CHEM 202 Accelerated General Chemistry I — *TA: Alex Wang*

Week 3 – Gases II — *September 9th, 2021*

MERIT WS 3.2 — *Section AQG*

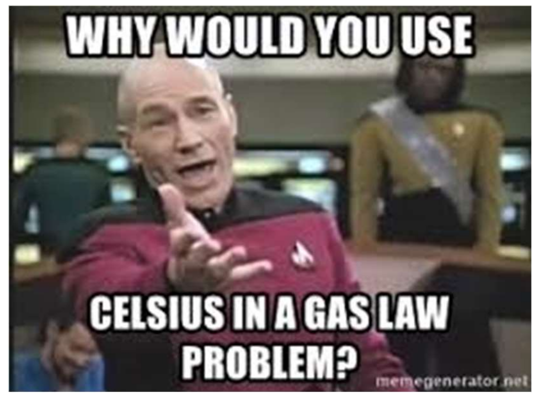
Me: Mom can we get $(P + an^2/V^2)(V - nb) = nRT$

Mom: We already have $(P + an^2/V^2)(V - nb) = nRT$ at home

$$(P + an^2/V^2)(V - nb) = nRT$$

at home:

$$PV = nRT$$



1. When can gases be considered ideal? State these assumptions.

2. Are gases in the world around you considered ideal? Why or why not? What implications does this have?

3. Do all the molecules in a 1-mole sample of $CH_4(g)$ have the same kinetic energy at 273 K? Do all the molecules in a 1-mole sample of $N_2(g)$ have the same velocity at 546 K? Explain.

4. Consider separate 1.0-L gaseous samples of H_2, Xe, Cl_2, and O_2, all at STP.
    a. Rank the gases in order of increasing average kinetic energy.
    b. Rank the gases in order of increasing average velocity.
    c. How can separate 1.0-L samples of O_2 and H_2 both have the same average velocity?

5. A 12.0 gram sample of helium gas occupies a volume of 25.0 L at a certain temperature and pressure. What volume does a 244.0 gram sample of neon gas occupy at these conditions of temperature and pressure?

6. Derive a linear relationship between gas density and temperature, and use it to estimate the value of absolute zero temperature (in degrees Celcius to the nearest degree) from an air sample whose density is 1.2930 g/L at 0.0 degrees Celsius and 0.9460 g/L at 100 degrees Celsius . Assume air obeys the ideal gas law and that the pressure is held constant. ***You may use graphing software if preferred.***

7. Sodium hydride (NaH) is an example of a rare situation in which the charge of hydrogen is not positive, but rather negative. It can react with water by the following equation:

$$H^{-}_{(aq)} + H_2O \rightarrow H_{2(g)} + OH^{-}_{(aq)}$$

   If you place 10 grams of NaH in water, how many liters of dry H_2 gas will you have if you collect all of the gas produced in the reaction and measure it at STP conditions?

8. Natural gas is a mixture of hydrocarbons, primarily methane (CH_4) and ethane (C_2H_6). A typical mixture might have $\chi_{metha} = 0.915$ and $\chi_{ethane} = 0.085$. What are the partial pressures of the two gases in a 15.00-L container of natural gas at 20.°C and 1.44 atm? Assuming complete combustion of both gases in the natural gas sample, what is the total mass of water formed?

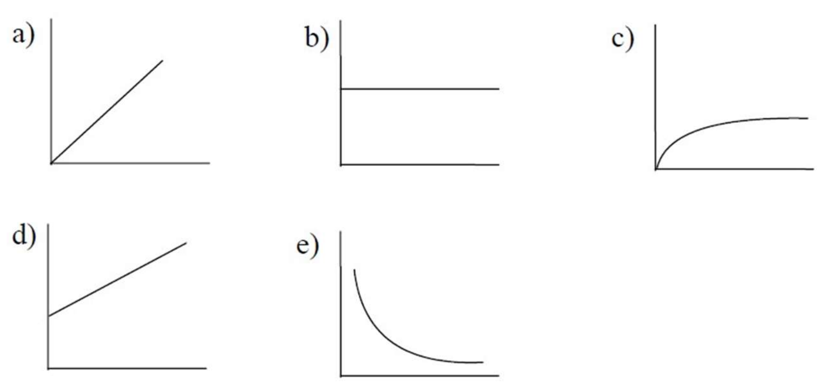
9. You are given an unknown gaseous binary compound (that is, a compound consisting of two different elements). When 10.0 g of the compound is burned in excess oxygen, 16.3 g of water is produced. The compound has a density 1.38 times that of oxygen gas at the same conditions of temperature and pressure. Give a possible identity for the unknown compound.

10. Small quantities of hydrogen gas can be prepared in the laboratory by the addition of aqueous hydrochloric acid to metallic zinc.

$$\mathrm{Zn}(s) + 2\mathrm{HCl}(aq) \longrightarrow \mathrm{ZnCl_2}(aq) + \mathrm{H_2}(g)$$

Typically, the hydrogen gas is bubbled through water for collection and becomes saturated with water vapor. Suppose 240. mL of hydrogen gas is collected at 30ºC and has a total pressure of 1.032 atm by this process. What is the partial pressure of hydrogen gas in the sample? How many grams of zinc must have reacted to produce this quantity of hydrogen? (The vapor pressure of water is 32 torr at 30ºC.)

11. Match the statements provided below with the graphical representations shown.



a. Density (y) vs. T(K) (x) for 1 mole of an ideal gas in a rigid steel container

b. Pressure (y) vs. molar mass (x) for 1 mole of a given volume of a series of ideal gases at the same temperature.

12. Ammonia gas [$NH_3(g)$] reacts with oxygen gas to produce $H_2O(l)$ and either $NO(g)$ or $NO_2(g)$, depending on the supply of oxygen. If oxygen gas is limiting, $NO(g)$ is one of the products. If oxygen gas is in excess, $NO_2(g)$ is a product.

    Suppose you react ammonia and oxygen gases in a container fitted with a piston in such a ratio that the reactant mixture at 25.0°C and 1.00 atm has the same density as air at these conditions (consider air to be 21.0% oxygen gas and 79.0% nitrogen gas by volume).

    a. Determine the balanced equation for the reaction that occurs and defend your answer with numbers.

    b. Determine the ratio of the volume of the container before and after the reaction. Assume the liquid water that is produced takes up negligible volume. Show all work.

c. Specify the temperature so that the gaseous mixture after the reaction is complete has the same density as the initial reactant gaseous mixture at 25.0oC and 1.00 atm. If there is a range of temperatures that work, explain. Show all work.

13. Derive Dalton's law of partial pressures from the kinetic molecular theory of gases. What assumptions are necessary?