Unit 6 - Gases

SECTION 1

SHORT ANSWER: *Answer the following questions in the space provided.*

1. ____ **Pressure = force ÷ surface area**
   For a constant force, when the surface area is tripled the pressure is
   (a) doubled.
   (b) **a third as much.**
   (c) tripled.
   (d) unchanged.

2. Explain how to calculate the partial pressure of a dry gas that is collected over water when the total pressure is atmospheric pressure.
   Subtract the partial pressure of water vapor (based on the temperature) from atmospheric pressure.

3. Convert a pressure of 0.200 atm to the following units:
   a. mm Hg 152 mm Hg b. kPa 20.3 kPa

4. When an explosive like TNT is detonated, a mixture of gases at high temperature is created. Suppose that gas X has a pressure of 50 atm, gas Y has a pressure of 20 atm, and gas Z has a pressure of 10 atm.
   a. What is the total pressure in this system? 80 atm
   b. What is the total pressure in this system in kPa? 8100 kPa

5. The height of the mercury in a barometer is directly proportional to the pressure on the mercury's surface. At sea level, pressure averages 1.0 atm and the level of mercury in the barometer is 760 mm (30. inches). In a hurricane, the barometric reading may fall to as low as 28 in.
   a. Convert a pressure reading of 28 in. to atmospheres. 0.94 atm
   b. What is the barometer reading, in mm Hg, at a pressure of 0.50 atm? 380 mmHg

SECTION 2

SHORT ANSWER: *Answer the following questions on the lines.*

1. State whether the pressure of a fixed mass of gas will increase, decrease, or stay the same in the following circumstances:
   a. Pressure increases temperature increases, volume stays the same
   b. Pressure decreases volume increases, temperature stays the same
   c. Pressure decreases temperature decreases, volume stays the same
   d. Pressure increases volume decreases, temperature stays the same

2. Two sealed flasks, A and B, contain two different gases of equal volume at the same temperature and pressure. Assume that flask A is warmed as flask B is cooled. Will the pressure in the two flasks remain equal? If not, which flask will have the higher pressure? Explain.

   The pressure of the two gases will no longer remain equal. In fact, the pressure of the gas in Flask A will increase while the pressure of gas B will decrease.

PROBLEMS: *Write your answers on the lines. Show your work in the spaces provided.*

3. A bicycle tire is inflated to 55 psi at 15°C. Assume that the volume of the tire does not change appreciably once it is inflated.

   a. increase If the tire and the air inside it are heated to 30°C by road friction, does the pressure in the tire increase or decrease? (Assume the volume of air in the tire remains constant.) Reason: because T and P have a direct relationship, an increase in T will cause P to increase.

   b. No Because the temperature has doubled, does the pressure double to 110 psi? Reason: The Celsius temp has doubled, but the temperatures must be converted to kelvins before finding the new pressure. If T_1 = 288 K and T_2 = 303 K. Pressure thus will not double.

   c. 55 psi / 288 K = P_2 / 303 K → P_2 = 58 psi What will the pressure be when the temperature has doubled? Express your answer in pounds per square inch.

4. 4.5 L A 24-L sample of a gas at fixed mass and constant temperature exerts a pressure of 3.0 atm. What pressure will the gas exert if the volume is changed to 16 L?

5. 16.7 mL A common laboratory system to study Boyle's law uses a gas trapped in a syringe. The pressure in the system is changed by adding or removing identical weights on the plunger. The original gas volume is 50.0 mL when two weights are present. Predict the new gas volume when four more weights are added.

6. 1030 mL A sample of argon gas occupies a volume of 950 mL at 25.0°C. What volume will the gas occupy at 50.0°C if the pressure remains constant?

7. 1.9×10^5 Pa A 500.0-mL gas sample at STP is compressed to a volume of 300.0 mL, and the temperature is increased to 35.0°C. What is the new pressure of the gas in **pascals**? (1000 Pa = 1 kPa)

8. 1270 mL A sample of gas occupies 1000. mL at standard pressure. What volume will the gas occupy at a pressure of 600. mm Hg if the temperature remains constant?

SECTION 3

SHORT ANSWER: *Answer the following questions in the space provided.*

1. _____ The molar mass of a gas at STP is the density of that gas in g/L
   a. multiplied by the mass of 1 mol.
   b. multiplied by 22.4 L.
   c. divided by the mass of 1 mol.
   d. divided by 22.4 L.

2. _____For the expression *PV= nRT* , which of the following will cause the volume to increase?
   a. increasing P
   b. increasing T
   c. decreasing T
   d. decreasing n

3. Two sealed flasks, A and B, contain two different gases of equal volume at the same temperature and pressure.

   true a. The two flasks must contain an equal number of molecules. True or False?

   false b. The two samples must have equal masses. True or False?

PROBLEMS: *Write the answer on the line to the left of each question.*

4. Use the data in the table below to answer the following questions. Assume all gases are at STP.

Formula	**Molar mass (g/mol)**
N_2	28.02
CO	28.01
C_2H_2	26.04
He	4.00
Ar	39.95

   a. All have the same # Which gas contains the most molecules in a 5.0 L sample?

   b. Helium Which gas is the least dense?

   c. N_2 and CO Which two gases have virtually the same density?

   d. 1.25 g/L What is the density of N_2 (in g/L) measured at STP? (Strategy to solve: First recall that 1 mole of any gas has a volume of 22.4 L. Multiply one mole by molar mass to get grams. Then divide by 22.4 L.)

5. 5.6 L ÷ 22.4 L/mol = 0.25 mol How many moles of gas are present in 5.6 L of any ideal gas at STP?

6. Consider the following reaction: CH_4 (g) + $2O_2$ (g) → CO_2 (g) + $2H_2O$ (g)

   a. 5.6 L ÷ 22.4 L/mol = 0.25 mol How many moles of methane are present in 5.6 L of CH_4 at STP? (You just solved this in Question 5)

   b. 4.0 g What is the mass of the 5.6 L sample of CH_4?

7. A large cylinder of He gas such as that used to inflate balloons has a volume of 25.0 L at 22°C and 5.6 atm.

   a. 5.8 mol How many moles of He are in such a cylinder?

   b. 23 g What is the mass of the He calculated in Question a?

8. When C_3H_4 combusts at STP, 5.6 L of C_3H_4 are consumed according to the following equation:

$$C_3H_4\,(g) + 4O_2\,(g) \rightarrow 3CO_2\,(g) + 2H_2O\,(l)$$

   a. 0.25 mol How many moles of C_3H_4 react?

   b. _____ How many moles of O_2, CO_2, and H_2O are either consumed or produced?
   0.25 mol C_3H_4 x 4 mol O_2/1 mol C_3H_4 = 1.0 mol O_2
   0.25 mol C_3H_4 x 3 mol CO_2/1 mol C_3H_4 = 0.75 mol CO_2
   0.25 C_3H_4 x 2 mol H_2O/1 mol C_3H_4 = 0.50 mol H_2O

   c. 40. g How many grams of C_3H_4 are consumed?

   d. 17 L How many liters of CO_2 are produced? (remember, we are at STP)

   e. 9.01 g How many grams of H_2O are produced?

SECTION 4

SHORT ANSWER: *Answer the following questions on the lines provided.*

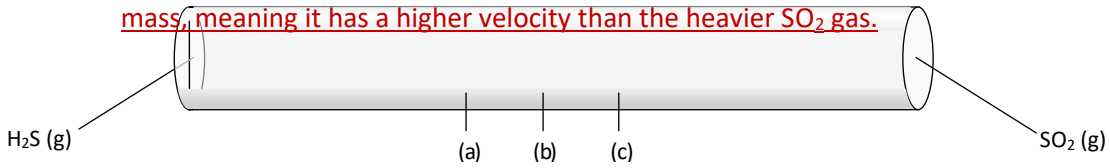
1. b) < d) < c) < a) List the following gases in order of increasing rate of effusion. (Assume all gases are at the same temperature and pressure.) Xe < Cl_2 < HCl < He

   (a) He (b) Xe (c) HCl (d) Cl_2

2. Explain your reasoning for the order of gases you chose in Question 1 above. Refer to the kinetic molecular theory to support your explanation.

   The kinetic energy is equal for all the gases at the same temperature; but because KE = ½ mv^2, the heavier a gas is (meaning the higher its molar mass is), the lower its velocity is. Thus the rate of effusion is highest for the gas with the lightest molar mass.

3. c The two gases in the figure below are simultaneously injected into opposite ends of the tube. At which labeled point should they just begin to mix? The answer is c because H_2S has a lower molar mass, meaning it has a higher velocity than the heavier SO_2 gas.



4. State whether each example describes effusion or diffusion.
   a. effusion As a puncture occurs in a tire, it loses air and becomes "flat".
   b. diffusion When ammonia is spilled on the floor, the smell reaches all parts of the house.
   c. diffusion The smell of car exhaust pervades an emissions testing station.

5. Describe what happens on a molecular level to cause a woman's perfume to diffuse throughout a room.

   When perfume vaporizes, its particles move in a constant, random motion (as all gases do) causing it to diffuse throughout whatever space it is allowed to move in. If that space is a room, then the perfume's particles will eventually become distributed throughout it.

PROBLEMS: *Write your answers on the lines. Show your work in the spaces provided.*

6. He travels 3.02 times faster than HCl at the same temperature. The molar masses of He and of HCl are 4.00 g/mol and 36.46 g/mol, respectively. Which gas travels faster, and how many times faster?

7. 1200 m/s ÷ 3 = 400 m/s If helium's average speed at a given temperature is 1200 m/s, what is the average speed of HCl?

8. Approx. 202 g/mol An unknown gas effuses 3.16 times more slowly than neon. Estimate the molar mass of this unknown gas.

MIXED REVIEW

SHORT ANSWER: *Answer the following questions on the lines provided.*

1. Consider the following atmospheric pressure data:

Approximate pressure (kPa)	Altitude above sea level (km)
100	0 (sea level)
50	5.5 (peak of Mt. Kilimanjaro)
25	11 (jet cruising altitude)
0.1	22 (ozone layer)

   a. Briefly explain why air pressure decreases as altitude increases.

   Because the gas particles in air are affected by gravity (as all matter is), they are held close to Earth's surface. The further above sea level we go, the fewer gas particles there are; and air pressure has a direct relationship to number of gas particles.

   b. A few places on Earth are below sea level (Death Valley, CA, for example). What would be true of the average atmospheric pressure in such places? Why?

   The average atmospheric pressure would be greater than 1 atm because there are more gas particles pressing down from above as gravity exerts its force.

PROBLEMS: *Write your answers on the lines. Show your work in the spaces provided when appropriate.*

2. 226 mL A 250. mL sample of gas is collected at 57°C. What volume will the gas sample occupy at 25°C?

3. H_2 and N_2 react in the synthesis of ammonia gas: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

   a. 0.0405 mol If 1.00 L of H_2 is consumed in this reaction at a temperature of 50.0°C, how many moles of N_2 will be consumed with it? The partial pressure of H_2 just before the reaction starts is 3.22 atm. To solve this, start by finding moles of H_2 using PV = nRT (n = 0.121 mol). Then use the molar ratio of N_2-to-H_2 to calculate moles N_2 consumed with the H_2.

   b. 1.07 atm What is the partial pressure of the N_2 just before the reaction begins? Since pressure is directly related to # of moles of a gas according to Avogadro's law and 0.121 mol H_2 has a partial pressure of 3.22 atm, then 0.0405 mol of N_2 should have a pressure that is one-third as much as the H_2:

$$\frac{3.22 \text{ atm}}{0.121 \text{ mol}} = \frac{P_{N2}}{0.0405 \text{ mol}}$$

4. Chlorine in the upper atmosphere can destroy ozone molecules. The reaction is represented by the following equation: $Cl_2(g) + 2O_3(g) \rightarrow 2ClO(g) + 2O_2(g)$

   2065 L ≈ 2100 L (rounded to 2 s.f.) How many liters of O_3 can be destroyed at 220. K and 5.0 kPa if 200.0 g of chlorine gas react with it?