Summary:

Mass of Mixture:
The mass of a mixture m_m is the sum of the masses of the individual components.

$$m_m = \sum_{i=1}^{k} m_i$$

Mole Number of a Mixture:
The mole number of a mixture N_m is the sum of the mole numbers of the individual components.

$$N_m = \sum_{i=1}^{k} N_i$$

Mass and Mole Fraction:
The mass fraction mf_i is the ratio of the mass of a component to the mass of the mixture. The mole fraction y_i is the ratio of the mole number of a component to the mole number of the mixture.

$$mf_i = \frac{m_i}{m_m} \quad \text{and} \quad y_i = \frac{N_i}{N_m}$$

For a mixture, the sum of the mass fractions and mole fractions is equal to 1.

$$\sum_{i=1}^{k} mf_i = 1 \quad \text{and} \quad \sum_{i=1}^{k} y_i = 1$$

Apparent (average) Molar Mass of Gas Mixture:

$$M_m = \frac{m_m}{N_m} = \frac{\sum m_i}{N_m} = \frac{\sum N_i M_i}{N_m} = \sum_{i=1}^{k=1} y_i M_i$$

Apparent (average) Gas Constant of Gas Mixture:

$$R_m = \frac{R_u}{M_m}$$

Partial Pressure:
For an *ideal-gas* mixture, the partial pressure P_i of a component in the mixture can be expressed as

$$P_i = y_i P_m$$

Extensive Properties:
The extensive properties of a nonreacting ideal or real-gas mixture are obtained by adding the contributions of each component of the mixture. Let X=(U,H,S) and □X=(□U, □H, □S)

$$X_m = \sum_{i=1}^{k} X_i = \sum_{i=1}^{k} m_i x_i = \sum_{i=1}^{k} N_i \bar{x}_i$$

The change in internal energy, enthalpy, and entropy of a gas mixture can be expressed similarly as

$$\Delta X_m = \sum_{i=1}^{k} \Delta X_i = \sum_{i=1}^{k} m_i \Delta x_i = \sum_{i=1}^{k} N_i \Delta \bar{x}_i$$

P-v-T Behavior of Gas Mixtures:

Dalton's Law of Additive Pressures

The pressure of a gas mixture, P_m, is equal to the sum of the pressures each component gas (P_i) would exert if it existed ALONE at the MIXTURE temperature (T_m) and volume (V_m)

$$P_m = \sum_{i=1}^{k} P_i(T_m, V_m)$$

Amagat's Law of Additive Volumes

The volume of a gas mixture, V_m, is equal to the sum of the volumes each component gas (V_i) would exert if it existed ALONE at the MIXTURE temperature (T_m) and volume (P_m)

$$V_m = \sum_{i=1}^{k} V_i(T_m, P_m)$$

Question:

An insulated tank that contains 1kg of O_2 at 15^oC and 300kPa is connected to a 2m^3 un-insulated tank that contains N_2 at 50^oC and 500kPa. The valve connecting the two tanks is opened, and the two gases form a homogeneous mixture at 25^oC. Assume the surroundings to be at 25^oC.

a) the final pressure in the tank,
b) the heat transfer,
c) the entropy generated during this process, and
d) the exergy destruction associated with this process.