Answer on the question #60311, Chemistry / General Chemistry

Question:

At 55 degree Celsius and 1 atmosphere N2O2 is 50.3% dissociated to NO2.Calculate the density and the average molecular weight of the gas

Solution:

Let's write the equation of reaction:

$$N_2O_2 \leftrightarrow 2NO$$

Density of the system is:

$$d = \frac{m(N_2O_2) + m(NO)}{V(N_2O_2) + V(NO_2)}.$$

Let's look at each term of this equation. All them can be expressed as a function of number of the moles: mass with a molar mass coefficient and volume through the ideal gas equation:

$$m(N_2O_2) = n(N_2O_2) \cdot M(N_2O_2)$$
$$m(NO) = n(NO) \cdot M(NO)$$
$$V(N_2O_2) = \frac{n(N_2O_2) \cdot RT}{p}$$
$$V(NO) = \frac{n(NO) \cdot RT}{p}.$$

If 50.03% of N_2O_2 is dissociated and if the initial number of the moles of N_2O_2 was N, then the equilibrium moles of substances are:

$$0.497N = n(N_2O_2)$$
$$2 \cdot 0.503N = n(NO).$$

Let's include now all that we have into the equation for density:

$$d = \frac{n(N_2O_2) \cdot M(N_2O_2) + n(NO) \cdot M(NO)}{\frac{n(N_2O_2) \cdot RT}{p} + \frac{n(NO) \cdot RT}{p}} = \frac{Np}{NRT} \cdot \frac{0.497M(N_2O_2) + 2 \cdot 0.503M(NO)}{0.497 + 2 \cdot 0.503}$$

$$d = \frac{101325 \text{ Pa}}{(8.314\text{J mol}^{-1}\text{K}^{-1}) \cdot (273.15 + 55 \text{ K})} \cdot \frac{0.497 \cdot 60.0122\text{g} + 2 \cdot 0.503 \cdot 30.00610\text{g}}{0.497 + 2 \cdot 0.503}$$

$$d = 1483 \text{ g m}^{-3}.$$

To calculate the average molar mass, we need molar percentages of gases.

$$x(N_2O_2) = \frac{0.497}{1.503} = 33\%, \qquad x(NO) = 67\%$$

Average molecular weight of gas is:

$$M = M(N_2O_2) \cdot x(N_2O_2) + M(NO) \cdot x(NO)$$
$$M = 60.0122 \cdot 0.33 + 30.00610 \cdot 0.67 = 39.91 \text{ g mol}^{-1}.$$

Answer: 1483 g m^{-3}; 39.91 g mol^{-1}