**Podcast 9.1: Kinetic Molecular Theory**

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ = Energy due to motion
* All Matter consists of tiny particles that are in constant motion
* Add K.E. – Atoms and molecules move \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and the object expands
* Lose K.E. – Atoms and molecules slow down and the object contracts
* To add or lose K.E., Temperature is adjusted
* Heat added = Energy added
* Additional K.E. causes atoms and molecules to collide more often

Gas Pressure

* Pressure = Force per area of an object
* Force is caused by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of gas particles
* Vacuum – empty space with no particles and no pressure.
* Compressibility – measure of how much the volume of a substance decreases under pressure
* Lots of empty space between gas particles
* Easily compressed, or squeezed, into a smaller volume

Atmospheric Pressure – results from collisions of particles in the air

* Pressure exerted on the earth by the layer of air around it
* Higher Elevation = fewer air particles = lower pressure
* Measured with a barometer

Vapor Pressure: a force exerted just above a liquid by the particles that have evaporated from the surface

* Higher Temp = Higher Vapor Pressure
* Lower Temp = Lower Vapor Pressure
* Sketch Vapor Pressure Below

Measuring Air Pressure

* Common Units
	+ Pascal, Pa or\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, **SI UNIT FOR PRESSURE**
	+ atmosphere, atm
	+ torr, or millimeters of mercury, mmHg
* Pressure Conversions: 1 atm = 760 mmHg = 760 torr = 101.3 kPa
* Since these are all equal, they can be used in t-tables to convert between pressure units
* Example 1: What is the pressure of 450 kPa in atm? mmHg?

**Podcast 9.2: Phases of Matter**

* Remember: Both Liquids and Gases take the shape of their containers
* However: Gases expand to fill their containers, whereas liquids do not! WHY???

Phases of Matter

* **Intermolecular Forces, IMFs:** Particles in liquids (and Solids) stay closer together because of the forces of attraction between positive and negative charges in atoms and molecules that keep particles close together
* In Gases, the Kinetic Energy is large enough to overcome the all of the IMFs



Phase Change Processes: Give simple definitions of each of the following

* Freezing \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Condensation \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Deposition\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Dissolving\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Melting\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Vaporizing\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Subliming\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The Process of Boiling

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_: Changing a liquid into a gas. Occurs at the surface of a liquid
2. Liquids evaporate faster when additional KE (heat) is added. Extra KE breaks the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ between particles.
3. Liquid molecules change to the gas phase, creating more \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ just above the surface of the liquid
4. When the vapor pressure equals the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, the liquid will boil. The temperature and pressure combination at which this occurs is called the BOILING POINT.

The Nature of Solids

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Solids: particles are arranged in an orderly, repeating, three dimensional pattern called a lattice
	+ Maintain own shape
	+ Higher melting points
	+ Typically good conductors
	+ Examples: NaCl, Granulated Sugar, CuSO4
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Solids: lack an ordered internal structure
	+ Moldable, can be formed into many shapes
	+ Melt over a wide range of temperatures
	+ Typically poor conductors
	+ Examples: Ca(C2H2O2)2 , Powdered Sugar, Glass, Plastic, Wax

Phase Diagrams: Graph representing all 3 major states of matter for a substance E

* Based on relationships between temperature and pressure
* Axes of graphs are typically distorted so all important points can still fit
* Interpreting Graphics – Refer to Handout

**Podcast 9.3: Gas Laws: Summarize the Behavior of Gases and Relationships Between Temperature, Pressure, And Volume**

Properties of Gases: Factors affecting gas pressure:

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of gas: more particles (moles) increases pressure
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_: reducing volume tends to increase pressure
3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_: increasing the temperature tends to increase pressure because particles collide more

Boyle’s Law

Pressure is the result of molecules colliding with the walls of a container (complete sketch below)

Volume = 4x4

Pressure = 1 atm

* Same # of particles in each box
* As the container gets smaller, collisions increase, so pressure increases (complete sketch below)

Volume = 2x2

Pressure = \_\_\_\_\_\_

* Still same # of particles in each box
* As the container gets smaller, collisions increase, so pressure increases (complete sketch below)

Volume = 1x1

Pressure = \_\_\_\_\_\_\_

* Sketch a graph to show how pressure changes

in response to increasing volume.

Boyle’s Law: Pressure and volume have an inverse relationship at a constant temperature

* P1V1 = P2V2 OR OR

Practice Problem 1:

P1 = 1 atm V1 = 8 mL V2 = 10 mL

What is the final pressure (P2)?

**Charles’s Law -** as the *Kelvin* temperature of a gas increases, the volume increases proportionally, provided that the pressure and amount of gas remain constant.

* There is a direct relationship between temperature and volume
* Sketch the graph of this relationship
* Hint: V/T = constant

* Doubling the Kelvin temperature of a gas sample doubles its volume
* Reducing the Kelvin temperature by one-half causes the gas volume to decrease by one-half

Practice Problem 2: A sample of gas occupies 3.5 L at 300 K. What volume will it occupy at 200 K?

Practice Problem 3: If a 1 L balloon is heated from 22°C to 100°C, what will its new volume be?

Gay-Lussac’s Law

* Pressure is directly proportional to **Kelvin** temperature if volume remains constant.
* If Temperature increases, then Pressure increases (and vice versa).

Combined Gas Law

* Describes the relationship among pressure, temp, and volume of a gas. Combines Boyle’s, Charles’s, and Gay-Lussac’s Laws

**Podcast 9.4: Ideal Gases**

Ideal Gas Law: Gas Law that incorporates all four possible variables P, V, T, and n (# of moles).

PV = nRT

* P=Pressure in kPa or atm
* V = Volume in Liters
* n = # of moles
* R = ideal gas constant
* T = Temperature in Kelvin

\*Describes the condition of gases as they are **now** but the other gas laws predict what they **WILL be**

when conditions change.

* Values of R

If Pressure is in kPa, R = \_\_\_\_\_\_\_

If Pressure is in atm, R =\_\_\_\_\_\_\_\_

Example Problem 1: How many kilograms of methane, CH4 are in a 225 L container at 150 kPa and 35oC?

Example Problem 2: Find the number of grams of CO2 that exert a pressure of 785 torrs at a volume of 32.5L and a temperature of 32oC.

Example Problem 3: If the density of a gas is 1.2 g/L at 745 torr and 20oC, what is its molecular mass?

Ideal vs Real Gases

Ideal

* Follows gas laws at all temps and pressures
* Conforms precisely to ALL assumptions of KMT
* Particles have no volume
* No IMFs between particles
* DON’T EXIST

Real

* Factor in Particle Volume
* Look at IMFs between particles
* Differ mostly at low temps and high pressures
* True picture of gases

Gas Mixtures

* Partial Pressure: pressure exerted by one component in a mixture of gases
* Dalton’s Law of Partial Pressures: For a mixture, the total pressure is the sum of all the partial pressures of the gases

Ptotal = P1 + P2 + P3 + …

Example Problem 4: A 250. mL sample of oxygen, O2, is collected over water at 25oC and 760.0 mmHg pressure. What is the pressure of the dry gas along? (Vapor pressure of water at 25oC = 23.8 mmHg)

Movement of Gases

* Effusion: Gas escapes from a tiny hole in a container.
	+ The smaller the gas particle is (ie, lower molar mass), the faster it effuses.
* Diffusion: Gas spreads out in space, moving from an area of high pressure to an area of low pressure
	+ The smaller the gas particle, the faster if diffuses