Solutions

S1. Ans.(d)

Path bc is an isochoric process.

Work done by gas along path bc is zero.

S2. Ans.(b)

$\eta = 1 - \frac{T_{\sin k}}{T_{source}} = 0.5$

$\frac{T_{\sin k}}{T_{source}} = 0.5$

$\Rightarrow T_{\sin k} = \frac{1}{2} \times (273 + 327)$

$= \frac{1}{2} \times 600$

$300\ K$

$= 27°C$

S3. Ans.(b)

1 : Isochoric

2 : Adiabatic

3 : Isothermal

4: Isobaric

S4. Ans.(a)

Efficiency of carnot engine (η)

$= 1 - \frac{T_2}{T_1} \begin{pmatrix} T_1 = \text{Temperature of source} \\ T_2 = \text{Temperature of sink} \end{pmatrix}$

S5. Ans.(b)

From this P-V diagram P = constant

∴ the given process is isobaric.

S6. Ans.(b)

An adiabatic process, occurs without exchange of heat or mass between a thermodynamic system and its surroundings.

S7. Ans.(c)

In this process P = constant

W = Work done = $P(V_2 - V_1)$

$= nR(T_2 - T_1) = nR\ \Delta T$

$Q = nC_P \Delta T \Rightarrow Q = n\left(\frac{5}{2}R\right)\Delta T$

Ratio of $\frac{W}{Q} = \frac{2}{5}$

S8. Ans.(c)

$\eta_{cannot} = \left(1 - \frac{T_L}{T_H}\right) \times 100 = \left(1 - \frac{273}{373}\right) \times 100$

$\eta_{cannot} = 26.8\%$

S9. Ans.(b)

$\Delta Q = W + \Delta U \Rightarrow \Delta U = \Delta Q - W$

$W = P\left(V_f - V_i\right)$

$W = 1.013 \times 10^5 \times \frac{167}{10^6} = 16.9\ T$

$\Delta U = 54 \times 4.18 - 16.9$

$\Delta U = 208.7\ J$

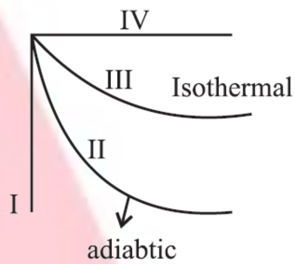
S10. Ans.(a)

Isochoric = V constant → I

Isobaric = P constant → IV

Isothermal = T constant → III

Adiabatic = Q constant → II



In an expansion adiabatic curve is more steeper than that of isothermal.

S11. Ans.(a)

$\beta = \frac{Q_2}{W} = \frac{1-\eta}{\eta}$

$\frac{Q_2}{10} = \frac{1-0.1}{0.1} \Rightarrow Q_2 = 90$ Joule

S12. Ans.(c)

Given relation

$V = \frac{b}{T}$

$VT = b$

On differentiation

VdT + TdV = 0

$dV = -\frac{VdT}{T}$

$W = \int pdV \Rightarrow \int \frac{nRT}{V} . \frac{(-VdT)}{T}$

$W = -nR\Delta T \Rightarrow \Delta Q = \Delta U + W$

$= nC_V \Delta T - nR\Delta T$

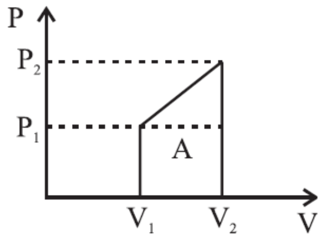
$= \frac{nR\Delta T}{\gamma - 1} - nR\Delta T$

$$\Delta Q = nR\Delta T\left[\frac{1}{\gamma-1} - 1\right]$$

$$= nR\Delta T\left[\frac{1-(\gamma-1)}{\gamma-1}\right]$$

$$= \frac{R\Delta T[2-\gamma]}{\gamma-1}$$

S13. Ans.(b)



W = Area under the curve

$$W = \frac{1}{2}[P_1 + P_2][V_2 - V_1]$$

S14. Ans.(a)

Heat delivered $= Q_1$

$$\text{C.O.P } (\beta) = \frac{Q_2}{W} = \frac{Q_1 - W}{W} = \frac{Q_1}{W} - 1 = \frac{T_2}{T_1 - T_2}$$

$$\Rightarrow \frac{Q_1}{W} = 1 + \frac{t_2° + 273}{t_1° - t_2°} = \frac{t_1° + 273}{t_1° - t_2°}$$

S15. Ans.(d)

Newton's law of cooling

$$\frac{T_1 - T_2}{t} = k\left(\frac{T_1 + T_2}{2} - T\right)$$

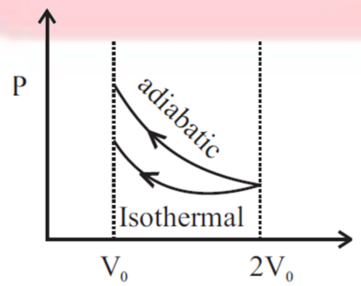
$$\frac{3T - 2T}{10} = k\left(\frac{5T - 2T}{2}\right) \Rightarrow \frac{T}{10} = k\left(\frac{3T}{2}\right) \quad \ldots\text{(i)}$$

$$\frac{2T - T'}{10} = k\left(\frac{2T + T'}{2} - T\right) \Rightarrow \frac{2T - T'}{10} = k\left(\frac{T'}{2}\right) \ldots\text{(ii)}$$

By solving Eqs. (i) and (ii)

$$T' = \frac{3}{2}T$$

S16. Ans.(b)



W_{ext} = negative of area with volume axis

$W_{(adiabatic)} > W_{(Isothermal)}$

S17. Ans.(c)

$$\beta = \frac{Q_2}{W} = \frac{T_2}{T_1 - T_2}$$

$$\frac{2520}{W} = \frac{277}{303 - 277}$$

$$\Rightarrow W = 236.5\,J$$

Power

$$= \frac{W}{t} = \frac{236.5}{1\,sec}\ joule$$

= 236.5 watt

S18. Ans.(b)

In cyclic process ABCA,

$\Delta U_{cyclic} = 0 \Rightarrow Q_{cyclic} = W_{cyclic}$

$Q_{AB} = +400\,J$ Heat absorbed

$Q_{BC} = +100\,J$ Heat absorbed,

Area under loop = +W (clockwise)

$Q_{AB} + Q_{BC} - Q_{CA}$ = closed loop area.

$$400 + 100 - Q_{CA} = \frac{1}{2} \times (2 \times 10^{-3}) \times 4 \times 10^4$$

$$400 + 100 - Q_{AC} = 40$$

$$Q_{AC} = 460\,J$$

S19. Ans.(b)

For engine and refrigerators operating between two same temperatures

$$= \frac{1}{1+\beta} \Rightarrow \frac{1}{10} = \frac{1}{1+\beta} \Rightarrow \beta = 9$$

$\beta = \frac{Q_2}{10}$ (From the principle of refrigerator)

$$9 = \frac{Q_2}{10} \Rightarrow Q_2 = 90\,J$$

S20. Ans.(a)

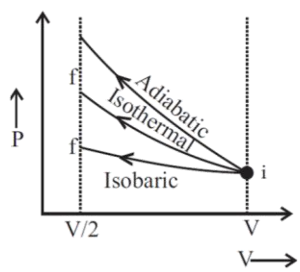
$$\Delta U = nC_v\Delta T \ \&\ T = \frac{PV}{nR}$$

so $\Delta T = T_2 - T_1 = \frac{P_2V_2 - P_1V_1}{nR}$

so $\Delta U = \frac{nR}{\gamma-1}\left(\frac{P_2V_2 - P_1V_1}{nR}\right) = \frac{P_2V_2 - P_1V_1}{\gamma-1}$

$$\Rightarrow \Delta U = \frac{-8 \times 10^3}{2/5} = -20\text{ kJ}$$

S21. Ans.(b)



Work done on the gas

$W_{isochoric} = 0$ and

$W_{adiabatic} > W_{Isothermal} > W_{Isobaric}$

S22. Ans.(b)

Coefficient of performance of refrigerator

$C.O.P = \frac{T_L}{T_H - T_L}$

Where $T_L \rightarrow$ lower Temperature

and $T_H \rightarrow$ Higher Temperature

So, $5 = \frac{T_L}{T_H - T_L}$

$\Rightarrow T_H = \frac{6}{5} T_L = \frac{6}{5}(253) = 303.6\ k$

$= 303.6 - 273 = 30.6°C$

$= 31°C$

S23. Ans.(d)

Work done by the system in the cycle

= Area under $P - V$ curve & V-axis

$= \frac{1}{2}(2P_0 - P_0)(2V_0 - V_0)$

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

$= \frac{P_0 V_0}{2} - \frac{P_0 V_0}{2} = 0$

S24. Ans.(c)

For isothermal process $P_1 V_1 = P_2 V_2$

$\Rightarrow PV = P_2(2V) \Rightarrow P_2 = \frac{P}{2}$

For adiabatic process $P_2 V_2^{\gamma} = P_3 V_3^{\gamma}$

$\Rightarrow \left(\frac{P}{2}\right)(2V)^{\gamma} = P_3 (16V)^{\gamma}$

$\Rightarrow P_3 = \frac{P}{2}\left(\frac{1}{8}\right)^{5/3} = \frac{P}{64}$

S25. Ans.(c)

Net work done = Area of triangle ABC

$= \frac{1}{2} \times [7 - 2] \times 10^{-3}[(6 - 2) \times 10^5] = 1000\ J$

S26. Ans.(a)

$P \propto T^3$

$P = kT^3$ ...(1)

Using adiabatic equation

$P^{1-\gamma} T^{\gamma} = k$

$P = cT^{-\gamma/1-\gamma}$

Compare this with equation (1)

$\frac{-\gamma}{1-\gamma} = 3 \Rightarrow \gamma = \frac{3}{2}$

S27. Ans.(c)

$\frac{C_p}{C_v} = \gamma$

By Mayer's equation

$C_p - C_v = R$

$\frac{C_p}{C_v} - 1 = \frac{R}{C_v}$

$\gamma - 1 = \frac{R}{C_v}$

$C_v = \frac{R}{\gamma - 1}$

S28. Ans.(d)

$PV = nRT \Rightarrow V = \left(\frac{nR}{P}\right)T \Rightarrow \text{slope} = \frac{nR}{P}$

As $\theta_2 > \theta_1$ so $\frac{1}{P_2} > \frac{1}{P_1} \Rightarrow P_1 > P_2$