

Monday/Tuesday - October 28 &amp; 29, 2019 - Properties of Gases &amp; Gas Stoichiometry: (Chapter 5 Pt 1)

**I. Big Idea –**

Let's think about the three physical states of substances: solid, liquid and gas. Today we're going to think about gas (*Solid and Liquid we'll do in 1C*). Chemical properties for gases vary significantly, but physical properties are simpler to talk about: Gases occupy the full **volume** of their containers. Gases also have a **pressure** and a **temperature**. By looking at these properties, we can understand the behavior of gases.

Pressure:

Temperature:

STP Conditions:

SATP Conditions:

11 elements are gases under standard conditions

Gases are **compressible**, and they fill up the space that is available. This implies that **the molecules are moving quickly in chaotic motion**.

As well as low molar mass compounds such as

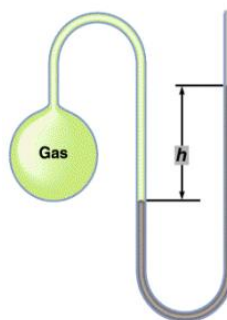
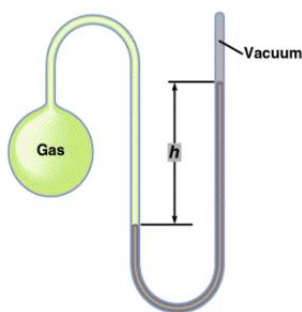
**II. Pressure in Systems**

1. A glass column is filled with mercury and inverted in a pool of mercury. The mercury column stabilizes at a height of 735 mm above the pool of mercury. What is the pressure of the atmosphere?

**Barometers**

2. Determine the pressure (atm) of the gas in the flask.
  - a.  $h = 0.15 \text{ m}$

- b.  $h = 0.08 \text{ m}$ ,  $P_{\text{atmosphere}} = 1 \text{ atm}$



### III. The Ideal Gas Law: \_\_\_\_\_

1. What volume (in L) is occupied by 35.2 g of nitrogen at 35°C and 0.975 atm?

What makes an ideal gas/ideal conditions?

2. A 36.4 L volume of methane gas is heated from 25°C to 88°C at constant pressure. What is the final volume of gas?
3. A sample of oxygen gas has a volume of 4.50 L at 27°C and 800.0 torr. How many oxygen molecules are in the sample?
4. The empirical formula of a gas is CH<sub>3</sub>O. If 2.77 g of the gas occupies 1.00 L at exactly 0°C at a pressure of 760 Torr, what is the molecular formula of the gas?  
A) C<sub>3</sub>H<sub>9</sub>O<sub>3</sub>      B) C<sub>5</sub>H<sub>15</sub>O<sub>5</sub>      C) C<sub>4</sub>H<sub>12</sub>O<sub>4</sub>      D) C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>      E) CH<sub>3</sub>O

5. In an experiment, 405 mL of methane gas was collected over water with a total pressure of 785 torr at 30°C. What is the vapor pressure of water (in torr) at 30°C if 0.258 g of methane was collected?

**Partial Pressure (P<sub>x</sub>):**

**Dalton's Law of Partial Pressures:**

**Mole Fraction:**

6. A 275.0-mL sample of O<sub>2</sub> is collected over water at 60.0°C. The total pressure is 755 torr. What is the volume of the O<sub>2</sub> at STP? (The vapor pressure of water at 60°C is 149 torr).  
(A) 180.0 mL      (B) 224.0 mL      (C) 244.0 mL      (D) 333.0 mL  
(E) none of these

7. Calculate the density of Hydrogen Bromide gas in g/L at 733 mmHg and 40 °C.

8. A mixture of gases contains 0.31 moles of  $\text{CH}_4$ , 0.25 moles of  $\text{C}_2\text{H}_6$ , and 0.29 moles of  $\text{C}_3\text{H}_8$  and the total pressure of the system is 1.50 atm. What is the partial pressure of  $\text{CH}_4$ ?
9. A mixture of oxygen and helium is 92.3% by mass oxygen. What is the partial pressure of oxygen if atmospheric pressure is 745 Torr?
10. Given a cylinder of fixed volume filled with 1 mol of argon gas, which of the following is correct? (Assume all gases obey the ideal gas law.)
- (A) If the temperature of the cylinder is changed from  $25^\circ\text{C}$  to  $50^\circ\text{C}$ , the pressure inside the cylinder will double.
- (B) If a second mole of argon is added to the cylinder, the ratio  $T/P$  will remain constant.
- (C) A cylinder of identical volume filled with the same *pressure* of helium must contain more atoms of gas because He has a smaller atomic radius than argon.
- (D) Two of these are correct. (E) None of these is correct.
11. Which of the following relationships is *not* true?
- (A)  $PV = \text{constant}$  when temperature and moles of gas are held constant.
- (B)  $V/T = \text{constant}$  when pressure and moles of gas are held constant.
- (C)  $nT = \text{constant}$  when pressure and volume are held constant.
- (D)  $P/n = \text{constant}$  when volume and temperature are held constant.
- (E) All of these are true.
12. Consider a sample of neon gas in a container fitted with a movable piston (assume the piston is massless and frictionless). The temperature of the gas is increased from  $20.0^\circ\text{C}$  to  $40.0^\circ\text{C}$ . The density of neon
- (A) increases less than 10%. (B) decreases less than 10%. (C) increases more than 10%.
- (D) decreases more than 10%. (E) does not change.
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#### IV. Other Equations of State

The ideal gas law does not account for a couple properties of real gases. Real gases \_ \_ and

1. Calculate the pressure exerted by 0.5000 mole of  $\text{N}_2$  in a 1.000-L container at  $25.0^\circ\text{C}$ . Use the van der Waals equation. (Use your constant sheet to find a and b). Compare this to the answer you would get using the ideal gas law.

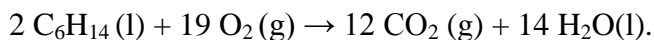
**Ideal Gas Law:**

**Van der Waals Equation State:**

**Virial Equation of State (experimental data)**

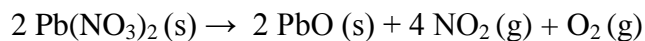
## V. Gas Stoichiometry

1. Consider the combustion of liquid hexane



If 1.52-g of hexane is combined with 2.95 L of oxygen at 312K and 890 torr. The carbon dioxide gas is collected at 297 K and 0.930 atm. What volume of carbon dioxide gas will be collected assuming 100% yield?

2. A 3.54-g sample of lead(II) nitrate (molar mass = 331 g/mol) is heated in an evacuated cylinder with a volume of 1.60 L. The salt decomposes when heated, according to the following equation:



Assuming complete decomposition, what is the pressure (in atm) in the cylinder after decomposition and cooling to a temperature of 300. K? Assume the  $\text{PbO}_{(\text{s})}$  takes up negligible volume.

3. 2.5 mol of  $\text{O}_2$  gas and 3.0 mol of solid carbon, C (s) are put into a 3.50-liter container at  $23^\circ\text{C}$ . If the carbon and oxygen react completely to form  $\text{CO}(\text{g})$ , what will be the final pressure (in atm) in the container at  $23^\circ\text{C}$ ?

4. The valve between two tanks is opened. See below. Calculate the total pressure in the container after the valve is opened.

