(Fall 2001Midterm)

An ideal gas mixture was put together by mixing the contents of three vessels, each containing a single component ideal gas at the specified temperature and pressure listed below.

Vessel number	Component in the vessel	Molar Mass, (kg/kmol)	Volume of the vessel, (m^3)	Temperature, (°C)	Pressure, (kPa)
1	CH_4	16	0.85	0	800
2	CO_2	44	0.30	25	400
3	N_2	28	0.35	35	600

The mixed gas was transferred to a fourth container whose volume was known to be 1.0 m^3. The mixture was then heated to a temperature of 400 K. Calculate the following for this mixture:

a. Number of moles of each component in the mixture.(4.5 points)

b. Mass of each component in the mixture.(4.5 points)

c. Mass fraction of CO_2 in the mixture.(2 points)

d. Mole fraction of CH_4 in the mixture. (2 points)

e. Pressure of the mixture after heating to 400 K. (4 points)

f. Partial pressure of CH_4 after heating to 400 K (3 points)

CHAPTER 5
FOIMT - SOLUTIONS

a) $$n_{CH_4} = \frac{PV}{RT} = \frac{(800\,kPa)(0.85\,m^3)}{\left(8.314\,\frac{kPa\,m^3}{kmol\,K}\right)(273.15K)} = 0.299\,kmol = \boxed{299\,mol}$$

$$n_{CO_2} = \frac{PV}{RT} = \frac{(400\,kPa)(0.30\,m^3)}{\left(8.314\,\frac{kPa\,m^3}{kmol\,K}\right)(298.15k)} = 0.0484\,kmol = \boxed{48.4\,mol}$$

$$n_{N_2} = \frac{PV}{RT} = \frac{(600\,kPa)(0.35\,m^3)}{\left(8.314\,\frac{kPa\,m^3}{kmol\,k}\right)(308.15k)} = 0.08197\,kmol = \boxed{81.97\,mol}$$

b) $$m_{CH_4} = 299\,mol \times 16\,g/mol = \boxed{4784\,g}$$

$$m_{CO_2} = 48.4\,mol \times 44\,g/mol = \boxed{2130\,g}$$

$$m_{N_2} = 81.97\,mol \times 28\,g/mol = \boxed{2295\,g}$$

c) $$\omega_{CO_2} = \frac{m_{CO_2}}{m_{tot}} = \frac{2130g}{4784g + 2130g + 2295g}$$

$$= \boxed{0.231}$$

d) $$y_{CH_4} = \frac{n_{CH_4}}{n_{tot}} = \frac{299\,mol}{299\,mol + 48.4\,mol + 81.97\,mol}$$

$$= \boxed{0.696}$$

e) $$P_{mix} = \frac{n_{tot} R T}{V}$$

$$= \frac{(429\,mol)\left(8.314\,\frac{kPa\,m^3}{kmol\,K}\right)(400K)\left(\frac{1kmol}{1000mol}\right)}{(1m^3)}$$

$$= \boxed{1427\ kPa}$$

f) $$\bar{P}_{CH_4} = y_{CH_4} \times P_{tot}$$

$$\bar{P}_{CH_4} = (0.696)(1427\,kPa)$$

$$= \boxed{993\ kPa}$$