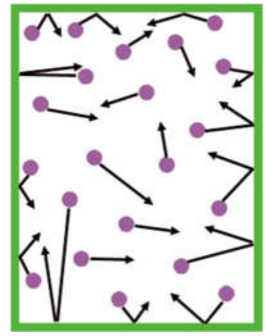
AP Chemistry
Ms. Ye

Name ________________________________
Date ______________________Block______

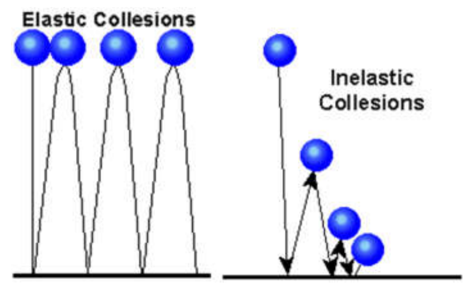
Kinetic Molecular Theory

- Explains properties of gases, liquids, and solids in terms of energy using an *ideal gas*, an **imaginary** which fits all the assumptions of kinetic molecular theory



Assumptions of Kinetic Molecular Theory:

1. Gas particles are in ____
2. The ____________________ of the gas particles is ________________________________ compared to the distance between gas particles. Therefore, gases are ________________________________
3. There are _______________________________________ between gas particles.
4. Elastic collisions occur between molecules during collisions, meaning there is ____ during collisions
5. The _______________________________ of the molecules is proportional to the absolute __________________ of the gas.



***Note: An IDEAL GAS is THEORETICAL and is used to PREDICT the behavior of REAL GASES (O_2, H_2, He, etc.). The ASSUMPTIONS above are not true of REAL GASES.

<u>Problems with KMT:</u>

1. Gas atoms/molecules <u>do take up space</u> (gases are a type of matter after all)
2. <u>Some intermolecular forces do exist</u> between gas molecules
3. Collisions are not perfectly elastic.

<u>Conditions in which a REAL GAS behaves MOST like an IDEAL GAS:</u>

1. ____(moves around more freely)
2. ____ (fast moving)
3. ____(not attracted to each other)
4. ____
5. ____ (more space to move, less likely to collide)

Physical Characteristics of Gases:

- Gases do not have a definite shape or volume; they ______________________________
- Gases have ______________________
- Gases can be _____________________

Variables that Define Gases

- _____________________ - how much space a gas takes up;
  may be expressed in **liters, milliliters, cm^3, dm^3**.
- _____________________ – **Always expressed in Kelvin**!!!!
  to convert between °C and Kelvin, you can use the following formula (yes you must know it!):

K = °C + 273	K = kelvin °C = degrees Celsius

Temperature Conversion Examples:

1. The temperature of the room was measured to be 25°C. What is this temperature in Kelvins?

2. If the boiling point of a substance was measured to be 300K, what is this temperature in °C?

- ______________________ - how many particles are present in the sample of gas
- _________________________-the force per unit area on a surface
  - Exerted by all gases on any surface they **collide** with
  - ________________________________cause pressure!
  - Units of Pressure: **Pascal** = Pa (SI unit of pressure); **Millimeter of mercury** = mmHg (used in a barometer); **Torr** = torr; **Atmosphere** = atm (pressure of the atmosphere at sea level=1atm)

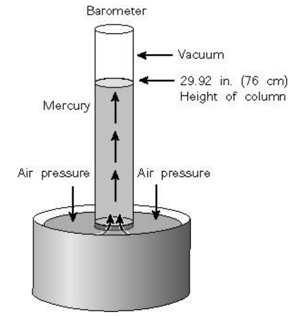
1 atm =

Pressure Conversion Examples:

1. What is the pressure in torr of 345mmHg?
2. What is the pressure in atm of 123 kPa?

Measuring Pressure

Barometer

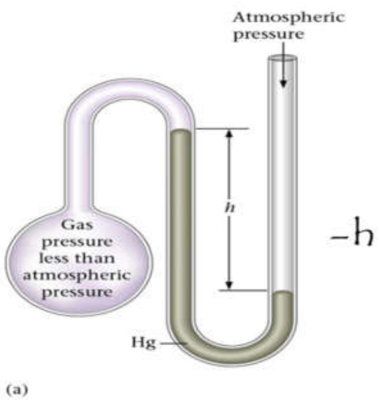


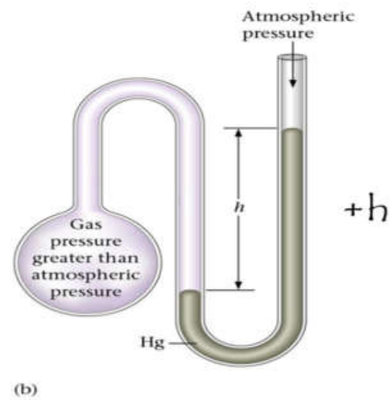
- used to measure ___________________________________
- The ______________________________ the ____________________
  _________________________________ and the ___________________
  the height of the mercury in the thermometer

Manometer-

- measures the pressure of an enclosed sample
- Can be open or closed

Open Manometer





- Gas pressure is _____________ than atmospheric (air) pressure when the height of the liquid in the manometer is higher on the _______________. Therefore you will ________________ the height and the atmospheric pressure.
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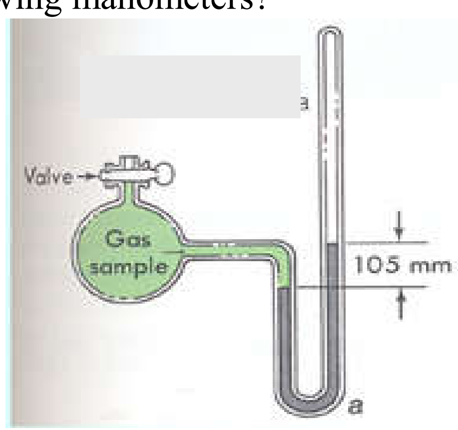
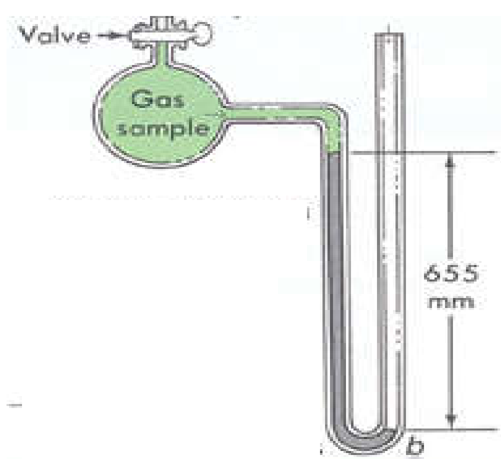
Examples:

If the atmospheric (air) pressure is 757.8mmHg, what is the pressure of the gas in each of the following manometers?





PRACTICE:

Convert the following temperatures.

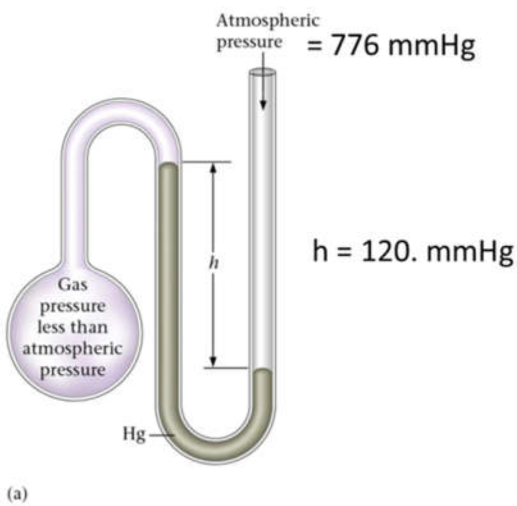
1. Convert 32°C to Kelvin
2. Convert 12°C to Kelvin
3. Convert 450 K to °C

Convert the following pressures.

1. What is pressure of 1.45 atm in torr?
2. What is the pressure of 890 torr in Pa?
3. What is the pressure of 645 mmHg in kPa?

Calculate the pressure for each gas in the following open manometers.

1.



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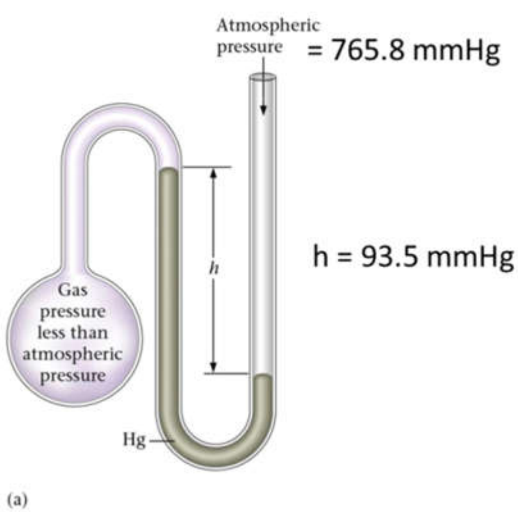

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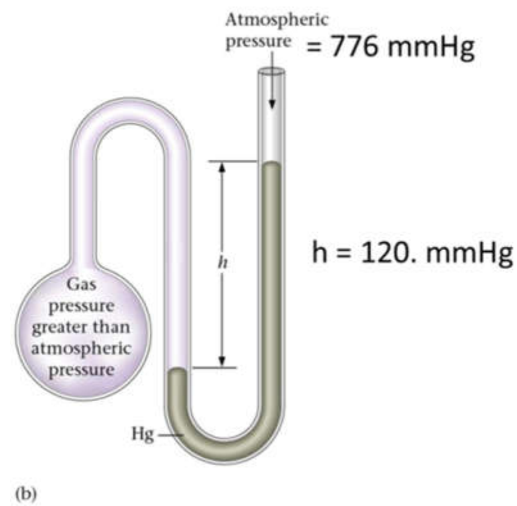
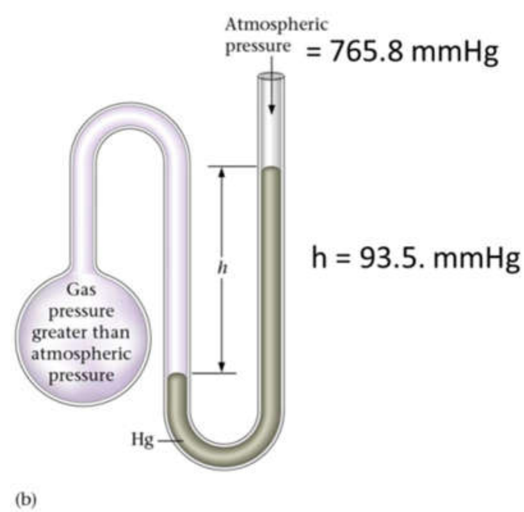


4.



Gas Laws Summary Table

Name of Law	Equation/Definition	Type of Relationship	Constant
Dalton's Law		----	----
Graham's Law			----
Boyle's Law			T
*Charles' Law			P
*Gay-Lussac's Law			V
*Combined Gas Law		----	----
Avogadro's Law			----
*Ideal Gas Law		----	$R = 0.0821 \frac{\text{atm} \bullet \text{L}}{\text{mol} \bullet \text{K}}$ $= 8.315 \frac{\text{kPa} \bullet \text{L}}{\text{mol} \bullet \text{K}}$

***Note: TEMPERATURES MUST BE IN KELVIN!!!**

STP =

Dalton's Law of Partial Pressures

- Each individual gas behaves as if it were **independent** of the others.
- The **total pressure** of a mixture of gases equals the **sum of the pressures** that each would exert if it were present alone.

  $\mathbf{P_{total}} =$

- When one collects a gas over water, there is water vapor mixed in with the gas.
- To find only the pressure of the desired gas, one must subtract the vapor pressure of water from the total pressure (P_{H2O} taken from table based on temperature)

  $\mathbf{P_{total}} =$

- The mole fraction of an individual gas component in an ideal gas mixture:

  $\mathbf{x_i} =$

- The partial pressure of an individual gas component in an ideal gas:

  $\mathbf{P_i} =$

$\mathbf{x_i}$ = mole fraction of any individual gas component in a gas mixture $\mathbf{P_i}$ = partial pressure of any individual gas component in a gas mixture $\mathbf{n_i}$ = moles of any individual gas component in a gas mixture **n** = total # moles of the gas mixture **P** = total pressure of the gas mixture

Examples:

1. Two gases such as oxygen and nitrogen are present in a flask at the following pressures. When combined, what is the pressure of the flask?

   $P_{Nitrogen}$ =250. mm Hg P_{Oxygen}=300. mm Hg

2. Neon gas has a pressure of 1.49atm in its container. When added to a container holding helium gas the total pressure is 2.34atm. What is the pressure of the helium gas?

3. Oxygen gas from the decomposition of potassium chlorate was collected by water displacement. The barometric pressure and the temperature during the experiment were 731.0torr and 20.0˚C respectively. What was the partial pressure of the oxygen collected? The vapor pressure of water at 20°C is 17.5 torr

4. A 250. mL sample of oxygen is collected over water at 25°C and 760.0 torr pressure. What is the pressure of the dry gas alone? (vapor pressure of water at 25°C=23.8 torr)

5. A tank contains 480.0 grams of oxygen and 80.00 grams of helium at a total pressure of 7.00 atmospheres. Calculate the following.
   a. How many moles of O_2 are in the tank?
   b. How many moles of He are in the tank?
   c. Total moles of gas in tank.
   d. Mole fraction of O_2.
   e. Mole fraction of He.
   f. Partial pressure of O_2.
   g. Partial pressure of He.

6. A mixture of 14.0 grams of hydrogen, 84.0 grams of nitrogen, and 2.0 moles of oxygen are placed in a flask. When the partial pressure of the oxygen is 78.00 mm Hg, what is the total pressure in the flask?

Graham's Law of Diffusion-

Under ideal conditions, the ______________ at which different gases diffuse (spread out) are

____________________ ____

Examples:

1. Compare the rates of diffusion of H_2 and O_2 gases at the same temperature and pressure.

2. Rank the following gases from slowest to fastest rate of diffusion: H_2, CO_2, Ne, H_2S.

3. Quantitatively compare the rate of effusion of carbon dioxide with hydrochloric acid at the same temperature and pressure.

4. A sample of hydrogen gas effuses through a porous container about 9 times faster than an unknown gas. Estimate the molar mass of the unknown gas.

5. If a molecule of neon gas travels at an average of 400.m/s at a given temperature, estimate the average speed of a molecule of butane gas, C_4H_{10}, at the same temperature

Gas Laws: Molecular Explanations

Gas Law	Explain what is happening on a MOLECULAR level
Boyle's Law	
Charles' Law	
Gay-Lussac's law	

Gas Laws: Calculations

1. A 12.3 L sample of helium fills a weather balloon at 20.0ºC. What would the volume change to if the weather balloon cooled to -12.0 ºC as it rose in the atmosphere?

2. A tire has a volume of 67.3 L at a pressure of 3.0 atm. What would the volume be if the pressure were increased to 3.5 atm?

3. A sample of methane occupies 445.9 mL at 75. ºC. At what temperature would it have a volume of 323.8 mL?

4. A sample of gas has a volume of 74.3 mL at a pressure of 106.8 kPa. What would the pressure be if the volume is increased to 113.5 mL?

5. A helium balloon has a volume of 8.09 L at STP. What volume would it have as it rose in the atmosphere if the pressure decreased to 89.7 kPa and the temperature decreased to -10.0ºC?

Avogadro's Law

- The __________________ of a gas at constant temperature and pressure is ____________ ____of the gas.
- __________________________ of gases at the same pressure and temperature contain the ____ and molecules
- **1 mole of any gas at STP is 22.4L**

Ex:

1. At STP, what is the volume of 7.08 mol of nitrogen gas?

2. If 1.0 mole of nitrogen has a volume of 22.4 L at STP, what volume would 5.0 g of N_2 occupy at STP?

Ideal Gas Law

$$R = 0.0821\frac{\text{atm}\bullet\text{L}}{\text{mol}\bullet\text{K}} = 8.315\frac{\text{kPa}\bullet\text{L}}{\text{mol}\bullet\text{K}} = 62.4\frac{\text{mmHg}\bullet\text{L}}{\text{mol}\bullet\text{K}}$$

- Describes the state of a hypothetical ideal gas.
- Good approximation of the behavior of many gases under many conditions.
- To determine which R to use in your equation you have to look at the ____________________

Ex:

1. What volume would 4.5 mole of hydrogen occupy at 25°C and 1.046 atm?

2. A balloon has a volume of 2.34L, and is at 47.5°C and 98.2kPa.

a. How many moles of Helium are contained in the balloon?

b. How many grams of Helium are contained in the balloon?

3. At 28 ˚C and 0.974 atm, 1.00 L of a gas has a mass of 5.16g.

a. How many moles of gas are present?

b. What is the molar mass of this gas?

4. What mass of methane would occupy 3.00 L at STP?