Name .... **Unit 9 Notes: Gas Laws** Period ______

Skills:

1. Distinguish between Ideal and Real Gas within KMT
2. Unit Conversion Review
3. Pressure and Partial Pressure
4. Relationships between P, V+ T
5. Identify and Solve Boyle's Law Problems
6. Identify and Solve Charles' Law
7. Use Combined Gas Law Equation
8. Vapor Pressure
9. Using Table H
10. Diffusion and Effusion
11. Convert Between Moles and Liters

Unit 9: Vocabulary: **Complete throughout unit. Due on test day!**

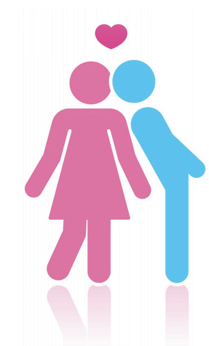
Word	**Definition**
Ideal Gas	
Kinetic Molecular Theory	
Pressure	
Diffusion	
Partial Pressure	
Molar Volume	
Vapor Pressure	
Temperature	
Direct Relationship	
Indirect Relationship	

Unit 9 Resources:

Skill 1A: Distinguish Between IDEAL vs. REAL Gases and Conditions

Ideal Gas	Real Gas
- ________________........! - Follows the gas laws - Particles are ______ attracted to each other - Particles have ____ volume (negligible)	- ________________________ - Do not follow gas laws exactly - Particles DO attract each other (have some intermolecular forces of attraction) - Particles DO have some volume…atomic radii

1. **Gases behave *most ideally*** under conditions of _____ _______ and ____ ______
   BECAUSE…….
   a. particles are moving _____AND
   b. particles are ______ _______
   } Less chance of gas particles attracting each other



2. **Gases *deviate* (stray) from ideal** under conditions of ______ __________ and ________ _______________.
   BECAUSE……
   1. particles are moving _____ AND
   2. particles are ______ ________
   } Gas particles will attract each other

3. **H_2 and** _____ are nearly ideal gases because they are the smallest and have the weakest intermolecular forces

Ideal gases are like an ideal good boyfriend or girlfriend….

___________________ and not a lot of ______________________.

Skill 1A: Define Kinetic Molecular Theory

Kinetic Molecular Theory (KMT): Model that explains ________________________ of an ideal gas!

Four Assumptions: (Memorize These ☹)

1. Gas particles are in ________, random, straight-line motion.
2. When gas particles collide, energy is __________ from one particle to another (_________ collisions).
3. Gas particles have no attraction to each other (no IMF).
4. Individual gas particles have no _________ (negligible).

Skill 2: Review Units of Temperature and Volume

Temperature: The average kinetic energy of a substance.

Unit Conversions: Kelvin ←→ Celsius K = °C + 273 (Table T)

Ex: What is 33.7°C equal to in Kelvins?

1) ______ °C = 400 K

2) 573 °C = ______K

Volume: The amount of space that a substance or object occupies.

Unit Conversions: Metric unit conversions (Table C)

Ex: How many liters is 3490 ml?

King Henry Does Usually Desire Chocolate Milk!

Ex: What is 0.845 L equal to in cm^3?

1 ml = $1cm^3$

1) _____ Kiloliters = 4356liters

2) _____liters= 1200 ml

Pressure: Force per unit area. Pressure is caused by the number of collisions of molecules on the walls of a container or in a particular area.

Unit Conversions: Atmospheres (ATM) or Kilopascals (KPA)

1 atm = 101.3 kpa (Ref. Table _____)

Ex: How many atmospheres is equal to 203.5kpa?

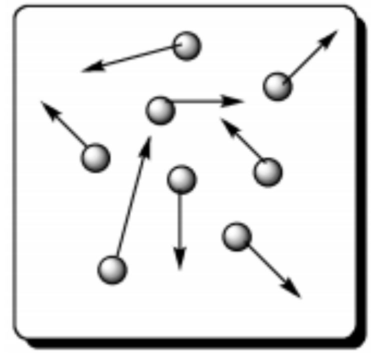
1) _____kpa = 4.5 atm

2) _____atm = 33.6 kpa

Skill 3: Exploration of Pressure and Partial Pressure

Part 1: What is pressure?

All gases exert pressure.
At any point, a gas exerts an equal **pressure** in all directions at any point within a gas.
Pressure is defined as the *force per unit area.*
Please note the diagram showing a sample of gas molecules enclosed in a container. The arrows indicate the velocities of the molecules.



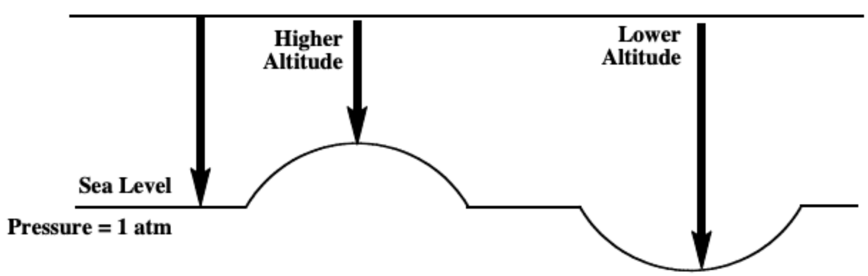
Student Molecules!

Describe how the pressure changes from the baseline, given the following scenarios!

1. Smaller area: _______________ (more or fewer) collisions
2. High Temperature: _______________ (more or fewer) collisions
3. Low temperature: _______________ (more or fewer) collisions

The more collisions of molecules with the container, the ______________the pressure!

Part 2: What is Atmospheric Pressure?



There is something called atmospheric pressure.
The pressure of the atmosphere varies with altitude.

Pressure is still defined as the *force per unit area.*

At higher altitudes, are there more or less collisions? Pressure?

At lower altitudes, are there more or less collisions? Pressure?

Part 3: Daltons Law of Partial Pressure:

Dalton's Law: The total pressure in a container is the _______ of the partial pressures of all the gases in the container.

$$P_{total} = P_1 + P_2 + P_3 + \ldots$$

Example:
The total pressure of three gas components in a mixture is 550 kpa. If the pressure of gas A is 200 kpa and the pressure of gas B is 75 kpa, what is the partial pressure of gas C?

Partial Pressure Problems:

1. A mixture of oxygen, nitrogen, and hydrogen gases exerts a total pressure of 74.0 kPa at 0°C. The partial pressure of the oxygen is 20.0 kPa and the partial pressure of nitrogen is 40.0 kPa. What is the partial pressure of hydrogen in this mixture?

2. A mixture of gases in a closed container has a total pressure of 5 atm. Oxygen has partial pressure of 2atm. Argon exerts a pressure of 1.5 atm. What is the partial pressure of the 3rd gas, helium?

Practice:

1. The air pressure for a certain tire is 109 kPa. What is this pressure in atmospheres?

1. A 1-Liter flask contains two gases at a total pressure of 3.0 atmospheres. If the partial pressure of one of the gases is 0.5 atmospheres, then the partial pressure of the other gas must be what?

2. In which location will a person experience the greatest atmospheric pressure, Mount Everest or the shore of the Dead Sea? Explain in terms of kinetic molecular theory.

Skill 4: Exploring the Relationships Between Pressure, Volume and Temperature

Relationship Claims:

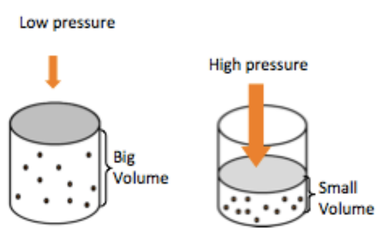
1) **As PRESSURE __________________ VOLUME __________________**
   Which experiment did you use to determine this?

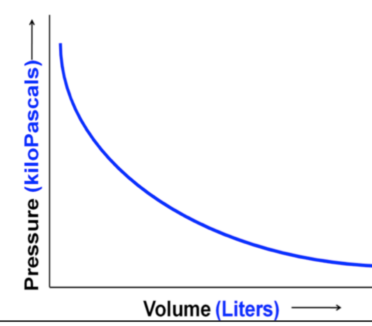
2) **As TEMPERATURE _________________ VOLUME __________________**
   Which experiment did you use to determine this?

3) **As TEMPERATURE _________________ PRESSURE ________________.**
   Which experiment did you use to determine this?

Skill 5: Identify and Solve Boyle's Law Problems

CLAIM: Boyle's Law: As the pressure on a gas _________, the volume of the gas ____________. This is an _______________ relationship.





Example: A balloon is filled with 25 L of air at 1.0 atm pressure. If the pressure is changed to 1.5 atm what is the new volume?

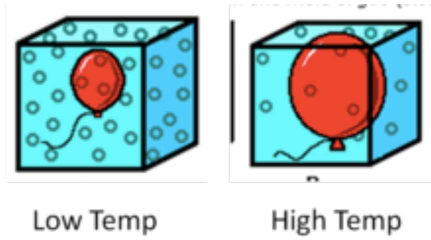
P_1= _______
V_1= _______
P_2= _______
V_2= _______

1. A balloon is filled with 73 L of air at 1.3 atm pressure. What pressure is needed to change to volume to 43 L?

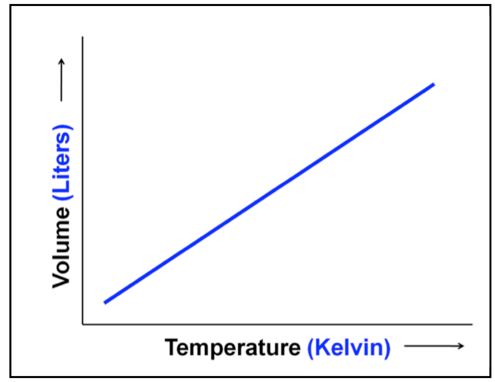
2. A sample of Helium gas is compressed from 4.0 L to 2.5 L at a constant temperature. If the pressure of the gas in the 4.0 L volume is 210 kPa, what will the pressure be at 2.5 L?

Skill 6: Identify and Solve Charles' Law Problems

Charles' Law: As the Temperature of a substance ___________________, the volume also ____________________. This is a ____________________ graphical relationship.



Temperature and volume are directly proportional



Example:

A sample of gas at 40.0 °C occupies a volume of 2.32 L. If the temperature is raised to 75.0 °C what will the new volume be?

1. A sample of nitrogen occupies a volume of 250 mL at 25°C. What volume will it occupy at 95°C?

2. Oxygen gas is at a temperature of 40°C when it occupies a volume of 2.3 liters. To what temperature should it be raised to occupy a volume of 6.5 liters?

3. Several balloons are inflated with helium to a volume of 0.75 L at 27°C. One of the balloons was found several hours later, the temperature had dropped to 22°C. What would be the volume of the balloon when found, if no helium has escaped?

4. A weather balloon is filled to the volume of 150.0 L on a day when the temperature is 10°C. If no gases escaped, what would be the volume of the weather balloon after it rises to an altitude where the temperature is -8°C?

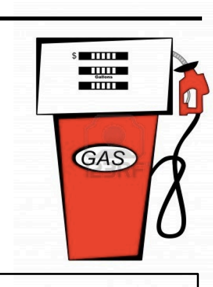
Skill 7: Use Combined Gas Law Equation

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

P = pressure (kPa or atm)

V = volume (L, mL, cm^3)

T = temperature (K)



Combined gas law examples:

A 45 mL sample of gas at standard pressure is heated from 20.°C to 50.°C. The pressure of the gas increases to 107.9 kPa. What is the new volume of the gas?

Combined Gas Law

1. A 280.0 mL sample of neon exerts a pressure of 660.0 atm at 26.0°C. At what temperature, °C, would it exert a pressure of 940. atm in a volume of 440.0 mL? (396°C)

2. A certain gas has a volume of 500.0 mL at 77.0°C and 0.79 atm. Calculate the temperature, °C, if the volume decreased to 400.0 mL and the pressure is increased to 1.00 atm. (81.4°C)

3. A given sample of gas has a volume of 4.20 L at 60.0°C and 1.00 atm pressure. Calculate its pressure if the volume is changed to 5.00 L and the temperature to 27°C. (0.76atm)

4. A certain gas occupies a volume of 550.0 mL at STP. What would its volume be at 27.0°C and 1000ml.

5. Air bags are an important safety feature in modern automobiles. An air bag is inflated in milliseconds by the explosive decomposition of $NaN_3(s)$. The decomposition reaction produces $N_2(g)$, as well as Na(s), according to the *unbalanced* equation below.

$$\_\_\ NaN_3(s) \rightarrow \_\_\_\ Na(s) + \_\_\_\ N_2(g)$$

(a) Balance the above equation using the smallest whole-number coefficients.

(b) When the air bag inflates, the nitrogen gas is at a pressure of 1.30 atmospheres, a temperature of 301 K, and has a volume of 40.0 liters. Calculate the volume of the nitrogen gas at STP.

Skill 8: Vapor Pressure

Vapor Pressure: *Any liquid in a closed system produces a vapor that exerts pressure on the container it is in.*

- ☐ As the temperature increases, the vapor pressure ____________________ (liquid to gas faster)
- ☐ As the temperature decreases, the vapor pressure____________ (liquid to gas slower)
- ☐ Substances that have ____________________ forces of attraction have higher vapor pressure and have lower boiling point
- ☐ Substances that have strong forces of attraction have lower vapor pressure and have _________ boiling points

Atmospheric Pressure: The pressure exerted by the weight of the atmosphere

Boiling Point: When external pressure is equal to vapor pressure.

Intermolecular Force Review

London Dispersion:

Dipole-dipole:

Hydrogen Bonding:

Vapor Pressure and IMF:

The ______________ the intermolecular forces between the molecules, the ____________ it is for vaporization to occur, since more energy is required to break the bonds holding the molecules together!

Practice:

Determine the strongest IMF in each of the following compounds.

CO_2 _____________ HF______________ H_2S______________

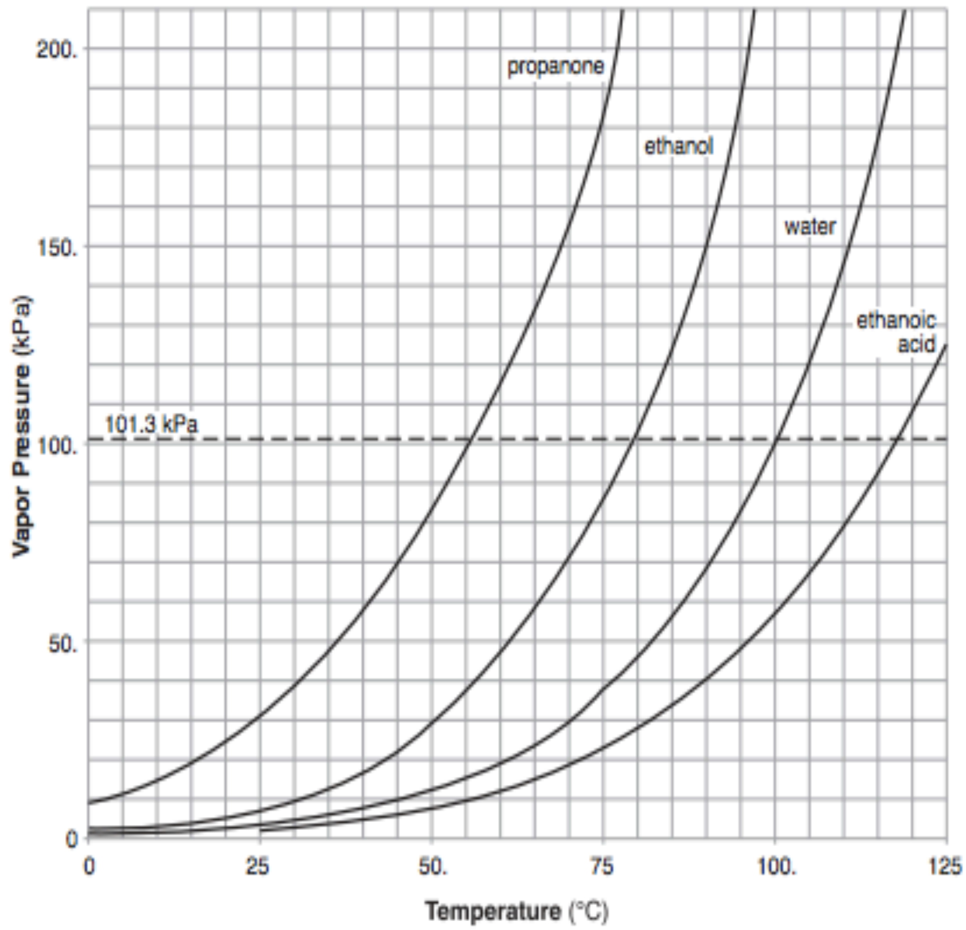
In terms of intermolecular forces, explain which substance would have a higher vapor pressure at 55°C.

Skill 9: Using Table H

Table H will allow you to determine boiling points of four liquids at different vapor pressures in kPa. Curves measure the temperature vs the vapor pressure.

Practice:

The graph below shows the vapor pressures of four common liquids as a function of temperature. Refer to the graph to answer the questions that follow.



1. _____________ Which of the substances has the lowest boiling point?

2. _____________ Which of the substances has a boiling point of 100˚C?

3. _____________ Which of the substances has the highest boiling point?

4. _____________ Which of the substances has the highest vapor pressure at 40˚C?

5. _____________ Which of the substances will boil at 79˚C?

6. _____________ At what temperature will alcohol boil when the atmospheric pressure is 50 kPa?

7. _____________ At what atmospheric pressure will propanone boil at 20˚C?

8. _____________ At what atmospheric pressure will water boil at 90˚C?

9. _____________ Which of the substances above has the lowest vapor pressure at 70˚C?

10. _____________ As the pressure decreases, the boiling point of water (a) increases, (b) decreases, or (c) remains the same?

11. _____________ What is the vapor pressure of water at 60˚C?

Answer:

1. As the pressure on the surface of a liquid decreases, the temperature at which the liquid will boil

   (1) decreases
   (2) increases
   (3) remains the same

2. Which liquid has the highest vapor pressure at 75°C?

   (1) ethanoic acid (3) propanone
   (2) ethanol (4) water

3. Which liquid has the lowest vapor pressure at 65°C?

   (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

VAPOR PRESSURE PRACTICE

1. According to Reference Table *H*, what is the boiling point of ethanoic acid at 80 kPa?

   A) 28°C B) 125°C
   C) 111°C D) 100°C

2. Water will boil at 50ºC if the pressure on the surface of the water is

   A) 12 kPa B) 3 kPa
   C) 101.3 kPa D) 50 kPa

3. What is the normal boiling point of ethanoic acid?

   A) 117.9°C B) 101.3°C
   C) 52°C D) 55°C

4. As the atmospheric pressure increases, the temperature at which water boils in an open vessel

   A) decreases B) increases
   C) remains the same

5. The strongest intermolecular forces of attraction exist in a liquid whose heat of vaporization is

   A) 100 J/g B) 200 J/g
   C) 300 J/g D) 400 J/g

6. A liquid would boil at the lowest temperature at a pressure of

   A) 1 atmosphere B) 2 atmospheres
   C) 50 kPa D) 101.3 kPa

7. The boiling point of a pure substance is defined as the temperature at which

   A) the vapor pressure equals the external pressure
   B) the liquid phase can be completely evaporated
   C) the kinetic energy of the molecules begins to increase
   D) the molecules of the substance break apart

Skill 10: Diffusion and Effusion:

Diffusion: Molecules moving from areas of ______ concentration to _____ concentration.

Example: Perfume molecules spreading across the room.

Define: Effusion - Gas _____________ through a tiny hole in a container.

- ☐ Both depend on the speed of the molecules
- ☐ Bigger molecules move slower at the same temp.
- ☐ Bigger molecules effuse and diffuse slower
- ☐ Helium effuses and diffuses faster than air -escapes from balloon.

Examples:

1. Does an atom of neon effuse faster or slower than C_2H_2?

2. Which will effuse faster, Br_2 or H_2?

3. A carbon dioxide molecule travels at 45.0 m/s at a certain temperature. At the same temperature, will an oxygen molecule travel faster or slower?

4. Hydrogen sulfide, H_2S, has a very strong rotten egg odor. Methyl salicylate, $C_8H_8O_3$, has a wintergreen odor, and benzaldehyde, C_7H_6O, has a pleasant almond odor. If the vapors for these three substances were released at the same time from across a room, which odor would you smell first? Show your work and explain your answer.

5. Which gas diffuses most rapidly at STP?

   1) O_2 2) He 3) I_2 4) Kr

Skill 11: Avogadro's Law and Mole to Liter Conversions

Avogadro's Law:

"EQUAL _________ of different gases at the SAME temperature and pressure contain EQUAL _____________ ____ ______________"

If the number of moles ___________________, the volume will increase in ____________ proportion!

Ex: 12 mL of CO_2 gas at STP has the same number of molecules as _________mL of O_2 gas at STP.

Ex: If 1.0mol of helium gas (He) at standard temperature and pressure (STP) has a volume of 22.4L, how many moles of carbon tetrachloride gas (CCl_4) will be present in a container with a volume of 22.4L at STP?

(Same conditions, same volumes, same # of particles)

1. Determine the volume, in liters, occupied by 0.030 moles of a gas at STP.

2. How many moles of argon atoms are present in 11.2 L of argon gas at STP?

3. What is the volume of 0.05 mol of neon gas at STP?

4. What is the volume of .67 mol of O_2 gas at STP?