

Problem 2

Given: Process 1-2: $V_{\text{constant}} = 0.028 \text{ m}^3$, $\Delta U_{12} = 26.4 \text{ kJ}$

Process 2-3: $U_3 = U_2$, $W_{23} = 18.78 \text{ kJ}$

Process 3-1: $P_{\text{constant}} = 1.4 \text{ bar}$, $V_3 = 0.103 \text{ m}^3$

$\Delta KE = \Delta PE = 0$ for all processes

Determine: - Sketch the cycle on a P-V diagram

- Net work for the cycle

- Q_{23}

- Q_{31}

- Is the cycle a power or refrigeration cycle

Process 1-2

$$\Delta E = Q - W$$

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

$$\Delta \bar{u}_{1-2} = Q_{12} - W_{12}$$

$$\bar{u}_2 - \bar{u}_1 = Q_{12} - W_{12}$$

$$26.4 \text{ kJ} = Q_{12} - W_{12}$$

$\rightarrow 0$ $V = \text{constant}$

$$Q_{12} = 26.4 \text{ kJ}$$

Process 2-3

$$\cancel{\bar{u}_3 - \bar{u}_2} = Q_{23} - W_{23}$$

$$0 = Q_{23} - 18.78 \text{ kJ}$$

$$Q_{23} = 18.78 \text{ kJ}$$

Process 3-1

$$\bar{u}_1 - \bar{u}_3 = Q_{31} - W_{31}$$

$$W_{31} = P(V_1 - V_3) \quad (P \text{ is constant})$$
$$= (1.4 \text{ bar}) \left(\frac{10^2 \text{ kPa}}{1 \text{ bar}} \right) (0.028 \text{ m}^3 - 0.103 \text{ m}^3)$$



$$\boxed{W_{31} = -10.5 \text{ kJ}}$$

For the cycle

$$\Delta E_{\text{cycle}} = 0$$

$$\cancel{\Delta PE} + \cancel{\Delta KE} + \Delta U_{\text{cycle}} = 0$$

$$\Delta U_{12} + \Delta U_{23} + \Delta U_{31} = 0$$

$$26.4 \text{ kJ} + 0 + \Delta U_{31} = 0$$

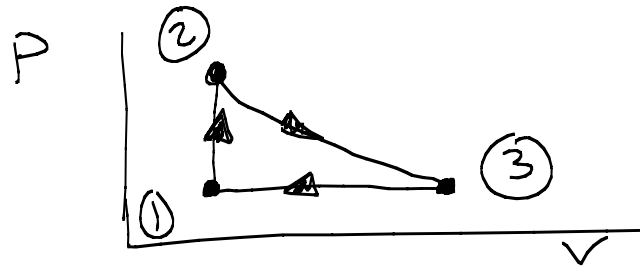
$$\boxed{\Delta U_{31} = -26.4 \text{ kJ}}$$

$$\Delta U_{31} = Q_{31} - W_{31}$$

$$-26.4 \text{ kJ} = Q_{31} - (-10.5 \text{ kJ})$$

$$\boxed{Q_{31} = -36.9 \text{ kJ}}$$

(a)



$$(b) \quad W_{\text{cycle}} = W_{12} + W_{23} + W_{31} \\ = 0 + 18.78 \text{ kJ} + (-10.5 \text{ kJ}) = \underline{8.28 \text{ kJ}}$$

$$(c) \quad Q_{23} = 18.78 \text{ kJ}$$

$$(d) \quad Q_{31} = -36.9 \text{ kJ}$$

$$Q_{\text{cycle}} = Q_{12} + Q_{23} + Q_{31} \\ = 26.4 \text{ kJ} + 18.78 \text{ kJ} + (-36.9 \text{ kJ}) \\ = 8.28 \text{ kJ} \checkmark$$

(e) $W_{\text{cycle}} > 0 \Rightarrow$ work is done by the system
 \Rightarrow Power cycle