Dalton's Law of Partial Pressures

1. What does Dalton's law of partial pressures state?

For a mixture of gases in a container, the total pressure exerted is the sum of the pressures that each gas would exert if it were alone.

$$P_{total} = \underbrace{P_a + P_b + P_c + \ldots}_{\text{partial pressures for each gas } a,\, b,\, c,\, \ldots}$$

2. What is a mole fraction?

$$\chi_a = \frac{\text{moles of a}}{\text{total moles}} = \frac{\text{partial pressure of a}}{\text{total pressure}}$$

Which in turn yields the important equation

$$P_a = \chi_a\,(P_{total})$$

3. If 1.83 g of hydrogen gas and 2.42 g of helium exerts a total pressure of 0.480 atm, what is the partial pressure of each gas?

In this question there is a mixture of gases exerting a "total pressure"…. This phrase alerts you to the fact that you are dealing with a Dalton's Law question. Sometimes it is less obvious that you are dealing with a mixture… so pay careful attention to the wording.

$$P_a = \chi_a\,(P_{total})$$

Another important point in this question is that hydrogen is a diatomic element (H_2). Make sure you have the diatomic gases committed to memory at this point.

$$1.83g\ H_2 \ \frac{1\ mol}{2.02\ g} = 0.906\ mol\ H_2$$

$$2.42g\ He \ \frac{1\ mol}{4.003\ g} = 0.605\ mol\ He$$

$$P_{H_2} = \frac{0.906\ mol}{(0.906\ mol + 0.605\ mol)}(0.480\ atm) = \boxed{0.288\ atm}$$

$$P_{He} = \frac{0.605\ mol}{(0.906\ mol + 0.605\ mol)}(0.480\ atm) = \boxed{0.192\ atm}$$

One quick and easy way to check you answer is make sure that the sum of the partial pressure is equivalent to the total pressure given in the question.

4. A sample of $N_{2\ (g)}$ was collected over water at 20.0°C and a total pressure of 1.04 atm. A total volume of 3.25 x 10^2 mL was collected. What mass of $N_{2\ (g)}$ was collected? (at 20.0°C the vapor pressure of water is 17.5 torr)

$$T = 293\ K$$
$$P_{TOTAL} = 1.04\ atm$$
$$V = 0.325\ L$$

Once again looking at the data clarifies what steps need to be taken to solve the problem. What piece is missing in the above information? Right, the moles. So what do we do? Plug everything into PV=nRT? Not quite yet.

Why? The question gives us two hints. First, the $N_{2\ (g)}$ sample is collected over water, which means there is some water vapor mixed in with the nitrogen sample due to evaporation. Additionally, the question uses the previously mentioned, caution inducing phrase – "total pressure".

That means we have to determine the pressure exerted by N_2 only. How do we do that? Subtracting the partial pressure of the water from the total pressure – this is information that will usually be provided with the question.

$$P_{N_2} = P_{TOTAL} - P_{H_2O} = 1.04\ atm - 0.023\ atm = 1.02\ atm$$

Now we can solve for moles of N_2

$$n_{N_2} = \frac{(1.02\ atm)\ (0.325\ L)}{\left(0.08206\ \frac{L\ atm}{mol\ K}\right)(293\ K)} = 0.0138\ mol\ N_2$$

$$0.0138\ mol\ N_2 \quad \frac{28.02g\ N_2}{1\ mol\ N_2} = \boxed{0.386g\ N_2}$$