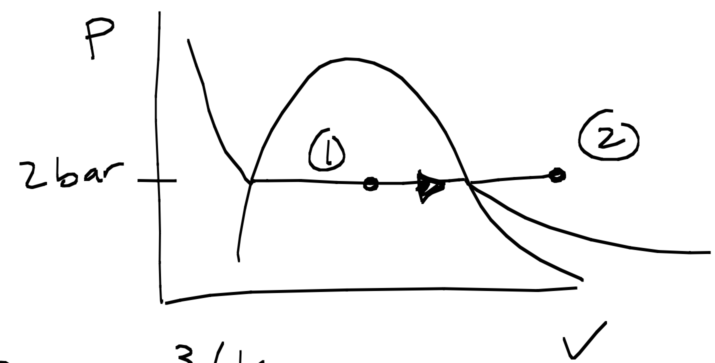
Problem 2

Given: - 2 Kg of Refrigerant 134a in a closed system

- $P_1 = 2$ bar , $V_1 = 0.12 m^3$
- $V_2 = 0.24 m^3$ while pressure is constant
- $\Delta KE = \Delta PE = 0$

Determine: Work and Heat Transfer



$$v_1 = \frac{V_1}{m} = \frac{0.12 m^3}{2 Kg}$$

$$v_1 = 0.06 m^3/Kg$$

$$v_2 = \frac{V_2}{m} = \frac{0.24 m^3}{2 Kg} = 0.12 m^3/Kg$$

Table A-11, @ p = 2 bar $v_f = 0.7532 \times 10^{-3} m^3/kg$

$v_g = 0.0993 m^3/kg$

$v_f < v_1 < v_g$ => ① => Two-phase liquid-vapor mixture

$v_2 > v_g$ => ② => Superheated vapor

$$W = \int_{V_1}^{V_2} p\,dV = p(V_2 - V_1) = \left(2\,\text{bar}\left(\frac{10^2\,\text{kPa}}{1\,\text{bar}}\right)\right)(0.24\,m^3 - 0.12\,m^3)$$

$$\boxed{W = 24\,kJ}$$

$$\cancel{\Delta KE}^{\,0} + \cancel{\Delta PE}^{\,0} + \Delta U = Q - W$$

$$U_2 - U_1 = Q - W$$

$$X_1 = \frac{v_1 - v_{f1}}{v_{g1} - v_{f1}} = \frac{0.06 - 0.7532\times10^{-3}}{0.0993 - 0.7532\times10^{-3}} = \underline{0.6012}$$

Table A-11 @ $p = 2\,\text{bar} \Rightarrow u_{f1} = 36.69\,kJ/kg,\ u_{g1} = 221.43\,kJ/kg$

$$u_1 = u_{f1} + x_1(u_{g1} - u_{f1})$$

$$= 36.69 + 0.6012(221.43 - 36.69)$$

$$\boxed{u_1 = 147.76\,kJ/kg}$$

Table A-12

$p = 2$ bar, $v_2 = 0.12 m^3$

@ $v = 0.11856 m^3/kg$, $u = 253.06$ kJ/kg

@ $v = 0.12311 m^3/kg$, $u = 261.26$ kJ/kg

Interpolating w/ $v_2 = 0.12 m^3 \Rightarrow u_2 = 255.66$ kJ/kg

$$(255.66 \text{ kJ/kg} - 147.76 \text{ kJ/kg})(2 \text{ kg}) = Q - 24 \text{ kJ}$$

$$\boxed{Q = 239.8 \text{ kJ}}$$