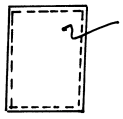
PROBLEM 12.2*

KNOWN: The molar analysis of a gas mixture is specified.

FIND: Determine the analysis in terms of mass fractions, the partial pressure of each component, and the volume occupied by 10 kg of mixture.

SCHEMATIC & GIVEN DATA:



30°C, 2 bar
10 kg

i	y_i
N_2	0.4
CO_2	0.5
CH_4	0.1

ASSUMPTIONS: (1) The overall mixture acts as an ideal gas. (2) Each mixture component behaves as if it were an ideal gas occupying the entire volume at the mixture temperature. (3) Calculations are based on 1 kmol of mixture in part (a).

ANALYSIS (a) Considering a typical 1 kmol of mixture

i	n_i	M_i	$m_i = n_i M_i$	mf_i
N_2	0.4	28.01	11.204	0.3218
CO_2	0.5	44.01	22.005	0.6321
CH_4	0.1	16.04	1.604	0.0461
			34.813 kg/kmol	1.0000

(1) ← (a)

(b) With Eq. 12.12

$$P_{N_2} = y_{N_2} P = (0.4)(2\,\text{bar}) = 0.8\,\text{bar}$$
$$P_{CO_2} = y_{CO_2} P = (0.5)(2\,\text{bar}) = 1.0\,\text{bar}$$
$$P_{CH_4} = y_{CH_4} P = (0.1)(2\,\text{bar}) = 0.2\,\text{bar}$$

← (b)

(c) With the ideal gas equation of state applied to the overall mixture.

$$V = \frac{m(\bar{R}/M)T}{P}$$
$$= \frac{(10\,\text{kg})\left(\frac{8314}{34.813}\ \frac{\text{N·m}}{\text{kg·K}}\right)(303\,\text{K})}{2\times 10^5\,\text{N/m}^2} = 3.618\ \text{m}^3$$

← (c)

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1. The apparent molecular weight of the mixture is obtained in the calculations of part (a). Equivalently, Eq. 12.9 can be used: $M = \sum y_i M_i$

$$M = y_{N_2} M_{N_2} + y_{CO_2} M_{CO_2} + y_{CH_4} M_{CH_4}$$
$$= (0.4)(28.01) + (0.5)(44.01) + (0.1)(16.04) = 34.813\ \frac{\text{kg}}{\text{kmol}}$$