Name___Key___________________ **DUE DATE:** Monday 10/15

*Regents Chemistry Unit 1 – Behavior of Gases Study Guide*

| | Unit Learning Target | YES. Got it. | Needs review | NOPE. Not yet. |
|---|---|---|---|---|
| **1** | I can use particle diagrams to model and describe the behavior of the three phases (states) of matter. | | | |
| **2** | I can use Table S to determine the phase of matter of each element at a given temperature. | | | |
| **3** | I can use the density equation and Table S to calculate unknown densities, masses, or volumes. | | | |
| **4** | I can convert between degrees Celsius and Kelvin. | | | |
| **5** | I can state the relationship between vapor pressure, intermolecular forces, and boiling point. | | | |
| **6** | I can use Table H to describe the effect of changes in temperature or vapor pressure of four different liquids. | | | |
| **7** | I can identify the properties and behavior of an ideal gas. | | | |
| **8** | I can state how pressure, temperature, or volume will change in response to one changed environmental condition (individual gas relationships). | | | |
| **9** | I can use the Combined Gas Law to calculate the magnitude of a change in pressure, volume, or temperature of a system of gas. | | | |

if these columns are checked, see Miss Virga!

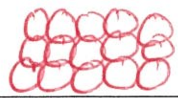
*Vocabulary*

1. __h__ solid
2. __e__ liquid
3. __i__ gas
4. __l__ density
5. __b__ kinetic molecular theory
6. __f__ ideal gas conditions
7. __c__ vapor pressure
8. __j__ pressure vs temperature
9. __a__ pressure vs volume
10. __k__ temperature vs volume
11. __g__ Avogadro's hypothesis
12. __d__ STP

a) Indirect relationship; less space means particles collide more often and vice versa
b) 4 components to describe an IDEAL gas: 1) gas particles are in continuous, random, straight-line motion 2) transfer of energy when gas particles collide 3) volume of gas particles is negligible 4) no attraction between particles
c) Force exerted by a gas above a liquid
d) 1 atm or 101.3 kPa, 273 K or 0°C
e) Particles are loosely arranged, have limited motion, take the shape of their container but have definite volume, moderate intermolecular forces
f) High temperature, low pressure
g) Samples of gas at the same temperature and pressure have the same number of molecules if the volume is also the same
h) Particles are arranged in a crystal structure, vibrate in place, are highly ordered, have a definite shape and volume, strong intermolecular forces
i) Particles are spread out, moving rapidly, take the shape and volume of their container, weak intermolecular forces
j) Direct relationship; when T increases particles collide more often and with more force
k) Direct relationship; particles expand when T increases
l) How compact particles are, can be calculated (D = mass/volume)

**#1)** States of Matter

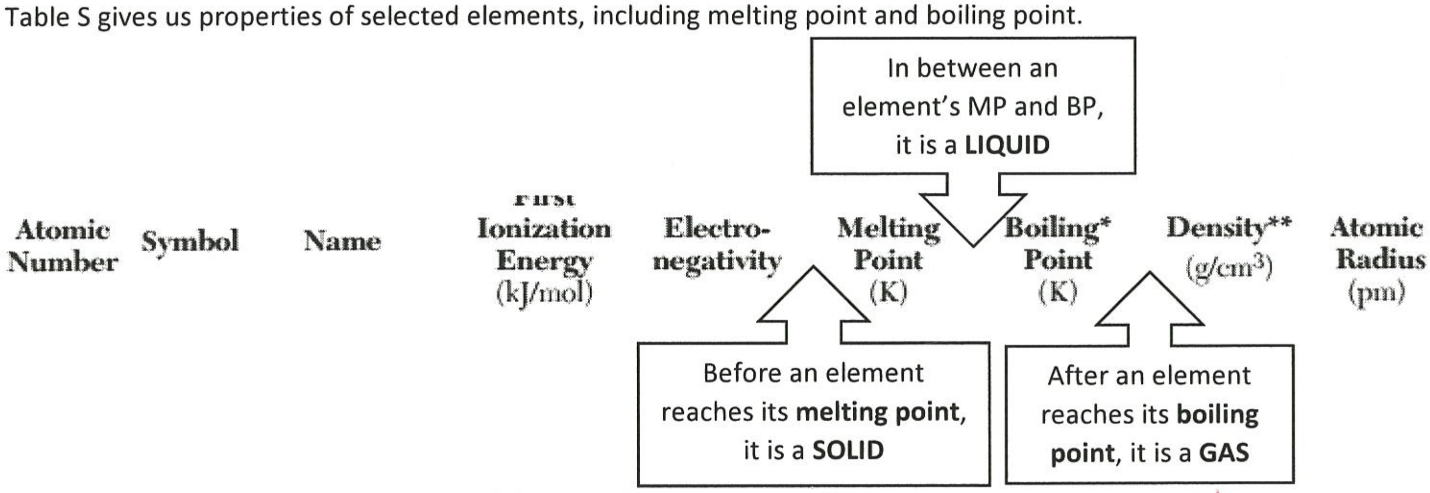
To review properties of solids, liquids, and gases, fill in the chart below.

| **Property or characteristic** | **SOLID** | **LIQUID** | **GAS** |
|---|---|---|---|
| Represented by… | (s) | (l) | (g) |
| Particle Diagram |  |  |  |
| Shape (definite/fixed or takes shape of container) | definite / fixed | takes shape of container | takes shape of container |
| Volume (definite/fixed or fills volume of container) | definite / fixed | definite / fixed | fills volume of container |
| Distance between particles (small, medium, large) | small | medium | large |
| Particle Movement (mostly fixed, limited, free to move) | mostly fixed | limited | free to move |
| Particle Attraction (weakest, moderate, strongest) | strongest | moderate | weakest |

**DETERMINING THE STATE AN ELEMENT IS IN AT STP**

STP = Standard Temperature and Pressure (Table A tell us standard temperature in Kelvin is: 273 )

Table S gives us properties of selected elements, including melting point and boiling point.




PRACTICE: What state of matter are the following elements in at STP?

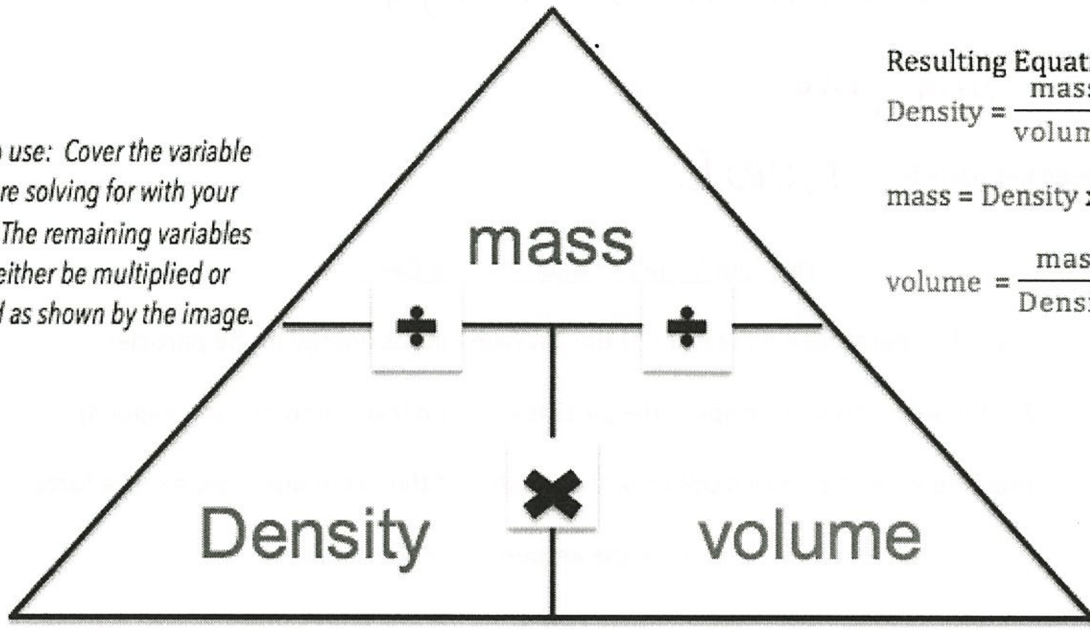
Mercury: liquid
Chlorine: gas
Platinum: solid

**#2)** Density

Density describes how **tightly packed** the particles are in a sample of matter. Density of a substances **can** change, depending on temperature. For instance, when you freeze water to make ice, the density changes (ice is actually less dense than water). We can calculate density using the density formula, given in **Table T.**

$$D = \frac{m}{v}$$

*How to use: Cover the variable you are solving for with your hand. The remaining variables will either be multiplied or divided as shown by the image.*




Resulting Equations:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\text{mass} = \text{Density} \times \text{volume}$$

$$\text{volume} = \frac{\text{mass}}{\text{Density}}$$

*How much space would a 10.0 gram chunk of silver take up?*

$D = 10.5\ g/cm^3$ (Table S)

0.952

$D = \frac{m}{V} \rightarrow \frac{10.5}{1} = \frac{10}{V} \rightarrow \frac{10.5V}{10.5} = \frac{10}{10.5} \rightarrow$ $V = 0.952\ cm^3$

*Calculate the mass of a 50.0 cm³ chunk of pure gold.*

$D = 19.3\ g/cm^3$ (Table S)

$50 \times 19.3 = \frac{m}{50} \times 50$

$m = 965\ g$

## #3) Gases

What are the four tenants of the Kinetic Molecular Theory?

**KINETIC MOLECULAR THEORY**

**1.** Motion of Gas Particles: random, straight - line

**2.** Gas Particle Collisions & Energy: transfer of energy

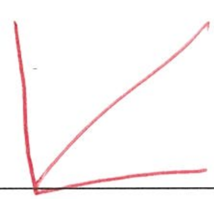
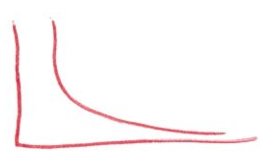
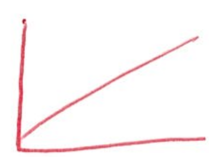
**3.** Size of Gas Particles: negligible

**4.** Attraction between gas particles: NONE

The Four Variables that Describe Gases:

1. Temperature = a measure of the **average kinetic energy** of the particles
2. Volume = how much space the particles take up (can **compress** and **expand**)
3. Pressure = when particles **collide** with the walls of their container they exert a **force**
4. Quantity = the **amount** of gas particles

**GAS LAWS**

| LAW | **VOLUME VS TEMPERATURE** *Charles'* | **VOLUME VS PRESSURE** *Boyles'* | **TEMPERATURE VS PRESSURE** *Gay-Lussac's* |
|---|---|---|---|
| Relationship | At constant pressure, as TEMPERATURE **increases,** VOLUME increases. *direct or inverse?* | At constant temperature, as PRESSURE **increases,** VOLUME decreases. *direct or inverse?* | At constant volume, as TEMPERATURE **increases,** PRESSURE increases. *Direct or inverse?* |
| Graph |  |  |  |
| Explanation | Particles move faster & expand | Particles contract into a smaller space | Particles collide more often & w/ more force |

# IDEAL GASES

**Under what conditions of temperature (high or low) and pressure (high or low) do gases behave **most ideally** (most like a gas)?*

**HIGH TEMPERATURE =** particles can move around quickly and spread out

**LOW PRESSURE =** less pressure exerted on a gas means the particles can spread out

**Under what conditions of temperature (high or low) and pressure (high or low) do gases behave **least ideally** (most like a gas)?*

**LOW TEMPERATURE =** particles slow down and get closer together

**HIGH PRESSURE =** high pressure on a gas forces the particles closer together

1.) Under which conditions of temperature and pressure would a real gas behave most like an ideal gas?
(1) 200. K and 50.0 kPa
(2) 200. K and 200.0 kPa
(3) 600. K and 50.0 kPa
(4) 600. K and 200.0 kPa

2.) Under which conditions of temperature and pressure does oxygen gas behave *least* like an ideal gas?
(1) low temperature and low pressure
(2) low temperature and high pressure
(3) high temperature and low pressure
(4) high temperature and high pressure

# AVOGADRO'S HYPOTHESIS

If different samples of gases have the **same** temperature, volume, and pressure, we can assume they have the **same** number of molecules. This will help us answer questions like these:

1.) Which two samples of gas at STP contain the same total number of molecules?
(1) 1 L of CO(g) and 0.5 L of $N_2$(g)
(2) 2 L of CO(g) and 0.5 L of $NH_3$(g)
(3) 1 L of $H_2$(g) and 2 L of $Cl_2$(g)
(4) 2 L of $H_2$(g) and 2 L of $Cl_2$(g)

2.) Which sample at STP has the same number of molecules as 5 liters of $NO_2$(g) at STP?
(1) 5 grams of $H_2$(g)
(2) 5 liters of $CH_4$(g)
(3) 5 moles of $O_2$(g)
(4) 5 x $10^{23}$ molecules of $CO_2$(g)

3.) At STP, 1.0 liter of helium contains the same total number of atoms as
(1) 1.0 L of Ne
(2) 2.0 L of Kr
(3) 0.5 L of Rn
(4) 1.5 L of Ar

# MATH OF GASES

## TEMPERATURE CONVERSIONS

| |
|---|
| ***Temperature*** |
| **** USE EQUATION ON TABLE T**** |
| **K = °C + 273** |

PRACTICE PROBLEMS:

1. 50°C = 323 K
2. 400 K = 127 °C
3. -75 °C = 198 K
4. 98 K = -175 °C

## COMBINED GAS LAW

**Get Equation from Table T!**

| | | |
|---|---|---|
| **Combined Gas Law** | $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ | $P$ = pressure<br>$V$ = volume<br>$T$ = temperature |

The 3 things to always remember when using this equation:

- Temperature MUST BE IN KELVIN before plugging in
- Volume just has to be in the same units
- Pressure just has to be in the same units

Tricks to using the equation

- Whenever a variable is held constant/doesn't change, that means you can leave it out of the equation (check out examples on next page)
- When a gas is held at STP that means you check out Table A to get the values needed for T and P! (check out examples on next page)

EXAMPLE PROBLEMS:

#1) A rigid cylinder contains a sample of gas at STP. What is the pressure of this gas after the sample is heated to 410 K?

$V_1$ = rigid cylinder (VOLUME IS CONSTANT) = $V_2$

$T_1$ = 273 K } STP

$P_1$ = 1 atm }

$T_2$ = 410 K

$P_2$ = ?

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

* notice I didn't include volume

$$\frac{1}{273} = \frac{x}{410}$$

$$\frac{410}{273} = \frac{273x}{273}$$

**1.5 atm** = x

* I know the units are atm b/c it has to match the $P_1$

#2) At 25°C, gas in a rigid cylinder with a movable piston has a volume of 145 mL and a pressure of 125 kPa. Then the gas is compressed to a volume of 80. mL. What is the new pressure of the gas if the temperature is held at 25°C?

$T_1$ = 25°C  $T_2$ = 25°C

$V_1$ = 145 mL  $V_2$ = 80 mL

$P_1$ = 125 kPa  $P_2$ = ?

* since temp. remains the same, I don't have to include it

$$P_1V_1 = P_2V_2$$

$$\frac{(125)(145)}{80} = \frac{P_2(80)}{80}$$

227 = $P_2$

**227 kPa**

Now you try!

#3) 2.00 L of a gas is collected at 25.0 °C and 0.98 atm. What is the volume at STP?

$V_1$ = 2.00 L

$P_1$ = 0.98 atm

$T_1$ = 25°C + 273 = 298 K

$V_2$ = x

$P_2$ = 1.00 atm

$T_2$ = 273 K

$$\frac{(2)(0.98)}{298} = \frac{(1)x}{273}$$

535.08 = 298x

**x = 1.8 L**

## #7) VAPOR PRESSURE

Water will completely evaporate if left in an open container at room temperature for long enough. How do water molecules go from liquid to gas if the water isn't boiling?! Remember, temperature is a measure of the **average** kinetic energy of particles...so, some particles have **enough KE** to escape into the gaseous phase. When evaporation occurs in a closed container, those gas particles get trapped and move around on the surface above the liquid. The **pressure** that those gas particles exert as they collide about and with the walls of the container is called **VAPOR PRESSURE.**

**Vapor Pressure, Particle Attractions/Intermolecular Forces (IMFs), & Boiling Point**

*RELATIONSHIP BETWEEN VP & IMFS*

**WHAT**

The stronger the attraction between particles, the lower the vapor pressure.

**WHY**

This is because less particles are likely to escape to the gaseous phase because they are strongly attracted to one another as a liquid.

*RELATIONSHIP BETWEEN VP & BP*

**WHAT**

The higher the vapor pressure, the lower the boiling point.

**WHY**

A liquid will boil when its vapor pressure matches atmospheric pressure, so if there is a lot of vapor pressure at the surface of the liquid, that means it takes less energy (heat) to get the rest of the liquid to completely boil.

**Table H**

Make sure you know how to interpret Table H! Practice these problems.

1.) Which liquid has the *lowest* vapor pressure at 65°C?
(1) ethanoic acid (3) propanone
(2) ethanol (4) water

2.) At which temperature is the vapor pressure of ethanol equal to the vapor pressure of propanone at 35°C?
(1) 35°C (3) 82°C
(2) 60.°C (4) 95°C
~48 kPa

3.) At 65°C, which compound has a vapor pressure of 58 kilopascals?
(1) ethanoic acid (3) propanone
(2) ethanol (4) water

4.) Which compound has the *lowest* vapor pressure at 50°C?
(1) ethanoic acid (3) propanone
(2) ethanol (4) water

VP ↓ IMF ↑

5.) At 50.°C and standard pressure, intermolecular forces of attraction are strongest in a sample of
(1) ethanoic acid (3) propanone
(2) ethanol (4) water

****MAKE SURE TO GET EXTRA HELP FROM MISS VIRGA IF YOU NEED IT!****

Your test is on Monday October 15th