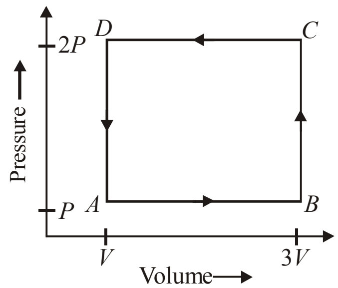
11 Thermodynamics

Diagram Based Questions :

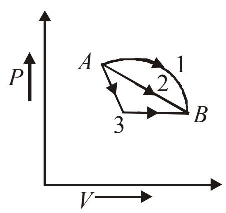
1. A thermodynamic system is taken through the cycle *ABCD* as shown in figure. Heat rejected by the gas during the cycle is



(a) 2PV (b) 4PV

(c) $\frac{1}{2}$ PV (d) PV

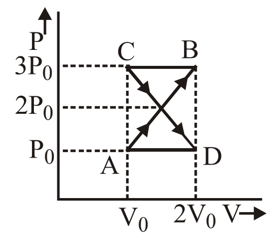
2. An ideal gas goes from state *A* to state *B* via three different processes as indicated in the *P-V* diagram



If Q_1, Q_2, Q_3 indicate the heat absorbed by the gas along the three processes and ΔU_1, ΔU_2, ΔU_3 indicate the change in internal energy along the three processes respectively, then

(a) $Q_1 > Q_2 > Q_3$ and $\Delta U_1 = \Delta U_2 = \Delta U_3$
(b) $Q_3 > Q_2 > Q_1$ and $\Delta U_1 = \Delta U_2 = \Delta U_3$
(c) $Q_1 = Q_2 = Q_3$ and $\Delta U_1 > \Delta U_2 > \Delta U_3$
(d) $Q_3 > Q_2 > Q_1$ and $\Delta U_1 > \Delta U_2 > \Delta U_3$

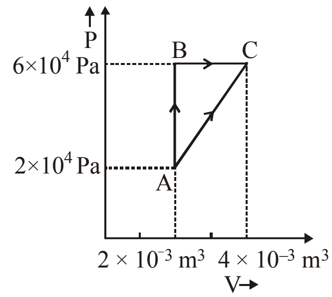
3. A thermodynamic system undergoes cyclic process ABCDA as shown in fig. The work done by the system in the cycle is



(a) P_0V_0 (b) $2P_0V_0$

(c) $\frac{P_0V_0}{2}$ (d) Zero

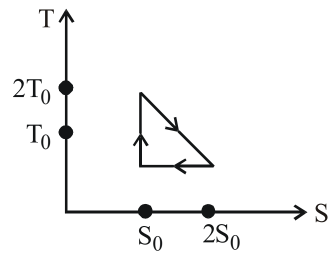
4. Figure below shows two paths that may be taken by a gas to go from a state A to a state C.



In process AB, 400 J of heat is added to the system and in process BC, 100 J of heat is added to the system. The heat absorbed by the system in the process AC will be

(a) 500 J (b) 460 J
(c) 300 J (d) 380 J

5. The temperature-entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is



(a) $\frac{1}{4}$ (b) $\frac{1}{2}$

(c) $\frac{2}{3}$ (d) $\frac{1}{3}$

Solution

1. **(a)** $\because$ Internal energy is the state function.
$\therefore$ In cyclic process; $\Delta U = 0$
According to 1st law of thermodynamics

$$\boxed{\Delta Q = \Delta U + W}$$

So heat absorbed
$\Delta Q = W =$ Area under the curve
$= -\ (2V)\ (P) = -\ 2PV$
So heat rejected $=\ 2PV$

2. **(a)** Initial and final condition is same for all process
$\Delta U_1 = \ \Delta U_2 = \Delta U_3$
from first law of thermodynamics
$\Delta Q = \Delta U + \Delta W$
Work done
$\Delta W_1 > \Delta W_2 > \Delta W_3$ (Area of P.V. graph)
So $\Delta Q_1 > \Delta Q_2 > \Delta Q_3$

3. **(d)** Work done by the system in the cycle
= Area under P-V curve and V-axis

$$= \frac{1}{2}(2P_0 - P_0)(2V_0 - V_0) + \left[-\left(\frac{1}{2}\right)(3P_0 - 2P_0)(2V_0 \quad V_0)\right.$$

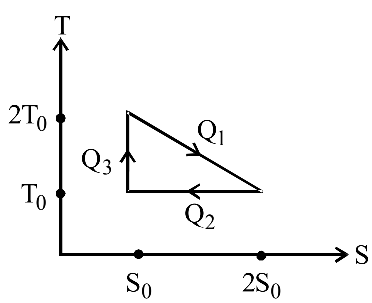
$$= \frac{P_0V_0}{2} - \frac{P_0V_0}{2} = 0$$

4. **(b)** In cyclic process ABCA
$Q_{cycle} = W_{cycle}$
$Q_{AB} + Q_{BC} + Q_{CA} =$ ar. of ΔABC

$$+400 + 100 + Q_{C\to A} = \frac{1}{2}(2\times10^{-3})\,(4\times10^{4})$$

$\Rightarrow \quad Q_{C\to A} = -460$ J
$\Rightarrow \quad Q_{A\to C} = +460$ J

5. **(d)**



$$Q_1 = T_0S_0 + \frac{1}{2}T_0S_0 = \frac{3}{2}T_0S_0$$

$$Q_2 = T_0(2S_0 - S_0) = T_0S_0 \text{ and } Q_3 = 0$$

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$$

$$= 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_0S_0}{\frac{3}{2}T_0S_0} = \frac{1}{3}$$