Exercise 11.1b(H)

Partial Pressures – Answers

Name: ____________________________

Date:_________________ Per:_________

In any mixture of gases, the partial pressures of the gases will be proportional to their quantities measured in moles. The gases act independently of one another, so their collisions (pressure) is simply a function of how many particles are present at a constant temperature and pressure. For example, in a mixture of two gasses A & B, if gas A exerts 2 atm of pressure and gas B exerts 1 atm of pressure, there must be twice as many particles of A to cause twice the collisions caused by gas B.

A mole fraction (X) is a ratio that compares the number of moles (n) of a particular part of a mixture to the total number of moles of the mixture(n_{tot}).

$$X_A = \frac{n_A}{n_{tot}} = \frac{n_A}{n_A + n_B + n_C \ldots}$$

The sum of the mole fractions of all the components present must equal 1. The amount of gas present in a mixture may be described by its partial pressure or its mole fraction. In a mixture of gases, the partial pressure of each gas is the product of the total pressure and the mole fraction of that gas.

$$\frac{P_A}{P_{tot}} = \frac{n_A}{n_{tot}} = X_A \text{ or rearranging the equation } \mathbf{P_A = (X_A)(P_{tot})}$$

DIRECTIONS: Complete the following in the space provided.

Pressure Unit Equivalences	
1.00 atm = 760 mm Hg	1.00 atm = 1013 mbars
1.00 atm = 14.7 psi	1.00 atm = 760 Torr
1.00 atm = 101 325 Pa	1.00 atm = 29.92 in Hg
1.00 atm = 101.325 kPa	1.00 atm = 407 in. H_2O

1. Blast furnaces give off many unpleasant and unhealthy gases. If the total air pressure is 0.990 atm, the partial pressure of carbon dioxide is 0.050 atm, and the partial pressure of hydrogen sulfide is 0.020 atm, what is the partial pressure of the remaining air?

   $P_{tot} = P_{CO_2} + P_{H_2S} + P_{air}$

   $0.990\text{atm} = 0.050\text{atm} + 0.020\text{atm} + P_{air} \Rightarrow P_{air} = 0.990\text{atm} - 0.050\text{atm} - 0.020\text{atm} = \boxed{0.920 \text{ atm}}$

2. A sample of gas is collected over water at 25 °C. It has a pressure of 1.315 atm. What is the partial pressure of the gas collected in kPa? *(P_{H2O} is 23.12 mmHg at 25 °C.)*

   $P_{tot} = P_{gas} + P_{water}$

   $P_{tot} = \frac{1.315 \text{ atm}}{} \Big| \frac{101.325 \text{ kPa}}{1 \text{ atm}} = 133.\underline{2}4 \text{ kPa}$ $\quad P_{water} = \frac{23.12 \text{ mmHg}}{} \Big| \frac{101.325 \text{ kPa}}{760 \text{ mmHg}} = 3.08\underline{2}4 \text{ kPa}$

   $133.\underline{2}4 \text{ kPa} = P_{gas} + 3.08\underline{2}4\text{kPa} \Rightarrow P_{gas} = 133.\underline{2}4 \text{ kPa} - 3.08\underline{2}4\text{kPa} = 130.\underline{1}57\text{kPa} \Rightarrow \boxed{130.2 \text{ kPa}}$

3. If a steel container holds 3.50 moles of hydrogen gas and 3.50 moles of helium gas, and the total pressure is 4.00 atm., what is the partial pressure of each of the gases?

   $\frac{P_{H_2}}{P_{gas}} = \frac{\text{mol } H_2}{\text{mol gas}} \Rightarrow \frac{P_{H_2}}{4.00 \text{ atm}} = \frac{3.50 \text{ mol } H_2}{7.00 \text{ mol gas}} \Rightarrow \boxed{P_{H_2} = 2.00 \text{ atm}}$

   $\frac{P_{He}}{P_{gas}} = \frac{\text{mol He}}{\text{mol gas}} \Rightarrow \frac{P_{He}}{4.00 \text{ atm}} = \frac{3.50 \text{ mol He}}{7.00 \text{ mol gas}} \Rightarrow \boxed{P_{He} = 2.00 \text{ atm}}$

4. What's the partial pressure of carbon dioxide in a container that holds 5.00 moles of carbon dioxide, 3.00 moles of nitrogen, and 1.00 mole of hydrogen and has a total pressure of 1.05 atm?

   $\frac{P_{CO_2}}{P_{gas}} = \frac{\text{mol } CO_2}{\text{mol gas}} \Rightarrow \frac{P_{CO_2}}{1.05 \text{ atm}} = \frac{5.00 \text{ mol } H_2}{9.00 \text{ mol gas}} \Rightarrow \boxed{P_{CO_2} = 0.583 \text{ atm}}$

5. A 22.4 L glass bulb has a total pressure of 760. mmHg at 0.0˚C and contains three different gases, nitrogen, helium and argon. If the partial pressure of nitrogen is 250. mmHg and the partial pressure of argon is 130. mmHg, what is the number of moles of helium in the tank? *(1 mol of gas at STP = 22.4L.)*

   $P_{tot} = P_{N2} + P_{He} + P_{Ar}$

   $760. \text{ mmHg} = 250. \text{ mmHg} + P_{He} + 130. \text{ mmHg} \Rightarrow P_{He} = 760. \text{ mmHg} - 250. \text{ mmHg} - 130. \text{ mmHg} = 38\underline{0}. \text{ mmHg}$

   $\frac{P_{He}}{P_{gas}} = \frac{\text{mol He}}{\text{mol gas}} \Rightarrow \frac{380. \text{ mmHg}}{760. \text{ mmHg}} = \frac{\text{mol He}}{1 \text{ mol gas}} \Rightarrow \boxed{\text{mol He} = 0.500}$

Answers: 1) 0.920 atm 2) 130.2 kPa 3) 2.00 atm H_2, 2.00 atm He 4) 0.583 atm 5) 0.500 mol He 6a) 10. mol He, 2.0 mol N_2, 1.0 mol Ar 6b) 7.7 atm 7) 239 psi O_2, 3188 psi He, 573 psi N_2

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6. A cylinder contains 40. g of He, 56 g of N_2, and 40. g of Ar.

   a. How many moles of each gas are in the mixture?

$$\frac{40.\ \text{g He}}{} \Big| \frac{1\ \text{mol He}}{4.003\ \text{g He}} = 9.99\ \text{mol He} \Rightarrow \boxed{10.\ \text{mol He}}$$

$$\frac{56.\ \text{g } N_2}{} \Big| \frac{1\ \text{mol } N_2}{28.014\ \text{g } N_2} = 1.99\ \text{mol } N_2 \Rightarrow \boxed{2.0\ \text{mol } N_2}$$

$$\frac{40.\ \text{g Ar}}{} \Big| \frac{1\ \text{mol Ar}}{39.948\ \text{g Ar}} = 1.00\ \text{mol Ar} \Rightarrow \boxed{1.0\ \text{mol Ar}}$$

   b. If the total pressure of the mixture is 10. atm, what is the partial pressure of He?

$$\frac{P_{He}}{P_{gas}} = \frac{\text{mol He}}{\text{mol gas}} \Rightarrow \frac{P_{He}}{10.\ \text{atm}} = \frac{9.99\ \text{mol He}}{12.98\ \text{mol gas}} \Rightarrow P_{He} = 7.69\ \text{atm} \Rightarrow \boxed{P_{He} = 7.7\ \text{atm}}$$

7. A 15L scuba tank is filled with a gas mixture of 21.0% O_2, 35.0% He, and 44.0% N_2 (by mass) to a pressure of 4000.psi. What is the partial pressure of each gas?

$$\frac{21.0\ \text{g } O_2}{} \Big| \frac{1\ \text{mol } O_2}{31.998\ \text{g } O_2} = 0.656\ \text{mol } O_2$$

$$\frac{35.0\ \text{g He}}{} \Big| \frac{1\ \text{mol He}}{4.003\ \text{g He}} = 8.743\ \text{mol He}$$

$$\frac{44.0\ \text{g } N_2}{} \Big| \frac{1\ \text{mol } N_2}{28.014\ \text{g } N_2} = 1.570\ \text{mol } N_2$$

Total = 10.969 mol gas

$$\frac{P_{O_2}}{P_{gas}} = \frac{\text{mol } O_2}{\text{mol gas}} \Rightarrow \frac{P_{O_2}}{4000.\text{psi}} = \frac{0.656\ \text{mol } O_2}{10.969\ \text{mol gas}} \Rightarrow P_{O_2} = 239.2\ \text{psi} \Rightarrow \boxed{P_{O_2} = 239\ \text{psi}}$$

$$\frac{P_{He}}{P_{gas}} = \frac{\text{mol He}}{\text{mol gas}} \Rightarrow \frac{P_{He}}{4000.\text{psi}} = \frac{8.743\ \text{mol He}}{10.969\ \text{mol gas}} \Rightarrow P_{He} = 3188\ \text{psi} \Rightarrow \boxed{P_{He} = 3190\ \text{psi}}$$

$$\frac{P_{N_2}}{P_{gas}} = \frac{\text{mol } N_2}{\text{mol gas}} \Rightarrow \frac{P_{N_2}}{4000.\text{psi}} = \frac{1.570\ \text{mol } N_2}{10.969\ \text{mol gas}} \Rightarrow P_{N_2} = 572.52\ \text{psi} \Rightarrow \boxed{P_{N_2} = 573\ \text{psi}}$$

Answers: 1) 0.920 atm 2) 130.2 kPa 3) 2.00 atm H_2, 2.00 atm He 4) 0.583 atm 5) 0.500 mol He 6a) 10. mol He, 2.0 mol N_2, 1.0 mol Ar 6b) 7.7 atm 7) 239 psi O_2, 3188 psi He, 573 psi N_2