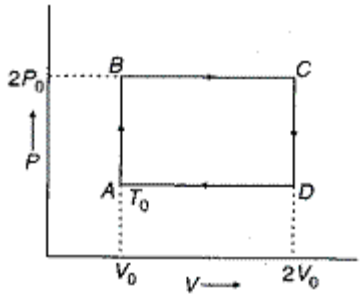
Answer on Question #40672, Physics, Molecular Physics

N MOLES OF A MONOATOMIC GAS IS CARRIED AROUND THE REVERSIBLE RECTANGULAR CYCLE ABCDA AS SHOWN IN THE DIAGRAM. THE TEMPERATURE AT A IS To . THE THERMODYNAMIC EFFICIENCY OF THE CYCLE IS : 1. 15 % 2. 20 % 3. 25 % 4. 50 %

Solution



In any cyclic process, the net work done by the system is equal to the area enclosed by the cyclic thermodynamic path in a p-V diagram. So

$$W_{net} = (p_B - p_A)(V_D - V_A) = (2p_0 - p_0)(2V_0 - V_0) = p_0V_0.$$

Total heat absorbed by the cycle is the sum of the heat absorbed along path AB and the heat absorbed along path BC:

$$Q_A = Q_{AB} + Q_{BC}.$$

The heat absorbed along path AB:

$$Q_{AB} = C_V N(T_B - T_0).$$

From the ideal gas state equation:

$$T_B = \frac{2p_0 \cdot V_0}{NR},$$

and

$$T_0 = \frac{p_0 \cdot V_0}{NR}.$$

The heat absorbed along path AB:

$$Q_{AB} = C_V N(T_B - T_0) = \frac{3}{2}RN\left(\frac{2p_0 \cdot V_0}{NR} - \frac{p_0 \cdot V_0}{NR}\right) = \frac{3}{2}p_0 \cdot V_0.$$

The heat absorbed along path BC:

$$Q_{BC} = C_P N(T_C - T_B).$$

From the ideal gas state equation:

$$T_C = \frac{2p_0 \cdot 2V_0}{NR}.$$

The heat absorbed along path AB:

$$Q_{BC} = C_P N(T_C - T_B) = \frac{5}{2} RN \left(\frac{2p_0 \cdot 2V_0}{NR} - \frac{2p_0 \cdot V_0}{NR} \right) = 5p_0 \cdot V_0.$$

Total heat absorbed by the cycle

$$Q_A = \frac{3}{2} p_0 \cdot V_0 + 5p_0 \cdot V_0 = \frac{13}{2} p_0 \cdot V_0.$$

Thermal efficiency of a cycle:

$$\eta = \frac{W_{net}}{Q_A} = \frac{p_0 \cdot V_0}{\frac{13}{2} p_0 \cdot V_0} = \frac{2}{13} \approx 15\%.$$

Answer: 1. 15%.