PHYSICS

**Q.1** The pressure and volume of a given mass of gas at a given temperature are P and V respectively. Keeping temperature constant, the pressure is increased by 10% and then decreased by 10%. The volume how will be -

(A) less than V

(B) more than V

(C) equal to V

(D) less than V for diatomic and more than V for monoatomic **[B]**

Sol. When the pressure is first increased by 10% it becomes (110/100) P. when it is decreased by 10% from there, the pressure becomes

$$\frac{110 \times 90}{100 \times 100} P = \frac{99}{100} P$$

Thus the pressure decreases by 1% volume is increased by nearly 1%

Q.2 A mass of an ideal gas of volume V at pressure P undergoes the cycle of changes shown in the graph –
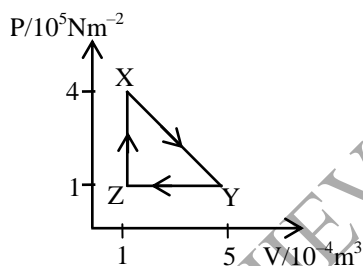

At which point is the gas coolest and hottest ?

Coolest	hottest
(A) X	Y
(B) Y	X
(C) Y	Z
(D) Z	Y	**[C]**

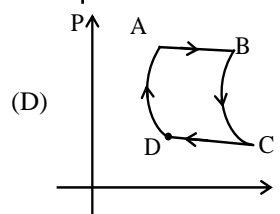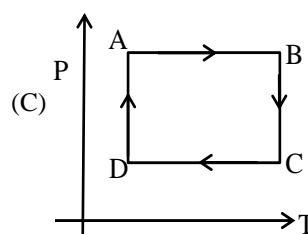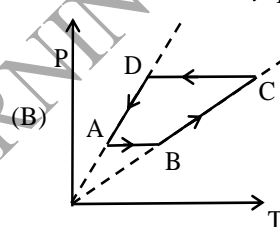**Sol.** For a mole of an ideal gas, the equation of state is PV = RT

or $T = \dfrac{PV}{R}$

which is proportional to the product pV

At x , PV = (4×10^5) (1×10^{-4}) = 40 Nm

At y, pV = (1×10^5) (5×10^{-4}) = 50 Nm

At z, pV = (1×10^5) (1×10^{-4}) = 10 Nm

Thus, T is maximum at y since pV is the highest and T is minimum at z since pV is the smallest

PV = RT

Q. 3 In the following cyclic process is
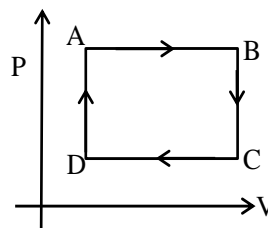
The above process in the P-T coordinates is given as
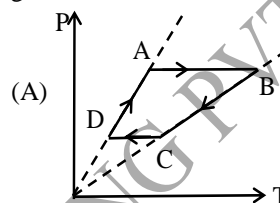
[A]

Q. 4 For an ideal gas graph is shown for three processes. Processes 1, 2 and 3 are respectively–

(A) Isochoric, isobaric, adiabatic
(B) Isochoric, adiabatic, isobaric
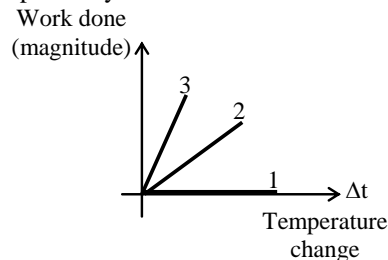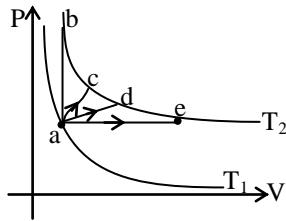(C) Isobaric, adiabatic, isochoric
(D) Adiabatic, isobaric, isochoric **[B]**

Q. 5 The figure shows two isotherms at temperatures T_1 & T_2. A gas is taken from one isotherm to another isotherm through different processes. Then change in internal energy ΔU has relation–

(A) $\Delta U_{ab} > \Delta U_{ac} > \Delta U_{ad} > \Delta U_{ae}$

(B) $\Delta U_{ab} = \Delta U_{ac} > \Delta U_{ad} > \Delta U_{ae}$

(C) $\Delta U_{ab} = \Delta U_{ac} = \Delta U_{ad} = \Delta U_{ae}$

(D) $\Delta U_{ab} < \Delta U_{ac} < \Delta U_{ad} < \Delta U_{ae}$ **[C]**

Q. 6 An ideal gas whose adiabatic exponent is γ is expanded so that the amount of heat transferred to the gas is equal to the decrease of its internal energy. Molar heat capacity of the gas for this process is –
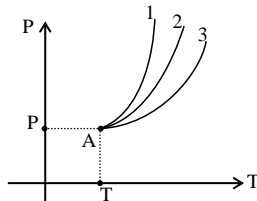
(A) $\dfrac{R}{1-\gamma}$ (B) $\dfrac{R}{\gamma-1}$

(C) R (D) $\dfrac{R}{2}$ **[A]**

Q. 7 The molar heat capacity for a process is $C = \dfrac{R}{\gamma-1} + \dfrac{\alpha}{T}$, then process equation is –

(A) $Ve^{-(\alpha/R)T}$ = Constant (B) $Ve^{(\alpha/R)T}$ = constant

(C) VT = constant (D) V/T = constant

[B]

Q. 8 The curves shown represent adiabatic curves for monoatomic, diatomic & polyatomic ($\gamma = 4/3$) gases. The slopes for curves 1, 2, 3 respectively at point A are –

(A) $2.5\dfrac{P}{T}, 3.5\dfrac{P}{T}, 4.5\dfrac{P}{T}$ (B) $2.5\dfrac{P}{T}, 3\dfrac{P}{T}, 4\dfrac{P}{T}$

(C) $2.5\dfrac{P}{T}, 3.5\dfrac{P}{T}, 4\dfrac{P}{T}$ (D) $2\dfrac{P}{T}, 3\dfrac{P}{T}, 4\dfrac{P}{T}$

[C]

Q. 9 When heat is supplied to the gas it expands and displaces piston by L/2 where natural length of springs are L = 1 m. Spring constant K = 100 N/m. Area of piston is 1 m^2. The pressure of gas in final situation is –
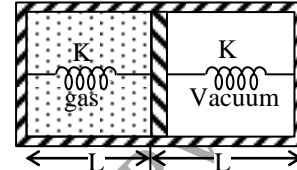
(A) 50 N/m^2 (B) 100 N/m^2

(C) 200 N/m^2 (D) 400 N/m^2 **[B]**

Q. 10 An ideal gas is expanded so that amount of heat given is equal to the decrease in internal energy. The gas undergoes the process $TV^{1/5}$ = constant. The adiabatic compressibility of gas when pressure is P, is –

(A) $\dfrac{7}{5P}$ (B) $\dfrac{5}{7P}$

(C) $\dfrac{2}{5P}$ (D) $\dfrac{7}{3P}$ **[B]**

Sol.

$dQ = -dU$

$C = -C_V = \dfrac{-R}{\gamma-1} = \dfrac{+R}{\gamma-1} + \dfrac{P}{n}\dfrac{dV}{dT}$

$\boxed{-\dfrac{P}{n}\dfrac{dV}{dT} = \dfrac{2R}{\gamma-1}}$

$T^5 V$ = const.

$V = \dfrac{const}{T^5}$

$\dfrac{dV}{dT} = -5\dfrac{const}{T^6}$

$PV = nRT$

$P/n = RT/V$

$+\dfrac{RT}{const}T^5 \times \left(-5\dfrac{const}{T^6}\right) = \dfrac{2R}{\gamma-1}$

$\dfrac{5}{2} = \dfrac{1}{\gamma-1} \Rightarrow \gamma-1 = 2/5$

$\gamma = 7/5$

adiabatic compressibility

$\beta = \dfrac{1}{\gamma P} = \dfrac{5}{7P}$

Q. 11 A mixture of 8gm of helium and 14gm of nitrogen is enclosed in a vessel of constant volume at 300K. The quantity of heat absorbed by the mixture to double the root mean velocity of its molecules is –

(R = universal gas constant)

(A) 2725 R   (B) 3630 R

(C) 3825 R   (D) 5625 R

Sol. **[C]**

$Q = \Delta U + W$

$W = 0$ since volume is constant

$Q = \Delta U$

$V_{rms} = \sqrt{3RT/M}$

$U_{mix} = U_1 + U_2$

$U_{mix} = n_1 C_{v_1} T + n_2 C_{v_2} T = (n_1 + n_2)(C_v)_{mix} T$

$(U_f) - (U_i) = nC_v(T_2 - T_1) = (n_1 + n_2)(C_v)_{mix}(T_2 - T_1)$

$V'_{rms} = 2V_{rms} \Rightarrow T' = 4T$
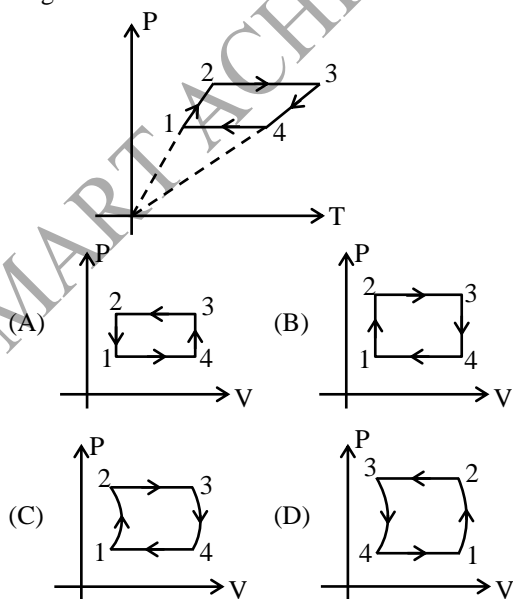
$n_1 = \dfrac{8}{4} = 2$; $n_2 = \dfrac{14}{28} = 1/2$

$(C_v)mix = \dfrac{n_1 Cv_1 + n_2 Cv_2}{(n_1 + n_2)}$

$U_f - U_i = (n_1 C_{v_1} + n_2 C_{v_2})(T_2 - T_1)$

$= \left(2 \times \dfrac{3}{2} + \dfrac{1}{2} \times \dfrac{5}{2}\right) R [1200 - 300]$

$\dfrac{17}{4} \times R \times 100 = 3825\ R$

Q. 12 P-T graph of ideal monoatomic gas is given as shown in figure. The corresponding P-V diagram is

Sol. **[B]**

$1 \to 2 =$ isochoric

$2 \to 3 =$ isobaric

$3 \to 4 =$ isochoric

            $4 \to 1 =$ isobaric

Q. 13 An expansion process on a diatomic ideal gas ($C_v = 5/2$ R), has a linear path between the initial and final coordinates on a pV diagram. The coordinates of the initial state are : the pressure is 300 kPa, the volume is 0.08 m^3 and the temperature is 390 K. The final pressure is 90kPa and the final temperature is 320 K. The change in the internal energy of the gas, in SI units, is closest to:

(A) –11, 000   (B) –6500

(C) 11, 000   (D) zero

Sol. **[A]**

$\Delta U = nC_v \Delta T$

$= n \dfrac{5}{2} R (T_f - T_i)$

$n = \dfrac{P_1 V_1}{RT_1}$

$\Delta U = \dfrac{P_1 V_1}{RT_1} \times \dfrac{5}{2} R (T_2 - T_1)$

$= \dfrac{300 \times 10^3 \times 0.08}{390} \times \dfrac{5}{2} (320 - 390)$

$= \dfrac{15 \times 10^3 \times 0.08 \times 5}{39} \times (-70)$
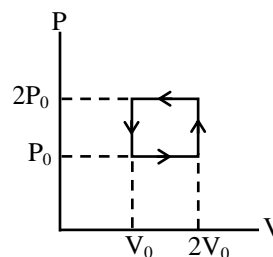
$= -\dfrac{0.40}{39} \times 15 \times 10^3 \times 70$

$= -\dfrac{40}{39} \times 150 \times 70$

$= -\dfrac{40}{39} \times 10500$

$\Delta U = -11000$ Joule

Q. 14 In Figure, an ideal gas is carried around the cyclic process. How much work is done in one cycle if $P_0 = 8$atm and $V_0 = 7.00$ liters.


(A) 5656 J   (B) –5656 J

(C) 10,600 J   (D) 11,300 J

Sol. **[B]**

Work done is area
under the curve
$W = -P_0 V_0$
$= -8 \times (10^5 \times 1.01) \times 7 \times 10^{-3}$
$W = -56 \times 1.01 \times 10^2$ Joule
$W = -5656$ Joule

Q. 15 Which of the following is a FALSE statement?
    (A) Heat is energy transferred into or out of a system as a result of a temperature difference between the system and its surroundings.
    (B) The heat added to an ideal gas during the transition from state 1 to state 2 depends only on the initial and final states, 1 and 2, and not on the path by which the gas went from one to the other.
    (C) When a gas goes from one state to another, the work done depends on the path followed
    (D) It does not make sense to refer to "the amount of heat in a body".

Sol. **[B]**

Heat is a path function. Heat transfer depends on process. Hence heat transfer is different for different paths between same initial & final status.

Q.16 An ideal mono-atomic gas undergoes a cyclic process ABCA as shown in the figure. The ratio of heat absorbed during AB to the work done on the gas during BC is –
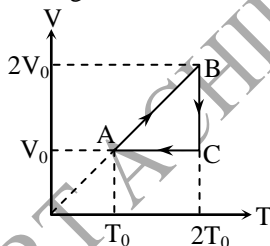
    (A) $\dfrac{5}{2\ln 2}$ (B) $\dfrac{5}{3}$

    (C) $\dfrac{5}{4\ln 2}$ (D) $\dfrac{5}{6}$

Sol. **[C]**

$Q_{AB} = nC_P \Delta T = n\dfrac{5}{2} R(2T_0 - T_0)$

$Q_{BC} = W_{BC} = NR.2T_0 \ln 2$

$\Rightarrow \dfrac{Q_{AB}}{W_{BC}} = \dfrac{5}{4\ln 2}$

Q.17 An ideal gas is taken through the cycle $A \to B \to C \to A$, as shown in the figure. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process $C \to A$ is –
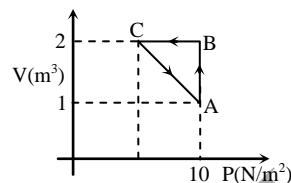
    (A) –5 J   (B) – 10 J
    (C) – 15 J   (D) – 20 J

Sol. **[A]**

$\Delta W_{AB} = P\Delta V = (10)(2-1) = 10$ J
$\Delta W_{BC} = 0$
From first law of thermodynamics
    $\Delta Q = \Delta W + \Delta U$
$\Delta U = 0$ (process ABCA is cyclic)
$\therefore \quad \Delta Q = \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CA}$
$\therefore \quad \Delta W_{CA} = \Delta Q - \Delta W_{AB} - \Delta W_{BC} = 5 - 10 - 0$
        $= -5$ J

Q.18 The equation of process of a diatomic gas is $P^2 = \alpha^2 V$, where α is a constant. Then choose the correct option-

    (A) Work done by gas for a temperature change T is $\dfrac{2}{3}\alpha$ nRT

    (B) The change in internal energy is $\dfrac{5}{2}$ nRT for a temperature change T

    (C) Specific heat for the process is $\dfrac{19}{9}$ R

    (D) The change in internal energy for a temperature change T is $\dfrac{5}{2}\alpha$nRT

Sol. **[B]** Internal energy change is
    $\Delta U = n\, C_V\, \Delta T$
    $= n\dfrac{5}{2} R\,(T - 0)$
    $= \dfrac{5}{2}$ nRT

Q.19 The curves shown represent adiabatic curves for monoatomic, diatomic & polyatomic ($\gamma = 4/3$) gases. The slopes for curves 1,2,3 respectively at point A are –
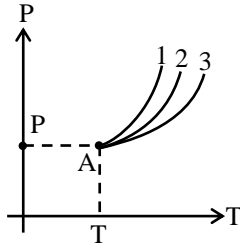
(A) $2.5 \dfrac{P}{T}$, $3.5 \dfrac{P}{T}$, $4.5 \dfrac{P}{T}$

(B) $2.5 \dfrac{P}{T}$, $3 \dfrac{P}{T}$, $4 \dfrac{P}{T}$

(C) $2.5 \dfrac{P}{T}$, $3.5 \dfrac{P}{T}$, $4 \dfrac{P}{T}$

(D) $4 \dfrac{P}{T}$, $3.5 \dfrac{P}{T}$, $2.5 \dfrac{P}{T}$

Sol. **[D]**

For adiabatic process :

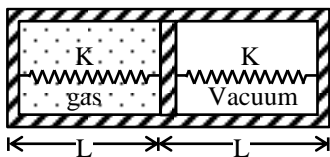Slope : $\dfrac{dP}{dT} = \left(\dfrac{\gamma}{\gamma-1}\right) \dfrac{P}{T}$

$\gamma = \dfrac{5}{3} \Big| \dfrac{dP}{dT} = \left(\dfrac{5/3}{5/3-1}\right) \dfrac{P}{T} = \dfrac{5/3}{2/3} \dfrac{P}{T}$

$= 2.5 \dfrac{P}{T}$

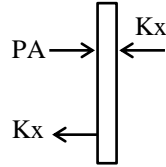$\gamma = \dfrac{7}{5} \Big| \dfrac{dP}{dT} = \left(\dfrac{7/5}{2/5}\right) \dfrac{P}{T} = 3.5 \dfrac{P}{T}$

$\gamma = \dfrac{4}{3} \Big| \dfrac{dP}{dT} = \left(\dfrac{4/3}{1/3}\right) \dfrac{P}{T} = 4 \dfrac{P}{T}$

Q.20 Area of piston is 1 m². When heat is supplied to the gas it expands and displaces piston by $\dfrac{L}{2}$ where $L = 1$m. Natural length of springs is $L = 1$m. Spring constant $K = 100$ N/m. The pressure of gas in final situation is –

(A) 50 N/m²   (B) 100 N/m²

(C) 200 N/m²   (D) 400 N/m²

Sol. **[B]**

$P = \dfrac{2Kx}{A}$

$= \dfrac{2 \times 100}{1} \times \dfrac{1}{2}$

$= 100$ N/m²

Q.21 The internal energy of a diatomic gas is given as $U = U_0V$, where U_0 is a constant. Molar heat capacity of gas is -

(A) $\dfrac{5}{2} R$

(B) $\dfrac{7}{2} R$

(C) $\dfrac{9}{2} R$

(D) $\dfrac{3}{2} R$

Sol. **[B]**

$U = U_0V \Rightarrow nC_VT = U_0V \Rightarrow T \propto V$ isobaric process

$$C = C_V + \dfrac{P}{n} \dfrac{dV}{dT}$$
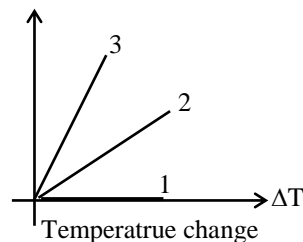
$\dfrac{dV}{dT} = $ constant

$\dfrac{P}{n} = \dfrac{nRT}{V} = \dfrac{nRT}{\text{constant}T}$

$C = C_V + \dfrac{R}{\text{constant}}$

$C = C_V + R = \dfrac{5}{2} R + R = \dfrac{7}{2} R$

Q.22 For an ideal gas graph is shown for three processes. Processes 1, 2, and 3 are respectively –

work done (magnitude)

Temperatrue change

(A) Isochoric, isobaric, adiabatic
(B) Isochoric, adiabatic, isobaric
(C) isobaric, adiabatic, isochoric
(D) Adiabatic, isobaric, isochoric

Sol. **[A]**

Isochoric process dV = 0

W = 0

Isobaric : W = PΔV = nRΔT

adiabatic : $W = \dfrac{nR(T_i - T_f)}{\gamma - 1}$

$|W| = \dfrac{nR\Delta T}{\gamma - 1}$

$0 < \gamma - 1 < 1$

Q.23 Two moles of monoatomic gas is mixed with one mole of diatomic gas at the same temperature. Molar heat capacity at constant volume for the mixture is -
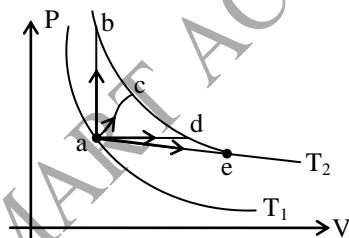
(A) $\dfrac{13R}{6}$ (B) $\dfrac{11R}{6}$

(C) $\dfrac{5R}{3}$ (D) $\dfrac{7R}{6}$

Sol. **[B]**

$\dfrac{n_1 c_{v_1} + n_2 c_{v_2}}{n_1 + n_2} = (c_v)_{mix} = \dfrac{2 \times \frac{3}{2}R + 1 \times \frac{5}{2}R}{2+1} =$

$\dfrac{3R + \frac{5}{2}R}{3}$

$= \dfrac{11R}{6}$

Q.24 The figure shows two isotherms at temperatures T_1 and T_2. A gas is taken from one isotherm to another isotherm through different processes. Then change in internal energy ΔU has relation -

(A) $\Delta U_{ab} > \Delta U_{ac} > \Delta U_{ad} > \Delta U_{ae}$
(B) $\Delta U_{ab} = \Delta U_{ac} > \Delta U_{ad} > \Delta U_{ae}$
(C) $\Delta U_{ab} = \Delta U_{ac} = \Delta U_{ad} = \Delta U_{ae}$
(D) $\Delta U_{ab} < \Delta U_{ac} < \Delta U_{ad} < \Delta U_{ae}$

Sol. **[C]**

Internal energy depends only on state but not on the process. Hence its change is same for all the processes between two same states.

Q.25 An ideal gas whose adiabatic exponent is γ is expanded so that the amount of heat transferred to the gas is equal to the decrease of its internal energy. Molar heat capacity of the gas for this process is -

(A) $\dfrac{R}{1-\gamma}$ (B) $\dfrac{R}{\gamma-1}$

(C) R (D) R/2

Sol. **[A]**

dQ = – dU

$nCdT = -nC_V dT$

$C = -C_V = -\dfrac{R}{\gamma - 1}$

$\boxed{C = \dfrac{R}{1-\gamma}}$

Q.26 The molar heat capacity for a process is :

$C = \dfrac{R}{\gamma-1} + \dfrac{\alpha}{T}$, then process equation is -

(A) $Ve^{-(\alpha/R)T} = $ constant

(B) $Ve^{(\alpha/R)T} = $ constant

(C) $VT = $ constant

(D) $Ve^{\alpha/RT} = $ constant

Sol. **[D]**

$\boxed{C = C_V + \dfrac{PdV}{dT}}$

$\dfrac{PdV}{ndT} = \dfrac{\alpha}{T}$

$\dfrac{nRT}{nv}\dfrac{dV}{dT} = \dfrac{\alpha}{T}$

$\int \dfrac{dV}{V} = \dfrac{\alpha}{R}\int \dfrac{dT}{T^2}$

$\ell n V = -\dfrac{\alpha}{RT} + \ell n\,C$

$\dfrac{V}{C} = e^{-\alpha/RT}$

$Ve^{\alpha/RT} = C$

Q.27 The volume of a gas increase by 0.5 m³ at a constant pressure of 1000 N/m². The work done by the gas is –

(A) 500 J   (B) 250 J

(C) 200 J   (D) 100 J   **[A]**

Q.28 The amount of external work done in reducing the volume of an ideal gas by 2.4×10^{-4} m³ at normal temperature and constant normal pressure

$(1.0 \times 10^5 N/m^2)$ will be –

(A) 2.4 J   (B) 0.24 J

(C) 24 J   (D) 240 J   **[C]**

Q.29 In a cyclic process, the internal energy of gas –

(A) increases   (B) decreases

(C) remains constant   (D) becomes zero   **[C]**

Q.30 100 Joule heat is given to a thermodynamic system and the work done by the system is 50 joule. The change in the internal energy of the system is –

(A) 100 Joule   (B) 150 Joule

(C) 50 Joule   (D) 200 Joule   **[C]**

Q.31 The molar specific heat of a diatomic gas at constant volume is –

(A) R/2   (B) 3R/2

(C) 5R/2   (D) 7R/2   **[C]**

Q.32 For a monoatomic gas, the adiabatic relation between pressure P and volume V is –

(A) PV = constant   (B) $PV^{5/3}$ = constant

(C) $PV^{7/5}$ = constant   (D) $PV^{2/3}$ = constant

[B]

Q.33 For an ideal gas, in isothermal expansion, the value of $\Delta P/P$ is equal to : $(\gamma = C_p/C_v)$–

(A) $-\gamma^{1/2} \dfrac{\Delta V}{V}$ (B) $-\dfrac{\Delta V}{V}$

(C) $-\gamma \dfrac{\Delta V}{V}$ (D) $-\gamma^2 \dfrac{\Delta V}{V}$ **[B]**

Q.34 If for a gas $R/C_v = 2/3$, then the gas is –

(A) monoatomic   (B) diatomic

(C) triatomic   (D) polyatomic   **[A]**

Q.35 In a thermodynamic process the pressure of a fixed mass of gas is changed in such a manner that the gas releases 20 J of heat and 8 J of work is done on the gas. If the initial internal energy of the gas was 30 J, then the final internal energy will be –

(A) 2 J   (B) 42 J

(C) 18 J   (D) 58 J   **[C]**

Q.36 Specific heat of a gas undergoing adiabatic change is -

(A) zero   (B) infinite

(C) positive   (D) negative   **[A]**

Q.37 A liquid is being converted into vapours as its bp; the specific heat of liquid at this temperature will be-

(A) zero   (B) infinite

(C) positive   (D) negative   **[B]**

Q.38 When vapour condenses into liquid -

(A) it absorbs heat

(B) it liberates heat

(C) its temperature increases

(D) its temperature decreases   **[B]**

Q.39 A gas undergoes process ABCDAC. Work done by gas is –
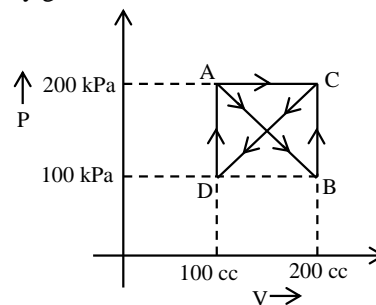
(A) 5 kJ   (B) 2.5 kJ

(C) – 5 kJ   (D) 7.5 kJ   **[B]**

Sol.
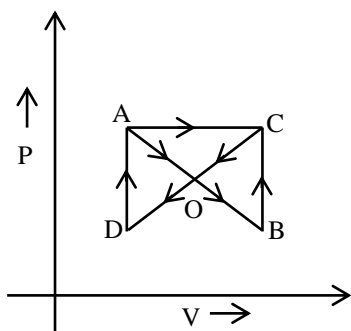
Work done = area (AOD) + area (AOC)

$\qquad$ – area (BOC)

$\qquad$ = area (AOC)

$\qquad$ = 2.5 kJ

Q.40 During an adiabatic process, the pressure of a gas is proportional to the cube of its absolute temperature. The value of C_p/C_v for that gas is –

(A) 3/5 $\qquad$ (B) 4/3

(C) 5/3 $\qquad$ (D) 3/2 $\qquad$ **[D]**

Sol. For adiabatic process

$\qquad P \propto T^{(\gamma/\gamma-1)}$ $\qquad$ (i)

$\qquad$ Given $P \propto T^3$ $\qquad$ (ii)

$\qquad$ From eq. (i) & (ii)

$\qquad \dfrac{\gamma}{\gamma-1} = 3 \Rightarrow \gamma = 3\gamma - 3$

$\qquad\qquad\qquad \gamma = 3/2$

Q.41 A polyatomic gas ($\gamma = \dfrac{4}{3}$) is compressed to $1/8^{th}$ its volume adiabatically. If its initial pressure is P_0, its new pressure will be –

(A) 8 P_0 $\qquad$ (B) 16 P_0

(C) 6 P_0 $\qquad$ (D) 2 P_0 $\qquad$ **[B]**

Sol. PV^γ = const.

$\qquad P_0 V^{4/3} = P'\left(\dfrac{V}{8}\right)^{4/3}$

$\qquad P' = (2)^4 P_0 = 16P_0$

Q.42 In adiabatic process, the pressure is increased by 2/3%. If $\gamma = 3/2$ then the volume decreases by nearly –

(A) $\dfrac{4}{9}$ % $\qquad$ (B) $\dfrac{2}{3}$ %

(C) 1 % $\qquad$ (D) $\dfrac{9}{4}$ % $\qquad$ **[A]**

Sol. For adiabatic process

$\qquad \dfrac{\Delta P}{\Delta V} = - \dfrac{\gamma P}{V}$

$\qquad \dfrac{\Delta P}{P} \times 100 = - \gamma \dfrac{\Delta V}{V} \times 100 = \dfrac{2}{3}$

$\qquad \dfrac{\Delta V}{V} \times 100 = -\dfrac{1}{\gamma} \times \dfrac{2}{3}$

$\qquad\qquad = -\dfrac{2}{3} \times \dfrac{2}{3} = -\dfrac{4}{9}$ %

Q.43 A gas is expanded to double its volume by two different processes. One is isobaric and the other is isothermal. Let W_1 and W_2 be the respective work done, then –

(A) $W_2 = W_1 \ln (2)$ $\qquad$ (B) $W_2 = \dfrac{W_1}{\ln (2)}$

(C) $W_2 = \dfrac{W_1}{2}$ $\qquad$ (D) data is insufficient

$\qquad\qquad\qquad\qquad\qquad\qquad$ **[A]**

Sol. $W_1 = P_i (V_f - V_i) = P_i V_i \left(\dfrac{V_f}{V_i} - 1\right)$

$\qquad = nRT (2 - 1) = nRT$

$\qquad W_2 = nRT \ln\left(\dfrac{V_f}{V_i}\right) = nRT \ln (2) = W_1 \ln (2).$

Q.44 Heat is supplied to a diatomic gas at constant pressure. The ratio of $\Delta Q : \Delta U : \Delta W$ is –

(A) 5 : 3 : 2 $\qquad$ (B) 5 : 2 : 3

(C) 7 : 5 : 2 $\qquad$ (D) 7 : 2 : 5 $\qquad$ **[C]**

Sol. $\Delta Q = nC_P \Delta T = \dfrac{7}{2} nR\Delta T$

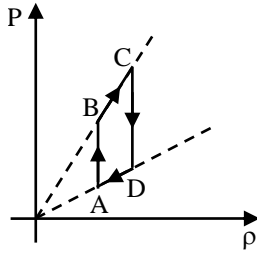$\qquad \left(C_P = \dfrac{7}{2}R\right)$

$\qquad \Delta U = nC_V \Delta T = \dfrac{5}{2} nR\Delta T$

$\qquad \left(C_V = \dfrac{5}{2}R\right)$

$\qquad$ and $\Delta W = \Delta Q - \Delta U = nR\Delta T$

$\qquad \therefore \Delta Q : \Delta U : \Delta W = 7 : 5 : 2$

Q.45 Pressure versus density graph of an ideal gas is shown in figure –

(A) during the process AB work done by the gas is positive

(B) during the process AB work done by the gas is negative

(C) during the process BC internal energy of the gas is increasing

(D) none of these **[D]**

Sol. $\rho = \dfrac{PM}{RT}$ and $\rho \propto \dfrac{1}{V}$

During AB, ρ and hence V is constant.

Therefore, work done is zero.

During BC, $P \propto \rho$ i.e., T

and hence, U is constant.

Q.46 A gas is expanded from volume V_0 to $2V_0$ under three different processes. Process 1 is isobaric, process 2 is isothermal and process 3 is isothermal and process 3 is adiabatic. Let ΔU_1, ΔU_2 and ΔU_3 be the change in internal energy of the gas in these three processes. Then –
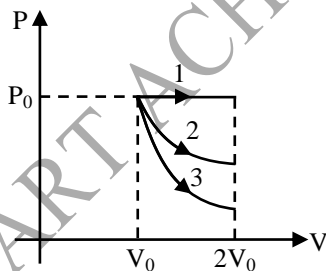
(A) $\Delta U_1 > \Delta U_2 > \Delta U_3$

(B) $\Delta U_1 < \Delta U_2 < \Delta U_3$

(C) $\Delta U_2 < \Delta U_1 < \Delta U_3$

(D) $\Delta U_2 < \Delta U_3 < \Delta U_1$ **[A]**

Sol. Process 2 is an isothermal process

Hence, $\Delta U_2 = 0$

Process 1 is an isobaric (P = constant) expansion.

Hence, temperature of the gas will increase

or $\Delta U_1 = $ positive

Process 3 is an adiabatic expansion. Hence, temperature will decrease

or $\Delta U_3 = $ negative

Therefore, $\Delta U_1 > \Delta U_2 > \Delta U_3$ is the correct option.

Q.47 During adiabatic process pressure (P) versus density (ρ) equation is –

(A) $P\rho^{\gamma} = $ constant

(B) $P\rho^{-\gamma} = $ constant

(C) $P^{\gamma}\rho^{1+\gamma} = $ constant

(D) $P^{1/\gamma}\rho^{\gamma} = $ constant **[B]**

Sol. In adiabatic process

$PV^{\gamma} = $ constant … (1)

density $\rho = \dfrac{m}{V}$

or $\rho \propto V^{-1}$

∴ Eq. (1) can be written as

$P\rho^{-\gamma} = $ constant

Q.48 One mole of an ideal gas undergoes a process $P = \dfrac{P_0}{1+\left(\dfrac{V_0}{V}\right)^2}$.

Here, P_0 and V_0 are constants. Change in temperature of the gas when volume is changed from $V = V_0$ to $V = 2V_0$ is –

(A) $-\dfrac{2P_0V_0}{5R}$ (B) $\dfrac{11P_0V_0}{10R}$

(C) $-\dfrac{5P_0V_0}{4R}$ (D) P_0V_0 **[B]**

Sol. At $V = V_0$, $P = \dfrac{P_0}{2}$

∴ $T_i = \dfrac{PV}{nR} = \dfrac{\left(\dfrac{P_0}{2}\right)(V_0)}{R} = \dfrac{P_0V_0}{2R}$ (n = 1)

and at $V = 2V_0$, $P = \dfrac{4P_0}{5}$

$$\therefore T_f = \frac{PV}{nR} = \frac{(2V_0)\left(\dfrac{4P_0}{5}\right)}{R} = \frac{8P_0V_0}{5R}$$

$$\therefore \Delta T = T_f - T_i = \left(\frac{8}{5} - \frac{1}{2}\right)\frac{P_0V_0}{R} = \frac{11P_0V_0}{10R}$$

Q.49 The relation between U, P and V for an ideal gas is
U = 2 + 3 P V
The gas is –
(A) monoatomic
(B) diatomic
(C) polyatomic
(D) either a monoatomic or diatomic   **[C]**

Sol. For an adiabatic process dQ = 0 = dU + dW
or   0 = dU + PdV
From the given equation
dU = 3 (PdV + VdP)
$\therefore$ 0 = 3 (PdV + VdP) + PdV
or 4P (dV) + 3V (dP) = 0

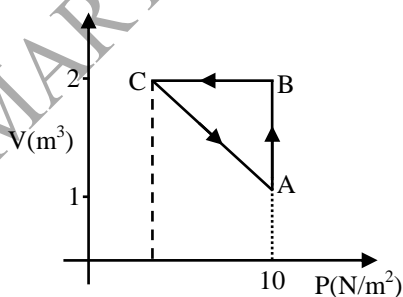or $4\left(\dfrac{dV}{V}\right) = -3\left(\dfrac{dP}{p}\right)$

On integrating, we get
$ln(V^4) + ln(P^3)$ = constant
or $PV^{4/3}$ = constant

i.e., $\gamma = \dfrac{4}{3}$

i.e., gas is polyatomic.

Q.50 An ideal gas is taken through the cycle A $\rightarrow$ B $\rightarrow$ C $\rightarrow$ A, as shown in the figure. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process C $\rightarrow$ A is –

(A) – 5 J   (B) – 10 J
(C) – 15 J   (D) – 20 J   **[A]**

Sol. $\Delta W_{AB} = P\Delta V = (10)(2 - 1) = 10$ J
$\Delta W_{BC} = 0$ (as V = constant)
From first law of thermodynamics
$\Delta Q = \Delta W + \Delta U$
$\Delta U = 0$ (process ABCA is cyclic)
$\therefore \Delta Q = \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CA}$
$\therefore \Delta W_{CA} = \Delta Q - \Delta W_{AB} - \Delta W_{BC} = 5 - 10 - 0$
$= -5$ J