TOPIC 1.1

STATES (PHASES) OF MATTER

How do we use particle models to show differences in solids, liquids, and gases?

Take a look at the world around you, even just in this classroom. You will find that there are many substances in the room, but not all are in the same state of matter. **State** (aka **phase) of matter** is a **physical property** that can be used to describe any element, compound, or mixture *at a particular temperature and pressure.*

Physical Property:

Property or Characteristic	SOLID	LIQUID	GAS
Represented by: (lowercase, always!)	(s)	(l)	(g)
Particle Diagram			
Shape • definite/fixed/crystal • always takes shape of container	definite/fixed/crystal	always takes shape of container	always takes shape of container
Volume • definite/fixed • always fills volume of container	definite/fixed	definite/fixed	always fills volume of container
Distance Between Particles • large • medium • small	small	medium	large
Particle Movement • free to move • limited motion • mostly fixed position	mostly fixed	limited motion	free to move
Particle Attraction • strongest • weaker • weakest	strongest	weaker	weakest

REFERENCE TABLES **Table A**

STP = Standard Temperature and Pressure

TOPIC 1.2 DENSITY

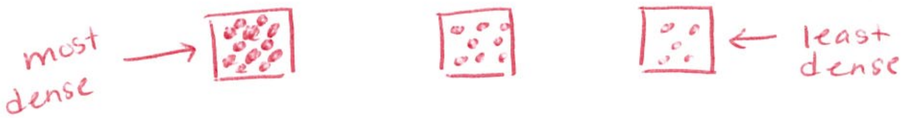
How can we mathematically represent "closeness" of particles?

The key difference between solids, liquids, and gases is just how far apart the individual particles are. Wouldn't it be great if we had some kind of scale to describe *just how* close particles were? Oh, you know chemistry has that.

Density: a measure of how compact particles are

☆ Ref Table T

$$\boxed{\text{Density} = \frac{\text{mass}}{\text{volume}}} \quad \begin{matrix} \leftarrow g \\ \leftarrow mL \text{ or } cm^3 \end{matrix}$$



At STP, King Joffrey has a crown that weighs 1060 g. When tested, it displaced 430 mL of water. According to Reference Table S, is this crown made of gold? Explain in terms of *density.*

$$D = \frac{m}{v} = \frac{1060g}{430\,mL} = 2.5\,g/mL$$

☆Ref Table S

Gold's actual density is 19.3 g/cm^3. King Joffrey's crown, therefore, is not made of gold b/c it only has a density of 2.5 g/cm^3.

How many grams of copper are needed to fill a 10 cm^3 container at STP?

↳ Cu, Table S to find density = 8.96 g/cm^3

① $D = \frac{m}{v}$

$8.96 = \frac{x}{10}$

$x = 89.6g$

OR

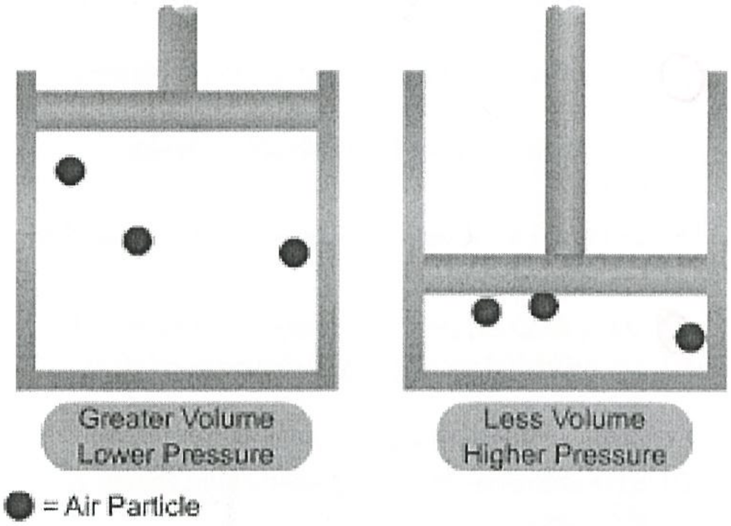
② $10\cancel{cm^3} \times \left(\frac{8.96g}{1\cancel{cm^3}}\right) = 89.6g$

TOPIC 1.3

KINETIC MOLECULAR THEORY

What is it about gases that allows them to be compressible and expandable?

Gases have three characteristic properties: they are easy to compress, they expand to fill their containers, and they occupy far more space than the liquids or solids from which they form. Think about solids and liquids for a moment...can they do that?



The best way to understand the cool, unique properties of gases is to model their behavior. We will use an online simulator to help visualize what goes on in a gaseous substance under varying conditions of **volume, temperature,** and **pressure.** Before we get to that, you need to understand the tenants of the **kinetic molecular theory.**

* particles have kinetic energy, which is measured by volume!

K INETIC M OLECULAR T HEORY (KMT)

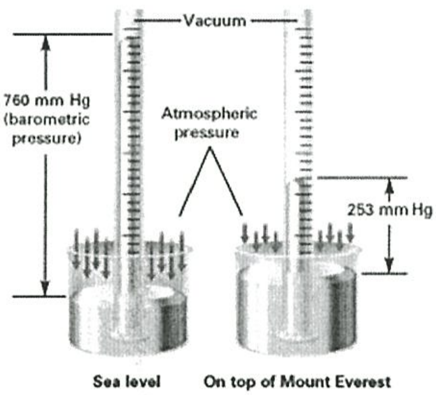
1. Gas particles are in continuous random, straight-line motion.
2. When gas particles collide, there is a transfer of energy; but the total amount remains constant.
   - elastic collisions
3. Gas particles are tiny and very far apart. The volume of the gas particles is negligent compared to the volume of space they are in.
4. NO ATTRACTION between particles.

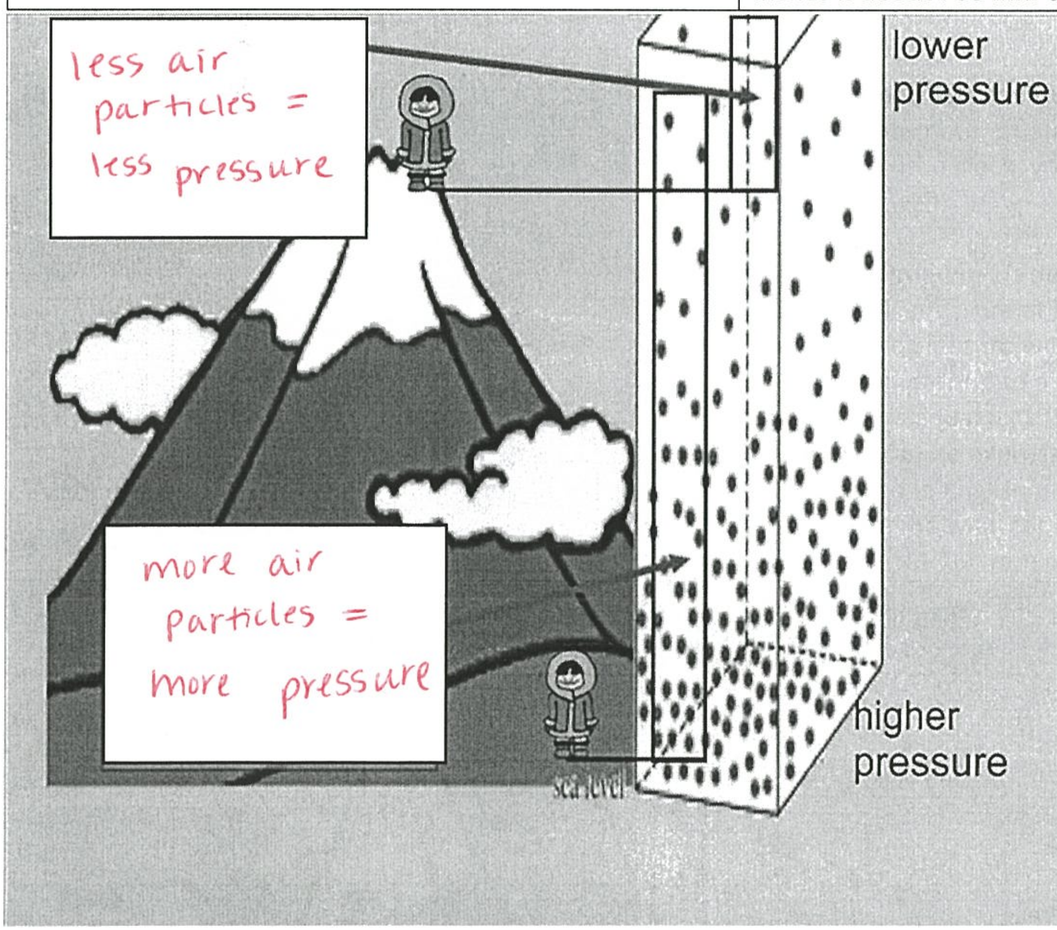
KMT describes how gases *should* behave: "ideal gases"

TOPIC 1.4

ATMOSPHERIC PRESSURE

What happens when gas particles collide into one another and other objects?

What is atmospheric $\boxed{\text{pressure}}$? pressing/pushing force *when gas particles collide*	pressure that gas particles in the atmosphere exert
Why does it decrease as elevation increases?	there is less air pushing down
How is it measured?  	Atmospheric Pressure is usually measured using either a mercury barometer or an aneroid barometer (one that looks like a little clock; you may have seen one like this on someone's wall). "Standard Pressure" is defined as the average atmospheric pressure at sea level. On the average day, atmospheric pressure will push the column of mercury in an Hg barometer up to a height of 760 mm. The actual "pressure" is equal to 101.3 kiloPascals (kPa) in metric units, or it can be expressed as "1 atmosphere" (1 atm) or expressed in English units, 14.7 pounds per square inch (psi), or like the weather man reports it "30.0 inches" (30 inches is about 760 mm on a ruler).

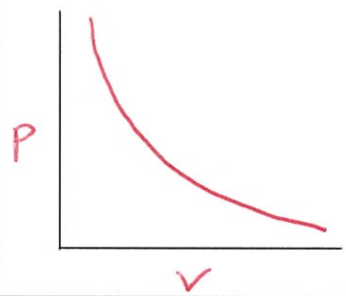
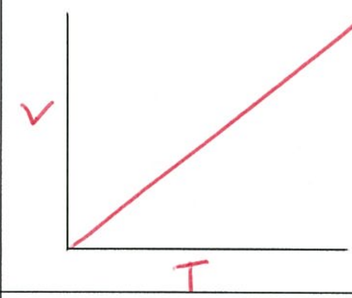
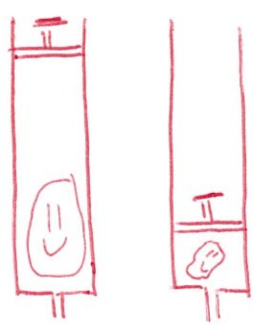
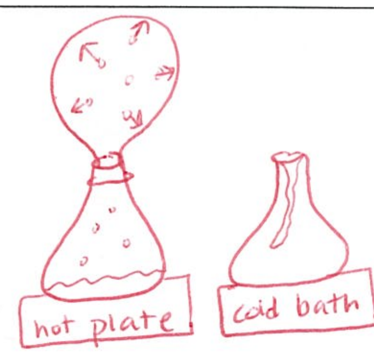


TOPIC 1.5

GAS LAWS

V T P

What are the relationships between volume, temperature, and pressure?

Law	***Gay-Lussac's***	***Boyle's***	***Charles'***
Relationship	As T ↑, P ↑ (as T ↓, P ↓) ☆ direct	As V ↓, P ↑ (as V ↑, P ↓) ☆ indirect	As T ↓, V ↓ (as T ↑, V ↑) ☆ direct
Graph			
Explanation *(in terms of particle collisions)*	higher T causes particle collisions to occur more frequently and with greater force	less V causes particles to collide more frequently	☆as T ↑, particle motion ↑, so expansion occurs ☆ as T ↓, particle motion ↓, so contraction occurs
Picture			

TOPIC 1.6

THE MATH OF GASES

What formulas and unit conversions are you responsible for?

Unit Conversions

Pressure

There are many units that are commonly used to describe **pressure,** the two that you need to know for the Regents are:

- Atmospheres (atm)
- kiloPascals (kPa)

★ REFERENCE TABLES **Table A**

Standard Pressure = 1atm = 101.3 kPa

Temperature

While in our everyday lives we are most familiar with using the Fahrenheit scale, in chemistry we will be exclusively using these two units for temperature:

- Celsius
- Kelvin

★ REFERENCE TABLES **Table T**

Temperature: K = °C + 273

example

1) 200K = <u>-73</u> °C

$$200 = °C + \cancel{273}$$
$$-273 \quad\quad -\cancel{273}$$
$$-73\ °C$$

2) 25°C = <u>298</u> K

K = 25 + 273 = 298

Formulas

REFERENCE TABLES
Table T

Combined Gas Law	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	P = pressure V = volume T = temperature

Anytime you use the combined gas law you must follow these three "rules:"

- Temperature **MUST BE** in Kelvin
- Pressure has to be in the same units
- Volume has to be in the same units

Practice Problems

1) A gas takes up a volume of 17 liters, exerts a pressure of 200 kPa, and has a temperature of 200 K. If I raise the temperature to 400 K and lower the pressure to 50 kPa, what is the new volume of the gas?

$V_1 = 17$ L $\quad V_2 = X$

$P_1 = 200$ kPa $\quad P_2 = 50$ kPa

$T_1 = 200$ K $\quad T_2 = 400$K

$$\frac{(\cancel{200})(17)}{(\cancel{200})} = \frac{(50)X}{(400)}$$

$6800 = 50x$

$\boxed{X = 136\text{ L}}$!

2) A gas that has a volume of 28 liters, a temperature of 45°C, and an unknown pressure has its volume increased to 34 liters and its temperature remains constant. If I measure the pressure after the change to be 2.0 atm, what was the original pressure of the gas?

$V_1 = 28$ L $\quad V_2 = 34$ L

$T_1 = 45°C \quad T_2 = 45°C$

$P_1 = X \quad P_2 = 2.0$ atm

$$\frac{P_1V_1}{\cancel{T_1}} = \frac{P_2V_2}{\cancel{T_2}}$$

$$\frac{(x)(\cancel{28})}{\cancel{28}} = \frac{(2)(34)}{28}$$

$\boxed{x = 2.5\text{ atm}}$!

3) A gas has a temperature of 14°C, and a volume of 4.5 liters. If the temperature is raised to 29°C and the pressure is not changed, what is the new volume of the gas?

$V_1 = 4.5$ L $\quad V_2 = x$

$T_1 = 14°C \quad T_2 = 29°C$

P_1 = constant = P_2

$$\frac{\cancel{P_1}V_1}{T_1} = \frac{\cancel{P_2}V_2}{T_2}$$

convert to Kelvin

$T_1 = 14 + 273 = 287$

$T_2 = 29 + 273 = 302$

$$\frac{4.5}{287} = \frac{x}{302}$$

$1359 = 287x$

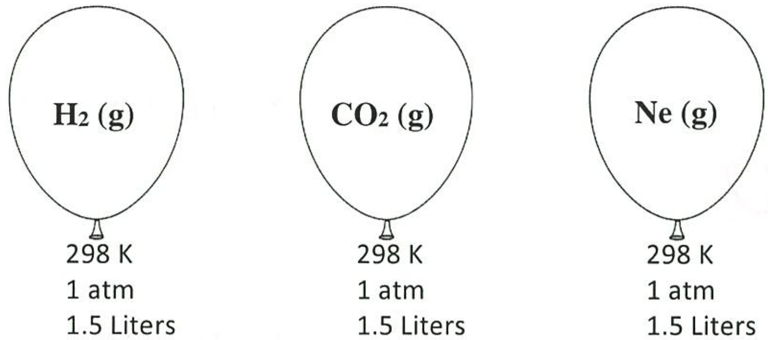
$x = 4.7$ L

TOPIC 1.7

AVOGADRO'S HYPOTHESIS & IDEAL GAS CONDITIONS

Under what conditions do gases behave most ideally (most like a gas)?

Avogadro's Hypothesis



1.) Analyze the balloons above. Each balloon is at 298 K, 1 atm, and contains a volume of gas that takes up 1.5 liters of space. The only difference is the type of gas contained within each balloon. Which of the following is **TRUE** regarding the number of molecules contained within the balloons?

a. The balloon containing the CO_2 (g) has the greatest number of molecules, H_2 (g) next, Ne (g) least.
b. The balloon containing the Ne (g) has the greatest number of molecules, H_2 (g) next, CO_2 (g) least.
c. All 3 balloons contain the same number of molecules.

Explain your choice! when T, V, and P are the same, the # of gas molecules must also be the same.

Ideal vs. Real Gas

2.) Draw a particle diagram to represent a gas inside this box →

- List as many properties of a gas as you can.

  move fast, can expand or contract, no def. volume/shape, not attracted to each other, tiny, very far apart

- Now THINK! What conditions of temperature (high or low) and pressure (high or low) allow gases to behave MOST like a gas wants to behave? ***Explain why!***

  High temp & low pressure
  → gas particles can move fast & spread out

- What conditions of temperature (high or low) and pressure (high or low) allow gases to behave LEAST like a gas wants to behave? ***Explain why!***

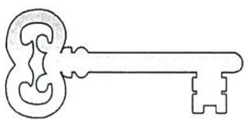
  Low temp (slow down) & high pressure (forced together)
  → gas particles start to condense

TOPIC 1.8

VAPOR PRESSURE

What is vapor pressure and what can it tell us about a substance's particle attractions?

According to the Kinetic molecular theory both the particles in gases and the particles in liquids have kinetic energy. This allows particles in gases and liquids to flow past one another.



The key difference → there are NO attractions between the particles in a gas; but the particles in a liquid are attracted to each other. These intermolecular attractions (or forces) keep the particles in a liquid close together, which explains why liquids have a definite volume

IMPORTANT VOCABULARY

Temperature → a measure of the AVERAGE kinetic energy of the particles

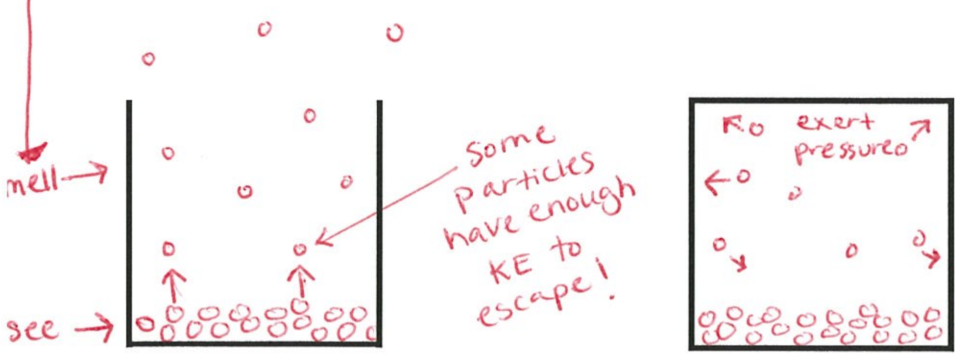
Sublimation → the phase change from a SOLID to a GAS

Vaporization → the phase change from a LIQUID to a GAS

Evaporation → vaporization that occurs at the surface of a liquid that is NOT at its boiling point

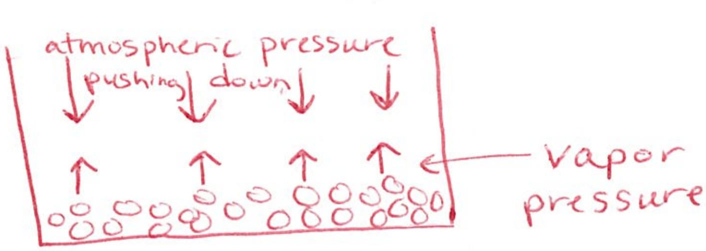
imagine a smelly liquid

Evaporation in an open vs closed container:



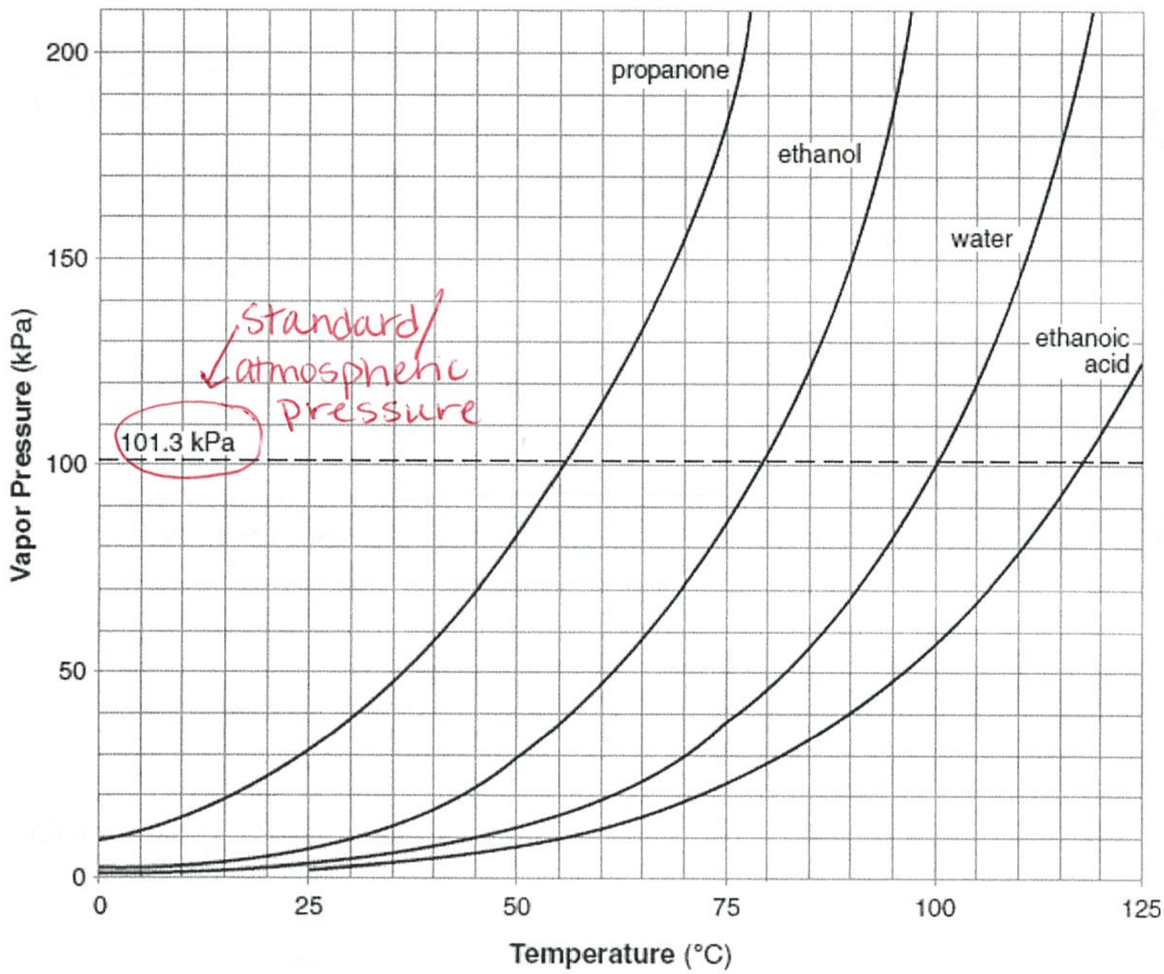
VAPOR PRESSURE → a measure of the force exerted by a gas above a liquid
(gas) (pushing force)

Boiling point → when enough liquid has "escaped" to the gas phase so that vapor pressure = atmospheric pressure



REFERENCE TABLES **Table H**

Table H
Vapor Pressure of Four Liquids



VAPOR PRESSURE & PARTICLE ATTRACTIONS/INTERMOLECULAR FORCES (IMFs)

IMFS: attractions between particles ("stickiness")

- weak attractions = "looser" particles = more escapees = more vapor [High Vapor Pressure]
- strong attractions = "tighter" particles = fewer escapees = less vapor [Low Vapor Pressure]

State the relationship between vapor pressure and strength of attraction between molecules.

As IMFs increase, VP decreases

VAPOR PRESSURE & BOILING

Boiling Point: when enough vapor builds up that every particles starts to escape as a gas

- more vapor = more escapees = easier to get boiling = low BP [High Vapor Pressure]
- less vapor = few/little escapees = harder to get boiling = high BP [Low Vapor Pressure]

State the relationship between vapor pressure and boiling point.

As VP increases, BP decreases