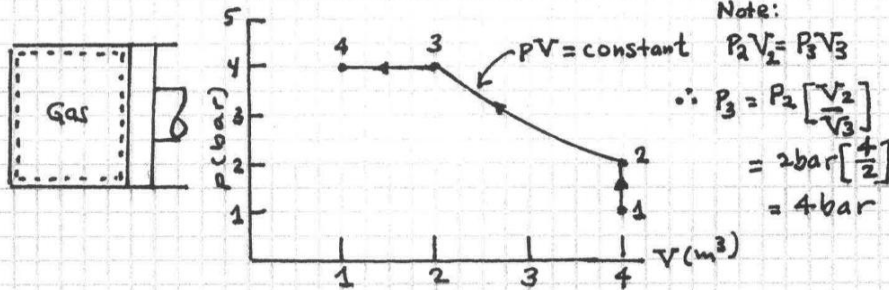


PROBLEM 2.33

KNOWN: A gas contained within a piston-cylinder assembly undergoes three processes in series. State data are provided.

FIND: Sketch the processes in series on p - V coordinates and evaluate the work for each process, in kJ.

SCHEMATIC & GIVEN DATA:



ENGINEERING MODEL:

1. The gas within the piston-cylinder is the closed system.
2. The gas experiences three processes in series, as shown in the sketch.

ANALYSIS: The work is given by Eq. 2.17: $W = \int p dV$

Process 1-2: V is constant. Thus, the piston does not move, and $W_{12} = 0$.

$$\begin{aligned} \text{Process 2-3: } W_{23} &= \int_2^3 \frac{C}{V} dV = C \ln \frac{V_3}{V_2} = P_2 V_2 \ln \frac{V_3}{V_2} \\ &= (2 \times 10^5 \frac{\text{N}}{\text{m}^2}) (4 \text{ m}^3) \left| \frac{1 \text{ kJ}}{10^3 \text{ N} \cdot \text{m}} \right| \ln \left[\frac{2}{4} \right] = -554.5 \text{ kJ} \end{aligned}$$

$$\begin{aligned} \text{Process 3-4: } W_{34} &= p [V_4 - V_3] \\ &= (4 \times 10^5 \frac{\text{N}}{\text{m}^2}) (1-2) \text{ m}^3 \left| \frac{1 \text{ kJ}}{10^3 \text{ N} \cdot \text{m}} \right| = -400 \text{ kJ} \end{aligned}$$

Note: Minus signs signify energy transfer by work to the gas.