K\_\_\_\_\_ Theory – Model of a **Gas**

Properties of Gases (*Postulates or Assumptions*)

* A \_\_\_\_\_ is composed of individual PARTICLES which are in \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ -line motion

a. \_\_\_\_\_ may result in a transfer of energy [\_\_\_\_\_ ***collisions***], but the total net energy of the system remains constant.

b. The \_\_\_\_\_ of particles is \_\_\_\_\_ in comparison with the space in which they are *contained (i.e. earth’s volume compared to the volume of the solar system*)

1. Gas particles are considered as having \_\_\_\_\_ attraction for each other

* Gases take the \_\_\_\_\_ and \_\_\_\_\_ of whatever \_\_\_\_\_, room, or space they occupy.
* The particles change direction only when they rebound from collisions.

Gas Pressure

* If no \_\_\_\_\_ are present, no \_\_\_\_\_ can occur, meaning there is no \_\_\_\_\_. An empty space with no particles and no pressure is called a \_\_\_\_\_.
* The collisions of atoms and molecules in \_\_\_\_\_ with objects results in \_\_\_\_\_ pressure.
* REALITY: \_\_\_\_\_ in the gas laws

a. This model is not perfect especially under conditions of \_\_\_\_\_ temperature & pressure

b. Particles do have some \_\_\_\_\_

c. Particles do have some \_\_\_\_\_ forces toward each other (Van der Waals forces)

Gas Pressure

* The \_\_\_\_\_ exerted by the particles of a gas \_\_\_\_\_ with the surface of an object.
* \_\_\_\_\_ KE 🡪 \_\_\_\_\_ collision force 🡪 \_\_\_\_\_ pressure
* More \_\_\_\_\_ 🡪 greater collision force 🡪 higher \_\_\_\_\_

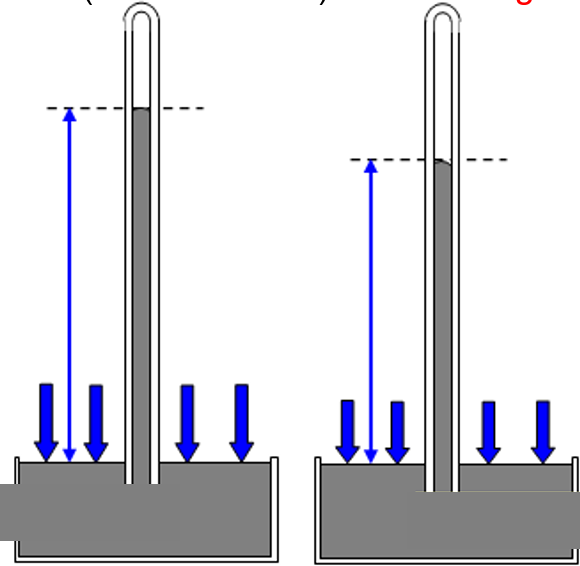
Atmospheric Pressure

* The \_\_\_\_\_ exerted on all objects [*force/area*]
* Gas pressure is actually the air molecules \_\_\_\_\_ with surfaces. The more molecules, the more \_\_\_\_\_ 🡪 the more \_\_\_\_\_.

Measuring Pressure of a Gas (\_\_\_\_\_)

* \_\_\_\_\_ 🡪 device used to measure \_\_\_\_\_ pressure
* Original barometers used mercury
  + \_\_\_\_\_
  + Low evaporation rate
  + Modern barometers use small cells of air
  + Expansion or contraction moves dial

Measuring Pressure

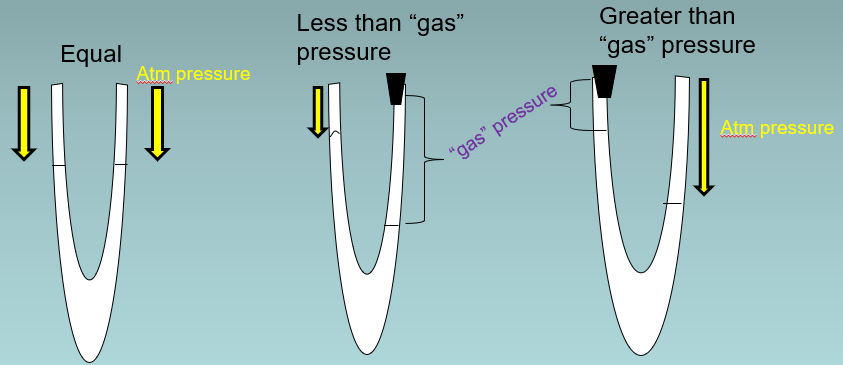


\_\_\_\_\_ pressure = \_\_\_\_\_ pressure

* *[left] Atmospheric* \_\_\_\_\_ *down much more than the “*\_\_\_\_\_*” inside the tube. So Patm > Pg*
* *[right] “gas”* \_\_\_\_\_ *the tube has greater pressure than before so the liquid in the tube is pushed down more than before.*

Reading a Barometer

Describe the atmospheric pressure in each manometer.



Standard \_\_\_\_\_ and \_\_\_\_\_

* Standard Temperature and Pressure (\_\_\_\_\_) standard conditions used to compare gas measurements; defined as an absolute temperature of \_\_\_\_\_ K and a pressure of \_\_\_\_\_ kPa
* Scientists use \_\_\_\_\_ temperature (K) in all gas calculations.
* One standard atmosphere (\_\_\_\_\_) is the pressure required to support 760 mm of mercury in a mercury barometer at 25°C.
* \_\_\_ atm = \_\_\_ mm Hg = \_\_\_ kPa

A pressure gauge records a pressure of 450 kPa. Convert this measurement to atmospheres and millimeters of mercury.

Temperature & \_\_\_\_\_ \_\_\_\_\_ Energy

* \_\_\_\_\_ Energy
  + As any substance is heated, its particles absorb energy, some of which is \_\_\_\_\_ within the particles. This stored portion of the energy is potential energy (\_\_\_). PE is responsible for \_\_\_\_\_ changes (\_\_\_\_\_ *to* \_\_\_\_\_ *to* \_\_\_\_\_*, gas to liquid to solid, etc.*) but does \_\_\_\_\_ raise the \_\_\_\_\_ of the substance.
* \_\_\_\_\_ Energy
  + The remaining absorbed energy speeds up the \_\_\_\_\_ of particles, which is their kinetic energy (\_\_\_). The particles in any collection of atoms or molecules at a given temperature have a wide range of kinetic energies. The \_\_\_\_\_ kinetic energy of particles in a system is called its \_\_\_\_\_.
  + The average kinetic energy of the particles in a substance is directly related to the substance’s temperature in \_\_\_\_\_ (K).
  + When average KE \_\_\_\_\_, K temperature also \_\_\_\_\_.
  + As a substance cools, the particles tend to move more \_\_\_\_\_, and their average kinetic energy \_\_\_\_\_.
  + \_\_\_\_\_ zero (\_\_\_ K, or \_\_\_ oC) is a theoretical temperature at which there is NO \_\_\_\_\_ of particles; and there is NO \_\_\_\_\_ at 0 K.
  + No temperature can be lower than \_\_\_\_\_ zero.

Properties of **Liquids**

* \_\_\_\_\_ definite shape, but a definite \_\_\_\_\_
* Fluidity 🡪 Less tightly packed molecules that take the \_\_\_\_\_ of the container and flow readily
* Less dense than solids, but greater than gases (usually d ∞ 1/T)
* Relatively \_\_\_\_\_ -compressible except for extreme temperatures and pressures
* Diffusion 🡪 \_\_\_\_\_ concentration or pressure toward a \_\_\_\_\_ concentration or pressure
* \_\_\_\_\_ 🡪 \_\_\_\_\_ liquid changing to gas
* According to kinetic theory, there are \_\_\_\_\_ intermolecular attractions between the particles in the gas state.
* The particles in a liquid are attracted to each other. These intermolecular attractions keep the particles in a liquid close together, which is why liquids have a definite volume.

Intermolecular Forces and Condensation

* Intermolecular forces affect interactions between particles
* Stronger forces means more energy to overcome
* \_\_\_\_\_ (\_\_\_ 🡪 \_\_\_): \_\_\_\_\_ < intermolecular forces … *Particles* \_\_\_\_\_ *together, forming* \_\_\_\_\_
* \_\_\_\_\_ & \_\_\_\_\_ (\_\_\_ 🡪 \_\_\_): KE > intermolecular forces … *Particles* \_\_\_\_\_ *apart forming* \_\_\_\_\_

Intermolecular Forces and Freezing

* Liquid particles have \_\_\_\_\_, random motion
* Solid particles are \_\_\_\_\_ in place, but \_\_\_\_\_
* Freezing (\_\_\_ 🡪 \_\_\_): KE < intermolecular forces … *Particles* \_\_\_\_\_ *together, forming* \_\_\_\_\_
* Melting (\_\_\_ 🡪 \_\_\_): KE > intermolecular forces … *Particles break away, forming* \_\_\_\_\_

Evaporation

* The conversion of a \_\_\_\_\_ to a \_\_\_\_\_ or vapor is called vaporization.
* When this conversion occurs at the \_\_\_\_\_ of a liquid that is not boiling, the process is called evaporation*.*
* Evaporation is \_\_\_\_\_ related to \_\_\_\_\_ area, \_\_\_\_\_, \_\_\_\_\_, and moisture (humidity).

The Irony of Evaporation

* Evaporation is a liquid becoming a gas, meaning that heat must be absorbed by the liquid. YET, evaporation is a \_\_\_\_\_ process. How can this be?

1) The particles that evaporate (escape) from a liquid MUST have \_\_\_\_\_ KE that the particles left in the liquid.

In this case, the escaped (*vapor or gas*) particles are taking \_\_\_\_\_ (*in the form of heat*) \_\_\_\_\_ from the liquid, cooling it.

2) You can experience the effects of evaporation cooling you off on hot days. When you perspire, water molecules in your perspiration absorb heat from your body, gaining enough KE to evaporate from the skin’s \_\_\_\_\_ (*taking heat with it*). The perspiration (sweat) that remains cools you further by absorbing more body heat.

\_\_\_\_\_ Pressure

* In an open system, molecules that evaporate can escape from the system.
* In an \_\_\_\_\_ system, equilibrium is \_\_\_\_\_ established and various factors must be considered:

\_\_\_\_\_ 🡪 > T, > evaporation

\_\_\_\_\_ area 🡪 > SA, > evaporation

air currents 🡪 > AC, > evaporation

ESTABLISHING Equilibrium

* In a \_\_\_\_\_ system, the molecules collect as a vapor above the \_\_\_\_\_, increasing pressure of the air above the liquid. Some condense back into a liquid.
* These particles collide with the walls of the sealed container, producing \_\_\_\_\_. A measure of the force exerted by a gas above a liquid is called \_\_\_\_\_ pressure = the TENDENCY TO \_\_\_\_\_.
* Over time, liquid particles continue to evaporate and gas particles condense and return to the liquid state.
* In a CLOSED system, \_\_\_\_\_ is established.
* Dynamic Equilibrium is a state of balance in which \_\_\_\_\_ processes (s ↔ l … l ↔ g ... s ↔ g ) are proceeding at equal \_\_\_\_\_. Must be in a \_\_\_\_\_ system.

\_\_\_\_\_ + energy 🡪 vapor [\_\_\_\_\_] *– heat added*

Liquid + energy 🡨 vapor [condensation] *– heat* \_\_\_\_\_

Before equilibrium *… evaporation > condensation*

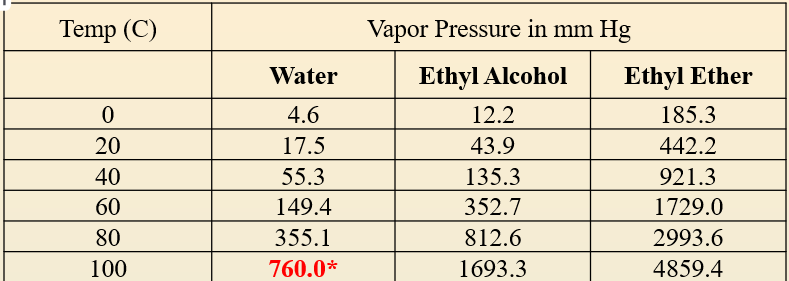
At equilibrium… evaporation RATE = condensation RATE

Dynamic Equilibrium l ↔ g

* In a closed system, eventually, the number of particles \_\_\_\_\_ will \_\_\_\_\_ the number of particles \_\_\_\_\_.
* The system is in equilibrium because the \_\_\_\_\_ of evaporation of liquid equals the \_\_\_\_\_ of condensation of the vapor.
* At equilibrium, the particles in the system continue to evaporate and condense, but no \_\_\_\_\_ change occurs in the number of particles in the liquid or vapor phases.
* The system is in equilibrium because the rate of evaporation of liquid equals the rate of condensation of the vapor.

Vapor Pressure

* Indicates how \_\_\_\_\_ a liquid will \_\_\_\_\_ or \_\_\_\_\_. This can be referred to as how volatile a given liquid is.
* Depends on the \_\_\_\_\_ of the liquid: liquids have characteristic forces of attraction between their molecules
  + \_\_\_\_\_ bonding
  + Van der Waals forces (*temporary dipoles that exist between virtually every molecule*)
* Depends on temperature (*avg KE*)



When does water “normally” boil?

When does Ethyl Alcohol “normally” boil?

When does Ethyl Ether “normally” boil?

Can Water boil at 0° C?

Which liquid is most volatile? Least volatile?

Boiling of Liquids

Atmospheric pressure acts on the surface of a vapor bubble, causing it to collapse.

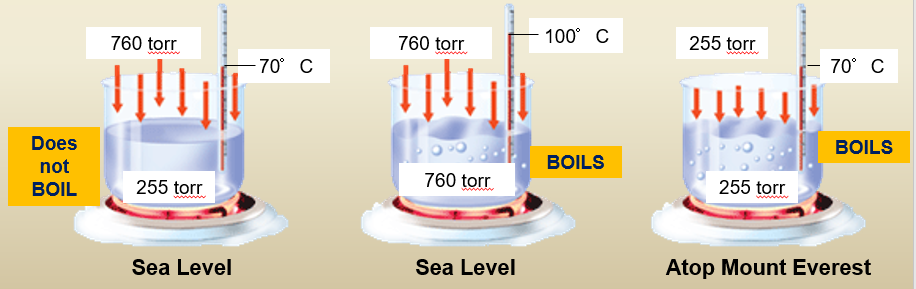
* \_\_\_\_\_ only occurs at the \_\_\_\_\_ of an object or liquid
* \_\_\_\_\_ occurs \_\_\_\_\_ a liquid, beginning at the heat source
* Avg \_\_\_\_\_ increases so bubbles (vapor) form throughout the liquid, rise to the surface, and \_\_\_\_\_ into the air.

\_\_\_\_\_ Point (bp)

* The temperature at which the equilibrium \_\_\_\_\_ pressure of the \_\_\_\_\_ is equal to the prevailing \_\_\_\_\_ pressure
* Boiling points \_\_\_\_\_ at higher \_\_\_\_\_
* Atmospheric pressure \_\_\_\_\_ with altitude, so \_\_\_\_\_ vapor pressure is needed to bring a liquid to boiling.
* “\_\_\_\_\_” Boiling Point means at STP

Boiling & Pressure

* If atmospheric pressure \_\_\_\_\_, liquids will boil at \_\_\_\_\_ than expected temperatures (*e.g like doing push ups with people helping lift you*)
* If atmospheric pressure \_\_\_\_\_, liquids will boil at \_\_\_\_\_ than expected temperatures (e.g *like doing push ups with people sitting on you*)



Properties of **Solids**

< Temperature < kinetic energy < particle motion

a. Definite \_\_\_\_\_

b. Definite \_\_\_\_\_

c. \_\_\_\_\_ packed molecules

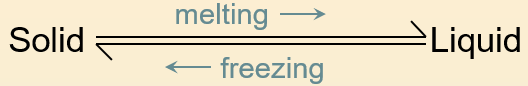
d. \_\_\_\_\_ density than liquids or gases

e. Usually least compressible of phases

f. Molecules move \_\_\_\_\_ of all the phases

g. Particles vibrate about \_\_\_\_\_ points, and do \_\_\_\_\_ flow

Phase Changes for Solids



\_\_\_\_\_ point (mp)

* The temperature at which a \_\_\_\_\_ changes into a \_\_\_\_\_.
* The disruptive vibrations of the particles are strong enough to overcome the \_\_\_\_\_ that hold them in fixed positions.
* Melting: \_\_\_\_\_ energy > intermolecular \_\_\_\_\_

\_\_\_\_\_ point (fp)

* The temperature at which a \_\_\_\_\_ changes into a \_\_\_\_\_.
* \_\_\_\_\_: kinetic energy < intermolecular forces
* Tmp = Tfp

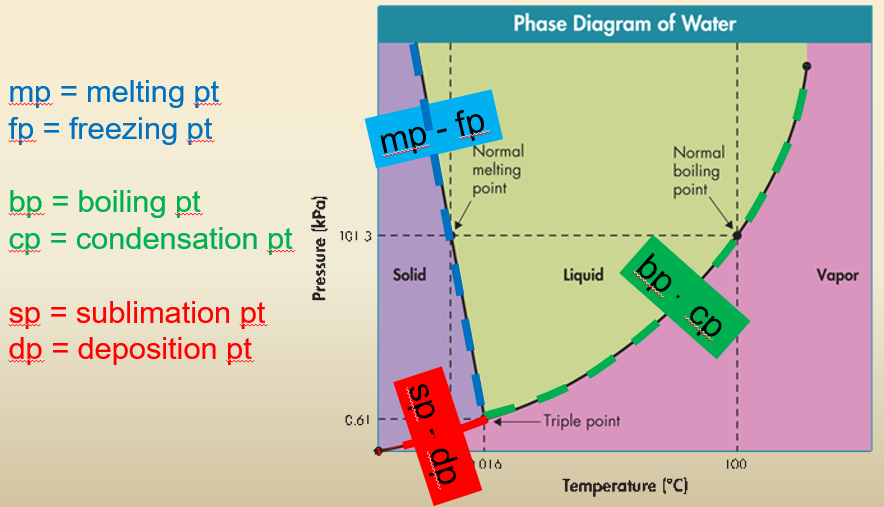


\_\_\_\_\_

* The change of a substance from a \_\_\_\_\_ to a \_\_\_\_\_ without passing through the liquid state is called sublimation. Sublimation occurs in solids with vapor pressures that exceed atmospheric pressure at or near room temperature.
* \_\_\_\_\_: KE > intermolecular forces
* \_\_\_\_\_: KE < intermolecular forces

Phase Diagrams

* Represent the relationships among the \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ states (or phases) of a substance in a sealed container
* The phase diagram of water shows the relationship among \_\_\_\_\_, \_\_\_\_\_, and the physical states of water (s, l, g).
* The conditions of \_\_\_\_\_ and \_\_\_\_\_ at which two phases exist in \_\_\_\_\_ are indicated on the phase diagram by a line separating the phases.
* Each slope line represent the equilibrium conditions for one of the phase changes. Label each phase change on the phase diagram:



\_\_\_\_\_ Point

* The point on the diagram at which all \_\_\_\_\_ phases can exist in equilibrium with one another.
* Freezing, melting, boiling, condensation, sublimation, & deposition are \_\_\_\_\_ occurring at the \_\_\_\_\_ time.
* \_\_\_\_\_ is unique:
* As pressure increases on solid water (*move up the slope line for s ↔ l*), it will eventually melt into liquid water, \_\_\_\_\_ as it \_\_\_\_\_.
* For all other substances in creation solids \_\_\_\_\_ as they freeze, meaning that the *s ↔ l* line on the phase diagram will slope the opposite direction.
* *God is very cool, isn't He?*