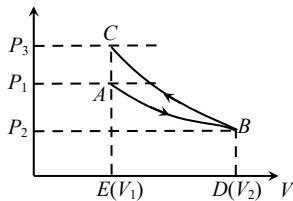


7. (c)  $\Delta Q = \Delta U + \Delta W \Rightarrow \Delta W = (\Delta Q)_P - \Delta U$   
 $= (\Delta Q)_P \left[ 1 - \frac{(\Delta Q)_V}{(\Delta Q)_P} \right]$   
 $= (\Delta Q)_P \left[ 1 - \frac{C_V}{C_P} \right] = Q \left[ 1 - \frac{3}{5} \right] = \frac{2}{5} Q$   
 $\therefore (\Delta Q)_P = Q$  and  $\gamma = \frac{5}{3}$  for monatomic gas

8. (d) Oxygen is diatomic gas, hence its energy of two moles  $= 2 \times \frac{5}{2} RT = 5RT$   
 Argon is a monoatomic gas, hence its internal energy of 4 moles  $= 4 \times \frac{3}{2} RT = 6RT$

Total Internal energy  $= (6+5)RT = 11RT$

9. (c) From graph it is clear that  $P_3 > P_1$ .  
 Since area under adiabatic process (BCED) is greater than that of isothermal process (ABDE). Therefore net work done  
 $W = W_f + (-W_A) \therefore W_A > W_f \Rightarrow W < 0$



10. (a) According to given Vander Waal's equation

$$P = \frac{nRT}{V - n\beta} - \frac{\alpha n^2}{V^2}$$

Work

done,

$$W = \int_{V_1}^{V_2} P dV = nRT \int_{V_1}^{V_2} \frac{dV}{V - n\beta} - \alpha n^2 \int_{V_1}^{V_2} \frac{dV}{V^2}$$

$$= nRT \left[ \log_e (V - n\beta) \right]_{V_1}^{V_2} + \alpha n^2 \left[ \frac{1}{V} \right]_{V_1}^{V_2}$$

$$= nRT \log_e \frac{V_2 - n\beta}{V_1 - n\beta} + \alpha n^2 \left( \frac{V_1 - V_2}{V_1 V_2} \right)$$

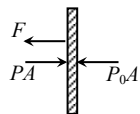
11. (b) Volume of the gas is constant  $V = \text{constant}$   
 $\therefore P \propto T$

i.e., pressure will be doubled if temperature is doubled

$$\therefore P = 2P_0$$

Now let  $F$  be the tension in the wire. Then equilibrium of any one piston gives

$$F = (P - P_0)A = (2P_0 - P_0)A = P_0 A$$



12. (c)  $dU = C_V dT = \left( \frac{5}{2} R \right) dT$  or  $dT = \frac{2(dU)}{5R}$

From first law of thermodynamics

$$dU = dQ - dW = Q - \frac{Q}{4} = \frac{3Q}{4}$$

Now molar heat capacity  $C = \frac{dQ}{dT} = \frac{Q}{\frac{2(dU)}{5R}} = \frac{5RQ}{2 \left( \frac{3Q}{4} \right)} = \frac{10}{3} R$ .

13. (b)  $Q = \Delta U = U_f - U_i =$  [internal energy of 4 moles of a monoatomic gas + internal energy of 2 moles of a diatomic gas] – [internal energy of 4 moles of a diatomic gas]

$$= \left( 4 \times \frac{3}{2} RT + 2 \times \frac{5}{2} RT \right) - \left( 4 \times \frac{5}{2} RT \right) = RT$$

**Note :** (a) 2 moles of diatomic gas becomes 4 moles of a monoatomic gas when gas dissociated into atoms.

(b) Internal energy of  $\mu$  moles of an ideal gas of degrees of freedom  $F$  is given by  
 $U = \frac{f}{2} \mu RT$

$F = 3$  for a monoatomic gas and 5 for diatomic gas.

14. (c)  $PV^\gamma = K$  or  $P^\gamma V^{\gamma-1} dV + dP V^\gamma = 0$

$$\text{or } \frac{dP}{P} = -\gamma \frac{dV}{V} \text{ or } \frac{dP}{P} \times 100 = -\gamma \left( \frac{dV}{V} \times 100 \right)$$

$$= -1.4 \times 5 = 7\%$$

15. (a)  $TV^{\gamma-1} = \text{constant}$

$$\therefore \frac{T_1}{T_2} = \left( \frac{V_2}{V_1} \right)^{\gamma-1} \text{ or } \left( \frac{1}{2} \right)^{\gamma-1} = \sqrt{\frac{1}{2}}$$

$$\therefore \gamma - 1 = \frac{1}{2} \text{ or } \gamma = \frac{3}{2} \quad \therefore PV^{\beta/2} = \text{constant}$$

16. (c)  $\eta_A = \frac{T_1 - T_2}{T_1} = \frac{W_A}{Q_1} \Rightarrow \eta_B = \frac{T_2 - T_3}{T_2} = \frac{W_B}{Q_2}$

$$\therefore \frac{Q_1}{Q_2} = \frac{T_1}{T_2} \times \frac{T_2 - T_3}{T_1 - T_2} = \frac{T_1}{T_2} \quad \therefore W_A = W_B$$

$$\therefore T_2 = \frac{T_1 + T_3}{2} = \frac{800 + 300}{2} = 550K$$

17. (b) For monoatomic gas

$$\gamma = \frac{C_P}{C_V} = \frac{5}{3} \text{ we know } \Delta Q = nC_P \Delta T$$

$$\text{and } \Delta U = nC_V \Delta T \Rightarrow \frac{\Delta U}{\Delta Q} = \frac{C_V}{C_P} = \frac{3}{5}$$

i.e. fraction of heat energy to increase the internal energy be 3/5.

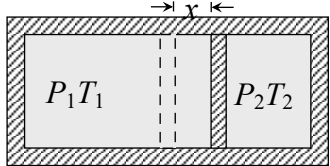
18. (a)  $\Delta Q = \Delta U + \Delta W \Rightarrow \frac{\Delta W}{\Delta Q} = 1 - \frac{\Delta U}{\Delta Q} = 1 - \frac{nC_V dT}{nC_P dT}$

$$\Rightarrow \frac{\Delta W}{\Delta Q} = 1 - \frac{C_V}{C_P} = 1 - \frac{3}{5} = \frac{2}{5} = 0.4$$

.....(i)

19. (b)  $\Delta U = \mu C_V \Delta T = \frac{m}{M} C_V \Delta T = \frac{N}{N_A} C_V \Delta T$   
 $\Rightarrow (\Delta U)_N = \frac{56 \times 10^3}{14} \times \frac{5}{2} R \times 300$   
 and  $(\Delta U)_A = \frac{6 \times 10^{26}}{6 \times 10^{23}} \times \frac{3}{2} R \times 900 \Rightarrow (\Delta U)_N > (\Delta U)_A$
20. (c)  $A$  is compressed isothermally, hence  
 $P_1 V = P_2 \frac{V}{2} \Rightarrow P_2 = 2P_1$   
 and  $B$  is compressed adiabatically, hence  
 $P_1 V^\gamma = P_2 \left(\frac{V}{2}\right)^\gamma \Rightarrow P_2 = (2)^\gamma P_1$   
 Since  $\gamma > 1$ , hence  $P_2' > P_2$  or  $P_2 < P_2'$
21. (b) In isothermal process  $P_1 V_1 = P_2 V_2$   
 or  $PV = P_2 \times 4V \quad \therefore P_2 = \frac{P}{4}$   
 In adiabatic process  
 $P_2 V_2^\gamma = P_3 V_3^\gamma \Rightarrow \frac{P}{4} \times (4V)^{1.5} = P_3 V^{1.5} \Rightarrow P_3 = 2P$
22. (d) Volume of the ideal gas is constant so  
 $W = P \Delta V = 0$  using FLOT  $\Delta Q = \Delta U \Rightarrow$   
 $\Delta U = \dot{P} R t = 1^2 \times 100 \times 5 \times 60$   
 $= 30 \times 10^3 = 30 \text{ kJ}$
23. (d) Initially  $\eta = \left(1 - \frac{T_2}{T_1}\right) = \frac{W}{Q} = \frac{1}{6} \quad \dots(i)$   
 Finally  $\eta' = \left(1 - \frac{T_2'}{T_1}\right) = \left(1 - \frac{(T_2 - 62)}{T_1}\right) = 1 - \frac{T_2}{T_1} + \frac{62}{T_1}$   
 $= \eta + \frac{62}{T_1} \quad \dots(ii)$   
 It is given that  $\eta' = 2\eta$ . Hence solving equation (i) and (ii)  
 $\Rightarrow T_1 = 372 \text{ K} = 99^\circ\text{C}$  and  $T_2 = 310 \text{ K} = 37^\circ\text{C}$
24. (b) Input energy  $= \frac{1g}{\text{sec}} \times \frac{2 \text{ kcal}}{g} = 2 \text{ kcal/sec}$   
 Output energy  $= 10 \text{ KW} = 10 \text{ K J / S}$   
 $= \frac{10}{4.2} \text{ kcal/sec}$   
 $\Rightarrow \eta = \frac{\text{output energy}}{\text{input energy}} = \frac{10}{4.2 \times 2} > 1$ , it is impossible.
25. (b) Gain of entropy of ice  
 $S_1 = \frac{\Delta Q}{T} = \frac{mL}{T} = \frac{80 \times 100}{(0 + 273)} = \frac{8 \times 10^3}{273} \text{ call K}$   
 Loss of entropy of water  $= S_2 = -\frac{\Delta Q}{T} = -\frac{mL}{T}$   
 $= \frac{80 \times 100}{(273 + 50)} = \frac{8 \times 10^3}{323} \text{ call K}$   
 Total change of entropy

$$S_1 + S_2 = \frac{8 \times 10^3}{273} - \frac{8 \times 10^3}{323} = +4.5 \text{ call K}$$

26. (b)  $PV^\gamma = \text{constant}$  represents adiabatic equation. So during the expansion of ideal gas internal energy of gas decreases and temperature falls.
27. (d) Initially  $\eta = \frac{T_1 - T_2}{T_1} \Rightarrow 0.5 = \frac{T_1 - (273 + 7)}{T_1}$   
 $\Rightarrow \frac{1}{2} = \frac{T_1 - 280}{T_1} \Rightarrow T_1 = 560 \text{ K}$   
 Finally  $\eta_1' = \frac{T_1' - T_2}{T_1'} \Rightarrow 0.7 = \frac{T_1' - (273 + 7)}{T_1'} \Rightarrow$   
 $T_1' = 933 \text{ K}$   
 $\therefore$  increase in temperature  
 $= 933 - 560 = 373 \text{ K} \approx 380 \text{ K}$
28. (c)  $P-V$  diagram of the gas is a straight line passing through origin. Hence  $P \propto V$  or  $PV^{-1} = \text{constant}$   
 Molar heat capacity in the process  
 $PV^\alpha = \text{constant}$   
 $C = \frac{R}{\gamma - 1} + \frac{R}{1 - \alpha}$ ; Here  $\gamma = 1.4$  (For diatomic gas)  
 $\Rightarrow C = \frac{R}{1.4 - 1} + \frac{R}{1 + 1} \Rightarrow C = 3R$
29. (c) As finally the piston is in equilibrium, both the gases must be at same pressure  $P_f$ . It is given that displacement of piston be in final state  $x$  and if  $A$  is the area of cross-section of the piston.  
 Hence the final volumes of the left and right part finally can be given by figure as  
  
 $V_L = \frac{V_0}{2} + Ax$  and  $V_R = \frac{V_0}{2} - Ax$   
 As it is given that the container walls and the piston are adiabatic in left side and the gas undergoes adiabatic expansion and on the right side the gas undergoes adiabatic compressive. Thus we have for initial and final state of gas on left side  
 $P_1 \left(\frac{V_0}{2}\right)^\gamma = P_f \left(\frac{V_0}{2} + Ax\right)^\gamma \quad \dots(i)$   
 Similarly for gas in right side, we have

$$P_2 \left( \frac{V_0}{2} \right)^\gamma = P_f \left( \frac{V_0}{2} - Ax \right)^\gamma \quad \dots(ii)$$

From eq. (i) and (ii)

$$\frac{P_1}{P_2} = \frac{\left( \frac{V_0}{2} + Ax \right)^\gamma}{\left( \frac{V_0}{2} - Ax \right)^\gamma} \Rightarrow Ax = \frac{V_0}{2} \left[ \frac{P_1^{1/\gamma} - P_2^{1/\gamma}}{P_1^{1/\gamma} + P_2^{1/\gamma}} \right]$$

Now from equation (i)  $P_f = \frac{P_1 \left( \frac{V_0}{2} \right)^\gamma}{\left[ \frac{V_0}{2} + Ax \right]^\gamma}$

30. (d) In both cylinders *A* and *B* the gases are diatomic ( $\gamma = 1.4$ ). Piston *A* is free to move i.e. it is isobaric process. Piston *B* is fixed i.e. it is isochoric process. If same amount of heat  $\Delta Q$  is given to both then

$$(\Delta Q)_{\text{isobaric}} = (\Delta Q)_{\text{isochoric}} \Rightarrow \mu C_p (\Delta T)_A = \mu C_v (\Delta T)_B$$

$$\Rightarrow (\Delta T)_B = \frac{C_p}{C_v} (\Delta T)_A = \gamma (\Delta T)_A = 1.4 \times 30 = 42 \text{ K}$$

### Graphical Questions

- (c) As internal energy is a point function therefore change in internal energy does not depend upon the path followed i.e.  $\Delta U_I = \Delta U_{II}$
- (b) Work done by the system = Area of shaded portion on *P-V* diagram  
 $= (300 - 100)10^{-6} \times (200 - 10) \times 10^3 = 20 \text{ J}$
- (a) Work done = Area enclosed by triangle  $ABC = \frac{1}{2} AC \times BC = \frac{1}{2} \times (3V - V) \times (3P - P) = 2 PV$
- (c) Area enclosed between *a* and *f* is maximum. So work done in closed cycles follows *a* and *f* is maximum.
- (a) Initial and final states are same in all the process.  
 Hence  $\Delta U = 0$ ; in each case.  
 By FLOT;  $\Delta Q = \Delta W = \text{Area enclosed by curve with volume axis}$ .  
 $\therefore (\text{Area})_1 < (\text{Area})_2 < (\text{Area})_3 \Rightarrow Q_1 < Q_2 < Q_3$ .
- (a) For an isothermal process  $PV = \text{constant}$

$$\Rightarrow PdV + VdP = 0 \Rightarrow -\frac{1}{V} \left( \frac{dV}{dP} \right) = \frac{1}{P}$$

So,  $\beta = \frac{1}{P} \therefore$  graph will be rectangular hyperbola.

7. (a) By adjoining graph  $W_{AB} = 0$  and

$$W_{BC} = 8 \times 10^4 [5 - 2] \times 10^{-3} = 240 \text{ J}$$

$$\therefore W_{AC} = W_{AB} + W_{BC} = 0 + 240 = 240 \text{ J}$$

$$\text{Now, } \Delta Q_{AC} = \Delta Q_{AB} + \Delta Q_{BC} = 600 + 200 = 800 \text{ J}$$

$$\text{From FLOT } \Delta Q_{AC} = \Delta U_{AC} + \Delta W_{AC}$$

$$\Rightarrow 800 = \Delta U_{AC} + 240 \Rightarrow \Delta U_{AC} = 560 \text{ J}$$

8. (b) In adiabatic process, slope of *PV*-graph.

$$\frac{dP}{dV} = -\gamma \frac{P}{V} \Rightarrow |\text{Slope}| \propto \gamma$$

$$\text{From the given graph } (\text{Slope})_2 > (\text{Slope})_1 \Rightarrow \gamma_2 > \gamma_1$$

therefore 1 should correspond to  $O_2$  ( $\gamma = 1.4$ ) and 2 should correspond to *He* ( $\gamma = 1.66$ )

- (c) As we know that slope of isothermal and adiabatic curves are always negative and slope of adiabatic curve is always greater than that of isothermal curve  
 Hence in the given graph curve *A* and *B* represents adiabatic and isothermal changes respectively.
- (d) Process *CD* is isochoric as volume is constant, Process *DA* is isothermal as temperature constant and Process *AB* is isobaric as pressure is constant.
- (d) Heat given  $\Delta Q = 20 \text{ cal} = 20 \times 4.2 = 84 \text{ J}$ .  
 Work done  $\Delta W = -50 \text{ J}$  [As process is anticlockwise]  
 By first law of thermodynamics  
 $\Rightarrow \Delta U = \Delta Q - \Delta W = 84 - (-50) = 134 \text{ J}$
- (a) For cyclic process. Total work done  
 $= W_{AB} + W_{BC} + W_{CA}$   
 $\Delta W_{AB} = P\Delta V = 10(2 - 1) = 10 \text{ J}$  and  $\Delta W_{BC} = 0$   
 (as  $V = \text{constant}$ )  
 From FLOT,  $\Delta Q = \Delta U + \Delta W$   
 $\Delta U = 0$  (Process *ABCA* is cyclic)  
 $\Rightarrow \Delta Q = \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CA}$   
 $\Rightarrow 5 = 10 + 0 + \Delta W_{CA} \Rightarrow \Delta W_{CA} = -5 \text{ J}$

13. (b) The cyclic process 1 is clockwise where as process 2 is anticlockwise. Clockwise area represents positive work and anticlockwise area represents negative work. Since negative area (2) > positive area (1), hence net work done is negative.

14. (c) Process AB is isochoric,  $\therefore W_{AB} = P\Delta V = 0$

Process BC is isothermal  $\therefore W_{BC} = RT_2 \ln\left(\frac{V_2}{V_1}\right)$

Process CA is isobaric

$\therefore W_{CA} = -P\Delta V = -R\Delta T = -R(T_1 - T_2) = R(T_2 - T_1)$

(Negative sign is taken because of compression)

15. (a) AB is isobaric process, BC is isothermal process, CD is isometric process and DA is isothermal process

These process are correctly represented by graph (a).

16. (c) Work done by the gas (as cyclic process is clockwise)  $\therefore \Delta W = \text{Area } ABCD$

So from the first law of thermodynamics

$\Delta Q$  (net heat absorbed) =  $\Delta W = \text{Area } ABCD$

As change in internal energy in cycle  $\Delta U =$

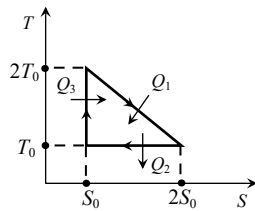
0.

17. (a)  $Q_1 = \tau_0 S_0 + \frac{1}{2} \tau_0 S_0 = \frac{3}{2} \tau_0 S_0$

$Q_2 = \tau_0 S_0$  and  $Q_3 = 0$

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

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



18. (a) Work done = Area of closed PV diagram  
 $= (2V - V) \times (2P - P) = PV$

19. (c) From the given VT diagram,

In process AB,  $V \propto T \Rightarrow$  Pressure is constant (As quantity of the gas remains same)

In process BC,  $V = \text{Constant}$  and in process CA,

$T = \text{constant}$

$\therefore$  These processes are correctly represented on PV diagram by graph (c).

20. (d)  $\Delta Q = \Delta U + \Delta W$ ;  $\Delta U$  does not depend upon path.

$\therefore \Delta W_A > \Delta W_B \Rightarrow \Delta Q_A > \Delta Q_B$

21. (d) Work done = Area under curve =  $\frac{6P_1 \times 3V_1}{2} = 9P_1V_1$

22. (d) Work done =  $\frac{1}{2} \times 2P_1 \times 2V_1 = 2P_1V_1$

23. (c) In a cyclic,  $\Delta U = 0$

From FLOT,  $\Delta Q = \Delta U + \Delta W = 0 + \Delta W =$

Area of closed curve  $\Rightarrow \Delta Q = \pi r^2$

$\pi \left(\frac{20}{2}\right)^2 kP_2 \times \text{litre}$

$= 100\pi \times 10^3 \times 10^{-3} J = 100\pi J$

24. (c) The work done in cyclic process is equal to the area enclosed by the PV diagram

25. (d) In all given cases, process is cyclic and in cyclic process  $\Delta U = 0$ .

26. (b) In cyclic process  $\Delta Q = \text{Work done} = \text{Area inside the closed curve.}$

Treat the circle as an ellipse of area

$= \frac{\pi}{4} (P_2 - P_1)(V_2 - V_1)$

$\Rightarrow \Delta Q = \frac{\pi}{4} \{(150 - 50) \times 10^3\} = \frac{\pi}{2} J$

27. (d)  $W_{BCOB} = - \text{Area of triangle } BCO = - \frac{P_0 V_0}{2}$

$W_{AODA} = + \text{Area of triangle } AOD = + \frac{P_0 V_0}{2}$

28. (c) AD and BC represent adiabatic process (more slope)  
 AB and DC represent isothermal process (less slope)

29. (c) Work done = Area of curve enclosed

$= 2V \times 2P = 4PV$

30. (c) Work done = Area of PV graph (here trapezium)

$= \frac{1}{2} (1 \times 10^5 + 5 \times 10^5) \times (5 - 1) = 12 \times 10^5 J$

31. (d) For path ab :  $(\Delta U)_{ab} = 7000 J$

By using  $\Delta U = \mu C_V \Delta T$

$7000 = \mu \times \frac{5}{2} R \times 700 \Rightarrow \mu = 0.48$

For path ca :

$(\Delta Q)_{ca} = (\Delta U)_{ca} + (\Delta W)_{ca} \dots(i)$

$\therefore (\Delta U)_{ab} + (\Delta U)_{bc} + (\Delta U)_{ca} = 0$

$\therefore 7000 + 0 + (\Delta U)_{ca} = 0 \Rightarrow (\Delta U)_{ca} = -7000 J \dots(ii)$

Also  $(\Delta W)_{ca} = P(V_1 - V_2) = \mu R(T_1 - T_2)$

$= 0.48 \times 8.31 \times (300 - 1000) = -2792.16 J \dots(iii)$

on solving equations (i), (ii) and (iii)

$$(\Delta Q)_{ca} = -7000 - 2792.16 = -9792.16 \text{ J} = -9800 \text{ J}$$

32. (b) Work done = Area enclosed by indicator diagram

$$= \frac{1}{2} \times (3V - V)(4P - P) = 3PV$$

33. (d)  $\Delta U$ , remains same for both path  
 For path *iaf*:  $\Delta U = \Delta Q - \Delta W = 50 - 20 = 30 \text{ J}$ .  
 For path *fi*:  $\Delta U = -30 \text{ J}$  and  $\Delta W = -13 \text{ J}$   
 $\Rightarrow \Delta Q = -30 - 13 = -43 \text{ J}$ .

34. (a)  $\Delta E_{\text{int}} = 0$ , for a complete cycle and for given cycle work done is negative, so from first law of thermodynamics  $Q$  will be negative i.e.  $Q < 0$ .

35. (d) Work done = Area enclosed by the curve

$$= \frac{1}{2} (3V - V)(2P - P) = PV$$

36. (d)  $W$  = Area bonded by the indicator diagram with  $V$ -axis)

$$= \frac{1}{2} (P_A + P_B)(V_B - V_A)$$

37. (a) Heat given  $\Delta Q = 40 \text{ J}$  and Work done  $\Delta W = 30 \text{ J}$

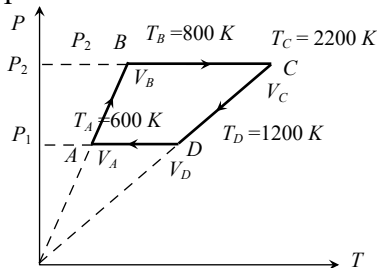
$$\Rightarrow \Delta U = \Delta Q - \Delta W = 40 - 30 = 10 \text{ J}$$

38. (a) As the volume is continuously increasing and the work of expansion is always positive, so the work done by the system continuously increases.

39. (c) Processes  $A$  to  $B$  and  $C$  to  $D$  are parts of straight line graphs of the form  $y = mx$

$$\text{Also } P = \frac{\mu R}{V} T \quad (\mu = 6)$$

$\Rightarrow P \propto T$ . So volume remains constant for the graphs  $AB$  and  $CD$



So no work is done during processes for  $A$  to  $B$  and  $C$  to  $D$  i.e.,  $W_{AB} = W_{CD} = 0$  and  $W_{BC} = P_2(V_C - V_B) = \mu R(T_C - T_B)$

$$= 6R(2200 - 800) = 6R \times 1400 \text{ J}$$

$$\text{Also } W_{DA} = P_1(V_A - V_D) = \mu R(T_A - T_D)$$

$$= 6R(600 - 1200) = -6R \times 600 \text{ J}$$

Hence work done in complete cycle

$$W = W_{AB} + W_{BC} + W_{CD} + W_{DA}$$

$$= 0 + 6R \times 1400 + 0 - 6R \times 600$$

$$= 6R \times 900 = 6 \times 8.3 \times 800 \approx 40 \text{ kJ}$$

40. (b) In isothermal process  $P \propto \frac{1}{V}$ .

Hence graph between  $P$  and  $V$  is a hyperbola.

41. (d) Adiabatic curves are more steeper than isothermal curves.

42. (d) During process  $A$  to  $B$ , pressure and volume both are decreasing. Therefore, temperature and hence, internal energy of the gas will decrease ( $T \propto PV$ ) or  $\Delta U_{A \rightarrow B} = \text{negative}$ . Further  $\Delta W_{A \rightarrow B}$  is also negative as the volume of the gas is decreasing. Thus  $\Delta Q_{A \rightarrow B}$  is negative.

In process  $B$  to  $C$  pressure of the gas is constant while volume is increasing. Hence temperature should increase or  $\Delta U_{B \rightarrow C} = \text{positive}$ . During  $C$  to  $A$  volume is constant while pressure is increasing. Therefore, temperature and hence, internal energy of the gas should increase or  $\Delta U_{C \rightarrow A} = \text{positive}$ . During process  $CAB$  volume of the gas is decreasing. Hence, work done by the gas is negative.

43. (a)  $\Delta W_{AB} = 0$  as  $V = \text{constant}$

$$\therefore \Delta Q_{AB} = \Delta U_{AB} = 50 \text{ J} \quad (\text{Given})$$

$$U_A = 1500 \text{ J} \therefore U_B = (1500 + 50) \text{ J} = 1550 \text{ J}$$

$$\Delta W_{BC} = -\Delta U_{BC} = -40 \text{ J} \quad (\text{Given})$$

$$\therefore \Delta U_{BC} = 40 \text{ J} \therefore U_C = (1550 + 40) \text{ J} = 1590 \text{ J}$$

44. (a) For adiabatic process  $T_1 V_1^{\gamma-1} = \text{Constant}$

$$\text{For } bc \text{ curve } T_1 V_b^{\gamma-1} = T_2 V_c^{\gamma-1} \text{ or } \frac{T_2}{T_1} = \left( \frac{V_b}{V_c} \right)^{\gamma-1} \dots\dots(i)$$

$$\text{For } ad \text{ curve } T_1 V_a^{\gamma-1} = T_2 V_d^{\gamma-1} \text{ or } \frac{T_2}{T_1} = \left( \frac{V_a}{V_d} \right)^{\gamma-1} \dots\dots(ii)$$

$$\text{From equation (i) and (ii) } \frac{V_b}{V_c} = \frac{V_a}{V_d}$$

**Assertion and Reason**

1. (a) In a perfectly reversible system, there is no loss of energy. Losses can be minimised, friction can be reduced, the resistance in L-C oscillating system can also be negligible. But one cannot completely eliminate energy losses. This makes a perfectly reversible system, an ideal.
2. (a) Adiabatic expansion produces cooling.
3. (a) In reversible process, there always occurs some loss of energy. This is because energy spent in working against the dissipative force is not recovered back. Some irreversible process occur in nature such as friction where extra work to cancel the effect of friction. Salt dissolves in water but a salt does not separate by itself into pure salt and pure water.
4. (a) When a bottle of cold carbonated drink is opened. A slight fog forms around the opening. This is because of adiabatic expansion of gas causes lowering of temperature and condensation of water vapours.
5. (e) As isothermal processes are very slow and so the different isothermal curves have different slopes so they cannot intersect each other.
6. (d) Adiabatic compression is a rapid action and both the internal energy and the temperature increases.
7. (e) As there is no change in internal energy of the system during an isothermal change. Hence, the energy taken by the gas is utilised by doing work against external pressure. According to FLOT  $\Delta Q = \Delta U + P\Delta V$   
Hence  $\Delta Q = \Delta U = P\Delta V$   
Therefore, reason is true and assertion is false.
8. (d) We can change the temperature of a body without giving (or taking) heat to (or from) it. For example in an adiabatic compression temperature rises and in an adiabatic expansion temperature falls, although no heat is given or taken from the system in the respective changes.
9. (a)  $c = \frac{Q}{m\Delta\theta}$ ; a gas may be heated by putting pressure, so it can have values for 0 to  $\infty$ .  
 $C_p$  and  $C_v$  are its two principle specific heats, out of infinite possible values.  
In adiabatic process  $C = 0$  and in isothermal process  $C = \infty$ .
10. (a) Heat is similar to work in that both represent ways of transferring energy. Neither heat nor work is an intrinsic property of a system, that is, we cannot say that a system contains a certain amount of heat or work.
11. (d) According to first law of thermodynamics,  $\Delta Q = \Delta U + \Delta W = \Delta U + P\Delta V$ . If heat is supplied in such a manner that volume does not change  $\Delta V = 0$  i.e., isochoric process, then whole of the heat energy supplied to the system will increase internal energy only. But, in any other process it is not possible.  
Also heat may be absorbed or evolved when state of thermal equilibrium changes.
12. (d) When the door of refrigerator is kept open, heat rejected by the refrigerator to the room will be more than the heat taken by the refrigerator from the room (by an amount equal to work done by the compressor). Therefore, temperature of room will increase and so it will be warmed gradually. As according to 2<sup>nd</sup> law of thermodynamics, heat cannot be transferred on its own, from a body at lower temperature to another at higher temperature.
13. (a) Second law of thermodynamics can be explained with the help of example of refrigerator, as we know that refrigerator, the working substance extracts heat from colder body and rejects a large amount of heat to a hotter body with the help of an external agency i.e., the electric supply of the refrigerator. No refrigerator can ever work without external supply of electric energy to it.
14. (d) If an electric fan is switched on in a closed room, the air will be heated because due to motion of the fan, the speed of air molecules will increase. In fact, we feel cold due to evaporation of our sweat.

15. (c) The internal energy of system depends only on its temperature. In isothermal process temperature does not change, therefore, internal energy of the system remains the same.
16. (c) In an adiabatic process, no exchange of heat is permissible i.e.,  $\Delta Q = 0$ .

$$\text{As, } \Delta Q = \Delta U + \Delta W = 0 \Rightarrow \Delta U = -\Delta W.$$

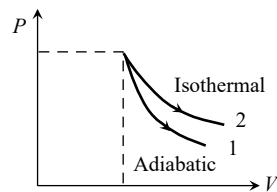
Also in adiabatic process, temperature of gas changes.

17. (a) Change in entropy,  $\Delta S = \frac{\Delta Q}{T}$ . In an adiabatic change, heat transfer  $\Delta Q = 0$ .  $\therefore \Delta S = 0$ , or  $S = \text{constant}$  i.e., entropy remains constant in an adiabatic process, or an adiabatic process is an isentropic process.
18. (b) As we know, in thermodynamic processes work done = Area covered by  $P$ - $V$  diagram with volume axis.

Hence, according to following graph.

$$(\text{Area})_1 < (\text{Area})_2 \Rightarrow W_{adi} < W_{iso}$$

Also in isothermal changes temperature remains same but in adiabatic



changes temperature also changes.

19. (c) First law of thermodynamics is restatement of the principal of conservation of energy as applied to heat energy.
20. (e) Zeroth law of thermodynamics explain the concept of temperature. According to which there exist a scalar quantity called temperature which is property of all thermodynamic system.
21. (b) Efficiency of cannot cycle  $\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$ , for Carnot engine when  $T_2$  decrease  $\eta$  increases.
22. (a) Entropy is a measure of the disorder or randomness of the system. Greater the randomness, greater the entropy.