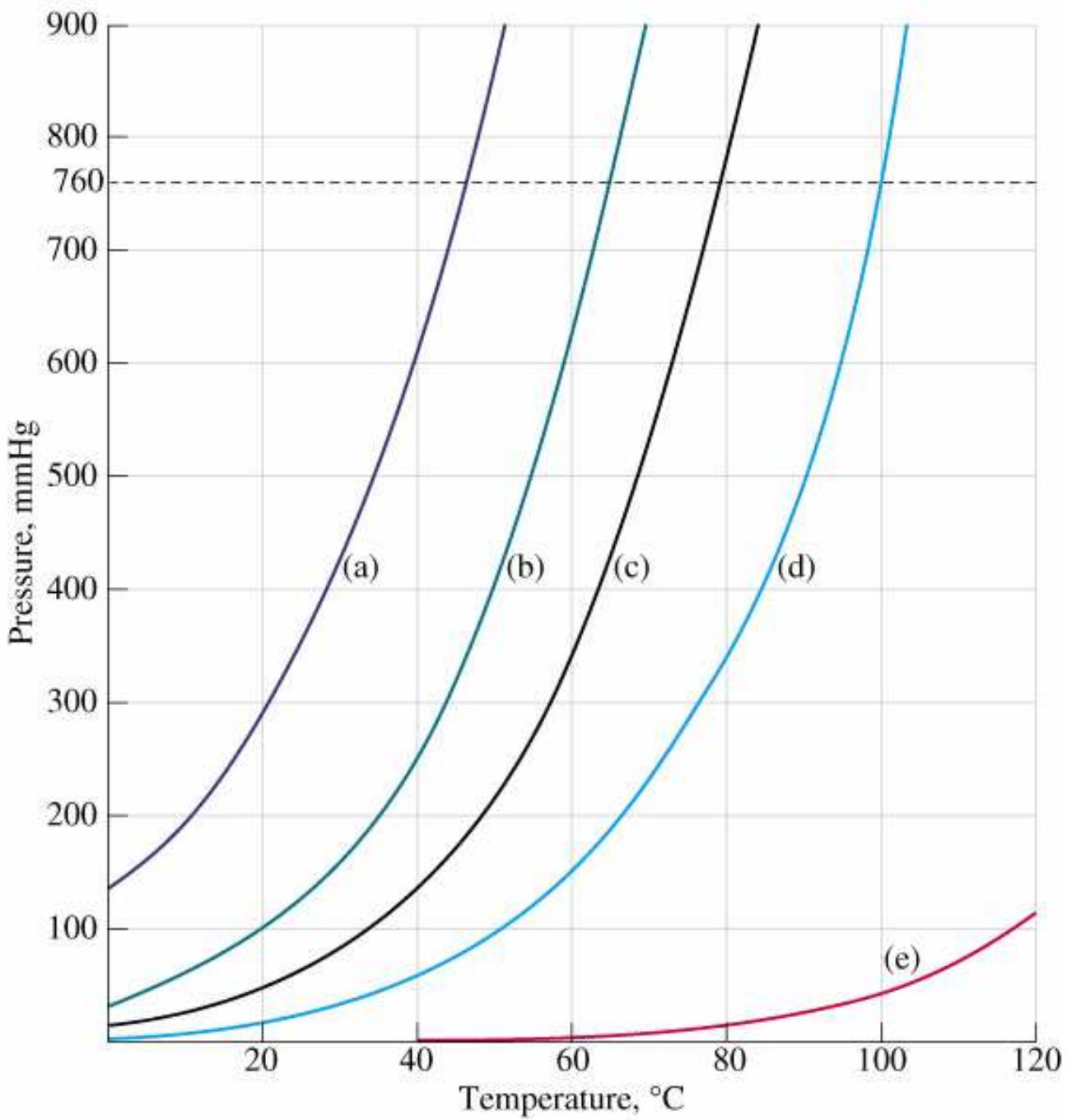
Liquids


Molecules undergoing vaporization
Molecules undergoing condensation
(a) Vaporization
(b) Vaporization rate > condensation rate
(c) Vaporization rate = condensation rate

VP varies with temperature

Liquids





vapor pressure curves several substances

PROPERTIES

boiling point

when vapor pressure equals atmospheric pressure

normal boiling point at 1 atm

B.P. varies with pressure

Lower P requires less energy to break intermolecular bonds

Solids

At room temperatures, solids:

are not compressible

commonly have repeating regular units

Two types of solids are known

Crystalline **have definite melting points**
ionic molecular network metallic

Amorphous **no definite melting points or regular repeating units**

ionic molecular network metallic

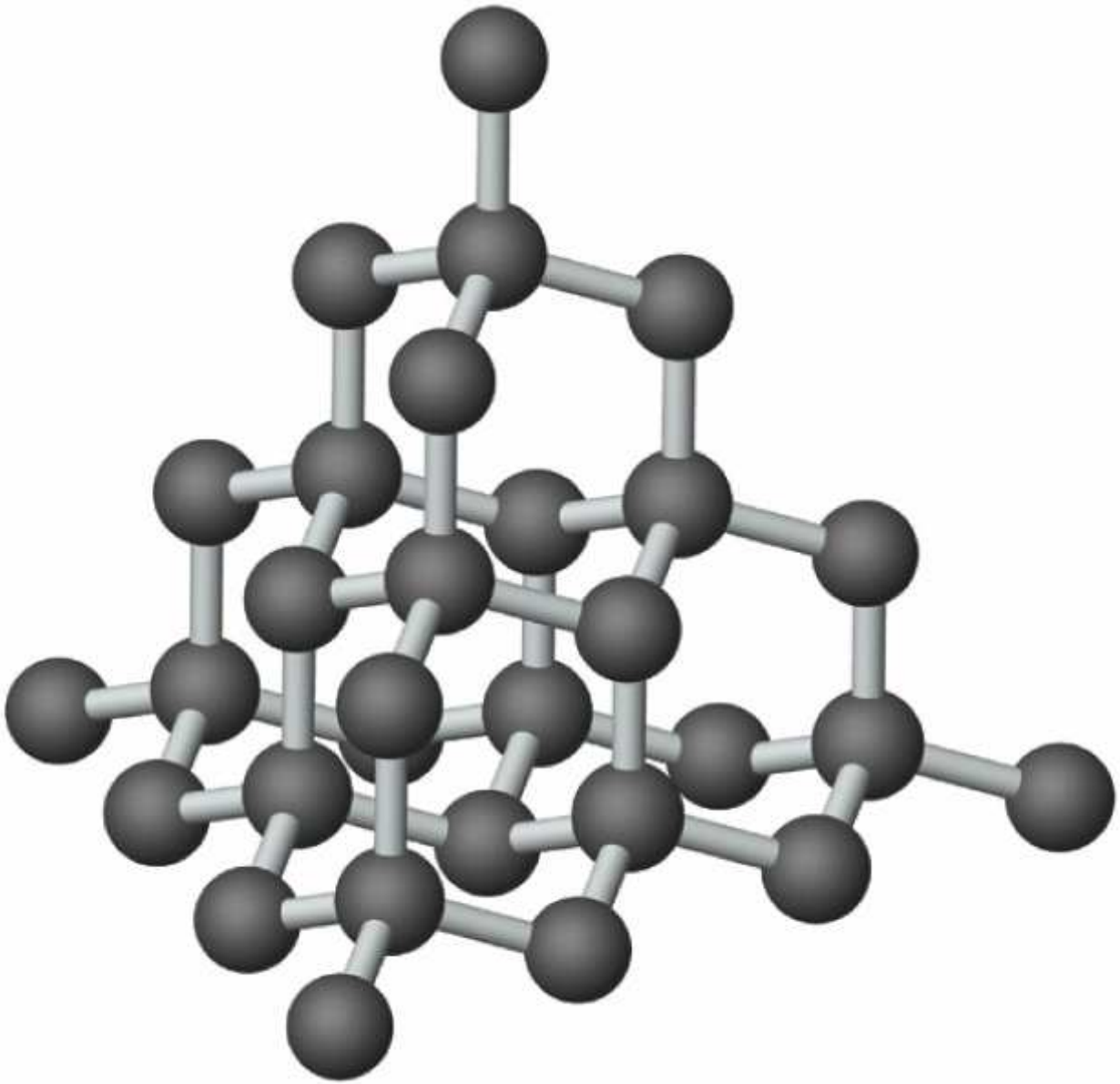
1. Ionic: high M.P., good conductor

2. Molecular: low M.P., poor conductor

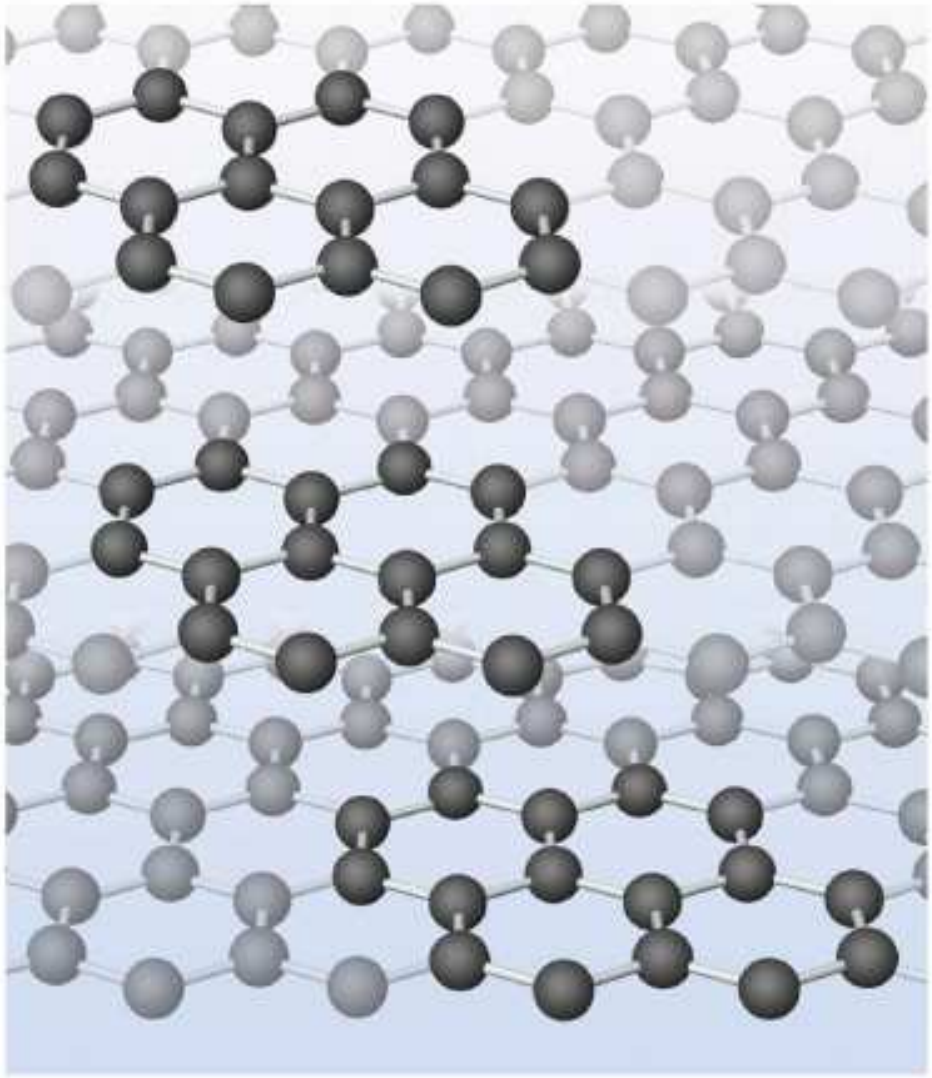
3. Network: high M.P., poor conductor

4. Metallic: high M.P., good conductor

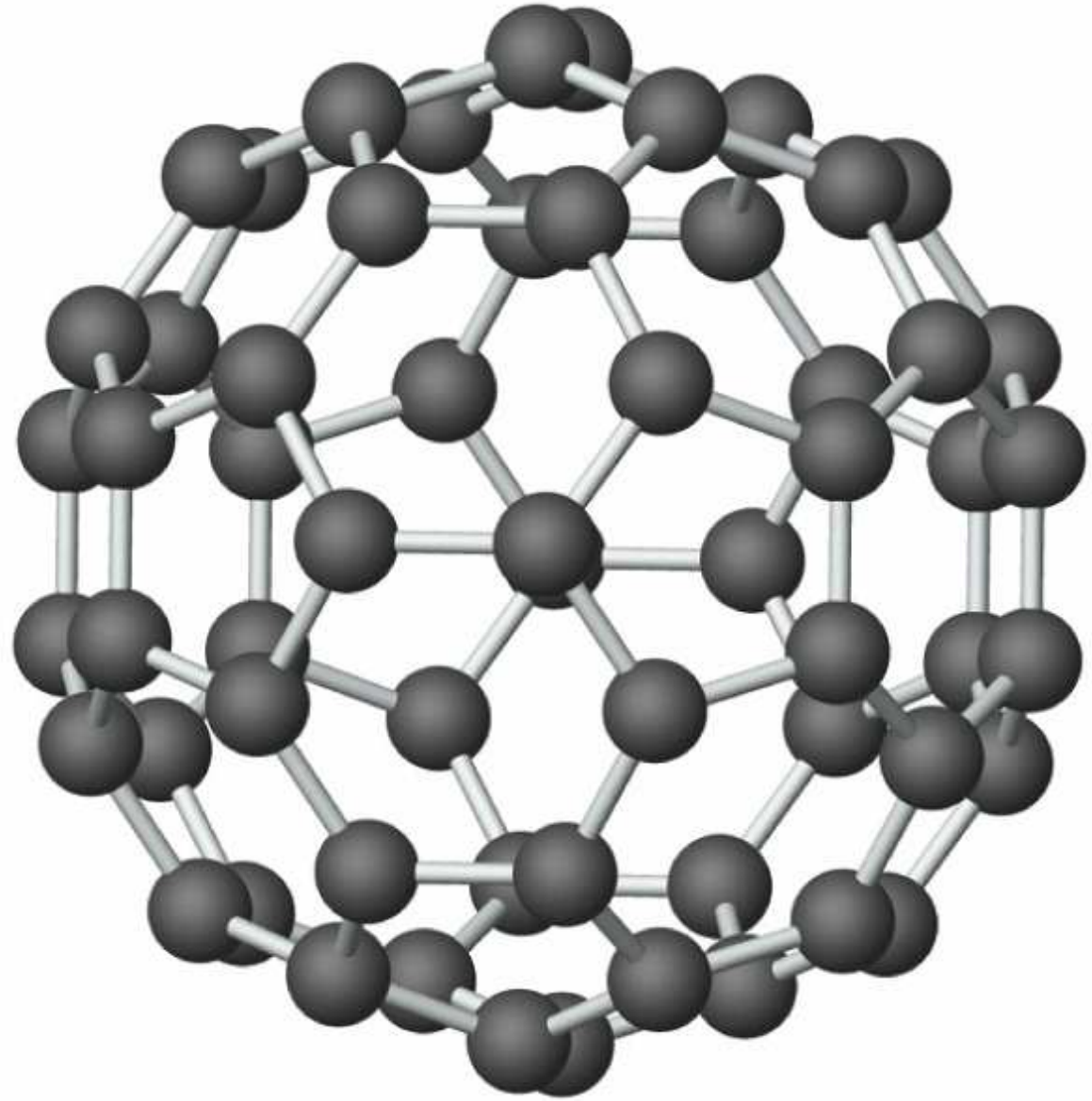
3. Network
diamond



3. Network
graphite



3. Network
fullerene



Sublimation

s 6 g

USES
refrigeration
“fog”
carbonation

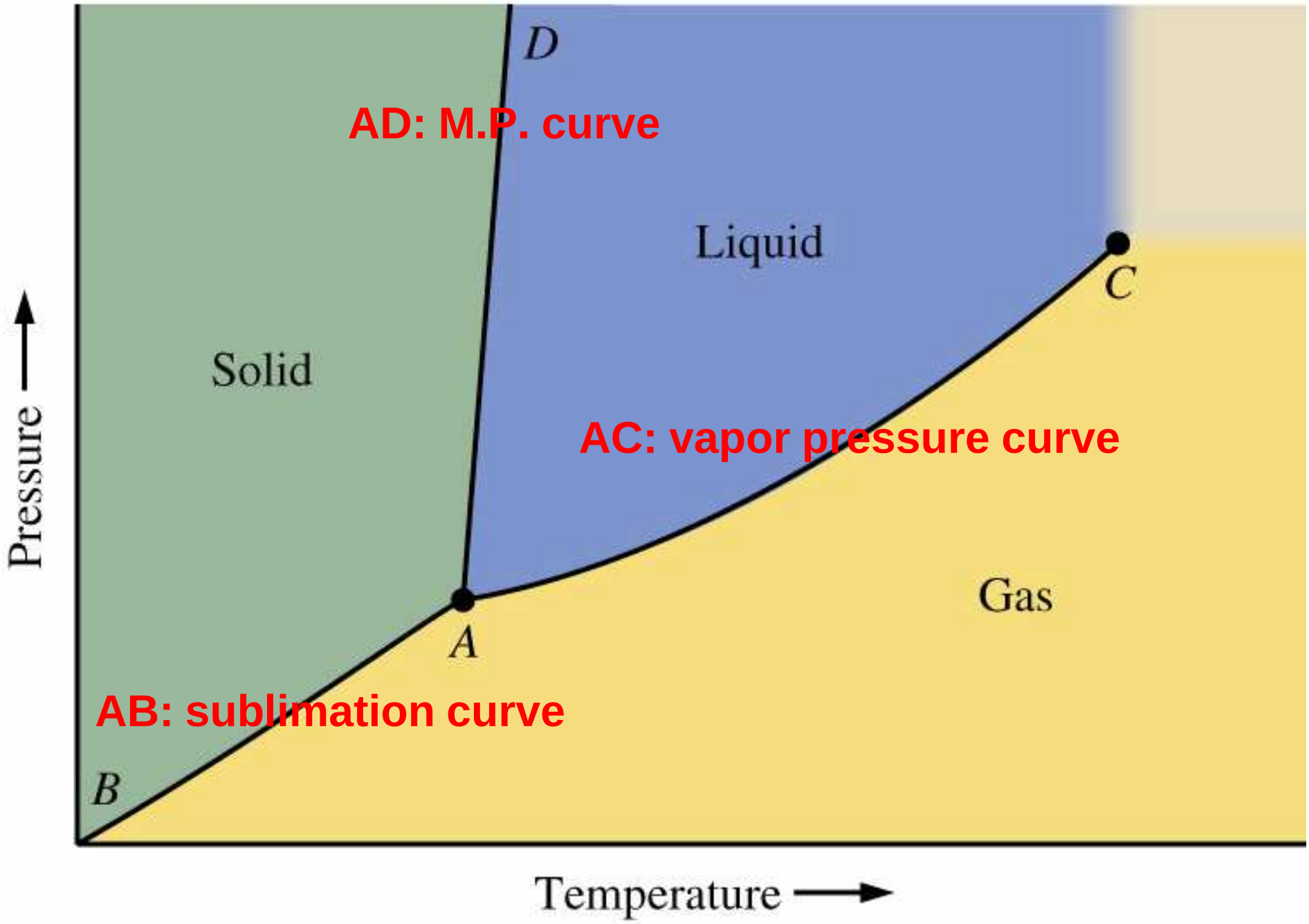
car dents
mosquitos
gophers

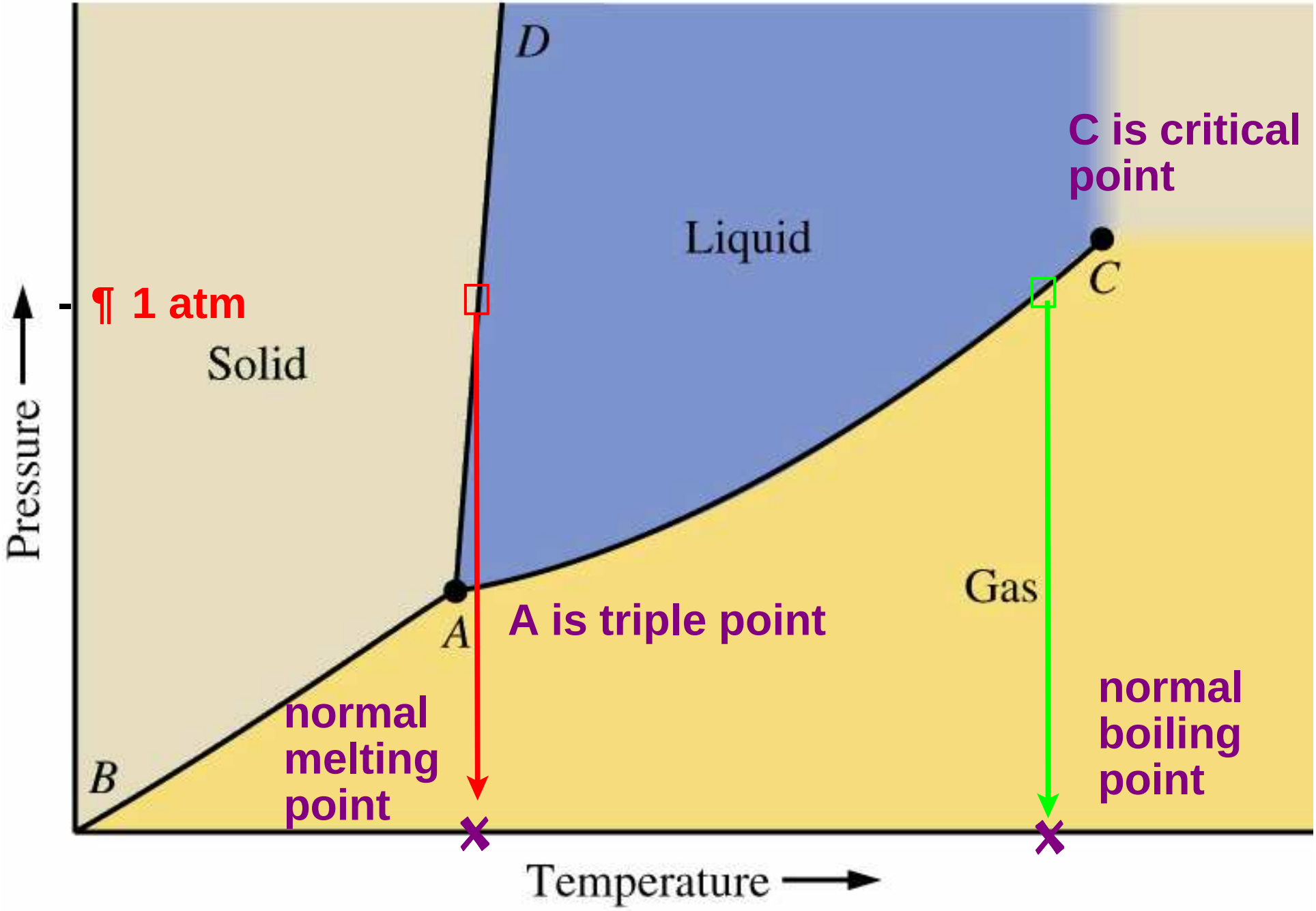
Liquids & Solids

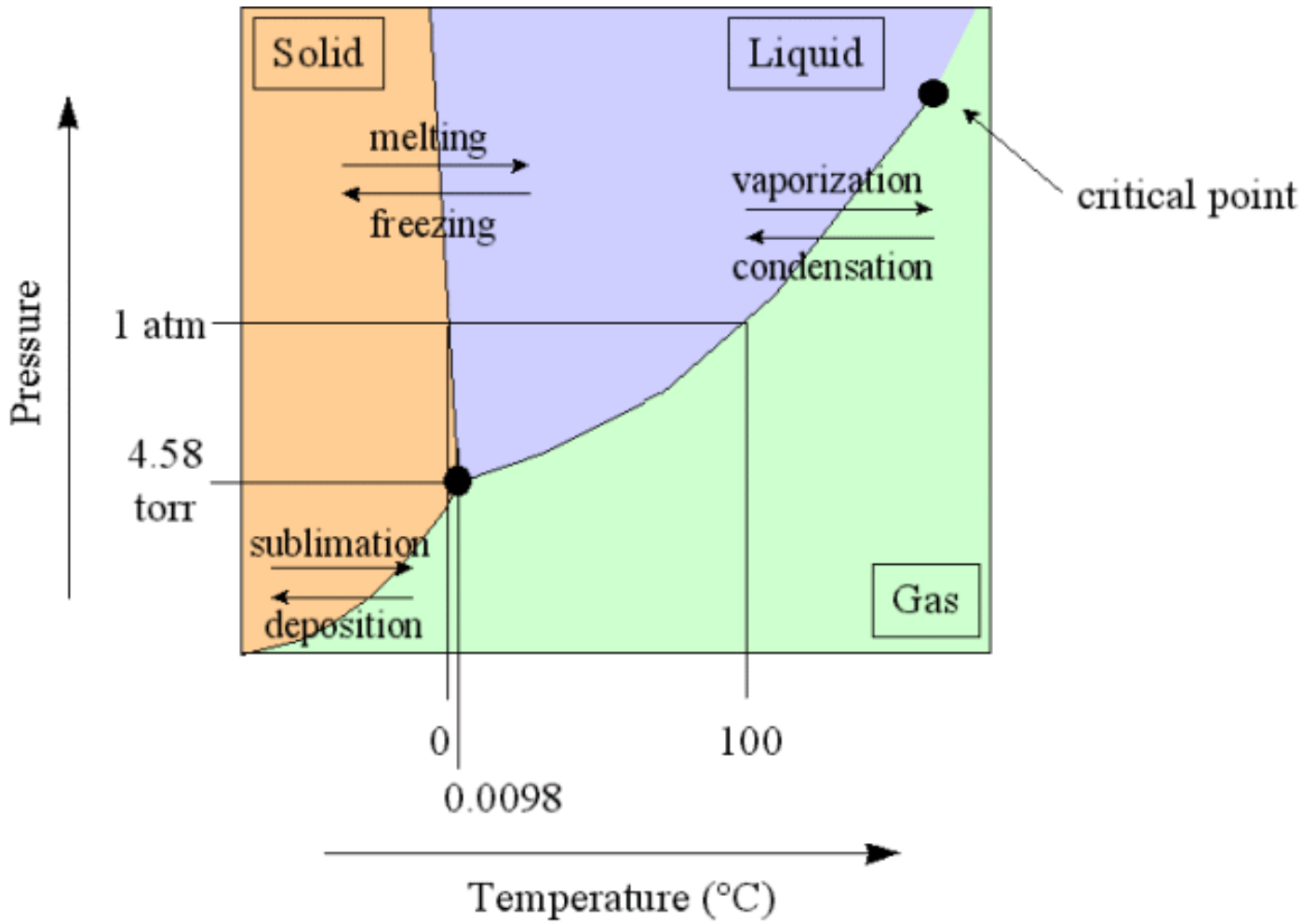
3. Phase diagrams

Combine: Vp curve
sublimation curve
M.P. curve

Indicates T and P for 3 states


D
AD: M.P. curve
Liquid
C
Solid
AC: vapor pressure curve
Gas
A
AB: sublimation curve
B
Pressure
Temperature


D
C is critical point
Liquid
C
¶ 1 atm
Solid
Pressure
Gas
A
A is triple point
normal melting point
normal boiling point
B
Temperature


Solid
Liquid
Gas
melting
freezing
vaporization
condensation
critical point
sublimation
deposition
1 atm
4.58
torr
Pressure
0
0.0098
100
Temperature (°C)

Critical Temperature

temperature above which a substance only exists as a gas

647K for H_2O