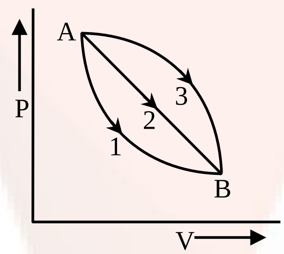
THERMODYNAMICS

MULTIPLE CHOICE QUESTIONS

1. In the following figure A certain mass of gas traces three paths 1,2 and 3 from state A to state B. If the work done by the gas along these paths are W_1, W_2 and W_3 respectively. Then -



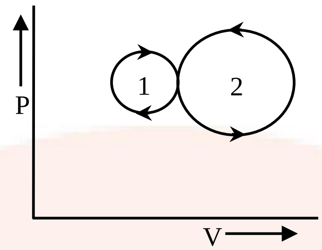
(A) $W_1 < W_2 < W_3$ (B) $W_1 > W_2 > W_3$

(C) $W_1 = W_2 = W_3$ (D) $W_1 < W_2$ but $W_3 < W_2$

EXPLANATION: A

The work done by the gas system depends upon the area enclosed between P-V curve and volume axis. The area enclosed by curve 3 is maximum and that enclosed by curve 1 is minimum. Hence $W_3 > W_2 > W_1$,

2. In the following indicator diagram (Figure), the net amount of work done will be -



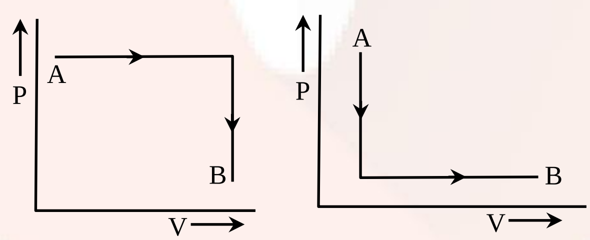
(A) Positive (B) negative

(C) Zero (D) infinity

Explanation: B

The cyclic process 1 is clockwise and the process 2 is anticlockwise. Therefore W, will be positive and W_2 will be negative. Area 2 > area 1, Hence the network will be negative.

3. In the following figure two indicator diagrams are shown. If the amounts of work done in them are W_1 and W_2 respectively, then –



(A) $W_1 > W_2$ (B) $W_1 < W_2$

(C) $W_1 = W_2$ (D) $W_1 = W_2/4$

Explanation: A

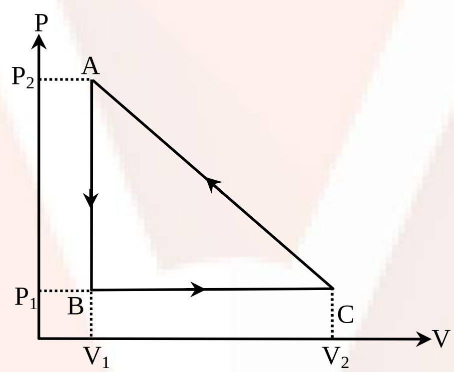
The area enclosed by first P-V curve is greater than that of by the second curve, Therefore, $W_1 > W_2$.

4. In the following figure the work done by the system in the enclosed path ABCA is

(A) $\frac{1}{2}(V_1 - V_2)(P_1 - P_2)$ (B) Zero

(C) $(P_2 - P_1)(V_2 - V_1)$ (D) $-\frac{1}{2}(P_2 - P_1)(V_2 - V_1)$

Explanation: D



Work done in closed path ABCA

$W_{ABCA} =$ Area of $\Delta ABC = \frac{1}{2} AB \times BC$

$W_{ABCA} = -\frac{1}{2}(P_2 - P_1)(V_2 - V_1)$

5. A lead bullet, when stopped by a target, just melts. If 25% of heat is absorbed by the target then the velocity of bullet will be if its initial temperature is 27ºC. Melting point of lead = 327ºC, specific heat of lead = 0.03 cal/gm/ºC, latent heat of fusion of lead = 6 cal/gm.

(A) 40.98 m/s (B) 409.8 m/s

(C) 4.098 m/s (D) 4098 m/s

Explanation: C

$Q = \frac{W}{J}$

$mL + ms(q_2 - q_1) = \frac{mv^2}{2J} \times \frac{75}{100}$

$\frac{75v^2}{2 \times 4.2 \times 10^7} = 6 + 0.03(327 - 27)$

$\therefore v^2 = 16.8 \times 10^8 \text{ (cm/s)}^2$

Taking square root $v = 4.098 \times 10^4$ cm/s.

$v = 4.098$ m/s.

6. A block of ice of mass 50 Kg. is pushed out on a horizontal plane with a velocity of 5 M/s. Due to friction it comes to rest after covering a distance of 25 meter. How much ice will melt ?

(A) 0.86 gm (B) 1.86 gm

(C) 100 gm (D) 1000 gm

Explanation: B

$m = \frac{W}{JL} = \frac{mv^2}{2JL} = \frac{50 \times 25}{2 \times 4.2 \times 80}$

$m = 1.86$ gm.

7. M kilograms of a material are to be kept in melted state at melting point and power required for this purpose is P. When the power source is disconnected then the sample completely solidifies in t second. The latent heat of fusion of the material will be -

(A) $\frac{M}{Pt}$ (B) $\frac{Pt}{M}$

(C) PtM (D) Pt

Explanation: B

Heat released in t second Q = ML ...(A)

Loss of heat per second $P = \frac{Q}{t}$ ...(B)

From equation (A) and (B) $P = \frac{ML}{t}$

$\therefore$ $L = \frac{Pt}{M}$

8. A bullet, moving with velocity v, is stopped by the target and then completely melts. If the mass of bullet is m, its specific heat is s, initial temperature is 25ºC, melting point is 475ºC and latent heat is L, then the velocity v is given by the relation —

(A) $mL = m(475 - 25) + \frac{mv^2}{2J}$

(B) $ms(475 - 25) + mL = \frac{mv^2}{2J}$

(C) $ms(475 - 25) + mL = \frac{2J}{mv^2}$

(D) $ms(475 - 25) = mL + \frac{2J}{mv^2}$

Explanation:

Θ W = JQ

W = $\frac{mv^2}{2}$ and Q = mL + ms ($\theta_2 - \theta_1$)

$\frac{mv^2}{2}$ = J [mL + ms ($\theta_2 - \theta_1$)]

$\frac{mv^2}{2}$ = mL + ms (475 – 25)

9. Isothermal curves are obtained by drawing –

(A) P against V (B) P against T

(C) PV against R (D) PV against V

Explanation: (A)

In an isothermal process, temperature remains constant and process equation is, PV = constant

So a graph is drawn between P and V.

10. The work done per mole in an isothermal process is –

(A) RT $\log_{10}\left(\frac{V_2}{V_1}\right)$ (B) RT $\log_{10}\left(\frac{V_1}{V_2}\right)$

(C) RT $\log_{e}\left(\frac{V_2}{V_1}\right)$ (D) RT $\log_{e}\left(\frac{V_1}{V_2}\right)$

Explanation: (C)

Work done is given by,

$\delta W = nRT \log_e \frac{V_2}{V_1}$

Form one mole

$\delta W = RT \log_e \frac{V_2}{V_1}$

11. dU = – dW is true for –

(A) Isothermal process (B) Adiabatic process

(C) Isobaric process (D) Isochoric process

Explanation: (B)

In an adiabatic process, heat cannot be exchanged between the system and surrounding so,

dQ = 0

By Ist law of thermodynamics

dQ = dU + dW

dU= –dW

12. An adiabatic change in represented by the equation –

(A) VP^{γ} = constant (B) PT^{γ} = constant

(C) TV^{γ} = constant (D) PV^{γ} = constant

Explanation: (D)

This is the actual process equation

PV^{γ} = constant

13. The internal energy of monatomic and diatomic gases are respectively due to

(A) Linear motion and rolling motion

(B) Rolling motion and linear motion

(C) Linear motion and rotatory motion

(D) Rotatory motion and linear motion

Explanation: (A)

The internal energy of a monatomic gas is due to linear motion only and that of the diatomic gas is due to rolling (linear rotatory) motion.

14. In the figure (A) indicator diagram, the net amount of work done will be :

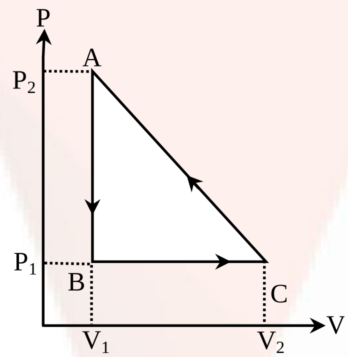


Figure-1

(A) Positive (B) Negative
(C) Zero (D) Infinity

Explanation: (B)

The cyclic process 1 is clockwise and the process 2 is anti-clockwise. Therefore w_1 will be positive and w_2 will be negative $area_2 > area_1$. Hence, the network will be negative.

15. In the figure (A) the work done by the system in the closed path ABCA is

(A) $(V_1 - V_2)(P_1 - P_2)$ (B) zero

(C) $\frac{1}{2}(P_1 - P_2)(V_1 - V_2)$ (D) $-\frac{1}{2}(P_1 - P_2)(V_1 - V_2)$

Explanation: (D)

Work done in closed path ABCA

W_{ABCA} = Area of ΔABC

$W_{ABCA} = \frac{1}{2} AB \times BC$

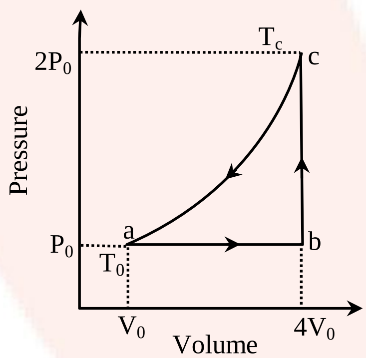
$W_{ABCA} = -\frac{1}{2}(P_1 - P_2)(V_1 - V_2)$

16. One mole of an ideal monatomic gas is caused to go through the cycle shown in fig. then the change in the internal energy in expanding the gas from a to c along path abc is

(A) $3P_0V_0$ (B) $6RT_0$

(C) 4.5 RT_0 (D) 10.5 RT_0

Explanation: (D)



$\Theta \frac{PV}{T} = nR$ = constant

For any state of an ideal gas. Therefore

$\frac{P_aV_a}{T_a} = \frac{P_cV_c}{T_c}$ or $\frac{P_0V_0}{T_0} = \frac{2P_0 4V_0}{T_C}$

$T_C = 8T_0$

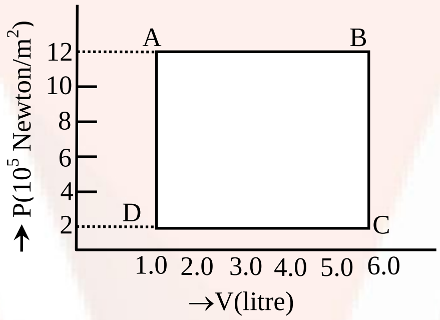
Thus change in internal energy

$\Delta U = nC_V\Delta T$

$= 1 \times \frac{3}{2} \times R \times 7T_0 = \frac{21}{2}RT_0$

$= 10.5\ RT_0$

17. The diagram shows a P-V graph of the thermodynamic behavior of an ideal gas. Find to this graph work done in processes A → B, B → C, C → D and D → A



(A) 6000 J, 0, 1000J, 0

(B) 5000 J, 0, 0, 1000 J

(C) 0, 0, 6000J, 1000J

(D) 6000J, 0, 1000J, 1000J

Explanation: (A)

The work done in a thermodynamic process is equal to the area enclosed between the P-V curve and the volume axis.

Work done by the gas in the process A → B is

W_1 = area ABB'A' = AB × A' × A

$\therefore W_1 = (6.0 - 1.0)$ litre × (12×10^5) Nxm^2

$\Rightarrow W_1 = 5.0 \times 10^{-3}\ m^3 \times 12 \times 10^5\ N/m^2$

$\Rightarrow W_1 = 6000$ N-m = 6000J

Work done in the process B $\rightarrow$ C is zero since volume remains constant.

Work done on the gas in the procces C $\rightarrow$ D is

W_2 = area DCB'A'

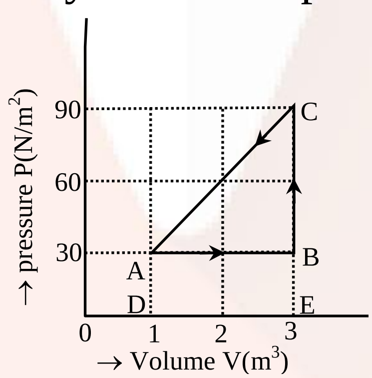
$W_2 = DC \times AD' = (5 \times 10^{-3}) \times (2 \times 10^5) = 1000J$

Work done in the process D $\rightarrow$ A is also zero.

18. The figure shows the change in a thermodynamic system is going from an initial state A to the state B and C and returning to the state A. if $U_A = 0$, $U_B = 30J$ an the heat given to the system in the process B $\rightarrow$ C, 50J, then determine:

(i) internal energy in the state C

(ii) heat given to the system in the process A □ B



(A) 80J, 90J | (B) 120J, 60J
(C) 90J, 80J | (D) 50J, 60J

Explanation: (A)

Work done in the process B $\rightarrow$ C, W = 0

Θ Volume is constant and heat given to the system

Q = 50J (given)

Hence, by the first law of thermodynamics, the change in the internal energy is

$\Delta U = (U_C - U_B) = Q - W = 50J$

$\Theta \quad = U_C = U_B + \Delta U = 30 + 50 = 80J$

(ii) For the process $A \rightarrow B$, $\Delta U = U_B - U_A$

= 30Joule and W = area ABCD = DE × DA

= 2 x 30 = 60J

$\therefore$ $Q = \Delta U + W = 30 + 60 = 90J$

$\therefore$

19. In the above question find out heat given to the system or taken out from the system in the process $C \rightarrow A$ and network done in complete cycle.

(A) – 200J, 50J (B) – 200J, 60J

(C) 60J, – 200J (D) +200J , – 69J

Explanation: (B)

For the process $C \rightarrow A$, $\Delta U = U_A - U_C = 0 - 80$

$\Rightarrow \Delta U = -80J$

and W = area ACED = area ACB + area ABED

$\therefore W = (\frac{1}{2} \times AB \times BC) + (DE \times DA)$

$\therefore W = (\frac{1}{2} \times 2 \times 60) + (2 \times 30) = 120\ J$

Since, in this process the volume decreases, the work will be negative (w=120Joule). That is, the work will be done on the system. Now, by the first law of thermodynamics, will have

$Q = \Delta U + W = -80 - 120 = -200J$

Since it is negative, this heat is given out by the system and work done in the whole cycle

$= \text{area ABC} = \frac{1}{2} \times 2 \times 60 = 60J$

Since, the cyclic process is traced anticlowise, the net work will be done on the system.

20. An ideal gas expands from state (P_1, V_1) to state (P_2, V_2) where $P_2 = 2P_1$ and $V_2 = 2V_1$. The path of the gas is expressed by the following relation

$P = P_1\left[1+\left(\frac{V-V_1}{V_1}\right)^2\right]$ work done is

(A) P_1V_1 (B) 4/3 P_1V_1

(C) $2P_1V_1$ (D) 4 P_1V_1

Explanation: (B)

$$W = \int_{V_1}^{2V_1} PdV \int_{V_1}^{2V_1} P_1\left[1+\left(\frac{V-V_1}{V_1}\right)^2\right]dV$$

$$\Rightarrow W = P_1\int_{V_1}^{2V_1}\left(1+\frac{V^2+V_1^2-2VV_1}{V_1^2}\right)dV$$

$$\Rightarrow W = P_1\left[2V+\frac{V^3}{3V_1^2}-\frac{2V^2}{2V_1}\right]_{V_1}^{2V_1}$$

$$\Rightarrow W = 4/3\ P_1V_1$$

21. A Carnot engine takes 103 kilocalories of heat from a reservoir at 627ºC and exhausts it to a sink at 27ºC. The efficiency of the engine will be

(A) 22.2% (B) 33.3%

(C) 44.4% (D) 66.6%

Explanation: (D)

Efficiency of Carnot engine

$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{900} = 2/3$

$\therefore \eta = 66.6\ \%$

22. From the relation Cp-Cv = $\frac{R}{J}$ it is inferred that

(A) the gas is monatomic

(B) gas is diatomic

(C) gas obeys ideal gas equation irrespective of whether it is mono or diatomic

(D) gas is monatomic and it can be ideal or real

Explanation: (C)

Gas obeys ideal gas equation irrespective of whether it is mono or diatomic.

INTEGER TYPE QUESTIONS

23. 3000 J of heat is given to a gas at constant pressure of 2×10^5 N/m^2. If its volume increases by 10 litres during the process find the change in the internal energy of the gas.

Explanation:

$\Delta Q = 3000$ J

$W = P \Delta V = (2 \times 10^5 \text{ N/m}^2)(10 \times 10^{-3} \text{ m}^3) = 2 \times 10^3$ J

$\Delta U = \Delta Q - W = 3000 - 2000 = 1000$ J.

24. The normal temperature of human body is 98.6°F what is this temperature in Celsius degrees ?

Explanation:

$t^oC = \frac{5}{9}(t^oF - 32^o)$

$= \frac{5}{9}(98.6^o - 32^o) = \times 66.6^o$

$= 37^oC$

25. For what value is the Fahrenheit temperature equal to the Celsius temperature?

Explanation:

Let x °F = x °C , then using it in

$t\ ^oC = \frac{5}{9}(t\ ^oF - 32^o)$

$x = \frac{5}{9}(x - 32)$

or $9x = 5x - 160$

or $x = -40$

Thus, – 40 ºC = 40 ºF

26. Water fall from a height 50m. If one third its mechanical energy converted into heat what will be the rise in temperature of water.

Explanation:

$\frac{1}{3}\frac{M\times10\times50}{J}$ = M × 10^3 × Δθ [Θ S_{water} = 10^3 cal/kg ºC]

Δθ = $\frac{500}{3\times4.2\times10^3}$ ⇒ Δθ = 0.04ºC

27. A man got 100 Kcal heat from its lunch. Its efficiency is only 25% and mass of man is 60 kg. Calculate the height he can acquire.

Explanation:

$\frac{50}{100}$ × 100 × 10^3 = Mgh

⇒ 25 × 10^3 = $\frac{60\times10\times h}{4.2}$

⇒ h = $\frac{25\times10\times4.2}{6}$ = 175m

28. A 63 gm bullet moving velocity 200 m/s. Collides against a wall consequently two third of it's kinetic energy is converted into heat. Than what will be the heat developed by bullet in calorie. (Given: J = 4.2)

Explanation:

Q = $\frac{2}{3}\times\left(\frac{1}{2}\frac{mv^2}{J}\right)=\frac{2}{3}\times\frac{1}{2}\frac{(0.063)(200)^2}{4.2}$ = 200 cal.

29. A body of mass 2kg is dragged on a horizontal surface with a constant speed of 2 m/s. If the coefficient of friction between the body and the surface is 0.2, then find the heat generated in 5 sec.

Explanation:

The work done against the force of friction

$= \mu R \times \text{displacement} = 0.2 \times 2 \times 9.8 \times 2$ (in one second)

$= (0.2 \times 2 \times 9.8 \times 2) \times 5$ (in 5 second)

$= 39.2\,J$

Heat generated $= \frac{39.2}{4.2} = 9.33$ cal

30. The height of a water spring is 50m. The difference of temperatures at the top and bottom of the spring will be

Explanation:

$mgh = ms\Delta\theta$

$\Delta\theta = \frac{gh}{s} = \frac{9.8 \times 50}{4.2 \times 10^3} = 0.117^o C$