Hint: Atomic weight: H 1.0076, C 12.01, N 14.01, O 16.00, Ar 39.95
Unit conversion: 1 L = 1 × 10^{-3} m^3, 1 kPa = 1 × 10^3 N m^{-2}, 1 V A s = 1 J
Constants: gas constant \( R = 8.31451 \text{ J K}^{-1} \text{ mol}^{-1} \)

(Concept of moles)
1. What amount (that is, how many moles) of H\(_2\)O molecules is present in 1.00 L of water? (5 pts) Assume that the density of water is 1.00 g/cm\(^3\).

\[ \text{Molecular weight of H}\_2\text{O} = 18.0152 \text{ g/mol} \]
\[ \text{mass of 1.00 L of H}\_2\text{O} = 1.00 \times 10^{-3} \text{ m}^3 \times 1.00 \times 10^6 \text{ g/m}^3 = 1.00 \times 10^3 \text{ g} \]
\[ \therefore n = \frac{m}{M} = \frac{1.00 \times 10^3 \text{ g}}{18.0152 \text{ g/mol}} = 55.5 \text{ mol} \]

2. Calculate the mole fractions of N\(_2\), O\(_2\), and Ar in dry air at sea level, given that 100.0 g of air consists of 75.5 g of N\(_2\), 23.2 g of O\(_2\), and 1.3 g of Ar. (5 pts)

\[ \text{Molecular weight of N}\_2 = 28.02 \text{ g/mol} \]
\[ n(\text{N}_2) = \frac{75.5 \text{ g}}{28.02 \text{ g/mol}} = 2.69 \text{ mol} \]
\[ \therefore \chi_{\text{N}\_2} = \frac{2.69}{2.70} = 0.981 \]

\[ \text{Molecular weight of O}\_2 = 32.00 \text{ g/mol} \]
\[ n(\text{O}_2) = \frac{23.2 \text{ g}}{32.00 \text{ g/mol}} = 0.725 \text{ mol} \]
\[ \therefore \chi_{\text{O}\_2} = \frac{0.725}{2.70} = 0.271 \]

\[ \text{Molecular weight of Ar} = 39.95 \text{ g/mol} \]
\[ n(\text{Ar}) = \frac{1.3 \text{ g}}{39.95 \text{ g/mol}} = 0.033 \text{ mol} \]
\[ \therefore \chi_{\text{Ar}} = \frac{0.033}{2.70} = 0.012 \]

(total = 3.46 mol)

(Perfect and real gases)
3. (a) What is the "ideal (or perfect)" gas? (5 pts)

"Ideal (or perfect) gas law" \( PV = nRT \) 만족하는 가스.

전체 자유도의 개수와 실제 자유도의 개수 간의 차이가 등준 (Potential energy = 0)

Internal energy도 Kinetic energy로만 되는 가스는 이상 가스라고 한다.

(b) In which condition real gases behave ideally (perfectly)? (5 pts)

\( P \rightarrow \infty \)
\( T \rightarrow 0 \)

\( 101.325 \text{ kPa} \)

4. Water vapor is at the pressure of \( P = 3\text{ kPa} \) and the temperature of \( T = 25^\circ \text{C} \).

(a) If this vapor behaved ideally, what would be its molar volume? (5 pts)

\[ V_m = \frac{RT}{P} = \frac{8.315 \text{ J K}^{-1} \text{ mol}^{-1} \times 298.15 \text{ K}}{3 \times 10^3 \text{ N m}^{-2}} = 5.0245 \text{ m}^3/\text{mol} = 24.5 \text{ L/mol} \]

(b) However, when the molar volume was actually measured at this condition, it was 18 L/mol, which was different from our expectation in (a). Based on the results, find which interaction, repulsions or attractions, are dominant in the intermolecular interactions between water molecules at this condition. (5 pts)

\( V_m (= 18 \text{ L/mol}) < V_m \text{ ideal} (= 24.5 \text{ L/mol}) \)

Attractions dominant