Problem Set 4: Gas Mixtures and Partial Pressures

1

10.60 Consider a mixture of two gases, A and B, confined in a closed vessel. A quantity of a third gas, C, is added to the same vessel at the same temperature. How does the addition of gas C affect the following: **(a)** the partial pressure of gas A, **(b)** the total pressure in the vessel, **(c)** the mole fraction of gas B?

2

A tank is filled with three inert gases: helium, argon, and xenon. The total pressure of the container measures 18.9 atm after adding 3.6 atm of helium, an unknown amount of argon, and 9.7 atm of xenon. What is the partial pressure of argon in the container?

3

89. The partial pressure of $CH_4(g)$ is 0.175 atm and that of $O_2(g)$ is 0.250 atm in a mixture of the two gases.

a. What is the mole fraction of each gas in the mixture?

b. If the mixture occupies a volume of 10.5 L at 65°C, calculate the total number of moles of gas in the mixture.

c. Calculate the number of grams of each gas in the mixture.

4

90. A tank contains a mixture of 52.5 g oxygen gas and 65.1 g carbon dioxide gas at 27°C. The total pressure in the tank is 9.21 atm. Calculate the partial pressures of each gas in the container.

5

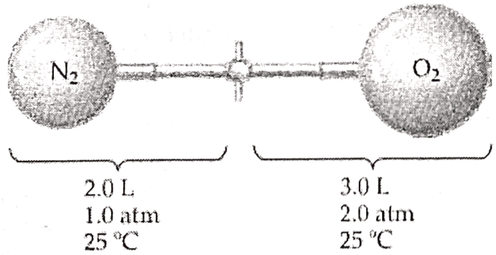
10.61 A mixture containing 0.477 mol He(*g*), 0.280 mol Ne(*g*), and 0.110 mol Ar(*g*) is confined in a 7.00-L vessel at 25 °C. **(a)** Calculate the partial pressure of each of the gases in the mixture. **(b)** Calculate the total pressure of the mixture.

6

88. At 0°C a 1.0-L flask contains 5.0×10^{-2} mole of N_2, 1.5×10^2 mg O_2, and 5.0×10^{21} molecules of NH_3. What is the partial pressure of each gas, and what is the total pressure in the flask?

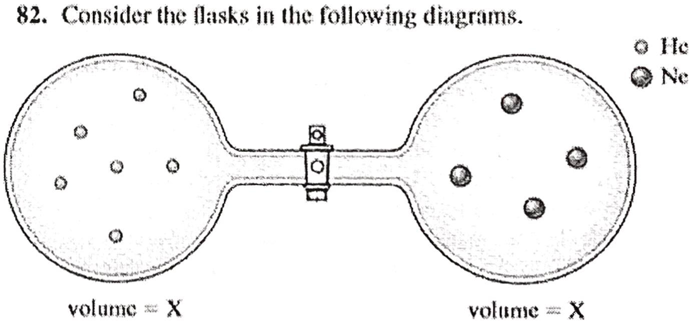
7

10.59 Consider the apparatus shown in the drawing on the next page. **(a)** When the stopcock between the two containers is opened and the gases allowed to mix, how does the volume occupied by the N_2 gas change? What is the partial pressure of N_2 after mixing? **(b)** How does the volume of the O_2 gas change when the gases mix? What is the partial pressure of O_2 in the mixture? **(c)** What is the total pressure in the container after the gases mix?



8

82. Consider the flasks in the following diagrams.



a. Which is greater, the initial pressure of helium or the initial pressure of neon? How much greater?

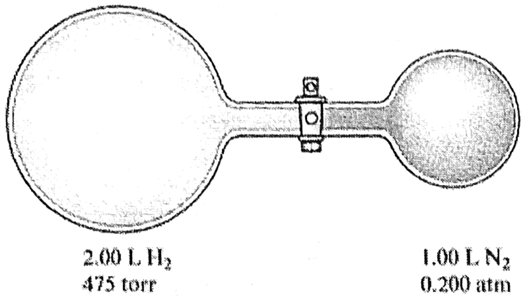
b. Assuming the connecting tube has negligible volume, draw what each diagram will look like after the stopcock between the two flasks is opened.

c. Solve for the final pressure in terms of the original pressures of helium and neon. Assume temperature is constant.

d. Solve for the final partial pressures of helium and neon in terms of their original pressures. Assume the temperature is constant.

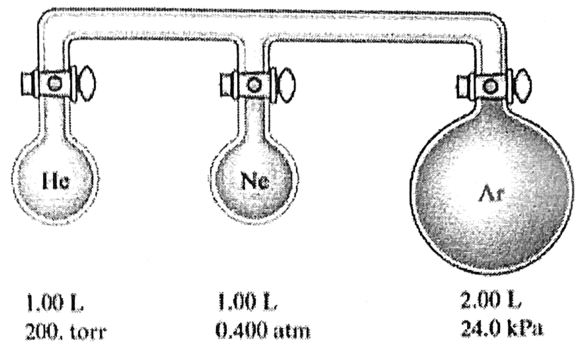
9

85. Consider the flasks in the following diagram. What are the final partial pressures of H_2 and N_2 after the stopcock between the two flasks is opened? (Assume the final volume is 3.00 L.) What is the total pressure (in torr)?



10

87. Consider the three flasks in the diagram below. Assuming the connecting tubes have negligible volume, what is the partial pressure of each gas and the total pressure after all the stopcocks are opened?



11

10.58 Acetylene gas, $C_2H_2(g)$, can be prepared by the reaction of calcium carbide with water:

$$CaC_2(s) + 2\,H_2O(l) \longrightarrow Ca(OH)_2(s) + C_2H_2(g)$$

Calculate the volume of C_2H_2 that is collected over water at 23 °C by reaction of 0.752 g of CaC_2 if the total pressure of the gas is 745 torr. (The vapor pressure of water is tabulated in Appendix B.)

12

10.57 Hydrogen gas is produced when zinc reacts with sulfuric acid:

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

If 159 mL of wet H_2 is collected over water at 24 °C and a barometric pressure of 738 torr, how many grams of Zn have been consumed? (The vapor pressure of water is tabulated in Appendix B.)

13

A rigid 5.00 L container contains 0.176 mol of NO (g) at 298 K. A 0.176 mol sample of O_2 (g) is added to the cylinder, where a reaction occurs to produce NO_2 (g). Calculate the total pressure in kPa inside the container after the reaction has gone to completion.

14

3.98 grams of propane gas (C_3H_8) are combusted with 1.77 mol of oxygen gas in a 2.78 L container at 157°C. What is the partial pressure of all 4 gases after reaction?

Problem Set 5: KMT, Effusion, and Diffusion

1

Indicate which of the following statements regarding the kinetic molecular theory of gases are correct. For those that are false, formulate a correct version of the statement:

a)The average kinetic energy of a collection of gas molecules at a given temperature is proportional to $m^{1/2}$.

b)The gas molecules are assumed to exert no forces on each other.

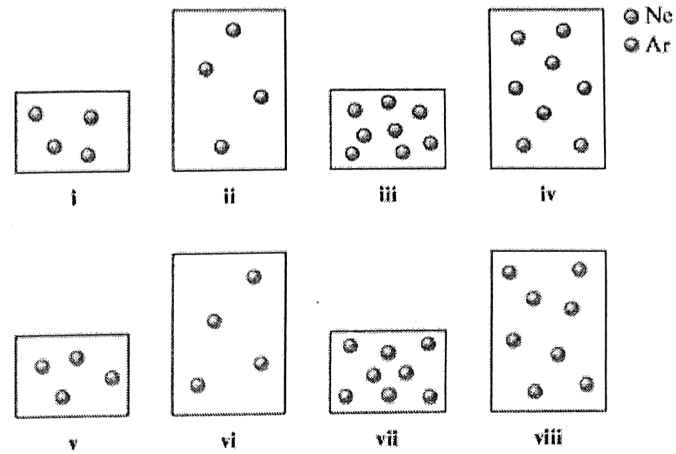
c)All the molecules of a gas at a given temperature have the same kinetic energy.

d)The volume of the gas molecules is negligible in comparison to the total volume in which the gas is contained.

e)All gas molecules move with the same speed if they are at the same temperature.

2

30. Consider the following samples of gases at the same temperature.



Arrange each of these samples in order from lowest to highest:

a. pressure

b. average kinetic energy

c. density

d. root mean square velocity

Note: Some samples of gases may have equal values for these attributes. Assume the larger containers have a volume twice the volume of the smaller containers, and assume the mass of an argon atom is twice the mass of a neon atom.

3

109. Consider three identical flasks filled with different gases.

Flask A: CO at 760 torr and 0°C

Flask B: N_2 at 250 torr and 0°C

Flask C: H_2 at 100 torr and 0°C

a. In which flask will the molecules have the greatest average kinetic energy?

b. In which flask will the molecules have the greatest average velocity?

4

10.75 The temperature of a 5.00-L container of N_2 gas is increased from 20 °C to 250 °C. If the volume is held constant, predict qualitatively how this change affects the following: **(a)** the average kinetic energy of the molecules; **(b)** the average speed of the molecules; **(c)** the strength of the impact of an average molecule with the container walls; **(d)** the total number of collisions of molecules with walls per second.

5

10.76 Suppose you have two 1-L flasks, one containing N_2 at STP, the other containing CH_4 at STP. How do these systems compare with respect to **(a)** number of molecules **(b)** density, **(c)** average kinetic energy of the molecules **(d)** rate of effusion through a pinhole leak?

6

10.78 **(a)** Place the following gases in order of increasing average molecular speed at 300 K: CO, SF_6, H_2S, Cl_2, HBr. **(b)** Calculate and compare the rms speeds of CO and Cl_2 molecules at 300 K.

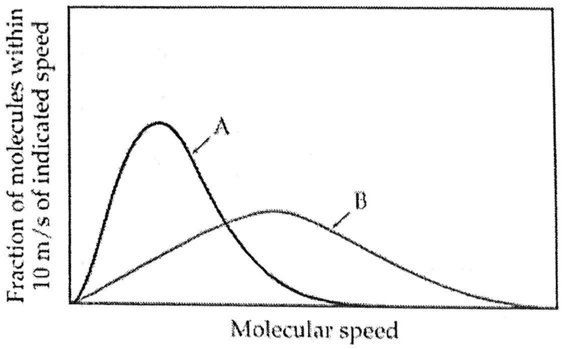
7

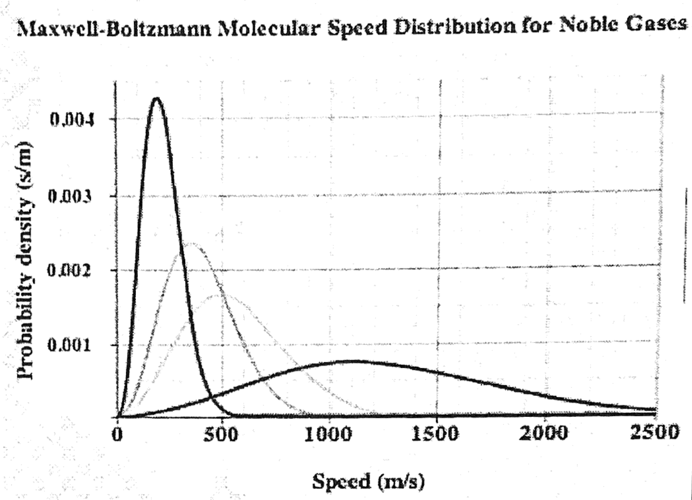
103. Calculate the root mean square velocities of $CH_4(g)$ and $N_2(g$ molecules at 273 K and 546 K.

8

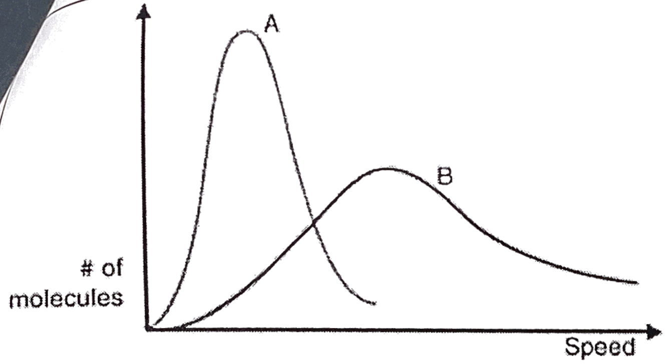
10.7 On a single plot, qualitatively sketch the distribution of molecular speeds for **(a)** Kr(*g*) at −50 °C, **(b)** Kr(*g*) at 0 °C, **(c)** Ar(*g*) at 0 °C.

9	10
10.8 Consider the following drawing. (a) If the curves A and B refer to two different gases, He and O_2 at the same temperature, which is which? Explain. (b) If A and B refer to the same gas at two different temperatures, which represents the higher temperature?	This Boltzmann distribution is for a set of noble gases. If temperature is held constant among the gases, which curve represents each of the following gases: helium, neon, argon, and krypton?





11	12
Use the Maxwell speed distribution curve below to: a)Determine which curve represents a gas existing at a higher temperature using the Maxwell distribution below. b)Then draw a new curve "C" that represents the highest temperature. c)Under which temperature conditions would the gas sample behave most ideally? Explain. d)Provide a molecular picture for each curve that accurately depicts the differences between the gas behaviors at different temperatures. Use arrows to represent the velocity of the gas molecules.	7. A chemistry student relates the following story: I noticed my tires were a bit low and went to the gas station. As I was filling the tires, I thought about the kinetic molecular theory (KMT). I noticed the tires because the volume was low, and I realized that I was increasing both the pressure and volume of the tires. "Hmmm," I thought, "that goes against what I learned in chemistry, where I was told pressure and volume are inversely proportional." What is the fault in the logic of the chemistry student in this situation? Explain *why* we think pressure and volume to be inversely related (draw pictures and use the KMT).



13	14
112. The rate of effusion of a particular gas was measured and found to be 24.0 mL/min. Under the same conditions, the rate of effusion of pure methane (CH_4) gas is 47.8 mL/min. What is the molar mass of the unknown gas?	111. Freon-12 is used as a refrigerant in central home air conditioners. The rate of effusion of Freon-12 to Freon-11 (molar mass = 137.4 g/mol) is 1.07:1. The formula of Freon-12 is one of the following: CF_4, CF_3Cl, CF_2Cl_2, $CFCl_3$, or CCl_4. Which formula is correct for Freon-12?
15	**16**
10.81 Arsenic(III) sulfide sublimes readily, even below its melting point of 320 °C. The molecules of the vapor phase are found to effuse through a tiny hole at 0.28 times the rate of effusion of Ar atoms under the same conditions of temperature and pressure. What is the molecular formula of arsenic(III) sulfide in the gas phase?	10.82 A gas of unknown molecular mass was allowed to effuse through a small opening under constant-pressure conditions. It required 105 s for 1.0 L of the gas to effuse. Under identical experimental conditions it required 31 s for 1.0 L of O_2 gas to effuse. Calculate the molar mass of the unknown gas.
17	**18**
114. It took 4.5 minutes for 1.0 L helium to effuse through a porous barrier. How long will it take for 1.0 L Cl_2 gas to effuse under identical conditions?	