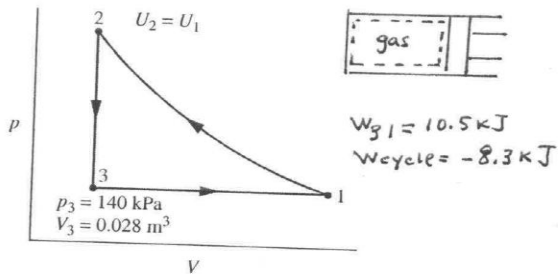


PROBLEM 2.80

KNOWN: A gas within a piston-cylinder assembly undergoes a thermodynamic cycle consisting of three processes in series.

FIND: Determine V_1 , W_{12} , and Q_{12} . Determine if the cycle can be power cycle or a refrigeration cycle.

SCHEMATIC & GIVEN DATA:



ENGR. MODEL:

1. The gas is the closed system.
2. Volume change is the only work mode.
3. For each process, $\Delta KE = \Delta PE = 0$

ANALYSIS:

(a) To find V_1 , note that

$$W_{31} = \int_3^1 p dV = p [V_1 - V_3] \Rightarrow V_1 = V_3 + \frac{W_{31}}{p}$$

\uparrow 140 kPa

or

$$V_1 = 0.028 \text{ m}^3 + \frac{10.5 \text{ kJ}}{140 \text{ kPa}} \left| \frac{10^3 \text{ N} \cdot \text{m}}{1 \text{ kJ}} \right| \left| \frac{1 \text{ kPa}}{10^3 \text{ N/m}^2} \right| = 0.103 \text{ m}^3 \quad \leftarrow V_1$$

(b) To find W_{12} , write $W_{\text{cycle}} = W_{12} + W_{23} + W_{31}$. Since the only work mode is volume change, the work is given by Eq. 2.17. Since the piston does not move in process 2-3 (volume is constant), $W_{23} = 0$. Thus

$$W_{12} = W_{\text{cycle}} - \cancel{W_{23}^0} - W_{31}$$

$$= -8.3 \text{ kJ} - 10.5 \text{ kJ} = -18.8 \text{ kJ} \quad \leftarrow W_{12}$$

A power cycle is one for which $W_{\text{cycle}} > 0$. Here, we have $W_{\text{cycle}} = -8.3 \text{ kJ}$. So, the cycle cannot be a power cycle, but \leftarrow cycle type it can be a refrigeration (or heat pump) cycle.

To find Q_{12} , write an energy balance: $\Delta U + \cancel{\Delta KE} + \cancel{\Delta PE} = Q_{12} - W_{12}$

$$\Rightarrow Q_{12} = \underbrace{\Delta U}_{U_2 = U_1} + W_{12}$$

$$\Rightarrow Q_{12} = -18.8 \text{ kJ} \quad \leftarrow Q_{12}$$