## Example

Combustion air is mixed with methane gas before it is ignited. The following *mole* analysis of the entering gas is known.

$CH_4$ - 8 %
$O_2$ - 16%
$N_2$ - 76%

(a) Determine the mass analysis of the gas mixture (mass fractions).
(b) Determine the mass flow rate of the gas mixture if the *molar* flow rate is 2000 kmol/min.
(c) Determine the apparent molar mass and the apparent ideal gas constant for the gas.
(d) If the temperature and the pressure of the mix are 25°C and 100 kPa, respectively, find the **partial pressure** of each component.
(e) Redo (a) through (d) if the analysis given were a *mass* analysis.

(a) Assume you have 1 kmol of mixture.

| i | $n_i$ | $M_i$ | $m_i = n_i M_i$ | $mf_i = m_i / m_{MIX}$ |
|---|---|---|---|---|
| $CH_4$ | 0.08 | 16.04 | 1.28 | 0.046 |
| $O_2$ | 0.16 | 32.00 | 5.12 | 0.185 |
| $N_2$ | 0.76 | 28.01 | 21.29 | 0.769 |
| | | Σ | 27.69 ($m_{MIX}$) | = ? = 1 ✓ |

(b) $M_{MIX} = \dfrac{m_{MIX}}{n_{MIX}} = \dfrac{27.69 \text{ kg}}{1 \text{ kmol}} = 27.69 \text{ kg/kmol}$

$\dot{m}_{MIX} = \dot{N} M_{MIX} = 2000 \dfrac{\text{kmol}}{\text{min}} \cdot 27.69 \dfrac{\text{kg}}{\text{kmol}} = \boxed{55,381 \dfrac{\text{kg}}{\text{min}}}$

(c) $M_{MIX} = 27.69 \dfrac{\text{kg}}{\text{k·mol}}$ $\quad R_{MIX} = \dfrac{\bar{R}}{M_{MIX}} = \dfrac{8.314 \text{ kJ/k·mol·K}}{27.69 \text{ kg/k·mol}}$

$= \boxed{0.300 \text{ kJ/kg·K}}$

(d) $P_{CH_4} = y_{CH_4} P_{MIX} = (0.08)(100 \text{ kPa}) = 8 \text{ kPa}$

$P_{O_2} = \ldots = 16 \text{ kPa}$

$P_{N_2} = \ldots = 76 \text{ kPa}$

ASSUME 1 kg of MIXTURE

| | $m_i$ [kg] | $M_i$ [kg/mol] | $n_i = m_i/M_i$ | $y_i = n_i/n_{MIX}$ |
|---|---|---|---|---|
| $CH_4$ | 0.08 | 16.04 | 0.00499 | 0.1344 |
| $O_2$ | 0.16 | 32.00 | 0.00500 | 0.1347 |
| $N_2$ | 0.76 | 28.01 | 0.0271 | 0.7301 |
| | | | $n_{MIX} = \Sigma = 0.03712$ | 1 |

(e,b) $M_{MIX} = \frac{m_{MIX}}{n_{MIX}} = \frac{1\text{ kg}}{0.03712\text{ k·mol}} = \boxed{26.94 \frac{\text{kg}}{\text{kmol}}}$

(e,c)

$\dot{m} = \dot{n} M_{MIX} = \ldots = 53,832$ kg/min

(e,d) $P_{CH_4} = y_{CH_4} P_{MIX} = (0.1344)(100\text{ kPa}) = 13.44$ kPa

$P_{O_2} = \ldots = 13.5$ kPa

$P_{N_2} = \ldots = 73.$ kPa