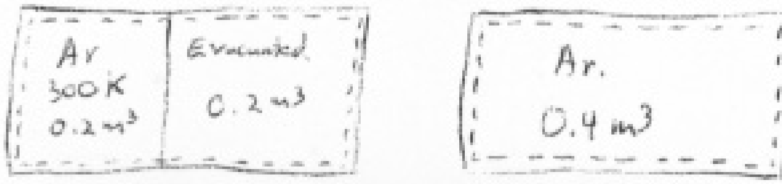
11.46 1 kmol Ar.



1. 2.

Assume the system is adiabatic and no work is done.

First Law: $Q = \Delta U + W$, since $W = Q = 0 \Rightarrow \Delta U = 0$.

Eq. 11.44: $\Delta u = \int_1^2 c_v\,dT + \int_1^2 \left[T\left(\frac{\partial p}{\partial T}\right) - p\right] dv = 0$

Van der Waals: $p = \frac{RT}{v-b} - \frac{a}{v^2}$

$\left[T\left(\frac{\partial p}{\partial T}\right) - p\right] = T\left(\frac{R}{v-b}\right) - p = \frac{RT}{v-b} - \left[\frac{RT}{v-b} - \frac{a}{v^2}\right] = \frac{a}{v^2}$

Since Ar is a monatomic gas, $c_v = \frac{3}{2}R$

$\Rightarrow 0 = \int_1^2 \frac{3}{2}R\,dT + \int_1^2 \frac{a}{v^2}\,dv$

$\frac{3}{2}R(T_2 - T_1) - a\left[\frac{1}{v_2} - \frac{1}{v_1}\right] = 0$

$\Rightarrow T_2 = T_1 + \frac{2a}{3R}\left[\frac{1}{v_2} - \frac{1}{v_1}\right]$

$a = \frac{27}{64}\frac{R^2 T_c^2}{p_c}$, $T_c = 151\,k$, $p_c = 48.6$ bar (A-1)

$\Rightarrow \boxed{T_2 = 272.6\,k}$

For an ideal gas, u is a function of T only, so $\boxed{T_2 = 300\,k}$, since $\Delta u = 0$.

(11.47) $p(v-b) = RT$

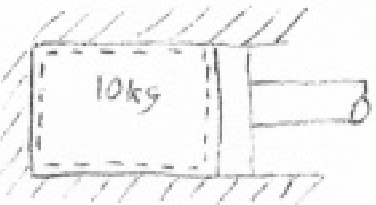
Eq. 11.68: $c_p - c_v = -T\left(\frac{\partial v}{\partial T}\right)_p^2 \left(\frac{\partial p}{\partial v}\right)_T$

$\left(\frac{\partial v}{\partial T}\right)_p = \frac{R}{p} \qquad \left(\frac{\partial p}{\partial v}\right)_T = -\frac{RT}{(v-b)^2} = \frac{-p^2}{RT}$

$\Rightarrow c_p - c_v = -T\left[\frac{R}{p}\right]^2\left(\frac{-p^2}{RT}\right)$

$$\boxed{c_p - c_v = R}$$

(12.12)



$(mf)_{N_2} = 0.5$

$(mf)_{CO_2} = 0.3$

$(mf)_{O_2} = 0.2$

$p_1 = 1\,\text{bar},\ T_1 = 280\,K \qquad p_2 = 5\,\text{bar},\ T_2 = 450\,K$

Assume the system is adiabatic and the mixture behaves like an ideal gas.

First Law: $Q = \Delta U + W = 0 \Rightarrow \Delta U = -W$

$$\Rightarrow -\frac{W}{m} = (mf)_{N_2}\Delta u_{N_2} + (mf)_{CO_2}\Delta u_{CO_2} + (mf)_{O_2}\Delta u_{CO_2}$$

from the ideal gas tables:

$$-\frac{W}{m} = (0.5)\left(\frac{9,363-5813}{28}\right) + 0.3\left(\frac{11,742-6,369}{44}\right) + 0.2\left(\frac{9,487-5,822}{32}\right)$$

$$\Rightarrow \boxed{W = -1,229\,kJ}$$

Entropy balance: $\Delta S = \cancel{\int_1^2 \left(\frac{\delta Q}{T}\right)_b} + \sigma \Rightarrow \sigma = \Delta S$

$$\sigma = \Delta S = (\Delta S)_{N_2} + (\Delta S)_{CO_2} + (\Delta S)_{O_2}$$

$$\Rightarrow \frac{\sigma}{m} = 0.5\left[\frac{203.523 - 189.873 - 8.314\ln 5}{28}\right] + \frac{0.3}{44}(230,194 - 211,376 - 8.314\ln 5)$$

$$+ \frac{0.2}{32}(217,342 - 203,141 - 8,314\ln 5)$$

$$\Rightarrow \boxed{\sigma = 0.5024\ kJ/K}$$