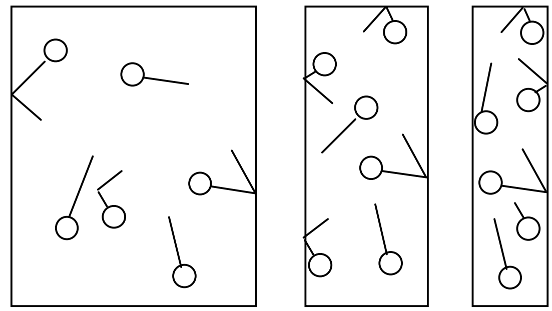
HONORS CHEMISTRY: Gases – Not Just For Fart Jokes! DATE:_____

Learning activities: **SWBAT. . .**

…explain the kinetic molecular theory of gases.

…define the traits of an ideal gas.



GASES: A REVIEW

- The state of matter with a ________________________.
- This means…
- The huge space between the particles makes gases…

KINETIC MOLECULE THEORY [KMT]:

- Uses an idealized version (called _______________) of a real gas to make simple, but useful assumptions.

DEWITT ON KMT

TRAITS OF AN IDEAL GAS:

1. *Tiny!*
2. *Random, rapid motion!*
3. *No attractive or repulsive forces between molecules!*
4. *Average kinetic energy (K.E.) is directly proportional to temperature (in Kelvin)!*

   Remember:

5. *Never condenses, no matter what pressure or temperature!*

No real gas is ideal. But we use the principles of an ideal gas because…

THERE ARE FOUR VARIABLES THAT ARE USED TO QUANTITATIVELY MEASURE GASES:

1. *Temperature* (T):

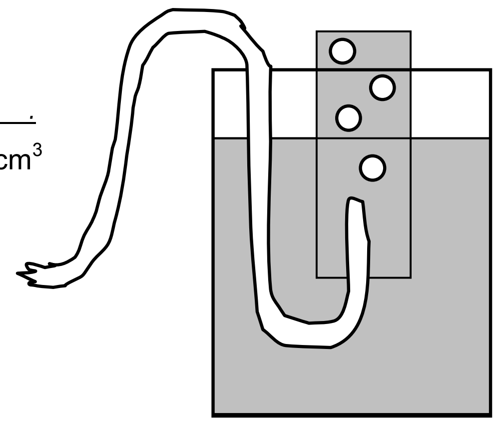
- Gas Law equations demand that temperature be measured in Kelvin. Remember to convert!
- The heavier the gas…
- The lower the temperature…

2. *Quantity* (n):

- The amount of gas is always measured in _________________.

3. *Volume* (V):

- Equals ______________ x _______________ x ___________.
- Most gas volumes are measured by __________________________.
- Watch units! Volume units can vary. Could be in L or mL, m^3 or cm^3
- Remember: 1mL =



4. *Pressure* (P):

- Every time a gas particle collides with container, it exerts a __________.
- Sum of all forces over surface area of container =
- Pressure is proportional to…
- If you can increase the number of collisions, you will increase…
- What are some ways that you can increase the number of collisions?
  -
  -
  -

DID YOU KNOW… Humans (men and women alike) normally release between 1/2 to one full liter of flatus (medical term for farts) per 24 hours.

There are two sources of flatus - external and internal. The external source is simply swallowed air, of which the oxygen (~ 20%) is normally absorbed in the digestive system, while the nitrogen (~ 80%) passes through and becomes one major component of flatus. The internal sources are various gaseous end products of the digestive process and vary greatly with diet. It is mainly hydrogen and methane with a lesser amount of carbon dioxide. The objectionable odors are due to very small amounts of hydrogen sulfide, methanethiol and dimethyl sulfide.

Ruminating animals emit such huge quantities of flatus (in their case mainly methane) that animal farting actually enters the equation of global greenhouse gases as a sizeable factor. Nothing funny about that! (http://everything2.com)

"It takes a long time to understand nothing." ~ Edward Dahlberg

HONORS CHEMISTRY: Under Pressure! DATE:_____

Objectives: **SWBAT. . .**

…convert between pressure units.

…explain how pressure affects everyday behaviors.

PRESSURE IS MEASURED IN MANY UNITS. You can convert between them using simple factor-label.

1 atm = 760 mm Hg = 29.92 in Hg = 760 torr = 101, 325 Pa = = 101.325kPa = 1.013 bar = 14.7 psi (lb/in^2)

-The SI unit for pressure is ____________________= a force of one Newton per square meter (N/m^2)

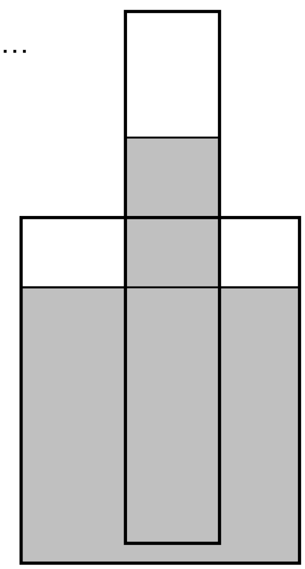
- The atmosphere creates a pressure on surface objects called ___________________.

Try this… Convert 28.10 in. Hg to KPa.

- Scientists need standard conditions when talking about gases. They came up with…

S.T.P. = =

THE TYPICAL WAY TO MEASURE PRESSURE IS BY USING A BAROMETER.



Imagine a glass tube in a liquid. Nothing happens to the height of the liquid since…

…

Even if we sealed the top of the tube, the liquid isn't going to rise, since…

…

If we evacuated the gas inside the tube, then…

…

The atmosphere will push the liquid up the straw until…

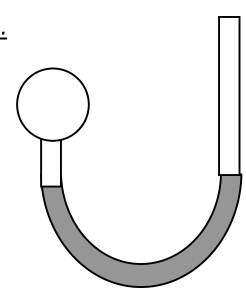
…

Changes in atmospheric pressure will cause changes in the column height.

ex) In a vacuum, the height of the column would be…

Can use any liquid, but mercury is normal choice due to its _______________.

1 atm can push mercury up _______________ or _________________.



MANOMETER: An even more basic device used to measure pressure.

- Usually matches an unknown pressure against atmospheric pressure.
- The liquid level will rise or fall depending on…

NOTE: Tire gauges measure…

So a tire gauge reading 20.0 psi means…

DIFFERENCES IN PRESSURE OFTEN LEAD TO MANY INTERESTING SITUATIONS:

Pressurized Cabins –

- Planes, spaceships, submarines, etc. are pressurized to be around atmospheric pressure because…

  ...

- If the hull is ruptured, then the atmosphere will…
- Under water, this means that…
- Up in the air/in space, this means that…

Breathing –

- When you are not breathing, your lung pressure equals ___________________________.
- When you expand your lungs you increase your lung volume ∴
- The outside air rushes in to…
- When you breathe out, you decrease the volume of your lungs ∴
- The air in your lungs rushes out to…

THE UPS AND DOWNS OF CABIN PRESSURE

How would being in a vacuum affect the air in your lungs?

Straws –

- A straw is a lot like a _______________.
- Remember, if a tube in a liquid is open to the atmosphere, the liquid will not…
- This is because…
- But when you use the straw, you expand your lungs, creating…
- The atmosphere outside the straw…

Will a drinking straw work in a vacuum?

Will a drinking straw work in a space ship orbiting earth?

"I know all one can know when one knows nothing." ~ Marguerite Duras

HONORS CHEMISTRY
PRESSURE

NAME _______________

Show all the work for these factor-label conversions.

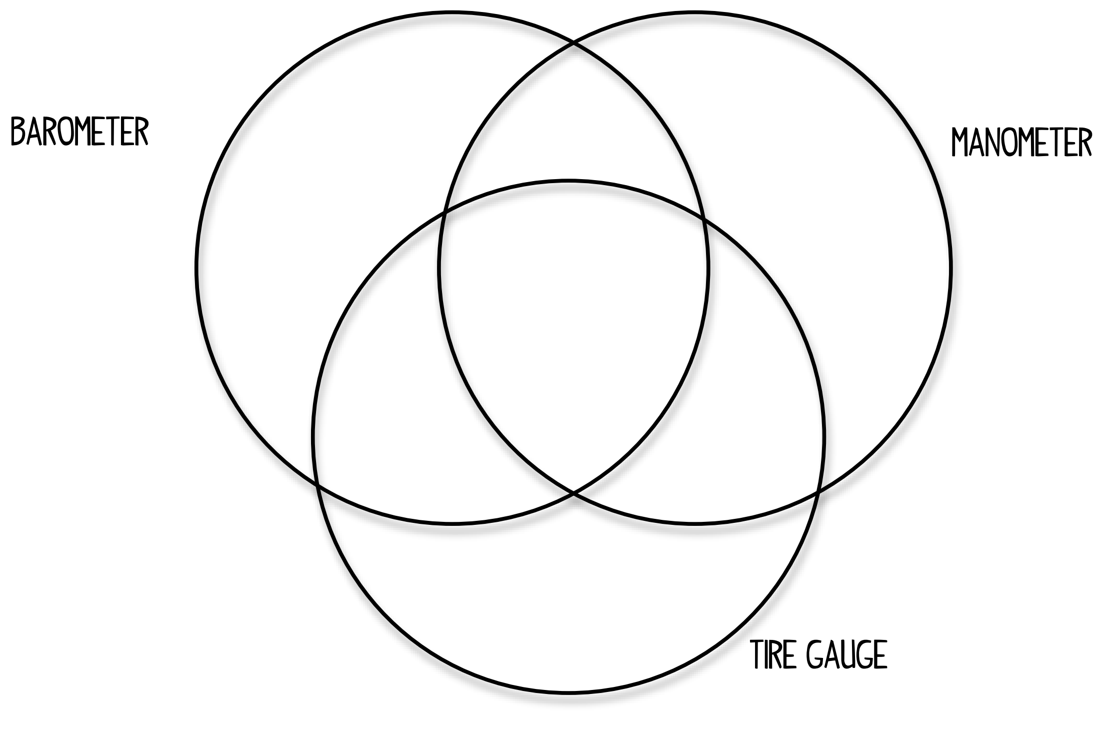
157.1 kPa to psi

73.2 cm Hg to inches Hg

Standard pressure to bar

725 torr to mm Hg

Venn Diagram Time! Compare and contrast these different ways of measuring atmospheric pressure. Feel free to add drawings to help.



"Have courage for the great sorrows of life and patience for the small ones; and when you have laboriously accomplished your daily task, go to sleep in peace. God is awake."
- Victor Hugo

HONORS CHEMISTRY: PHASE CHANGES AND PRESSURE *DATE:_____*

Learning Activities: **SWBAT. . .**

…explain how things evaporate/boil.

…explain how pressure and temperature affect states of matter.

AN IDEAL GAS DOESN'T CONDENSE INTO A LIQUID. REAL ONES DO. WHY?

-

- At _________ pressures and/or _________ temperatures these attractive forces can dominate, allowing…

…

CRASH COURSE PARTIAL
PRESSURE & VAPOR PRESSURE

Evaporation is the opposite process:

- Adding heat simply…

- In an open system (i.e. open to the surrounding environment):

- In a closed system (sealed bottle): .

An equilibrium (forward reaction proceeds at same rate at reverse reaction) will develop:

EVAPORATION ↔ CONDENSATION

Each substance exerts a certain pressure as a gas called its _____________.

- As temperature increases, vapor pressure ______________.

When vapor pressure of a gas = atmospheric pressure…

⑧ For a bubble to form in a liquid, the vapor pressure in that bubble must…
bubble must…

…

There is a relationship between:

- At lower atmospheric pressure, there is less pressure to overcome,
overcome,

∴

- At higher atmospheric pressure, there is a greater pressure to overcome,
pressure to overcome,

∴

Why do ingredients often have longer baking times at higher altitudes?
higher altitudes?

Temp (ºC)	V.P. (mm Hg)
-10	2.15
0	4.58
5	6.54
10	9.21
15	12.79
20	17.54
25	23.76
30	31.8
40	55.3
60	149.4
80	355.1
95	634
100	760
110	1074.6
120	1489
200	11659

THE STRENGTH OF THE INTERMOLECULAR FORCES WILL AFFECT HOW EASILY A SUBSTANCE BOILS/CONDENSES!

If a substance has **low** intermolecular forces it…

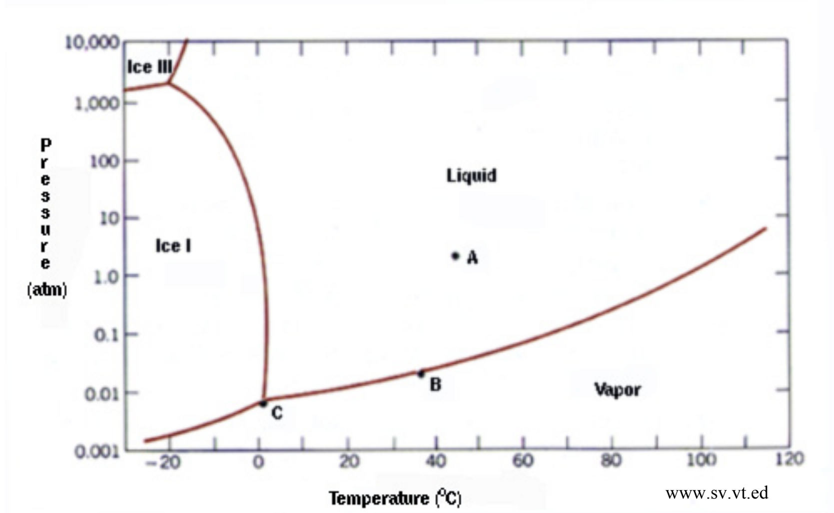
…

…

If a substance has **high** intermolecular forces it…

…

…



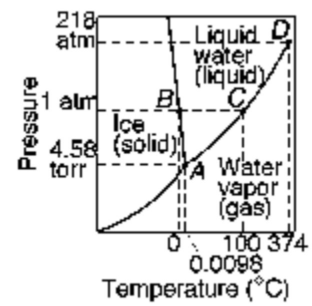
PHASE DIAGRAM:

NORMAL BOILING POINT:

NORMAL FREEZING/MELTING POINT:

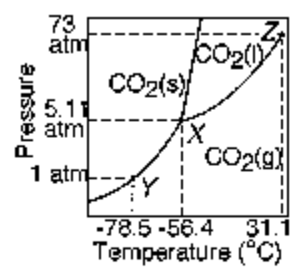
SUBLIMATION:

TRIPLE POINT:



(a)

NOTE: Different substances will have different phase diagrams. (ex) H_2O vs. CO_2)

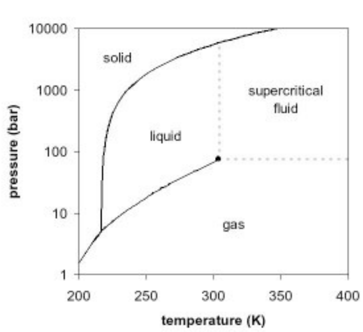


www.science.uwaterloo.ca

In conclusion, there are two ways to cause a liquid to boil. What are they?

-

Homework:
Convert entire water vapor pressure chart to two other pressure units (your choice).



DID YOU KNOW… as you increase temperature, a liquid phase becomes less dense due to thermal expansion. Meanwhile, as you you increase pressure, a gas phase becomes more dense. Eventually, Eventually, the densities of the two phases converge and the distinction between gas and liquid disappears. Above this critical critical point, you have a **supercritical fluid (SCF).**

SCFs can be regarded as "hybrid solvents" with properties between between those of gases and liquids. Carbon dioxide (304.1 K & 7380 7380 KPa) and water (647.3 K & 221,200 KPa) are the most frequently used in a wide range of applications, including extractions, dry cleaning and chemical waste disposal. - www.wikipedia.org & www.chem.leeds.ac.uk

"Every exit is an entry somewhere else." ~ Tom Stoppard

HONORS CHEMISTRY

NAME ________________

VAPOR PRESSURE & BOILING POINTS

Using the vapor pressure chart from your notes, estimate what would happen to the boiling point if the pressure was both increased and decreased by one order of magnitude.

Draw a three-panel comic explaining how a bubble forms when a liquid boils. Be funny too!

Try and draw a phase diagram for a make-believe substance. Be sure to include the information on the normal boiling point and freezing points (if they exist for your substance). Point out the sublimation curve and triple point.

"The world is wide, and I will not waste my life in friction when it could be turned into momentum." - Frances Willard

Learning activities: **SWBAT. . .**

…determine the relationship between pressure and volume.
…determine the relationship between temperature and volume.

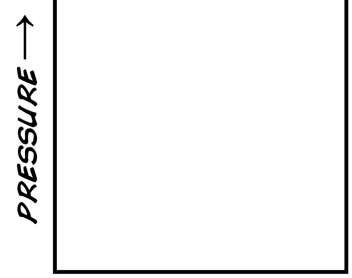
ROBERT BOYLE

BOYLE'S LAW:

- As pressure goes up, volume goes…
- Where PV = k (where k is a constant)
- Think of a toy syringe. How does pulling/pushing effect pressure?

When observing a sample of gas under changing conditions you can use:

$$P_1V_1 = P_2V_2$$



Try this… Balloon has a volume of 4 L at 100 KPa. At what pressure will the balloon have a volume of 8 L?

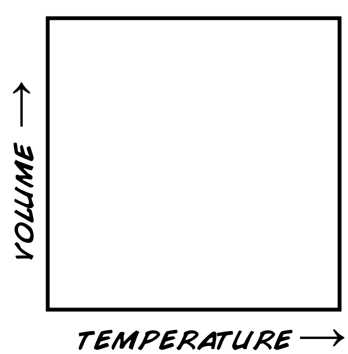
Try this… A gas in a 10.0 L container is under a pressure of 100. KPa. If the pressure increases five-fold, what will the new volume be?

CHARLES'S LAW:

The volume of gas at a constant pressure is directly proportional to the absolute temperature.

JACQUES CHARLES

- As the temperature goes up, the volume goes… up and vice-versa.
- v/t = k (where k is a constant)
- Think of a balloon. How would changing the temperature affect the size?



When observing a sample of gas under changing conditions you can use:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

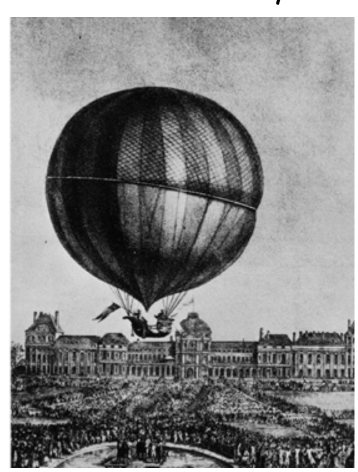
Try this… a sample of gas occupies 24 m^3 at 100. K. What would volume be at 400. K?

Try this… Gas in a balloon occupies 2.5 L at 300. °C. At what temp. will the balloon expand to 7.5 L?

DID YOU KNOW… "**Robert Boyle** (January 25, 1627 - December 30, 1691) was the first prominent scientist to perform controlled experiments and to publish his work with elaborate details concerning procedure, apparatus and observations. Boyle's insistence on experimentation established him as a founder of the modern scientific method and his arguments were so persuasive as to win many important converts, most notably Isaac Newton.

In 1661 Boyle published *The Sceptical Chymist* in which he argued against many of the faulty assumptions of his day regarding such things as the nature of elements (i.e. all objects must contain at least a tiny amount of all elements).

It is noteworthy that Boyle was among the first to publish the details of his work, including unsuccessful experiments, but Boyle was never able to abandon the beliefs of alchemy. He believed in transmutation of the elements and in 1676, he reported to to the Royal Society on his attempts to change quicksilver into gold. gold. He believed that he was near success in this endeavor."



DID YOU ALSO KNOW… "In 1783, realizing that hydrogen was lighter lighter than air, **Jacques Charles** made the first balloon using hydrogen gas and, on August 27, 1783, the balloon ascended to a height height of nearly 3,000 feet. Upon landing outside of Paris, it was destroyed by terrified peasants."

www.woodrow.org & www.centennialofflight.gov

"The best armor is to keep out of range." ~ Italian Proverb

HONORS CHEMISTRY
BOYLE'S LAW

NAME ________________

Explain what variables change in Boyle's Law problems. Is/are those direct or inverse relationships? What variables remain constant?

Treat these like test problems! List all relevant information, write out the blank equation, manipulate for the appropriate variables, show all work, show all units, and watch you sig figs!

One source states that 2.0×10^{6} atm is the highest pressure ever produced in a laboratory setting. If you have a 10.1 microliter sample of gas at that pressure, then release the pressure until it equals 752 mm Hg, what will the new volume be?

Bubbles change their size as they ascend through water. If a bubble starts at 5.2 mL under a pressure of 10.0 atm (about 220 ft), then rises what will be it's volume when it reaches 1.0 atm (surface level)?

"Don't try to solve serious matters in the middle of the night." - Philip K. Dick

HONORS CHEMISTRY
CHARLES' LAW

NAME ________________

Explain what variables change in Charles Law problems. Is/are those direct or inverse relationships? What variables remain constant?

Treat these like test problems! List all relevant information, write out the blank equation, manipulate for the appropriate variables, show all work, show all units, and watch you sig figs!

A clever student makes a thermometer that measures the temperature by the compression and expansion of gas of in a piston. She measures that at 99.7°C the piston has a volume of 2.01 L. What is the temperature (in °C) outside if the volume of the piston is 1.48 L? How should you dress for that?

Some students believe Mr. Anticole is full of hot air. If he inhales 2.1 liters of gas at a temperature of 18 °C and heats that gas to his body temperature (98.3 °F) what will be the new volume of gas (in mL)?

"The scientists of today think deeply instead of clearly.
One must be sane to think clearly, but one can think deeply and be quite insane."
- Nikola Tesla

Learning activities: **SWBAT. . .**

…determine the relationship between pressure and temperature.

…use the Combined Gas Law to solve changing gas conditions.

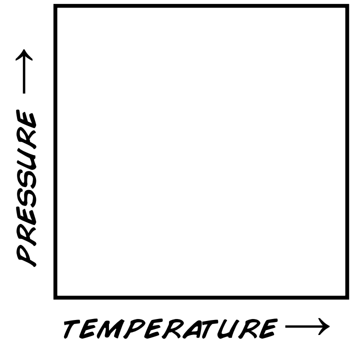
GAY-LASSAC'S LAW:

JOSEPH GAY-LUSSAC

- As temperature goes up, pressure goes…
- P/T = k (where k is a constant)
- What would happen if you were to put an aerosol container in a fire?

When observing a sample of gas under changing conditions you can use:

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



Try this… a gas exerts a pressure of 1.12 atm at 100.K. What would the pressure be at 350.K?

Try this… A container of gas is at 25°C & 225 kPa. It will rupture at 1000. kPa. What temperature will that be?

The gas laws you currently know all require some conditions remain constant.

(You can use the **PTV** Pivot – Pinch one variable and rotate. Shows relationship for the other two.)

When using the **COMBINED GAS LAW**, you can account for any changing conditions.

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

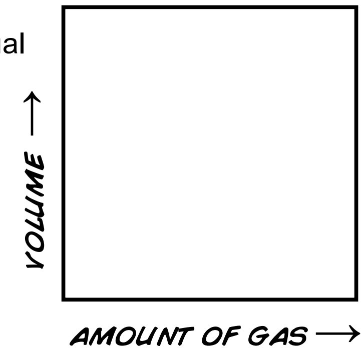
⇐ By keeping any one variable constant, you can derive the three more basic gas laws.

Try this… A 17.2 L sample of gas is at atmospheric pressure (101.3 kPa) and 9.87ºC. What would the temperature change to if the volume doubled and the pressure changes to 1.267 atm?

AVOGADRO'S LAW:

AMEDEO AVOGADRO

- As the number of moles of a gas goes up, volume goes…
- V/n = k (where k is a constant)
- Equal volumes of gases under the same conditions have equal numbers of molecules, no matter what the gases are!
- One mole of any gas at STP will have a volume of 22.4 L (= molar volume)



When observing a sample of gas under changing conditions you can use:

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Try this… Atmospheric oxygen can be converted to ozone when exposed to high electrical fields. If 1.00 moles of O_2 with a volume of 15.5 L is completely converted to O_3, what will the new volume be, assuming a constant temperature and pressure?

DID YOU KNOW… "John Dalton, not knowing about diatomics, proposed the incorrect assumption that in the most common compound between two elements, there was one atom of each.

Gay-Lussac was studying the chemical reactions of gases, and found that the ratios of volumes of the reacting gases were small integer numbers. Dalton realized that a simple integral relation between volumes of reacting gases implied an equally simple relation between reacting particles. Dalton could not accept how one particle of oxygen could yield two particles of water.

In 1811, Avogadro pointed out that Dalton had confused the concepts of atoms and molecules. The "atoms" of nitrogen and oxygen are in reality "molecules" containing two atoms each. Thus two molecules of hydrogen can combine with one molecule of oxygen to produce two molecules of water. Avogadro suggested that equal volumes of all gases at the same temperature and pressure contain the same number of molecules which is now known as Avogadro's Principle." ~ www.bulldog.u-net.com

"The real voyage of discovery consists not in seeking new landscapes, but in having new eyes." ~ Marcel Proust

HONORS CHEMISTRY
GAY-LUSSAC'S LAW

NAME ________________

Explain what variables change in Gay-Lussac's Law problems. Is/are those direct or inverse relationships? What variables remain constant?

Treat these like test problems! List all relevant information, write out the blank equation, manipulate for the appropriate variables, show all work, show all units, and watch you sig figs!

Another clever student builds a gas thermometer which measures temperature by measuring the pressure of a gas inside the fixed volume container. A thermometer reads a pressure of 248 Torr at 0 ˚C. What is the temperature when the thermometer reads a pressure of 345 Torr?

The temperature of a sample of gas in a sealed steel container at 30.0 kPa is - 100.0 °C. The container is then heated up to 1.00×10^3 °C. What is the final pressure inside the tank?

"Morality, like art, means drawing a line someplace." - Oscar Wilde

HONORS CHEMISTRY
COMBINED GAS LAW

NAME ________________

Please derive the three prior gas laws from the combined gas law.

Treat these like test problems! List all relevant information, write out the blank equation, manipulate for the appropriate variables, show all work, show all units, and watch you sig figs!

2.00 L of a gas is collected at 25.0°C and 745.0 mmHg. What is the volume of that gas if it is allowed to reach STP?

A gas sample has a volume of 28 liters, a temperature of 45.0°C and ... whoops! Mr. Anticole forgot to measure the initial pressure. By the time the mistake was caught, the volume increased to 34 liters and its temperature decreases to 35.1°C. The final pressure of the gas is 1.75 atmospheres, so what was the original pressure of the gas?

"Nature is trying very hard to make us succeed, but nature does not depend on us. We are not the only experiment." - R. Buckminster Fuller

HONORS CHEMISTRY: DALTON AND THE IDEAL GAS LAW **DATE:_____**

Learning activities: **SWBAT. . .**

…explain and use Dalton's Law of Partial Pressures.
…explain and use the Ideal Gas Law

JOHN DALTON

DALTON'S LAW OF PARTIAL PRESSURES:

PARTIAL PRESSURE:

$$P_{total} = P_a + P_b + P_c + P_{etc}. . .$$ …where a, b, c, etc. are…

Try this… Total pressure of three gases is 700. torr. If oxygen is 200. torr and nitrogen is 450. torr, how many torrs of pressure is the third gas?

Try this…You are collecting butane gas over water at 40 °C. The total pressure reading is 75.05 KPa. What is the partial pressure of butane? (The vapor pressure of water @ 40 °C = 7.38 KPa.)

The partial pressure of any gas in a mixture can be expressed as a MOLE FRACTION:

$$\text{Mole fraction of gas X} = \frac{\text{moles of gas X}}{\text{total moles of gas}}$$

Note: mole fractions are always…

Try this…A gas contributes 1/4 of the total number of particles in a container. What is its mole fraction?

Try this… Oxygen gas composes about 21% of the atmosphere. What is the mole fraction of oxygen?

THE IDEAL GAS LAW:

$$PV = nRT$$

…where R is… **R = 8.314 $\frac{L \cdot kPa}{mol \cdot K}$ or 0.08206 $\frac{L \cdot atm}{mol \cdot K}$**

- **R is NOT an equation, it is a CONSTANT.** Do **not** plug numbers into it!
- Given any three variables, you can solve for the fourth, but watch your units!!!!

Try this…You have a 0.0568 mole sample of CO_2. It was placed in a 350. mL container at 400. K. What is the pressure (in KPa) exerted by the gas?

CRASH COURSE ON IDEAL GAS

Try this…The average lung capacity for humans is around 4.0×10^3 mL. At body temperature (37 °C) and 1.1 atm, how many moles of oxygen gas can your lungs hold? How many grams is that?

REVIEW & REFLECTION

"A great man does not lose his childlike heart." ~ Mencius

HONORS CHEMISTRY NAME ________________
AVOGADRO'S AND DALTON'S LAWS

Treat these like test problems! List all relevant information, write out the blank equation, manipulate for the appropriate variables, show all work, show all units, and watch you sig figs!

Three balloons at identical conditions are filled with different amounts of gases. One balloon is filled with 6.0 grams of He, filling the balloon to 33 L. How many moles of helium is that?

The second balloon contains 18.1 g carbon dioxide. What is the volume of the balloon?

The third balloon encloses a volume of 45 L. How many moles of methane are in it?

Blast furnaces give off many unpleasant and unhealthy gases. If the total air pressure is 0.99 atm, the partial pressure of carbon dioxide is 0.05 atm, and the partial pressure of hydrogen sulfide is 0.02 atm, what is the partial pressure of the remaining air?

If the air contains 22% oxygen, what is the partial pressure of oxygen near a blast furnace?

"To obtain a man's opinion of you, make him mad." - Oliver Wendell Holmes

HONORS CHEMISTRY
IDEAL GAS LAW

NAME ________________

Please derive the super combined gas law from the ideal gas law.

Convert R so it solves for a pressure in p.s.i.

Treat this like a test problems! List all relevant information, write out the blank equation, manipulate for the appropriate variables, show all work, show all units, and watch you sig figs!

A sample of air is captured and heated to 250 °C in a 3.8 daL chamber. The pressure in the chamber reached 199 psi. Given typical atmospheric concentrations, how many moles of diatomic oxygen, diatomic nitrogen and carbon dioxide were in the sample? (HINT: solve for total moles first...).

"This time, like all times, is a very good one, if we but know what to do with it."
- Ralph Waldo Emerson

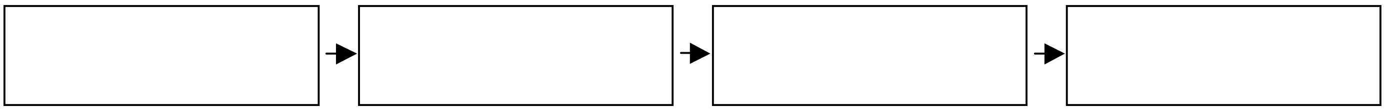
HONORS CHEMISTRY: Gas Stoichiometry DATE:_____

Learning activity: **SWBAT. . .**

…combine stoichiometry with the Ideal Gas Law to solve chemical challenges.

Remember, Stoichiometry is a method for examining mass and/or quantity relationships among reactants and products in a balanced chemical reaction.

- It uses _____________ and _______________ in a factor-label framework.



- To go from grams to moles (or vice-versa) you'll use a molar mass conversion (one step)
- To go from moles to moles you'll use a mole ratio conversion (one step)

Since amount is one of the variables in the Ideal Gas law, we can combine it with stoichiometry to solve all kinds of problems!

Try this… If water is added to solid magnesium nitride, the two will react to form solid magnesium oxide and ammonia gas. If you have 10.3 grams of magnesium nitride, how many cm^3 of ammonia gas will be collected at 24°C and 752 mm Hg?

DEWITT ON GAS STOICHIOMETRY

REVIEW & REFLECTION

"Reality is nothing but a collective hunch." ~ Jane Wagner

HONORS CHEMISTRY
GAS STOICHIOMETRY

NAME ________________

Treat these like test problems! List all relevant information, write out the blank equation, manipulate for the appropriate variables, show all work, show all units, and watch you sig figs!

You have 10.0 grams of oxygen in a sealed 250. mL container. How many grams of hydrogen gas must be injected for a perfect stoichiometric reaction?

Assume the reaction reaches a maximum temperature of 2800 °C. What will be the pressure of the water vapor in the sealed container?

Complete gasoline (C_8H_{18}) combustion produces carbon dioxide and water vapor. If you burn 1.000 gallons of gasoline (.77 g/mL), at 21 °C and 744 mm Hg, what volume of carbon dioxide gas will you produce?

"I can't understand why people are frightened of new ideas. I'm frightened of the old ones."
- John Cage

HONORS CHEMISTRY LET'S GO DIVING!

DIRECTIONS: *The following a summary of information found in a variety of internet sites regarding the some of gas chemistry implications of scuba diving. Read the material and then take notes on it. Remember, 'taking notes' means you create an organized structure/hierarchy of importance. The simplest way to do this is by using a classic outline structure (I., A., 1, 2, 3, etc.).*

"The relationship of solubility to pressure is given by Henry's Law. **Henry's law states that the amount of gas that will dissolve in a liquid at a given temperature varies directly with the pressure above the liquid.** For example, when you open a can of soda, the dissolved carbon dioxide bubbles out of the solution because the pressure of the container has been lowered.

The general rule of thumb when diving is that pressure increases by 1 atm. for every 33 feet someone dives. This means at 33 feet below the surface, a diver will experience 2 atm of pressure from the water. Due to Henry's Law, this means that the deeper a diver goes, the greater the dissolved gas amounts become. **This does not create problems during the dive, but if the diver ascends rapidly to the surface, the excess dissolved gases can form bubbles in the blood**. Divers must carefully follow ascent rates from depths greater than 10 meters. By remaining at fixed interval depths for a period of time, the diver allows dissolved nitrogen to slowly escape without creating large bubbles in the blood.

The air we breathe is mostly a mixture of two gases, nitrogen (78%) and oxygen (21%). Unlike oxygen, nitrogen is a biologically inert gas. For this reason, most of the nitrogen we inhale is expelled when we exhale, but some is dissolved into the blood and other tissues. As the water pressure increases, so does the pressure of the nitrogen in the compressed air inhaled by the diver. The diver takes in more nitrogen with each breath than would occur at sea level, but instead of being exhaled, the extra nitrogen safely dissolves into the blood and tissues. Increased nitrogen concentration in the blood can also cause nitrogen narcosis (rapture of the deep) when divers dive below 30 meters. Divers experience intoxicating symptoms such as happiness, overconfidence and impaired memory.

On the way up, decompression occurs; in other words, the water pressure drops. With the decrease in pressure, the extra nitrogen gradually diffuses out of the tissues and is delivered by the bloodstream to the lungs, which expel it from the body. **If the diver surfaces too quickly, potentially dangerous nitrogen bubbles can form in the tissues and cause decompression sickness.** Since the nitrogen bubbles that cause decompression sickness can affect all body tissues, many different symptoms are possible. Symptoms can appear minutes after a diver returns to the surface. The appearance of symptoms occurs within eight hours in about 80% of cases. Pain is often the only symptom. This is sometimes called "the bends," although many people incorrectly use that term as a synonym for decompression sickness. Pain, which ranges from mild to severe, is usually limited to the joints, but can be felt anywhere. Severe itching, skin rashes, and skin mottling are other relatively common symptoms. All of these are sometimes classified as manifestations of Type 1 or "mild" decompression sickness. Type 2 or "serious" decompression sickness can result in paralysis, brain damage, heart attack, and death. Many persons with decompression sickness experience both Type 1 and Type 2 symptoms.

Decompression sickness is treated by giving the affected person oxygen and placement in a hyperbaric chamber. A hyperbaric chamber is an enclosure in which the air pressure is first gradually increased and then gradually decreased. This shrinks the bubbles and allows the nitrogen to safely diffuse out of the tissues. People suffering from decompression sickness who undergo chamber treatment within a few hours of symptom onset usually enjoy a full recovery. If treatment is delayed, the consequences are less predictable, although many people have been helped even after several days have passed. A 1992 report on diving accidents indicated that full recovery following chamber treatment was immediate in about 50% of divers. Some people, however, suffer numbness, tingling, or other symptoms that last for weeks, months, or even a lifetime.

Hyperbolic chambers can also be used in medical therapy since, while under pressure, there are more molecules of oxygen available to the body's cells. The treatment is either for carbon monoxide poisoning or for wounds or infections that respond well to hyperbaric oxygen therapy.

As the temperature is increased the solubility of a dissolved gas is actually decreases. You see this every day as bubbles form when a cold glass of water is allowed to warm to room temperature. Another example of this can be seen when water is heated on a stove. The gas bubbles which appear on the sides of the pan well below the boiling point of water are bubbles of air, which is evolved when water at lower temperatures is heated and the amount of air which it can contain decreases. A third example of this is when boiled or distilled water is added to a fish tank. This can cause the fish to die of suffocation unless the water has been allowed to re-aerate before addition.

A diver must not take a hot shower or bath immediately after a deep dive because an increase of body temperature will cause a faster release of dissolved gases.

In diving, the pressure inside the lungs must equal the pressure outside the body, otherwise the lungs collapse. One solution is a rigid articulated diving suit, but these are bulky and clumsy. Another solution is known as 'liquid breathing'. Liquid breathing is a form of respiration in which a normally air-breathing organism breathes an oxygen rich liquid (usually from the perfluorocarbon family), rather than breathing air. **Breathing liquid instead of air seems odd, but if the technique could be perfected it would revolutionize diving.** With liquid in the lungs, the pressure in our body could accommodate changes in the pressure of the surrounding water without the huge gas partial pressure changes required when the lungs are filled with gas. The elimination of gasses at high partial pressures would eliminate the need for decompression and its above inherent problems.

If the technique could be perfected, it would be extremely useful for submarine escape and undersea oxygen support facilities, and for underwater work, as portrayed in the 1989 science-fiction film *The Abyss*. Unfortunately, there are problems with execution of the idea. All uses of liquid breathing for diving must involve total liquid ventilation. Total liquid ventilation, however, has difficulty moving enough fluid to carry away CO_2. It seems unlikely that a person would move enough of the liquid without assistance from a mechanical ventilator. **The "free breathing" of liquids by working human aquanauts as seen in the film *The Abyss*, will probably be a long time coming.**

The immediate use of liquid breathing is likely to be in treating premature babies, and adults with severe lung damage from causes such as fires. Liquid breathing began to be used by the medical community after the development of the fluorochemical perfluorooctyl bromide, or perflubron for short. It is instilled directly into the lungs of patients with acute respiratory failure (caused by infection, severe burns, inhalation of toxic substances, and premature birth), whose air sacs have collapsed. Once inside the lungs, perflubron enables collapsed alveoli (air sacs) to open and permits a more efficient transport of oxygen and carbon dioxide. Current tests are focusing on premature babies, but trials with adults are ongoing.

Liquid breathing has also found its way into science-fiction where special liquid filled suits enabled spacemen to withstand extreme acceleration forces. Forces applied to fluids (such as gravitational forces on Earth) are distributed as omnidirectional pressures. In the ocean, this distribution of force allows organisms such as whales to grow to sizes that would be unsupportable on dry land.

Because liquids are incompressible fluids, they do not change density under high acceleration such as performed in aerial maneuvers or space travel. A man immersed in such a liquid would have inertial forces distributed around his body, rather than applied at a single point such as a seat or harness straps. The effect of high acceleration is caused by different parts of the accelerating volume having different densities and thus different momentums, and with acceleration in air in the spaceman's body has a very different density from the air or vacuum in the spacecraft; as a result, the effect is much less if he is immersed in liquid and is breathing liquid.

However, such application is probably physically and anatomically not possible. The main problem with acceleration forces is that they force the heart to pump blood at much higher pressures. Liquid breathing would not change that. Moreover, filling lungs with liquid, especially as heavy as perflurocarbon, will dramatically increase their weight. At extreme G forces experienced by pilots and astronauts, the filled lungs are likely to rupture.

SOURCES: **www.sdm.scot.nhs.uk** **www.chemistry.boisestate.edu** **www.psigate.ac.uk** **www.health.enotes.com** **www.en.wikipedia.org**

"I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."
~ Sir Isaac Newton