KINETIC MOLECULAR THEORY

Describes how/why gases behave the way they do

1) gases have low density
   - ↳ particles typically occupy a volume about 1000 times greater than the volume occupied by particles in liquid/solid state

   molecules of gases are much farther apart as most of the volume occupied by a gas is empty space

   density: $\frac{\text{mass}}{\text{volume}}$ gas: $\frac{\text{less mass}}{\text{more space}}$ = ↓D

   gas can expand/compress

2) Gas particles bounce off each other when they collide
   - ↳ elastic collisions = no net loss of kinetic energy

   kinetic energy (KE) = energy of motion
   - ↳ usually KE is transferred between 2 particles during collisions but the total KE is same when temperature is same

   because KE is same for gases in a specific space, they do not loose energy

3) Gas particles move fast, all the time
   - ↳ therefore, they possess kinetic energy

   gas particles move in all directions

   the KE overcomes the attractive forces between them
   - ↳ only when gas, does not apply to liquids/solids

4) There are no intermolecular forces between gas particles.
   - ↳ assumed for now

5) The KE of gas particles depends on the temperature of gas
   - ↳ more heat = more speed

   KE only depends on speed, not mass because mass (m) is the same regardless of the temperature. So, speed only matters

   $KE = \frac{mv^2}{2}$

   ↑KE = ↑T

PRESSURE

Pressure: force per unit area

temperature: degree of hotness

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

volume: space taken up

mass: amount of matter

↑A = ↓P

Ex. sneakers have less pressure than high heels because more surface area and the weight is more spread out.

↓P in sneakers allows it to stay flat on wet grass as not much force pushing down

↑P in high heels causes it to sink on wet grass as more force down
- ↳ in both cases weight (F) is same

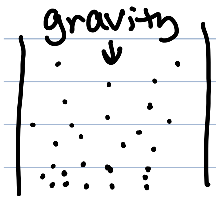
Atmospheric Pressure: Air pushes down on us all the time as a result of gravity pulling down air particles towards the center of the Earth

our body is used to it and so many gas molecules average out, so we don't feel anything

1 atm: normal atmospheric pressure
psi = pounds per square inch
mmHg = millimeters per mercury

Pa = Pascal
kPa = kilo Pascal
torr = mm Hg

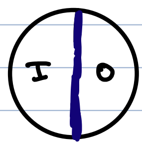
REAL LIFE EXAMPLES



Gravity pushes down on gas molecules so there is more concentration on the bottom

harder to breathe at high temperatures because there are less gas molecules

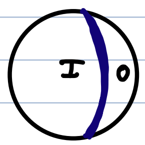
Ears Popping:



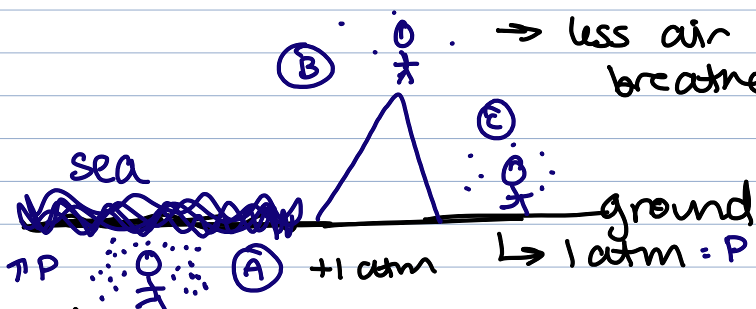
▬ is ear drum I = inside ear O = outside ear

at 1 atm, I force = outside force

at high altitudes, there is less pressure because there is less gas molecules and less weight (F) $\downarrow F = \downarrow P$



so, I force > O force which causes ear drum to bulge forward as the greater force tries to overcome the weak force. "Popping" adjusts ear drum and I = O again



→ less air hard to breathe (thin air)

↓P

↳ 1 atm = P (normal)

4 mi above = 0.5 atm
10 mi above = 0.2 atm
↳ P↓ as height ↑

↳ H_2O is more dense than gas, so more force and more pressure

some animals have their own adaptations (fish) for the pressure in their enviornment

too fast change in pressure is bad because adaptations can't happen that quickley.

coke is made under high pressure (hard to press) but releasing pressure (open) causes gas to escape and the carbonation escapes too heat increases the pressure → atoms are faster and they bounce off sides more often, causing can to burst in high temp.

in coke, CO_2 does not dissolve with the soda.
shaking the can makes the CO_2 surface, so opening it causes it to fizz

PRESSURE AND GAS CHARACTERISTICS

expansion: gases will expand to fit the size of their container

compression: volume changes with pressure
↳ push on something squishes particles closer

vaccum: no air at all (space: total vaccum)
↳ astronauts struggle with the transition from 0 atm to 1 atm

Boiling water: water boils at a lower temperature at high altitudes
water boils when its molecules are able to spread out enough to become a gas.
↳ this requires a certain amount of energy because there is a certain amount of force being pushed down on the water molecules that prevents it from turning into gas

at high altitudes, there are less gas molecules and less pressure there is less force applied on the water which means that it does not require as much heat energy to overcome attraction

GAS LAWS

Boyles Law: $P_1V_1 = P_2V_2$ when temperature and moles are constant
pressure and volume are inversely related in flexible container

Charles law: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ when pressure and moles are constant
volume and temp. are directly related in flexible container

Gay-Lussac law: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ when volume and moles are constant
pressure and temp are directly related in rigid container

Avagadros law: $\frac{V_1}{n_1} = \frac{V_2}{n_2}$ when pressure and temp. are constant
volume and moles are directly related in flexible

GAS LAW REASONING

1) as ↑P ↓V (inverse in flexible) → Boyle's law
more outside pressure pushes the object with flexible container and it takes up less space (less volume)

decreasing the outside pressure increases the volume because not as much force pushing down on object, allowing it to expand

2) as ↑T ↑V (direct in flexible) → Charles's law
heat makes particles move faster. This expands the object because particles are colliding with the surface of the object more frequently and with more force.

3) as ↑T ↑P (directly related in rigid) → Gay Lussac's law
heat makes the gas particles move faster. This makes the collide to the sides of the rigid container more frequently and more forcefully, but the rigid container can't change to adapt to the pressure change

Diffusion: goes from high concentration to low concentration
pressure goes from high to low as well
↳ high pressure exerts more force on low pressure

GAS LAW EQUATIONS

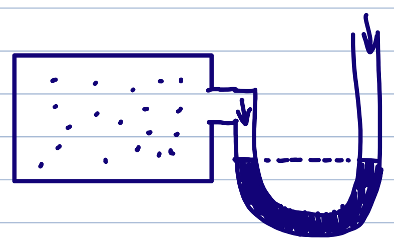
Combined Gas law: $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ → combines Boyles and Charles's law because they are both for flexible containers

Ideal Gas law: $PV = nRT$ → R = constant equation can derive all other gas laws when constant

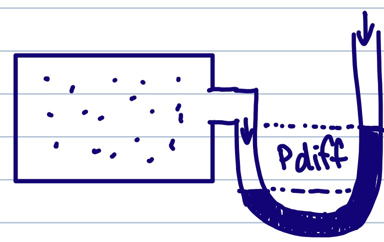
$\frac{1\ mol}{22.4\ L}$ volume : mol

MANOMETERS

manometer: device that measures the pressure of a gas in an enclosed container
made from U-tube filled with mercury
the pressure of the gas in container is compared to the atmosphere

A

Gas pressure is same as atmosphere pressure

$P_{gas} = P_{atm}$

B


Gas pressure is more than atmosphere pressure

$P_{gas} = P_{atm} + P_{diff}$

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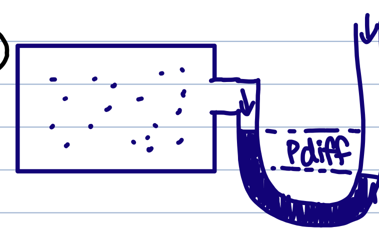


Gas pressure is less than atmosphere pressure

$P_{gas} = P_{atm} - P_{diff}$

The one with more pushes the mercury towards the other side

* make sure the units are all the same when adding/subtracting them *

KELVIN

Temperature for gas MUST always be in kelvin, not C° or F°

absolute zero : when atoms COMPLETELY stop moving
cold temp. still vibrates them, not stop

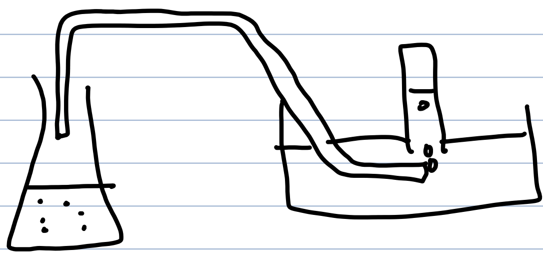
kelvins : at 0 K is absolute zero which has not achieved
can never be -ve cause below not moving makes no sense
↳ allows our gas laws to be true

DALTON'S LAW of PARTIAL PRESSURE

Dalton's law : the total pressure of a mixture of gases is equal to the sum of partial pressures (part of the pressure)

$P_{total} = P_1 + P_2 + \ldots + P_n$

collecting gas over water : way to trap gas produced by reaction to quantify it
have to use Dalton's law because both the gas and water vapor contribute to overall pressure in the tube



gas from the reaction goes to the test tube and occupies space above the water because it has less density

The gas is creating pressure on the wall
↳ not only gas, but so is H_2O

The number of moles is directly related to pressure
↳ mass does not matter because pressure is based on # of moles

GRAHAMS LAW

graham's law : temp. is directly proportional to kinetic energy ↑T ↑KE
small molecules have more kinetic energy

$KE = \frac{1}{2}mv^2$ m = molar mass v = velocity / speed   m and v are inversely related

It takes more energy to move a big molecule

At the same kinetic energy and same temp, smaller molecules will move faster than the larger one

Same kinetic energy for big/small mass, but different speed/velocity

$\frac{r_1}{r_2} = \sqrt{\frac{mm\,s_2}{mm\,s_1}}$ rate₁ and rate₂ $s_{1,2}$ = substance (only when temp same)