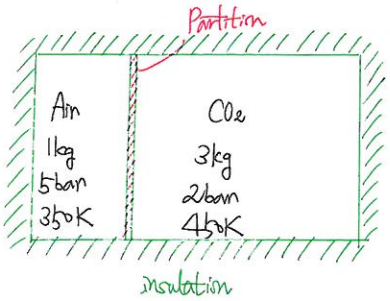
Problem> 3.96



* Determine the final temperature and pressure.

1.

온도를 찾기 위해서!

< Energy Balance >

$$\Delta KE + \Delta PE + \Delta U = Q - W$$

$$\Delta U = m_{air}\Delta u_{air} + m_{CO_2}\Delta u_{CO_2}$$

$$= m_{air} \cdot C_{v,air}(T_2 - T_{1,air}) + m_{CO_2} \cdot C_{v,CO_2}(T_2 - T_{1,CO_2}) \quad \leftarrow du = C_v dT$$

$$= 0$$

$$\therefore T_2 = \frac{m_{air} \cdot C_{v,air} \cdot T_{1,air} + m_{CO_2} \cdot C_{v,CO_2} \cdot T_{1,CO_2}}{m_{air} \cdot C_{v,air} + m_{CO_2} \cdot C_{v,CO_2}} = \frac{(1kg) \cdot 0.726\,kJ/kg\cdot K \cdot (350K) + (3) \cdot (0.750) \cdot (450)}{(1kg) \cdot (0.726\,kJ/kg\cdot K) + (3) \cdot (0.750)}$$

$$= 425.6\,K \quad \text{Ans}$$

★★ 이상기체 사용 가정은 T_2 미지라서 C_v의 값이 350K~450K로 아주 넓은 범위의 온도가 아니므로 만족한다!

• Ideal Gas Specific Heats of Some Common Gases.

< Air: $C_v = 0.726$ ← 400K
CO2: $C_v = 0.750$ ← 400K

350K와 400K의 평균값인 400K를 사용 ★★★

2.

압력을 찾기 위해서!

$PV = n\overline{R}T$

$\forall$ 따로 구하자.

$R_{air} = \frac{\overline{R}\ (\text{공통기체상수})}{M\ (\text{분자량})}$, $\overline{R} = 8.314\,kJ/kmol\cdot K$, $M_{air} = 28.97$ (분자량)

$$V_{1,air} = \frac{m_{air} \cdot R_{air} T_{1,air}}{P_{1,air}} = \frac{(1kg) \cdot \left(\frac{8.314}{28.97}\frac{kJ}{kg\cdot K}\right) \cdot (350K)}{(5\,bar)} \cdot \left|\frac{1\,bar}{10^5\,N/m^2}\right| \cdot \left|\frac{10^3\,N\cdot m}{1kJ}\right| = 0.201\,m^3$$

$$V_{1,CO_2} = \frac{m_{CO_2} \cdot R_{CO_2} \cdot T_{1,CO_2}}{P_{1,CO_2}} = \frac{(3) \cdot \left(\frac{8.314}{44.01}\right) \cdot (450)}{(2)} \left|\frac{10^3}{10^5}\right| = 1.275\,m^3$$

$$\therefore \forall_{total} = 0.201 + 1.275 = 1.476\,m^3$$

$$\therefore P_2 = \frac{n_{tot}\overline{R}T_2}{\forall_{tot}} = \frac{(n_{air} + n_{CO_2})\overline{R}T_2}{\forall_{tot}} \quad \leftarrow n = \frac{m}{M}\ \begin{matrix}(\text{질량})\\(\text{분자량})\end{matrix}$$

$$= \frac{\left[(m_{air}/M_{air}) + (m_{CO_2}/M_{CO_2})\right] \cdot \overline{R} \cdot T_2}{\forall_{tot}}$$

$$= \frac{\left[\left(\frac{1kg}{28.97\,kg/kmol}\right) + \left(\frac{3}{44.01}\right)\right] \cdot \left(8.314\frac{kJ}{kmol\cdot K}\right)(425.6K)}{(1.476m^3)} \left|\frac{10^3\,N\cdot m}{1kJ}\right| \left|\frac{1\,bar}{10^5\,N/m^2}\right|$$

$$= 2.462\,bar \quad \text{Ans.}$$