CHAPTER 16

Solids, Liquids and Gases

SECTION 16.1: KINETIC THEORY

- Kinetic Theory of Matter
  - All matter is composed of tiny particles in constant motion.
  - The higher the temperature, the faster the motion.
- The state of matter changes as temperature changes

  Solid → Liquid → Gas

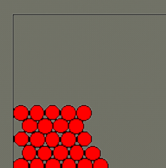
  K.E. increases →

STATES OF MATTER

- physical property
  - describes matter as it is without changing it
    - color, texture, density, smell, taste, phase
- four states: solid, liquid, gas, plasma

SOLIDS

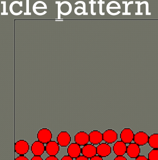
- definite shape, definite volume
  - particles tightly packed
  - movement limited to vibration



- 2 types
  - Crystalline
    - Regular repeated particle pattern
    - Examples: Quartz, Salt
  - Amorphous
    - No pattern
    - Can lose its shape
    - Particles can flow (slowly)
    - Super cooled liquids
    - Examples: Clay, Butter, Glass

LIQUIDS

- definite volume, no definite shape
- particles close, but flow around each other (fluid)
- no set particle pattern

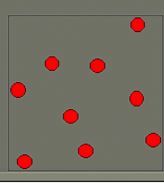


- **Melting point**
  - the temperature at which a solid begins to liquefy
- **Heat of fusion**
  - the amount of energy required to change a substance from the solid phase to the liquid phase at its melting point

- Viscosity
  - property of a liquid that describes its resistance to flow
  - Ex: Honey – high viscosity
    Milk – low viscosity

GAS

- indefinite shape and volume
  - both change to fill container (fluid)
- compressible because of space between particles
- greatest kinetic energy of 3 phases



- vaporization
  - point at which the liquid breaks free of all attractive forces and changes into a gas
  - 2 ways
    1. evaporation (happens at the surface of the liquid)
    2. boiling (throughout entire substance)

- **Boiling point**
  - the temperature at which the pressure of the vapor in the liquid is equal to the external pressure acting on the surface of the liquid
- **Heat of vaporization**
  - the amount of energy required for the liquid at its boiling point to become a gas

- Gas particles are moving **so fast** that they overcome the attraction forces between them.
- **Diffusion**
  - is the spreading of particles throughout a given volume until they are uniformly distributed

PLASMA

- **Plasma**
  - matter consisting of positively and negatively charged particles
  - overall charge is neutral (pos. = neg.)
- found in stars, the Sun, lightning bolts, neon and fluorescent tubes and auroras

THERMAL EXPANSION

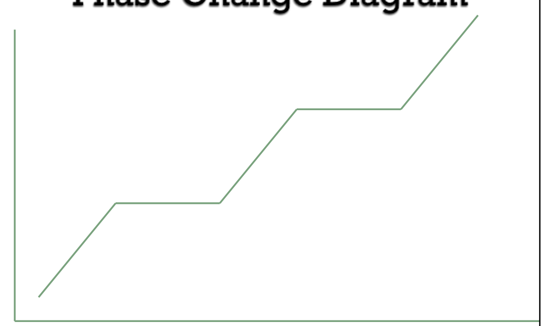
- If heat energy is added to matter,
  - average K.E. increases causing particles to collide more, moving particles further apart **(increasing volume)**
  - Example: Bridges, concrete (expansion joints), thermometers, hot-air balloons

PHASE CHANGES

- during phase change, temperature is **always constant!!!**

- melting → solid to a liquid
- vaporization → liquid to a gas
- condensation → gas to a liquid
- freezing → liquid to a solid
- sublimation → solid to a gas
  - dry ice (frozen CO_2), iodine
- deposition → gas to a solid
  - frost, snow

Phase Change Diagram



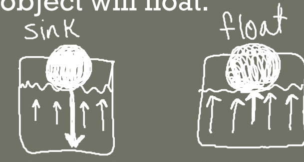
SECTION 16.2: PROPERTIES OF FLUIDS

- Buoyancy
- Archimedes' Principle
- Pascal's Principle
- Bernoulli's Principle

BUOYANCY

- **buoyancy**
  - the ability of a fluid (a liquid or a gas) to exert an upward force on an object immersed in it
- Archimedes Principle
  - the amount of weight lost by an object in water is equal to the weight of the water displaced
  - this is the amount of buoyant force on an object

- *If the buoyant force is less than the object's weight, the object will sink.
- *If the buoyant force is equal to or greater than the object's weight, the object will float.



EXAMPLE

- If an object weighs 25 N and is put in a container of water displacing 10 N of water, the buoyant force on the object is 10 N, making it weigh only 15 N.

- If an object displaces equal or more weight in water than its own weight, **it floats**.
- If it displaces less weight in water than its own weight, **it sinks**.
- If an object has a greater density than the fluid it is in, it will sink.
- If an object has a density that is less than the object it is in, it will float.

PASCAL'S PRINCIPLE

- the pressure applied to a fluid is transmitted unchanged throughout the fluid
- **pressure**
  - force exerted per unit area
- **Examples**
  - squeezing a tube of toothpaste

- According to Pascal's principle, pressure is transferred unchanged; therefore, a greater force is created over a greater area.

Calculating forces using Pascal's Principle

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

- F_1 = initial force (N)
- A_1= initial area (m^2)
- F_2= final force (N)
- A_2= final area (m^2)

- N = Newton (unit of force)
- m^2 = meter squared

A hydraulic lift is used to lift a heavy machine that is pushing down on a 2.8 m^2 piston with a force of 3,700 N. What force needs to be exerted on a 0.072 m^2 piston to lift the machine?

A heavy crate applied a force of 1,500 N on a 25 m^2 piston. What is the area of the piston needed to lift a 48 N crate?

BERNOULLI'S PRINCIPLE

- as the velocity (speed) of a fluid increases, the pressure exerted by the fluid decreases
  - explains how planes fly (increased speed creates lift)
  - explain why birds fly in a V
  - blowing across the top of paper

SECTION 16.3: BEHAVIOR OF GASES

- Gases exert forces on everything (constant motion)
- The larger the area, the greater the force

- Pressure is the amount of force exerted per unit of area

$$P = \frac{F}{A}$$

Pascal (Pa) – SI unit of pressure

- Tool – Barometer
  - invented by Evangelista Torricelli
- factors that affect pressure of a gas: volume, temperature, amount of gas

Different Units of Pressure

- atm = atmosphere
- torr = Torr
- mmHg = millimeters of mercury
- Pa = pascal
- kPa = kilopascal

1 atm = 760 torr = 760 mmHg
= 101,325 Pa = 101.325 kPa

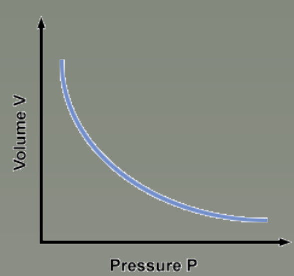
BOYLE'S LAW
ROBERT BOYLE (1662)

- As volume decreases to ½ the original, pressure increases 2x's

(pressure decreases, volume increases)
(pressure increases, volume decreases)

- temperature held steady
- amount of gas the same

BOYLE'S LAW – INVERSELY PROPORTIONAL



USING BOYLE'S LAW
$$P_1V_1 = P_2V_2$$

Ammonia gas occupies a volume of 450 mL at a pressure of 720 mmHg. What volume will it occupy at 760 mmHg?

$$P_1V_1 = P_2V_2$$

Nitrogen gas occupies of volume of 680 L at a pressure of 0.8 atm. What is the volume of the gas at pressure of 1 atm?

CHARLES' LAW
JACQUES CHARLES (1760)

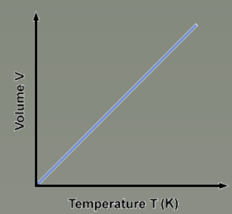
- If the temperature of a gas increases, the volume also increases

Temperature is in KELVIN!!!!
K = °C + 273

(temperature increases, volume increases)
(temperature decreases, volume decreases)

- Pressure is constant
- At fixed amount of gas

CHARLES' LAW – DIRECTLY PROPORTIONAL



USING CHARLES' LAW

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

- What would be the resulting volume of a 2.0-L balloon at 25.0°C that was placed in a container of ice water at 3.0°C?