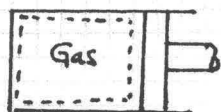


PROBLEM 2.57

KNOWN: A gas contained in a piston-cylinder assembly undergoes two processes, A and B, between the same end states. State data are provided.

FIND: For each process, sketch it on p - V coordinates and evaluate the work and heat transfer, each in kJ.

SCHEMATIC & GIVEN DATA:

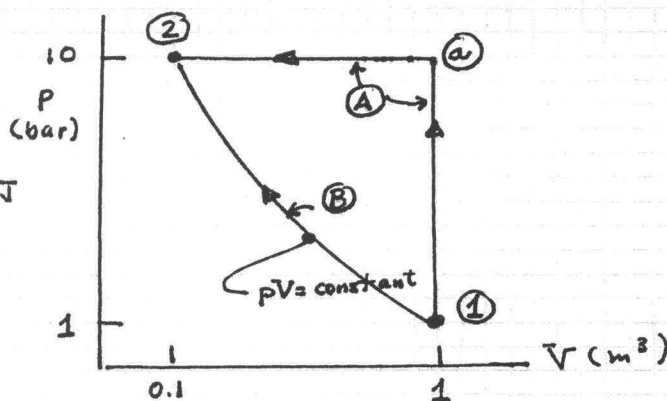


$$P_1 = 1 \text{ bar}, V_1 = 1 \text{ m}^3, U_1 = 400 \text{ kJ}$$

$$P_2 = 10 \text{ bar}, V_2 = 0.1 \text{ m}^3, U_2 = 450 \text{ kJ}$$

ENGINEERING MODEL:

1. The gas is the closed system.
2. Volume change is the only work mode.
3. Kinetic and potential energy effects are ignored.



ANALYSIS: Reducing an energy balance for the gas: $\Delta U + \Delta KE + \Delta PE = Q - W$

$$\Rightarrow Q = \Delta U + W = (450 - 400) \text{ kJ} + W$$

$$\Rightarrow Q = 50 \text{ kJ} + W \quad (1)$$

Eq. (1) applies to each of the processes, A and B.

Evaluating work from Eq. 2.17, $W = \int_1^2 p dV$.

Process A: $W_A = \cancel{W_{A1}} + W_{A2} = P_2 [V_2 - V_1]$

$$= (10 \times 10^5 \frac{\text{N}}{\text{m}^2}) (0.1 - 1) \text{ m}^3 \left| \frac{1 \text{ kJ}}{10^3 \text{ N} \cdot \text{m}} \right| = -900 \text{ kJ} \leftarrow$$

Then, with Eq. (1)

$$Q_A = 50 \text{ kJ} + (-900 \text{ kJ}) = -850 \text{ kJ} \leftarrow$$

Process B: $W_B = \int_1^2 p dV = \int_1^2 \frac{C}{V} dV = C \ln \frac{V_2}{V_1} = P_1 V_2 \ln \frac{V_2}{V_1}$

$$= (10^5 \frac{\text{N}}{\text{m}^2}) (1 \text{ m}^3) \ln \left[\frac{0.1}{1.0} \right] \left| \frac{1 \text{ kJ}}{10^3 \text{ N} \cdot \text{m}} \right| = -230.3 \text{ kJ} \leftarrow$$

Then, with Eq. (1)

$$Q_B = 50 \text{ kJ} + (-230.3 \text{ kJ}) = -180.3 \text{ kJ} \leftarrow$$