8 Thermodynamics

Thermal Equilibrium

When temperature of system A and system B becomes equal, then heat exchanged between them becomes zero. It is said that thermal equilibrium has been established between system A and system B.

Zeroth law of thermodynamics

When system A and system B are in thermal equilibrium with a third system C then system A and B are said to be in thermal equilibrium with each other.

$$\left.\begin{array}{l} T_A = T_C \\ T_B = T_C \end{array}\right\} \Rightarrow T_A = T_B$$

Thermal Expansion

Thermal Expansion		
Linear expansion (1- dimensional)	**Surface expansion (2-dimensional)**	**Volume expansion (3-dimensional)**
- Change in length takes place.	- Change in length and breadth takes place.	- Change in length, breadth and height takes place. (photographic enlargement)
- $\Delta l = \alpha l \Delta T$ $\alpha = \frac{\Delta l}{l \Delta T}$ α = Coefficient of linear expansion Unit : α = °C^{-1} or K^{-1}	$\Delta A = \beta A \Delta T$ $\beta = \frac{\Delta A}{A \Delta T}$ β = Coefficient of surface expansion $\beta = 2\alpha$ Unit : °C^{-1} or K^{-1}	$\Delta V = \gamma V \Delta T$ $\gamma = \frac{\Delta V}{V \Delta T}$ γ = Coefficient of volume expansion $\gamma = 3\alpha$ Unit : °C^{-1} or K^{-1}

Percentage change in density due to volume expansion :

$$\frac{\rho - \rho_0}{\rho_0} = \frac{\gamma \Delta T}{1 + \gamma \Delta T}$$

Relation between different scales of temperature :

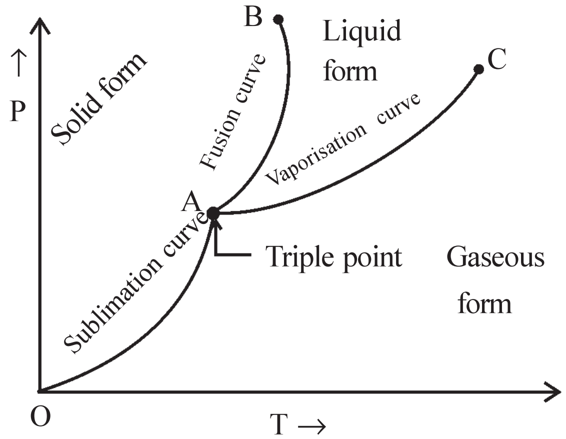
(1) Celsius and kelvin : $T_C = T_k - 273$

(2) Fahrenheit and celsius : $T_F = \frac{9}{5} T_C + 32$

(3) Fahrenheit and kelvin : $T_F = \frac{9}{5} [T_k - 273] + 32$

Phase diagram :

Graph of P $\rightarrow$ T for any substance is called its phase diagram.



Curve OA : Sublimation curve. Solid and gaseous form coexists.

Curve AB : Fusion curve. Solid and liquid form coexists.

Curve AC : Vaporisation curve. Liquid and gaseous form coexists.

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(1) A gas thermometer is used to measure temperature. When it is dipped in water, triple point temperature is 273.16 K and pressure is 3×10^4 Nm^{-2}. When this gas thermometer is dipped in some other liquid, pressure indicated is 3.5×10^4 Nm^{-2} then the new temperature will be ....

(A) 54.6 K (B) 45.6 K (C) 54.6 °C (D) 45.6 °C

(2) There are two similar metal strips one of copper and other of brass. Here $\alpha_B > \alpha_C$. On increasing temperature by ΔT, both strips form an arc of radius R. Then R ....

(A) d $(\alpha_B - \alpha_C)\Delta T$ (B) $\frac{d^2}{(\alpha_B - \alpha_C)\Delta T}$ (C) $\frac{d}{(\alpha_B - \alpha_C)\Delta T}$ (D) $\frac{(\alpha_B - \alpha_C)\Delta T}{d^2}$

(3) On adding steam to 100 g water, temperature of water increases from 24°C to 90°C. How much steam should be added ?

(A) 25 g (B) 12 g (C) 21 g (D) 100 g

(4) In a temperature scale "A", melting point of water is shown as –160° A and boiling point of water as –50° A then in its scale, temperature 340 K will be shown as ....

(A) –86.3 °A (B) +86.3 °A (C) –86.3 °K (D) –86.3 °C

(5) In a thermometer, if melting point of water is 20 °C and boiling point of water is 150 °C then 50 °C will be shown in this thermometer as ....

(A) 85 °C (B) –85 °C (C) 58 °C (D) –58 °C

(6) Mass of ice at –20 °C temperature is 1200 g. To completely melt it, how much steam at 100 °C will be required ?

Here, specific heat of ice S = 0.5 cal g^{-1} $°C^{-1}$

specific heat of water S = 1 cal g^{-1} $°C^{-1}$

Latent heat of ice L = 80 cal g^{-1}

Latent heat of steam L = 540 cal g^{-1}

(A) 18.75 kg (B) 18.75 g (C) 1.875 kg (D) 1.875 g

(7) A copper sphere of mass 1 kg is heated upto 500 °C and then placed on a big piece of ice at 0 °C then how much ice will melt ?

[specific heat of copper S = 400 Jkg^{-1} $°C^{-1}$, latent heat of ice L = 3.5 $\times 10^5$ Jkg^{-1}]

(A) 0.57 kg (B) 570 gm (C) 5.7 kg (D) 57 kg

(8) On heating a metal sphere to temperature 60 °C, its volume increases by 0.12 % then coefficient of linear expansion of metal wil be ....

(A) 6.66×10^{-6} $°C^{-1}$ (B) 66.6×10^{-6} $°C^{-1}$ (C) 5.56×10^{-5} $°C^{-1}$ (D) 55.6×10^{-6} $°C^{-1}$

(9) Co-ordinate of triple point of water is ....

(A) 4.58 mm-Hg, 273.16 K (B) 4.58 mm-Hg, 0 K

(C) 5.58 m-Hg, 273.16 K (D) 5.58 mm-Hg, 0 K

(10) For values of pressure and temperature at triple point, ... forms of matter coexists in equilibrium.

(A) Gas and liquid (B) Solid and gas (C) Solid and liquid (D) All three

(11) Relation between temperature in Fahrenheit (T_F) and in Celsius (T_C) is ....

(A) $T_F = \frac{5}{9} T_C - 32$ (B) $T_F = \frac{9}{5} T_C + 32$

(C) $T_F = \frac{5}{9} T_C + 32$ (D) $T_F = \frac{9}{5} T_C - 32$

(12) Temperature difference of 10 °C is equal to ...... temperature difference.

(A) 10 °F (B) 20 °F (C) 50 °F (D) 40 °F

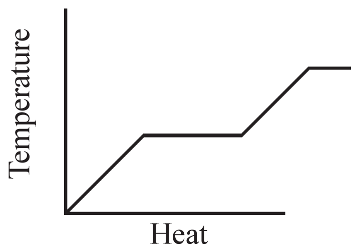
(13) Temperature of body of a patient is 40° C. It would be ...... in Fahrenheit scale.

(A) 100 °F (B) 101 °F (C) 102 °F (D) 104 °F

(14) If temperature of a substance changes by 20° C then change in kelvin scale will be ....

(A) 293 K (B) 20 K (C) 293 °F (D) –20 °C

(15) Ice at –5 °C temperature is heated slowly till it converts into steam at 100°C. Which of the following graph shows this entire process ?

(A)


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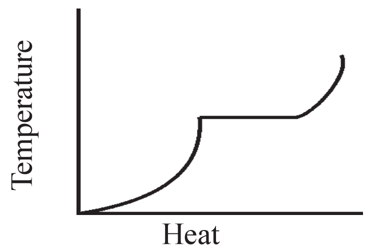
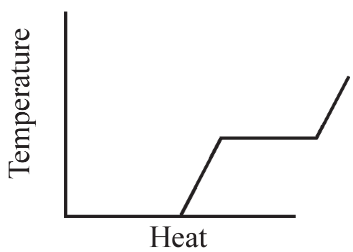
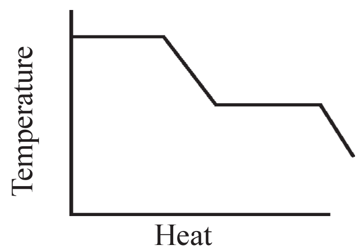


(C)


(D)


Heat on X-axis Temperature on Y-axis

(16) A metal sphere of radius R and having specific heat S is rotating with angular speed f rotation/sec about an axis passing through its centre. Now, on stopping it suddenly, its 50 % energy is used in increasing its temperature then the equation giving increase in temperature of sphere will be ΔT = ...

(A) $\frac{2}{5}\ \frac{S}{\pi^2 R^2 f^2}$ (B) $\sqrt{\frac{2}{5}}\ \frac{\pi R^2 f^2}{S}$ (C) $\sqrt{\frac{2}{5}}\ \frac{\pi^2 R f}{S^2}$ (D) $\frac{2}{5}\ \frac{\pi^2 R^2 f^2}{S}$

(17) Heat capacity of aluminium piece of mass 100 g is .... (specific heat S = 0.2 cal g^{-1} $°C^{-1}$)

(A) 4.4 J °C (B) 44 J °C (C) 4.4 J $°C^{-1}$ (D) 44 J $°C^{-1}$

(18) At triple point of water, temperature measured in Celsius scale will be ...... °C.

(A) 0 (B) –273.16 (C) 100 (D) 0.01

(19) At atmospheric pressure, when equilibrium is established between pure water and its vapour, temperature is taken ...... K.

(A) 100 (B) 273.15 (C) 373.15 (D) 273.16

(20) Value of absolute zero temperature in fahrenheit scale is ...... °F.

(A) 0 (B) –273.15 (C) –459.67 (D) –356.67

(21) At which temperature does value on °C scale and °F scale becomes same ?

(A) 0 (B) 40 (C) –40 (D) 32

(22) At which temperature density of water is maximum ?

(A) 32 °F (B) 39.2 °F (C) 42 °F (D) 4 °F

(23) At which temperature does coefficient of volume expanssion of water becomes zero ?

(A) 0 °C (B) 4 °C (C) 15.5 °C (D) 100 °C

(24) Ratio of heat required to raise temperature of two copper spheres of radii R_1 and R_2 by 1K is .... Here $R_1 = 2R_2$

(A) $\frac{8}{27}$ (B) $\frac{27}{8}$ (C) $\frac{8}{1}$ (D) $\frac{1}{8}$

(25) A thermodynamic system moves in states (i) from P_1, V to $2P_1$, V and (ii) P_1, V_1 to P_1, $2V_1$ work done in both cases is ....

(A) 0, 0 (B) 0, P_1V_1 (C) PV_1 , 0 (D) PV_1 , P_1V_1

(26) 100 g pure water is heated from 25°C to 50°C temperature. If we neglect expansion of water, change in internal energy will be ....

(specific heat of water = 4184 J kg^{-1} K^{-1})

(A) 1046.00 cal (B) 10460 cal (C) 1046.00 J (D) 10460 J

(27) For isothermal process of an ideal gas, $\frac{dP}{P}$ = ...

(A) $-\gamma\ \frac{dV}{V}$ (B) $-\frac{dV}{V}$ (C) $-\sqrt{\gamma}\ \frac{dV}{V}$ (D) $-\gamma^2\ \frac{dV}{V}$

(28) For adiabetic process of an ideal gar $\frac{dP}{P}$ = ...

(A) $-\gamma \frac{dV}{V}$ (B) $-\frac{dV}{V}$ (C) $-\sqrt{\gamma} \frac{dV}{V}$ (D) $-\gamma^2 \frac{dV}{V}$

(29) Amount of heat required to raise temperature of a substance by 1° C is called ....

(A) Water equivalent (B) Heat capacity (C) Entropy (D) Specific heat

(30) Unit of coefficient of linear expansion is ....

(A) °C (B) $°C^{-1}$ (C) m °C (D) m $°C^{-1}$

(31) Length of a metal rod is 50 cm. On increasing its temperature by 100 °C, how much increase in its length takes place ? (for metal, $\alpha = 1.1 \times 10^{-5}\ °C^{-1}$)

(A) 5.5×10^{-2} m (B) 5.5×10^{-2} cm (C) 5.5×10^{-3} m (D) 5.5×10^{-3} cm

(32) Radius of a circular disc made of copper is 10 cm and there is a hole of radius 1 cm at its center. On heating the dics, area of hole ....

(A) increases (B) decreases

(C) does not change (D) hole will be destroyed

(33) 5 mole gas at temperature 20 °C is adiabetically compressed at pressure 1 atm such that its volume becomes tenth part of its original volume then final temperature is ....

(A) 736 K (B) 846 K (C) 736 °C (D) 523.5 K

(34) An ideal gas having volume 3 Litre and pressure 20 atm is isothermally expanded to make volume 24 L. Work required is ....

(A) 15600 J (B) 12600 J (C) 13750 J (D) 12.600 J

(35) A crystal has coefficient of linear expansion in one direction as "a" and in all perpendicular direction coefficient of linear expansion is "b". Then coefficient of volume expansion for this crystal becomes ....

(A) 2a + b (B) a + 3b (C) a + 2b (D) 3a + b

(36) For adiabetic process of an ideal gas, relation between pressure and temerature is ....

(A) $P^{\gamma} T^{\gamma-1}$ = constant (B) PV^{γ} = constant

(C) PV = constant (D) $P^{1-\gamma} T^{\gamma}$ = constant

(37) Dimensional equation of γ in equation PV^{γ} = constant for adiabetic process is ....

(A) $M^0L^1T^{-1}$ (B) $M^1L^1T^0$ (C) $M^1L^0T^1$ (D) $M^0L^0T^0$

(38) On adiabetically compressing a gas at 1 atm pressure, its volume becomes half of original volume then new pressure will be ...... m – Hg. [$\gamma = 1.4$]

(A) $\frac{0.76}{(2)^{1.4}}$ (B) $0.76 \times (2)^{1.4}$ (C) $7.6 \times (2)^{0.4}$ (D) $0.76 \times (2)^{0.4}$

(39) Temperature of a substance on kelvin scale is T K and same temperature on fahrenheit scale is T°F then T = ...

(A) 40 (B) 313 (C) 574.25 (D) 301.25

(40) Air inside tyre of vehicle has pressure 4 atm and temperature 27 °C. Suddenly tyre bursts, then new temperature of air becomes .... [$\gamma = \frac{7}{5}$]

(A) $300(4)^{\frac{-2}{7}}$ (B) $400(3)^{\frac{-2}{7}}$ (C) $300(4)^{\frac{2}{7}}$ (D) $400(3)^{\frac{2}{7}}$

(41) 95 K temperature on kelvin scale is equivalent to ...... on fahrenheit scale.

(A) –288° F (B) –146° F (C) –338° F (D) 178° F

(42) On heating a metal wire, its length increases by 2 % then increase in its area of cross-section is ....

(A) 1 % (B) 2 % (C) 3 % (D) 4 %

(43) A glass beaker at 4 °C temperature is completely filled with water and kept in a fridge. Now, its temperature goes below 4 °C, then ....

(A) water will come out.

(B) no change in level of water.

(C) water will go in the beaker.

(D) water will initially go inside and then come out.

(44) A long rod of $L_A + L_B$ is made by joining rod having length L_A and L_B of metal A and B respectively. Coefficient of linear expansion of A and B are α_A and α_B respectively. When temperature of rods are increased up to T °C, change in length of every rod is equal, then ratio $\frac{L_A}{L_A + L_B}$ = ... (α_C acoefficient of combine linear expansion).

(A) $\frac{\alpha_C}{\alpha_A}$ (B) $\frac{\alpha_A}{\alpha_C}$ (C) $\alpha_A \cdot \alpha_C$ (D) $\alpha_A + \alpha_B$

(45) Two thermometers-one having celsius scale and other having fahrenheit scale, are kept in a hot substance showing 212° F temperature. When fahrenheit thermometer shows temperature 140 °C then celsius thermometer will shows decrease in temperature by ....

(A) 40° (B) 30° (C) 60° (D) 80°

(46) Length of a metal wire at 30 °C temperature is 30 cm then its length at 10 °C temperature is ....

($\alpha = 11 \times 10^{-6}$ °C^{-1})

(A) 30 cm (B) 29.99 cm (C) 30.10 cm (D) 29.10 cm

(47) Efficiency of carnot engine at temperature (i) 100 K and 500 K and (ii) T K and 900 K are same. Then value of T = ...

(A) 250 K (B) 280 K (C) 200 K (D) 180° K

(48) On increasing temperature of a metal sphere upto 30 °C, its volume increases by 0 0.30 % then coefficient of its volume expansion (γ) will be ....

(A) 0.00003 °C^{-1} (B) 0.0003 °C^{-1} (C) 0.0001 °C^{-1} (D) 0.001 °C^{-1}

(49) In thermal expansion, ratio of coefficient of linear expansion (α), coefficient of surface expansion (β) and coefficient of volume expansion (γ) is ....

(A) 3 : 2 : 1 (B) 2 : 3 : 1 (C) 1 : 2 : 3 (D) 1 : 3 : 2

(50) Amount of heat required to convert substance of unit mass from solid state to liquid state at constant temperature is called ....

(A) Heat energy (B) Latent heat of fusion (C) Specific heat (D) Internal energy

(51) Depending on phase diagram, match the following :

Column-1		Column-2	
(a)	Solid and gaseous form of substance coexists	P	Sublimation curve
(b)	Liquid and gaseous form of substance coexists	Q	Fusion curve
(c)	Solid and liquid form of substance coexists	R	Triple point
(d)	All three forms of substance coexists	S	Vaporisation curve

(A) $a \rightarrow S$; $b \rightarrow R$; $c \rightarrow P$; $d \rightarrow Q$ (B) $a \rightarrow P$; $b \rightarrow S$; $c \rightarrow Q$; $d \rightarrow R$

(C) $a \rightarrow Q$; $b \rightarrow P$; $c \rightarrow S$; $d \rightarrow R$ (D) $a \rightarrow R$; $b \rightarrow Q$; $c \rightarrow P$; $d \rightarrow S$

Ans. : 1 (D), 2 (C), 3 (B), 4 (A), 5 (A), 6 (B), 7 (A), 8 (A), 9 (A), 10 (D), 11 (B), 12 (C), 13 (D), 14 (B), 15 (A), 16 (D), 17 (D), 18 (D), 19 (C), 20 (C), 21 (C), 22 (B), 23 (B), 24 (D), 25 (B), 26 (D), 27 (B), 28 (A), 29 (B), 30 (B), 31 (B), 32 (A), 33 (A), 34 (B), 35 (C), 36 (D), 37 (D), 38 (B), 39 (C), 40 (A), 41 (A), 42 (D), 43 (A), 44 (A), 45 (A), 46 (B), 47 (D), 48 (C), 49 (C), 50 (B), 51 (B)

1st law of thermodynamics :

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

where,

(A) ΔU = Change in internal energy of system

$\rightarrow$ depends only on initial and final state of system.

$\rightarrow$ If temperature of system increases, ΔU = positive

$\rightarrow$ If temperature of system decreases, ΔU = negative

$\rightarrow$ It is a function depending only on temperature of system

(B) ΔQ = Change in heat energy of system

$\rightarrow$ If heat given to system, ΔQ = positive

$\rightarrow$ If heat lost by system, ΔQ = negative

(C) ΔW = Work done

$\rightarrow$ If work done by system (its volume increases), ΔW = positive

$\rightarrow$ If work done on system (its volume decreases), ΔW = negative

1st law of thermodynamics for different processes :

(A) Isothermal process :

- Temperature remains constant during entire process.
- $\Delta T = 0 \Rightarrow \Delta U = 0$

$\therefore 0 = \Delta Q - \Delta W$

$\boxed{\therefore \Delta Q = \Delta W}$

- Boyle's law : PV = constant
- Work done $W = \Sigma P\Delta V = \int PdV$

$$W = \mu RT \ln\left(\frac{V_2}{V_1}\right) = \mu RT \ln\left(\frac{P_1}{P_2}\right)$$

$$= 2.303\ \mu RT \log\left(\frac{V_2}{V_1}\right) = 2.303\ \mu RT \log\left(\frac{P_1}{P_2}\right)$$

(B) Adiabetic Process :

- Exchange of heat energy between system and surrounding $\Delta Q = 0$
- $\Delta U = -\Delta W$

  $\therefore$ if work done by system, ΔU = negative

  & if work done on system, ΔU = positive

- Work done $W = \Sigma P\Delta V = \int PdV$

$$W = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} = \frac{\mu R (T_1 - T_2)}{\gamma - 1}$$

- **Relation between P, V and T :**

PV^{γ} = constant, $TV^{\gamma-1}$ = constant, $TP^{\frac{1-\gamma}{\gamma}}$ = constant

(C) Isobaric process :

- Pressure of system remain constant
- $\Delta P = 0$

(D) Isochoric process :

- Volume of system remains constant
- $\Delta V = 0$

  $\therefore W = P(\Delta V) = P(0) = 0$

  $\therefore \Delta U = \Delta Q$

(E) For isolated system :

- $\Delta Q = 0 \Rightarrow \Delta U = 0 \Rightarrow U$ = constant

  $\Delta W = 0$

- **Heat capacity :**

$H_C = \frac{\Delta Q}{\Delta T}$ Unit : $\frac{cal}{°C}$; $\frac{J}{K}$

- Depends on type and mass of substance.
- **Specific heat :**

$C = \frac{H_C}{m} = \frac{\Delta Q}{m\Delta T}$ [for solid and liquid]

- depends only on type of substance

  Unit : $\frac{\text{cal}}{\text{g °C}}$; $\frac{\text{J}}{\text{kg K}}$

- **Specific heat of gas at constant volume (C_V) :**

  $$C_V = \left(\frac{\Delta Q}{\mu \Delta T}\right)_{v\,=\,\text{constant}} = \frac{fR}{2}$$

- **Specific heat of gas at constant pressure (C_P) :**

  $$C_P = \left(\frac{\Delta Q}{\mu \Delta T}\right)_{P\,=\,\text{constant}} = \left(1+\frac{f}{2}\right)R = \frac{fR}{2} + R$$

- **Relation between C_P and C_V :**

  $C_P - C_V = R$ (for ideal gas)

  $$\gamma = \frac{C_P}{C_V} = \frac{f+2}{f} = 1 + \frac{2}{f}$$

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(52) During a thermodynamic process, 1000 J heat is lost on doing 100 J work. Thus, change in its internal energy will be ....

(A) –900 J (B) +900 J (C) +1100 J (D) –1100 J

(53) In a thermodynamics process, on changing pressure of gas, it releases 200 J heat and 100 J work is done on it. If initial internal energy of system is 10 J then final internal energy will be ....

(A) 290 J (B) 90 J (C) –290 J (D) –90 J

(54) 420 J work is done on a system, then change in its internal energy is ...... cal.

(A) 420 (B) +100 (C) –420 (D) –100

(55) For hydrogen gas, C_P = 3400 cal $kg^{-1}\,°C^{-1}$ and C_V = 2400 cal $kg^{-1}\,°C^{-1}$. Work required to increase temperature of hydrogen gas from 30° C to 40° C at constant pressure is ...... J if mass of hydrogen gas is 10 kg.

(A) 100 cal (B) 1000 cal (C) 100000 cal (D) 10 cal

(56) If temperature of 100 m^3 gas at 1 atm pressure is increased from 27° C to 627° C adiabetically, then final pressure will be .... (Take γ = 1.5)

(A) 27 atm (B) 2.7 atm (C) 270 atm (D) 2700 atm

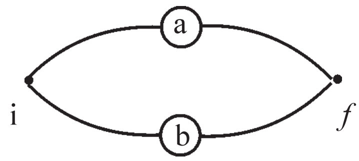
(57) Heat Q is given to a diatomic (rigid rotator) gas at constant pressure then work done by gas is ....

(A) $\frac{2}{3}$ Q (B) $\frac{3}{2}$ Q (C) $\frac{2}{7}$ Q (D) $\frac{7}{2}$ Q

(58) When a system is taken from initial state (i) to find state (f) through path iaf, Q = 500 cal and W = 100 cal is needed. When system is taken through path ib$f$, Q = 2000 cal then W = ... on path ibf.

(A) 1400 cal (B) 1900 cal

(C) 1600 cal (D) 1500 cal



(59) For an ideal gas, specific heat at constant pressure is $\frac{7}{2}$R then ratio of specific heats at constant pressure to that at constant volume is ....

(A) $\frac{5}{7}$ (B) $\frac{7}{5}$ (C) $\frac{9}{7}$ (D) $\frac{7}{9}$

(60) 5.6 L Helium gas at STP is adiabetically compressed to volume 0.7 L. If initial temperature is T_1 then work done during the process is ....

(A) $\frac{3}{2}RT_1$ (B) $\frac{9}{2}RT_1$ (C) $\frac{8}{9}RT_1$ (D) $\frac{9}{8}RT_1$

(61) During adiabetic process, relation between pressure and volume is $P^3 \propto \frac{1}{V^4}$ then ratio of specific heat is ....

(A) 1.80 (B) 1.33 (C) 1.67 (D) 1.42

(62) On expanding 10 mole ideal gas at 100 K constant temperature, its volume increases from 10 L to 20 L. Work done during this process is ....

(A) 5763 J (B) 5673 J (C) 57.63 J (D) 567.3 J

(63) Work done during adiabetic compression of 1 kilo mole gas is 146 kJ. During this process, its temperature increases by 7 °C. This gas will be .... ($R = 8.3\ Jmol^{-1}\ k^{-1}$)

(A) Monoatomic (B) Diatomic (C) Triatomic (D) Polyatomic

(64) Coefficient of volume expansion of glycerine is $49\times10^{-5}\ °C^{-1}$. On increasing its temperature by 20 °C, percentage decreases in its density is ....

(A) 10 % (B) 0.98 % (C) 1 % (D) 9.8 %

(65) If γ is ratio of specific heats and R is gas constant then molar specific heat at constant pressure C_P = ...

(A) $\frac{\gamma R}{\gamma+1}$ (B) $\frac{R}{\gamma+1}$ (C) $\frac{\gamma R}{\gamma-1}$ (D) $\frac{R}{\gamma-1}$

(66) If γ is ratio of specific heats and R is gas constant then molar specific heat at constant volume C_v = ...

(A) $\frac{\gamma+1}{R}$ (B) $\frac{\gamma-1}{R}$ (C) $\frac{R}{\gamma+1}$ (D) $\frac{R}{\gamma-1}$

(67) During an adiabetic process, pressure of a gas is directly proportional to cube of its temperature. Then for this gas γ = ...

(A) $\frac{3}{2}$ (B) $\frac{5}{3}$ (C) $\frac{7}{5}$ (D) $\frac{5}{7}$

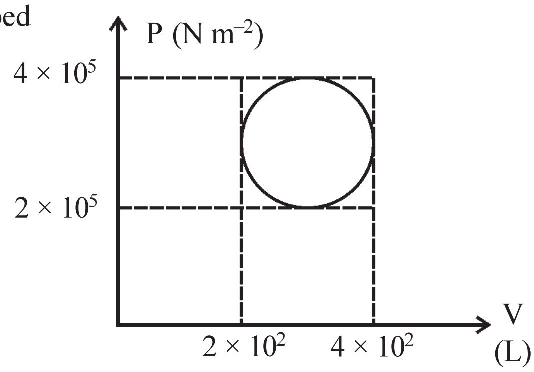
(68) 1 mole ideal gas at temperature T_1 K does 6R J work adiabetically. If $\gamma = \frac{5}{3}$ then final temperature of gas is ....

(A) $(T_1 + 4)$ K (B) $(T_1 - 4)$ K (C) $(T_1 + 8)$ K (D) $(T_1 - 8)$ K

(69) Latent heat of vaporisation for water is 2240 J. If energy required to vaporize 1 g water is 168 J then change in internal energy is ....

(A) 2408 J (B) 2240 J (C) 2072 J (D) 1904 J

(70) For cyclic process shown in figure, net heat absorbed by system in every cycle is ....

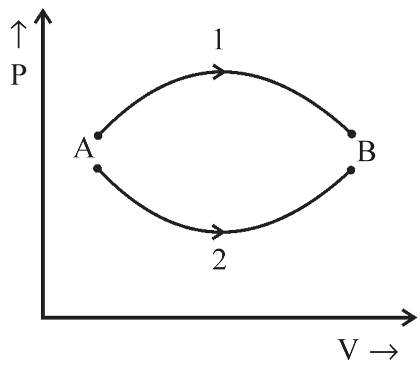


(A) 10 π unit

(B) π unit

(C) 100 π unit

(D) π^2 unit

(71) 

In the figure, ideal gas 1 and 2 move from state A to state B by different path. If change in internal energy for path 1 and 2 are $(\Delta U_{int})_1$ and $(\Delta U_{int})_2$ then ....

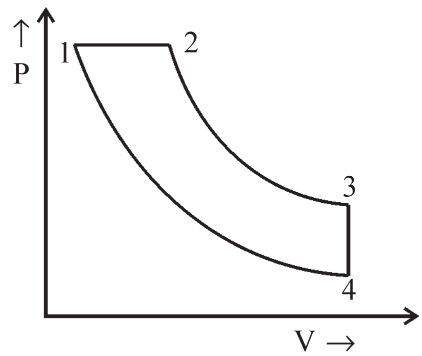
(A) $(\Delta U_{int})_1 = (\Delta U_{int})_2$

(B) $(\Delta U_{int})_1 < (\Delta U_{int})_2$

(C) $(\Delta U_{int})_1 > (\Delta U_{int})_2$

(D) $(\Delta U_{int})_1 = 5\ (\Delta U_{int})_2$

(72) Which part of graph of P → V shown in figure represents Isothermal process, Isochoric process and Isobaric process ...... respectively.

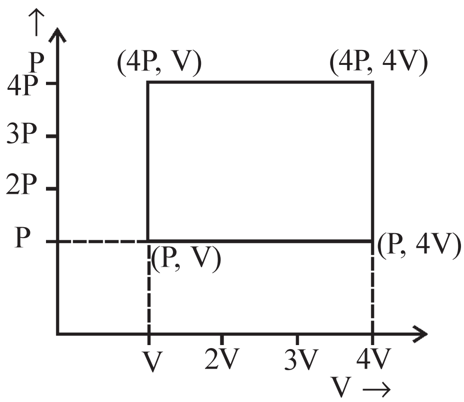


(A) 12 ; 34 ; 23

(B) 12 ; 14 ; 34

(C) 23 ; 34 ; 12

(D) 34 ; 12 ; 23

(73) 

For cyclic process in graph of P → V shown in figure, work done = ...

(A) 2 PV

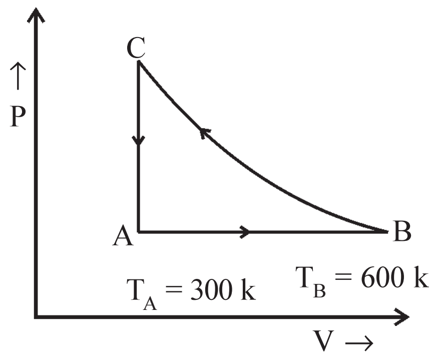
(B) 4 PV

(C) 9 PV

(D) 6 PV

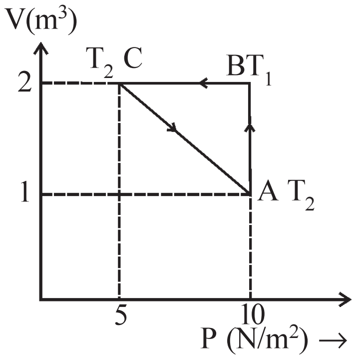
(74) As shown in figure, 1 mole He gas experience cyclic process ABCA. During the process, 1000 J heat is obtained from the gas then work done during stage BC is ....

($R = 8.3\ 1\ mol^{-1}\ K^{-1}$)



(A) +3490 J (B) 1490 J

(C) –3490 J (D) – 1490 J

(75) 

Cyclic process of μ mole Ar gas is shown in figure. Efficiency of thermodynamic process is ....

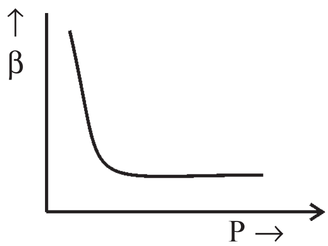
(A) 100 %

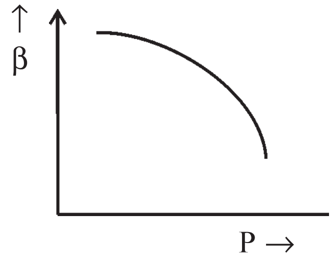
(B) 25 %

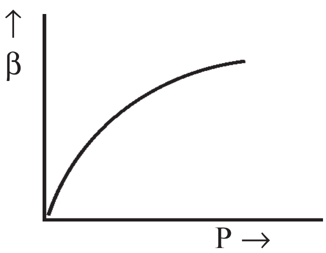
(C) 75 %

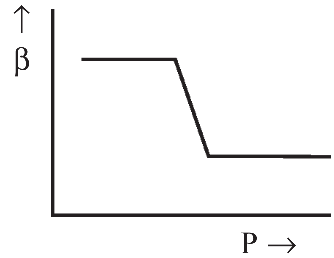
(D) 50 %

(76) Which of the following is the graph of $\beta \rightarrow P$ for an ideal gas at constant temperature where β = compressibility of gas = $\frac{-dV/dP}{V}$.

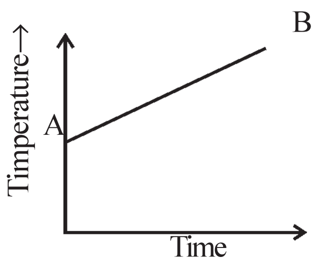
(A) 

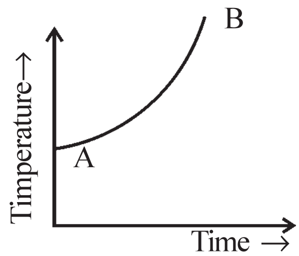
(B) 

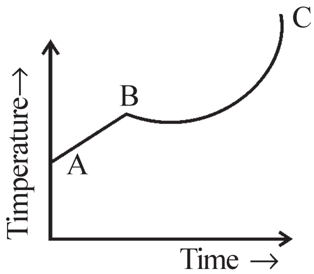
(C) 

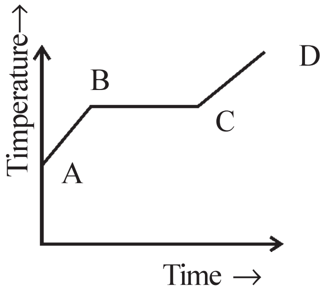
(D) 

(77) Liquid O_2 at 1 atm pressure is heated from 50 K to 300 K at constant pressure. Rate of heating is constant. Which of the following shows graph of change in temperature with time ?

(A) 

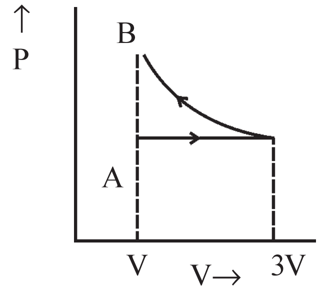
(B) 

(C) 

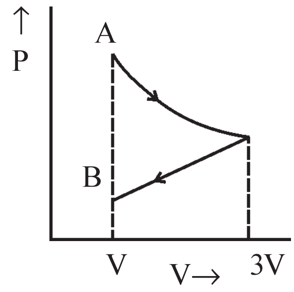
(D) 

(78) 1 mole ideal gas moves from state A to state B by two different ways. Firstly, volume is changed from V to 3V by isothermal expansion and then volume is decreased from 3V to V at constant pressure. Which of the following is the graph of $P \rightarrow V$ showing these two processes ?

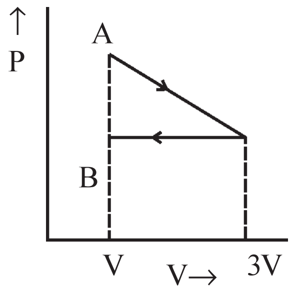
(A)



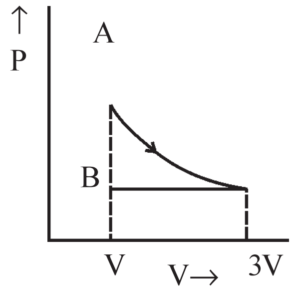
(B)



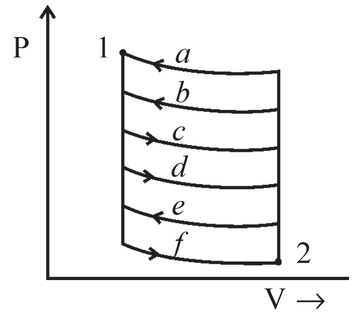
(C)



(D)



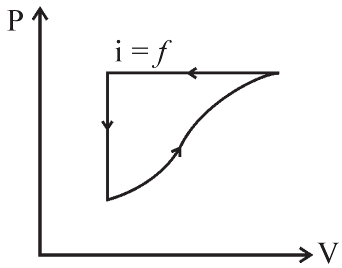
(79) In the figure, a system moves on path 1-2-1. In the $P \rightarrow V$ graph, different paths are shown such that each time thermal equilibrium is set up between system and environment. During which closed path is work done maximum positive ?



(A) 1 – b – 2 – f – 1 (B) 1 – c – 2 – e – 1

(C) 1 – d – 2 – e – 1 (D) 1 – a – 2 – f – 1

(80)



For graph of $P \rightarrow V$ of a cyclic process, shown in figure, change in internal energy of gas ΔU = ... and net heat exchange ΔQ = ...

(A) positive, negative (B) positive, zero

(C) zero, negative (D) zero, positive

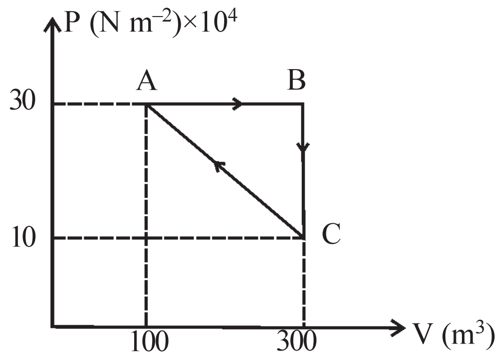
(81) During cyclic process shown in figure, net heat absorbed by system per cycle is ....

(A) 20×10^6 J

(B) 2×10^5 J

(C) 200×10^7 J

(D) 20×10^7 J



Ans. : 52 (A), 53 (D), 54 (B), 55 (C), 56 (A), 57 (C), 58 (C), 59 (B), 60 (D), 61 (B), 62 (A), 63 (B), 64 (B), 65 (C), 66 (D), 67 (A), 68 (B), 69 (C), 70 (B), 71 (A), 72 (C), 73 (C), 74 (C), 75 (D), 76 (A), 77 (D), 78 (D), 79 (B), 80 (C), 81 (A)

Efficiency of heat engine :

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

$\eta < 1$ (always)

where Q_1 = Heat absorbed from heat source at high temperature

Q_2 = Heat released in sink at low temperature

Coefficient of performance of refrigerator :

$$\alpha = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}$$

$\alpha > 1$ but never infinity

where Q_1 = Heat released by working substance in surrounding at higher temperature (T_1)

Q_2 = Heat absorbed by working substance from arrangement at lower temperature (T_2)

Efficiency of Carnot engine :

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{Q_2}{Q_1}$$

where T_1 = Temperature of heat source

T_2 = Temperature of sink

---

(82) Efficiency of a heat engine is 30 %. During each cycle, difference of heat absorbed and heat released is 60 J. Then heat absorbed from heat saurce during every cycle, is .... and that released in sink is ....

(A) 100 J, 63 J (B) 150 J, 65 J (C) 200 J, 63 J (D) 200 J, 140 J

(83) A heat engine absorbs 50 kJ heat from heat source. If its efficiency in 30 % then it releases ...... heat in sink.

(A) 35 kJ (B) 350 kJ (C) 35 J (D) 350 J

(84) If heat engine absorbs 2 kJ heat from heat source and releases 1.5 kJ heat in sink then efficiency η = ...

(A) 5 % (B) 25 % (C) 50 % (D) 2.5 %

(85) A Carnot engine absorbs heat 3×10^6 cal from heat source at temperature 627 °C and releases some heat in sink at temperature 27 °C then work done is ....

(A) 8.4×10^6 cal (B) 2×10^6 J (C) 8.4×10^6 J (D) 12×10^6 J

(86) Efficiency of a Carnot engine is 40 % and temperature of sink is 400 K. Keeping temperature of heat source constant, if efficiency is to be made 80 %, temperature of sink should be made ....

(A) 300 K (B) 667 K (C) 532 K (D) 133 K

(87) A heat engine works between temperature 227° C and 127° C of Carnot cycle. If it absorbs 6 kJ heat from heat source then it converts ...... heat into work,

(A) 1.2×10^3 J (B) 1.2×10^3 cal (C) 1200 J (D) 1200 cal

(88) Efficiency of a heat engine with sink temperature 300 K is 40 %. How much the temperature of heat source should be increased so as to increase the efficiency by 50 % by keeping sink temperature constant.

(A) 2500 K (B) 250 K (C) 250 K (D) 200 K

(89) Efficiency of a heat engine is $\frac{1}{6}$. When temperature of sink is reduced by 62 °C, its efficiency doubles. Temperature of heat source will be ....

(A) 37 °C (B) 99 °C (C) 62 °C (D) 52 °C

(90) Efficiency of a Carnot engine is 20 %. It work as heat system for a refrigerator. If 50 J is work done on the system then how much heat will sink absorb ?

(A) 200 cal (B) 100 cal (C) 200 J (D) 100 J

(91) Coefficient of performance of a refrigerator is $\alpha = 5$. If it absorbs 120 J heat per cycle from cold reservoir then how much heat does it release in every cycle to hot reservoir at higher temperature ?

(A) 96 cal (B) 144 cal (C) 96 J (D) 144 J

Ans. : 82 (D), 83 (A), 84 (B), 85 (C), 86 (D), 87 (A), 88 (A), 89 (B), 90 (C), 91 (D)

Assertion - Reason type Question :

Instruction : Read assertion and reason carefully, select proper option from given below.

(a) Both assertion and reason are true and reason explains the assertion.

(b) Both assertion and reason are true but reason does not explain the assertion.

(c) Assertion is true but reason is false.

(d) Assertion is false and reason is true.

(92) **Assertion :** Its difficult to find reversible process in practice.

Reason : Most of the processes lost on energy.

(A) a (B) b (C) c (D) d

(93) **Assertion :** When air comes out of balloon, it feels instantly cool.

Reason : Air experiences adiabetic expansion while coming out.

(A) a (B) b (C) c (D) d

(94) **Assertion :** Carnot cycle is useful in understanding efficiency of heat engine.

Reason : It shows probability of obtaining maximum possible efficiency at a given temperature.

(A) a (B) b (C) c (D) d

(95) **Assertion :** On cooling milk kept in a glass in a room, its disorderness (entropy) decreases.

Reason : on cooling a hot substance, it does not dissolved. second law of Themodyhamics.

(A) a (B) b (C) c (D) d

(96) **Assertion :** Entropy (Disorderness) of an isolated always increases.

Reason : Processes occuring in isolated system are adiabetic.

(A) a (B) b (C) c (D) d

(97) **Assertion :** A Temperature on surface of Sun is 6000 K. Now, by focusing sunrays with help of huge lens, one can obtain 8000 K temperature.

Reason : This temperature can be obtained according to thermodynamics second law.

(A) a (B) b (C) c (D) d

(98) **Assertion :** Refrigerator absorb heat from low temperature and releases at high temperature.

Reason : Normally heat can not be flow from high temperature to low temperature.

(A) a (B) b (C) c (D) d

(99) **Assertion :** An efficiency of Carnot engine will increase when temperature of sink will decrease.

Reason : $\eta = 1 - \frac{T_2}{T_1}$

(A) a (B) b (C) c (D) d

(100) **Assertion :** Internal energy of ideal gas depends only on temperature and not on volume.

Reason : Temperature is more important than volume.

(A) a (B) b (C) c (D) d

(101) **Assertion :** Internal energy and temperature of system will be decrease in adiabatic compression process.

Reason : An adiabatic process is very slow process.

(A) a (B) b (C) c (D) d

(102) **Assertion :** When a bottle of cold drink like pepsi is opened, some fogg will produced around it.

Reason : As low temperature, gas get adiabatic expansion and vapour of water cools.

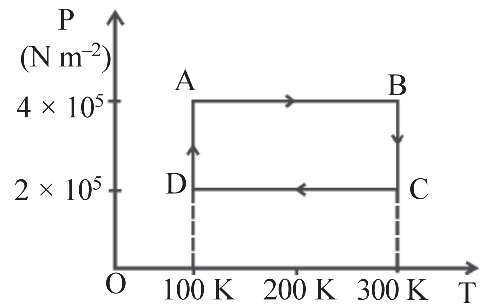
(A) a (B) b (C) c (D) d

Ans. : 92 (A), 93 (A), 94 (A), 95 (A), 96 (A), 97 (D), 98 (C), 99 (A), 100 (A), 101 (D), 102 (A)

Comprehension Type Questions :

Paragraph :

A P $\rightarrow$T cyclic process done on 1 mole Ar gas is shown in figure along path ABCD.



(103) Work done to take Ar gas from A to B at constant pressure (4×10^5 N m^{-2}) is ....

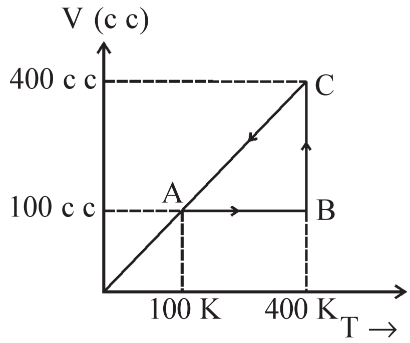
(A) 16628 J (B) 1662.8 J (C) 166.28 J (D) 16.628 J

(104) Work done to take Ar gas from B to C at constant temperature (300 K) is ....

(A) 17.29 J (B) 172.9 J (C) 172900 J (D) 1729 J

Paragraph :

A process ABCA on 1 mole Ar is shown in figure .



(105) Work done during isochoric process AB is ....

(A) 0 J (B) 300 J

(C) 100 J (D) 200 J

(106) Work done during isothermal process BC is ....

(A) 46.11 J (B) 461.1 J (C) 3586 J (D) 4611 J

(107) Work done during adiabatic process CA is ....

(A) 0 J (B) 1000 J (C) 3200 J (D) 2494 J

Paragraph :

Pressure of gas and volume change while heat of gas remain constant. This process is known as Adiabatic process. For such process PV^{γ} = constant. Process is very rapid and walls of a system are thermal insulator, so no exchange of heat takes place between system and its environment. For this changes, $\Delta Q = 0$ and according to thermodynamics first law $\Delta Q = \Delta U + \Delta W = 0 \therefore \Delta U = -\Delta W$

Answer the following questions according to above paragraph :

(108) Bicycle's tyre burst suddenly. Changes in air pressure and volume will be ....

(A) Isothemal (B) Adiabatic (C) Isobaric (D) Isochoric

(109) The temperature of gas, which is suddenly compressed in system, ...

(A) Increase (B) Decrease

(C) Constant (D) Depend on environment temperature

(110) When gas in system is suddenly compressed then internal energy of gas will be ....

(A) increase (B) decrease

(C) constant (D) no comment

(111) The specific heat of gas during adiabatic process ....

(A) 1 (B) –1 (C) 0 (D) infinite (∞)

Match the columns :

(112) A thermodynamic processes are shown in column-1 and in column-2 equation of work done are given. Match it appopriately.

	Column-1		Column-2
(a)	Adiabatic process	(P)	$W = 0$
(b)	Isothermal process	(Q)	$W = \frac{\mu R(T_1 - T_2)}{\gamma - 1}$
(c)	Isochoric process	(R)	$W = 2.303\ \mu RT \log\left(\frac{V_2}{V_1}\right)$
(d)	Isobaric process	(S)	$W = P\ \Delta V$

(A) a → P ; b → R ; c → Q ; d → S (B) a → Q ; b → R ; c → S ; d → R

(C) a → R ; b → S ; c → P ; d → Q (D) a → S ; b → Q ; c → R ; d → P

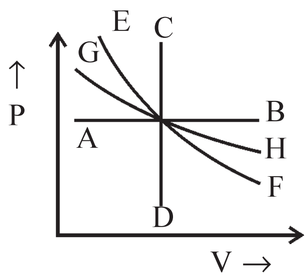
(113)

	Column-1		Column-2
(a)	Adiabatic process	(P)	$\Delta U = 0$
(b)	Isothermal process	(Q)	$\Delta Q \neq 0; \Delta U \neq 0, \ \Delta W \neq 0$
(c)	Isochoric process	(R)	$\Delta W = 0$
(d)	Isobaric process	(S)	$\Delta Q = 0$

(A) a → R ; b → P ; c → Q ; d → S
(B) a → Q ; b → R ; c → S ; d → P
(C) a → S ; b → P ; c → R ; d → Q
(D) a → P ; b → S ; c → Q ; d → R

(114) Different thermodynamic processes are shown in graph of (P) → (V)

Column-1		Column-2	
(a)	Graph AB	(P)	Isochoric process
(b)	Graph GH	(Q)	Adiabatic process
(c)	Graph EF	(R)	Isobaric process
(d)	Graph CD	(S)	Isothermal process



(A) a → Q ; b → P ; c → S ; d → R
(B) a → P ; b → Q ; c → R ; d → S
(C) a → S ; b → R ; c → P ; d → Q
(D) a → R ; b → S ; c → Q ; d → P

(115) Match according to concept of heat transfer :

Column A		Column B	
(a)	Heat required to convert a gas from liquid.	(P)	2256 kJ
(b)	Heat required to convert a liquid from solid.	(Q)	333 kJ
(c)	Heat required to convert 1g ice to water	(R)	Heat of fusion
(d)	Heat required to convert 1g water to vapour.	(S)	Heat of vaporization

(A) a → B b → C c → D d → A
(B) a → D b → C c → B d → A
(C) a → A b → B c → C d → D
(D) a → D b → A c → B d → C

Ans. : 103 (A), 104 (D), 105 (A), 106 (D), 107 (D), 108 (B), 109 (A), 110 (A), 111 (C), 112 (B), 113 (C), 114 (D), 115 (B)

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