1

States of Matter

Solid
Liquid
Gas
Most (All) things can exist in all three states.

2

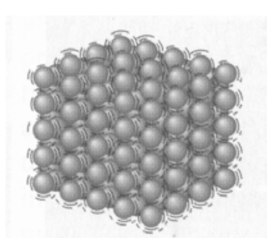
The Kinetic Molecular Theory (KMT)

1. All matter is composed of particles which are in continuous, random motion.
2. Particles move in straight lines, and change direction only when they collide with something.
3. Collisions between particles are elastic.
4. As the temperature increases, so does the kinetic energy of the particles.
5. The distance between particles increases as the temperature increases.

3

The KMT and the Properties of Solids

1. Movement is restricted to vibration and rotation about a fixed space.
2. The volume of a given mass (number of particles) is small (high density)- because atoms are tightly packed.
3. Cannot be compressed - particles are close together already and cannot be compressed further.
4. Not fluid - particles are too close together to move past each other.



Similar to Fig. 6.1 Blei & Odian

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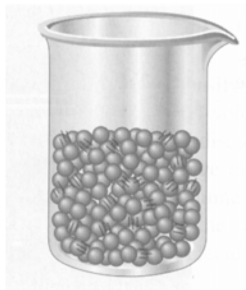
The KMT and the Properties of Liquids

1. Particles can move, but do not go far before a collision occurs.
2. Because of the extra space, liquids usually have a density less than that of the corresponding solid.
3. Liquids are slightly compressible because there is some extra space between particles.
4. Liquids are fluid because there is more space between them and they can thus move past one another.



Similar to Fig. 6.1 Blei & Odian

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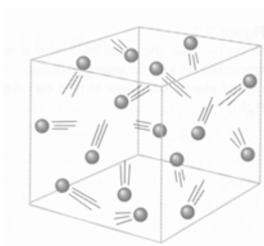
The KMT and the Properties of Gases

1. Travel quite a ways before a collision occurs.
2. Density very low, because a given number of particles spreads out to such a high volume.
3. Gas molecules are a <u>long</u> ways apart. Therefore, we can compress them into a much smaller space.
4. Gases can mix, because the particles are a long ways apart and easily go past one another.



Similar to Fig. 6.1 Blei & Odian

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Forces between Molecules I. London Forces

- <u>all</u> particles have London forces
- larger particles have larger London forces
- <u>only</u> force between noble gases and nonpolar compounds
- about 1/1000 as strong as a covalent bond

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Forces between Molecules
II. Dipole-Dipole Interactions

- different from London forces only in permanence
- somewhat stronger than London forces because permanent
- occurs in all polar molecules
- weaker than ionic bond because only δ+ or δ-

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Forces between Molecules
III. Hydrogen Bonds

- rare
- occur between one H which is covalently bonded to an N, O, or F atom and a second N, O, or F atom
- strongest of three intermolecular forces

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Forces between Molecules
(Ionic Bonds)

Not really an intermolecular force, but need to keep it in mind.

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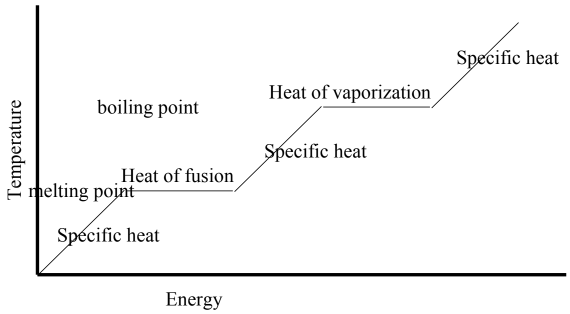
Changes in Physical State



11

Melting/Freezing

Melting- the process of going from (s)→(l)

Freezing- the process of going from (l)→(s)

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Sublimation

Sublimation- conversion of a (s) →(g)

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Evaporation

Vaporization- going from (l)→(g)

Condensation- going from (g)→(l)

Vapor Pressure- the pressure that develops in a closed container when the (l) ↔ (g) are in equilibrium.

- Dependent on intermolecular forces
- Dependent on temperature

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Boiling

Like evaporation, (l) → (g).

Unlike evaporation, (l) →(g) in solution, not just at the surface

Boiling point (bp)- the temperature at which the vapor pressure = the atmospheric pressure.

bp is unique for each (l), and can be used for identification.

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mp, bp, and Intermolecular Forces

Consider H_2O *vs*. H_2S.

What intermolecular forces are present in these molecules?

	H_2O	H_2S
melting point	0°C	-85.5°C
boiling point	100°C	-60.3°C
specific heat	1.00 cal/g°C	0.27 cal/g°C