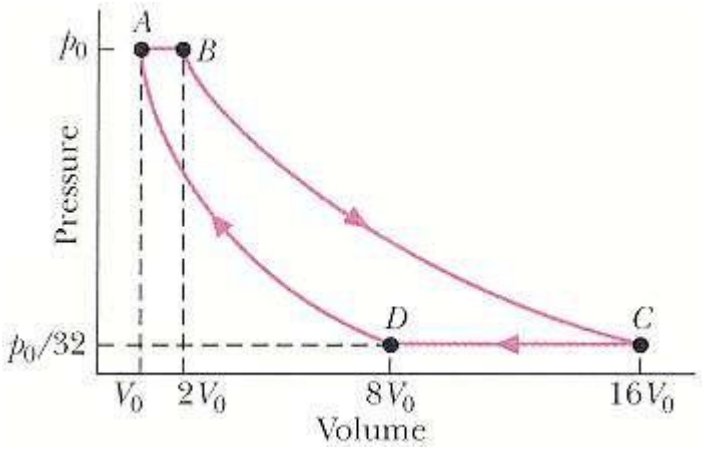
Q- One mol of an ideal monatomic gas is used as the working substance in an engine. The engine operates on the cycle shown in the diagram. Processes *BC* and *DA* are reversible and adiabatic. What is the efficiency of the engine?



The efficiency of a cycle is given by the ratio of useful work done by the engine to the heat absorbed by the engine.

Now in this cycle heat is absorbed during the isobaric expansion AB and given by

$$Q_{AB} = nC_P\Delta T = 1 * \frac{5R}{2}(2T_0 - T_0) = \frac{5RT_0}{2} = \frac{5P_0V_0}{2}$$

The work done in the four processes is given by

Isochoric expansion $W_{AB} = P_0(2V_0 - V_0) = P_0V_0$

Adiabatic expansion $W_{BC} = \frac{1}{1-\gamma}(P_2V_2 - P_1V_1) = -\frac{3}{2}\left(\frac{P_0}{32} * 16V_0 - P_0 * 2V_0\right) = \frac{9P_0V_0}{4}$

Isochoric compression $W_{CD} = \frac{P_0}{32}(8V_0 - 16V_0) = -\frac{8}{32}P_0V_0 = -\frac{1}{4}P_0V_0$

Adiabatic compression $W_{DA} = \frac{1}{1-\gamma}\left(P_0V_0 - \frac{P_0}{32} * 8V_0\right) = -\frac{3}{2}\left(P_0V_0 - \frac{P_0V_0}{4}\right) = -\frac{9P_0V_0}{8}$

Hence the net work done in the whole cycle is the sum of all four

Or $W = P_0V_0 + \frac{9P_0V_0}{4} - \frac{1}{4}P_0V_0 - \frac{9P_0V_0}{8} = \frac{15P_0V_0}{8}$

Thus efficiency of the cycle

$$\eta = \frac{W}{Q_{AB}} = \frac{15P_0V_0}{8} * \frac{2}{5P_0V_0} = \frac{3}{4} = 75\ \%$$