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DPP – 4 (Thermodynamics)

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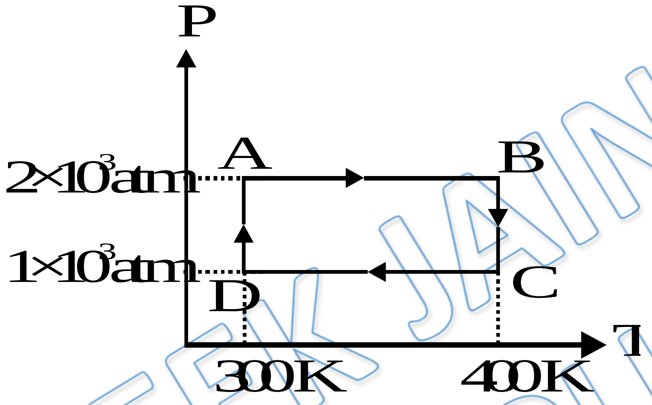
Q 1. 1/R (R is universal gas constant) moles of an ideal gas (γ=1.5) undergoes a cyclic process (ABCDA) as shown in fig. Assuming the gas to be ideal. If the net heat exchanger is 10x Joules, find the value of x ? [In 2 = 0.7].

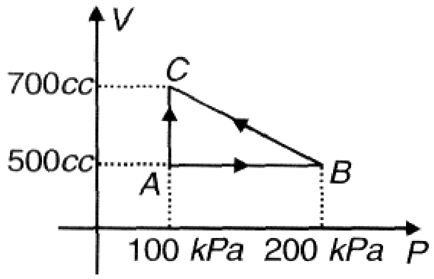


Q 2. One mole of an ideal gas (mono-atomic) at temperature T_0 expands slowly according to law P = cV (c is constant). If final temperature is $2T_0$, heat supplied to gas is

(a) $2RT_0$ (b) (3/2) RT_0

(c) RT_0 (d) (1/2) RT_0

Q 3. A gas is taken through cyclic process ABCA is shown in figure. If 2.4 cal. of heat is given in the process, what is value of J ?



(a) 4.17J/cal (b) 4.4J/cal

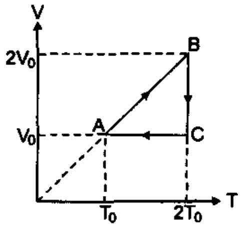
(c) 4.1 J/cal (d) None of these

Q 4. Heat is supplied to a diatomic gas at constant pressure. The ratio of $\Delta Q : \Delta U : W$ is:

(a) 5 : 3 : 2 (b) 5 : 2 : 3

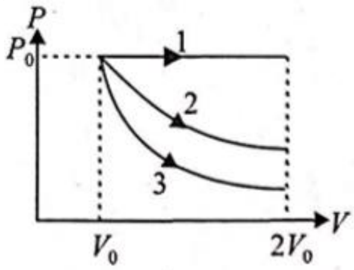
(c) 7 : 5 : 2 (d) 7 : 2 : 5

Q 5. An ideal monoatomic 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) $\frac{5}{2In2}$ (b) $\frac{5}{3}$ (c) $\frac{5}{4In2}$ (d) $\frac{5}{6}$

Q 6. 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 adiabatic. Let ΔQ_1, ΔQ_2 and ΔQ_3 be the heat absorbed by gas in these three processes. Then:



(a) $\Delta Q_1 > \Delta Q_2 > \Delta Q_3$
(b) $\Delta Q_1 < \Delta Q_2 < \Delta Q_3$
(c) $\Delta Q_2 < \Delta Q_1 < \Delta Q_3$
(d) $\Delta Q_2 > \Delta Q_3 > \Delta Q_1$

Q 7. Certain amount of an ideal gas are contained in a closed vessel. The vessel is moving with a constant velocity v. The molar mass of gas is M. The rise in temperature of the gas when the vessel is suddenly stopped is : (γ = adiabatic constant)

(a) $\frac{Mv^2}{2R(\gamma+1)}$ (b) $\frac{Mv^2(\gamma-1)}{2R}$
(c) $\frac{Mv^2}{2R\gamma}$ (d) $\frac{Mv^2\gamma}{2R(\gamma-1)}$

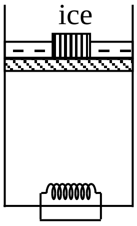
Q 8. A monoatomic gas undergoes a process given by 2dU + 3dW = 0, then the process is:
(a) isobaric (b) adiabatic
(c) isothermal (d) none

Q 9. STATEMENT – 1
Adiabatic expansion is always accompanied by fall in temperature.
because
STATEMENT – 2
In adiabatic process, volume is inversely proportional to temperature.

Q 10. *n* moles of an ideal monatomic gas undergoes a process in which the temperature changes with volume as $T = KV^2$. If the temperature of the gas changes from T_0 to $4T_0$ then
(a) work done by the gas is $3nRT_0$

(b) heat supplied to the gas is $4nRT_0$
(c) work done by the gas is $(3/2)nRT_0$
(d) heat supplied to the gas is $\frac{3}{2}nRT_0$

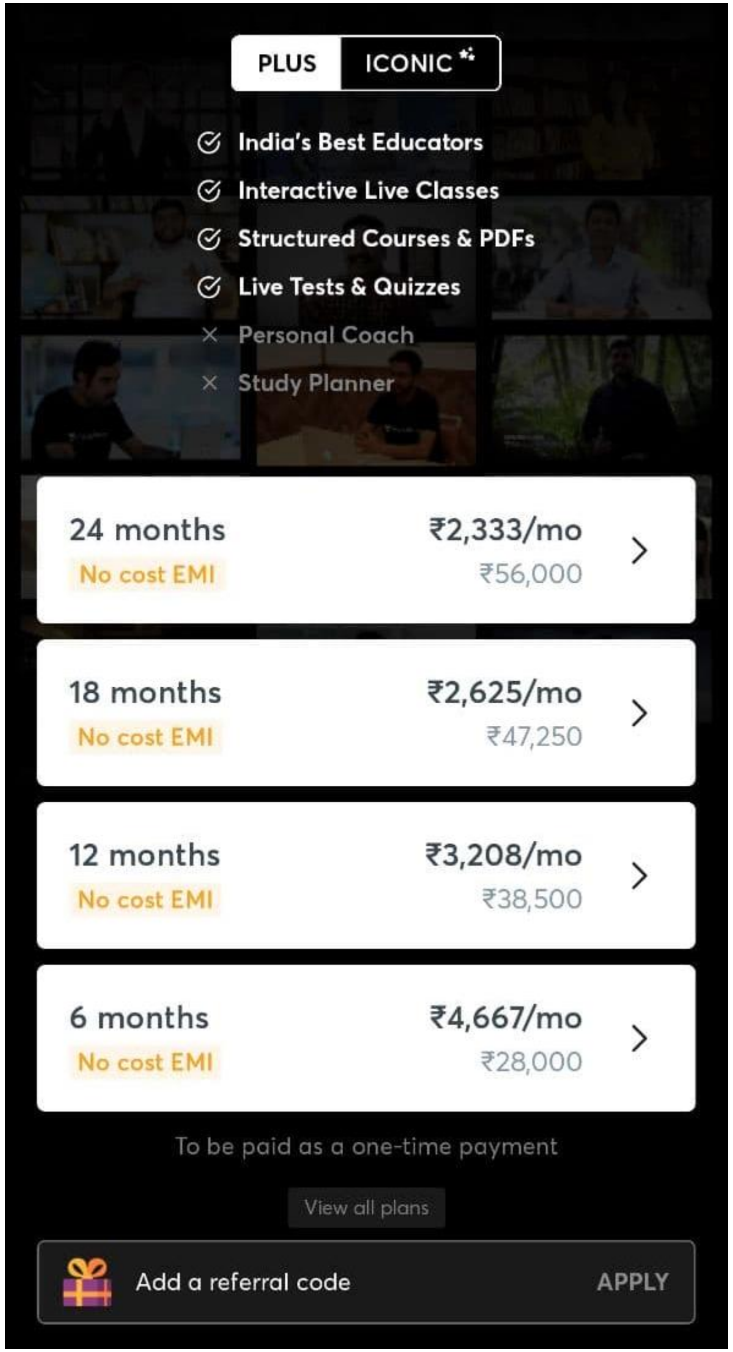
Q 11. A block of ice mass 10 gm is in thermal equilibrium with a water bath containing 10 gm of water which is kept on a conducting movable massless piston on a cylinder containing 3 moles of an ideal diatomic gas in thermal equilibrium with water. The walls of cylinder are adiabatic and heat lost to surroundings is negligible. The gas is heated slowly by a heater. (Latent heat = 80 cal/gm, specific heat of water = 1 cal/gm, $R = 25/3$ J/mol K, mechanical equivalent of heat = 4.2 J/cal)



Column I	Column II
I. Work done by the gas till ice melts	A. 6250 J
II. Change in internal energy of the gas till the water starts boiling	B. 2500 J
III. Work done by the gas till water starts boiling	C. zero
IV. Net heat supplied by heater till the water starts boiling	D. 20510 J

Answer Key

Q.1 7	Q.2 a	Q.3 a	Q.4 c	Q.5 c
Q.6 a	Q.7 b	Q.8 d	Q.9 c	Q.10 c
Q.11 I – C, II – A, III – B, IV – D				



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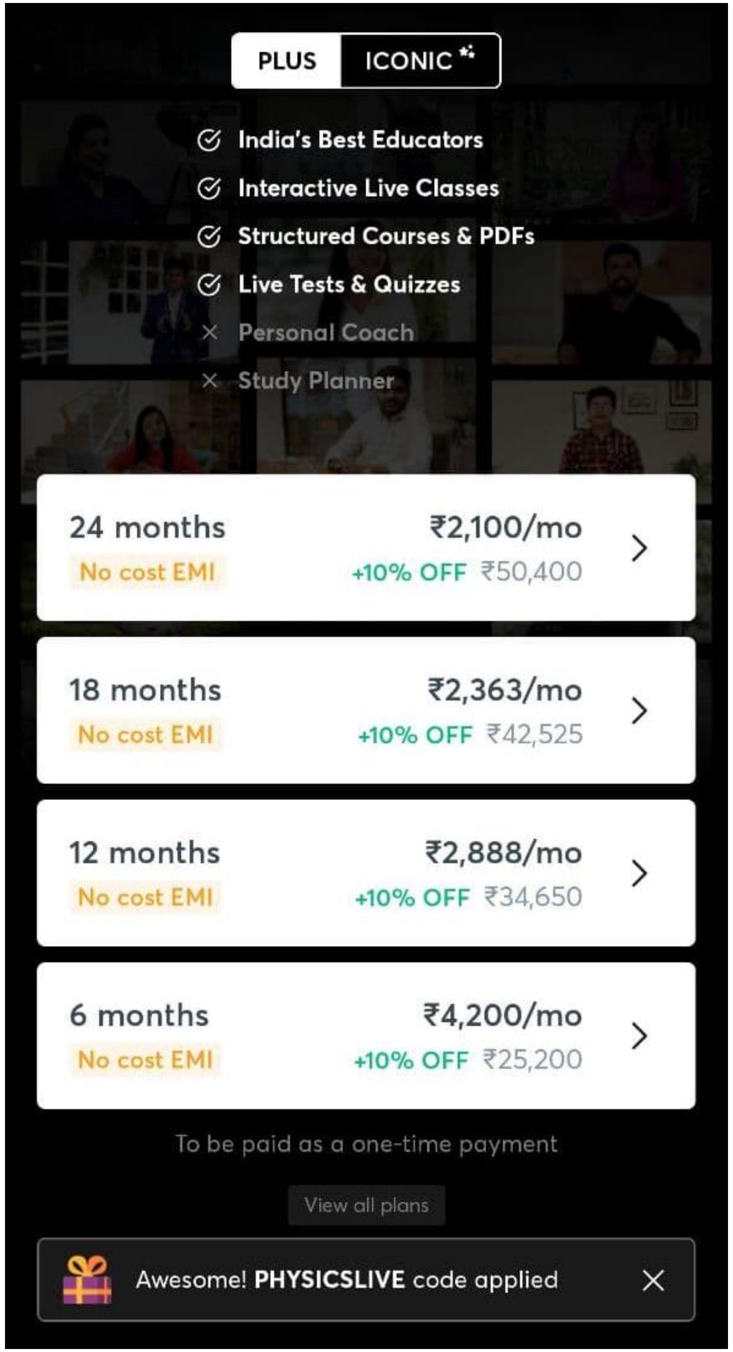
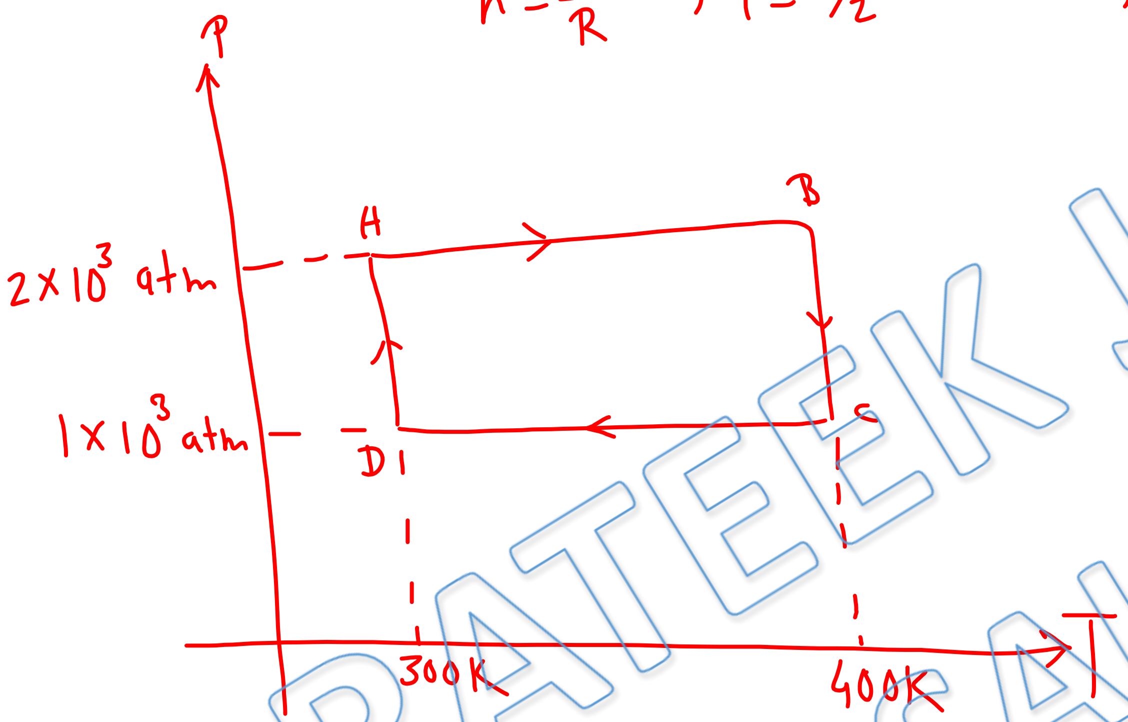


Written Solution

DPP- 4 Thermodynamics- Applying FLOT in different processes

By Physicsaholics Team

1)



$n = \frac{1}{R}$, $\gamma = 3/2$

for Cyclic process

$\Delta Q = W_{gas}$

$W_{AB} = nR\Delta T = \frac{1}{R} \times R \, (400-300)$

$= 100$

$W_{BC} = nRT \ln\left(\frac{P_1}{P_2}\right)$

$= \frac{1}{R} \times R \times 400 \ln\left(\frac{2\times10^3}{1\times10^3}\right) = 400 \ln 2$

$W_{CD} = \frac{1}{R} \times R \, (300-400) = -100$

$W_{DA} = \frac{1}{R} \times R \times 300 \ln\left(\frac{1\times10^3}{2\times10^3}\right)$

$= -300 \ln 2$

$\Delta Q = W_{gas} = 100 + 400\ln 2 - 100 - 300 \ln 2$

$= 100 \ln 2 = 70 = 7X$

$\Rightarrow X = 7$

2)

$$\Delta U = \frac{f}{2} nR\Delta T = \frac{3}{2} \times 1 R \times (2T_0 - T_0) = \frac{3}{2} RT_0$$

Equation of process is $P = CV \Rightarrow PV^{-1} = C \rightarrow$ Polytropic process

$$W_{gas} = \frac{-nR\Delta T}{x-1} = \frac{-1 \times R \times T_0}{-1-1} = \frac{RT_0}{2}.$$

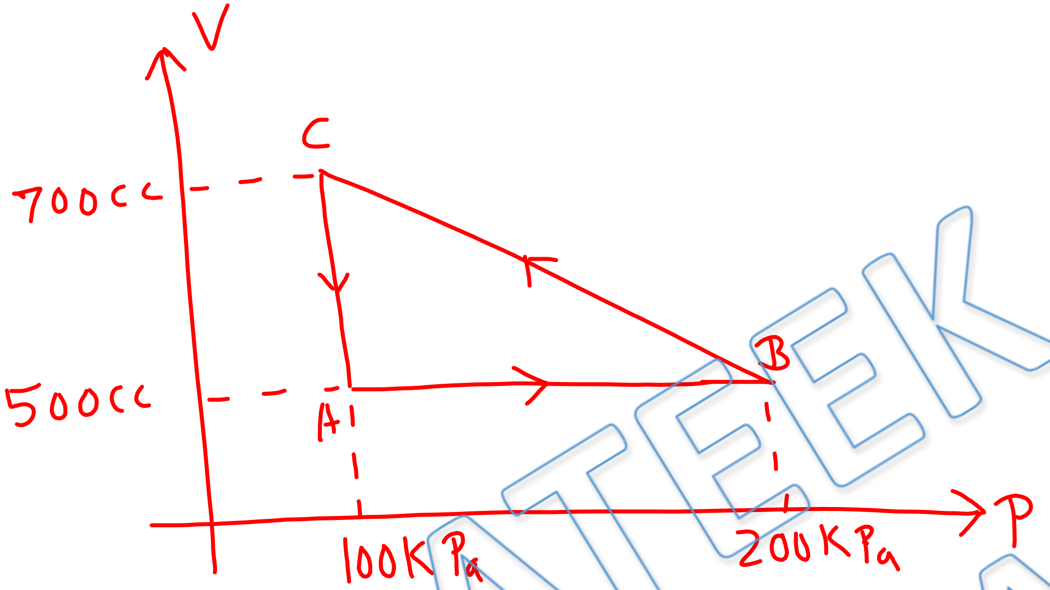
$$\Delta Q = \Delta U + W_{gas}$$

$$= \frac{3}{2} RT_0 + \frac{RT_0}{2}$$

$$= 2RT_0$$

Ans. a

3)



W_{gas} = Area of loop

$= \frac{1}{2} \times 200 \times 10^{-6} \times 100 \times 10^{3}$

$= 10\,J$

$\Delta Q = 2.4\,Cal$

In cyclic process

$\Delta Q = W_{gas}$

$\Rightarrow 2.4\,Cal = 10\,J$

$\Rightarrow 1\,Cal = \frac{10}{2.4}\,J = 4.17\,J$

$\Rightarrow J = 4.17\,J/Cal$

Ans. a

4)

for diatomic ($f = 5$) gas at Constant pressure

$$W = nR\Delta T$$

$$\Delta U = \frac{f}{2} nR\Delta T = \frac{5}{2} nR\Delta T$$

$$\Delta Q = \Delta U + W = \frac{7}{2} nR\Delta T$$

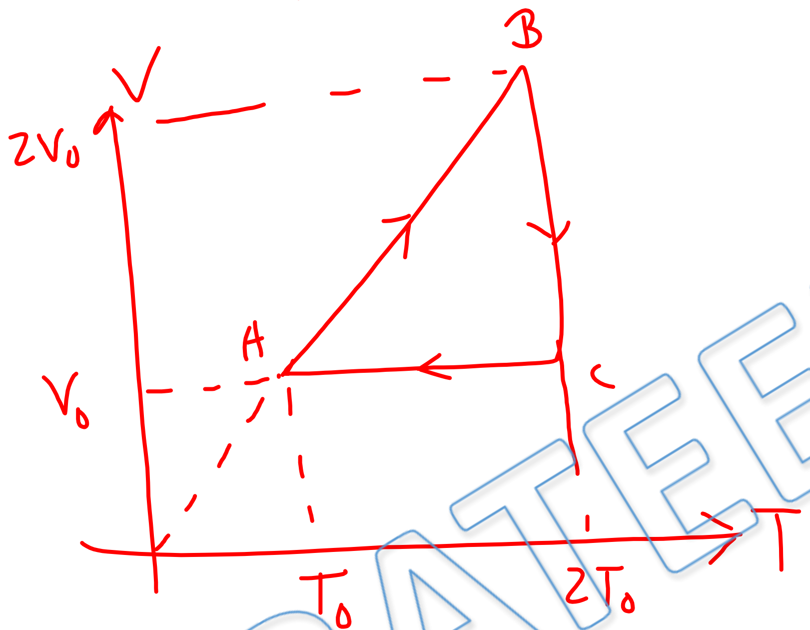
$$\Rightarrow \Delta Q : \Delta U : W = \frac{7}{2} : \frac{5}{2} : 1$$

$$= 7 : 5 : 2$$

Ans. c

5)

$f = 3$



$\Delta Q_{AB} = \Delta U_{AB} + W_{AB}$

$= \frac{3}{2} nRT_0 + nRT_0$

$= \frac{5}{2} nRT_0$

$W_{BC} = nRT \ln\left(\frac{V_2}{V_1}\right)$

$= 2nRT_0 \ln\left(\frac{V_0}{2V_0}\right)$

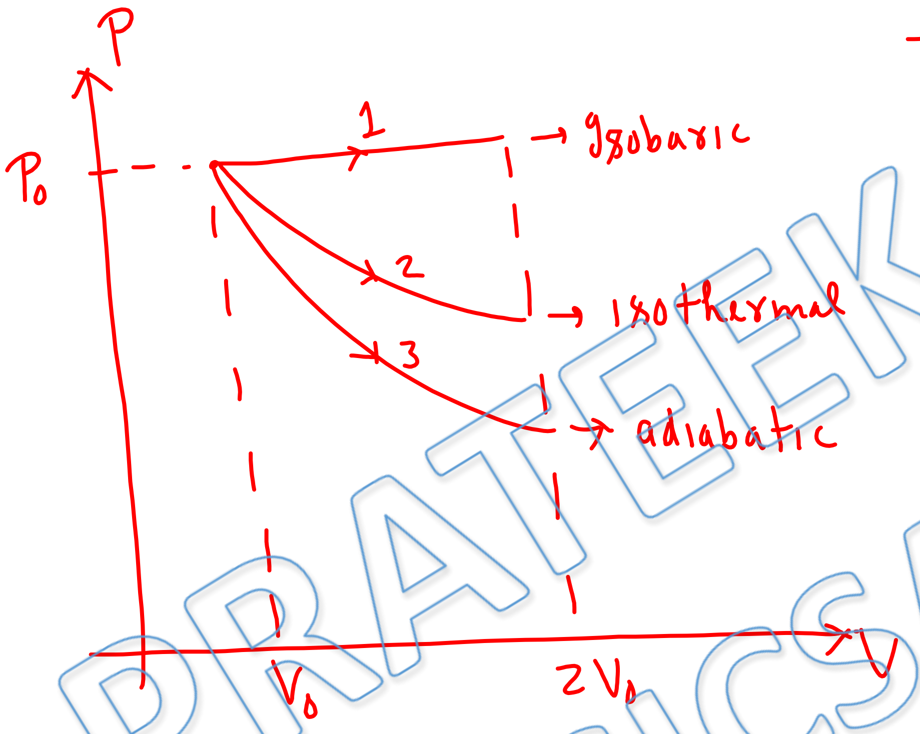
$= -2nRT_0 \ln 2$

Work done on gas in BC $= 2nRT_0 \ln 2$

$\text{Ratio} = \frac{5/2}{2\ln 2} = \frac{5}{4\ln 2}$

Ans. c

6)



In Process 3 → $\Delta Q_3 = 0$

In Process 2 → $\Delta Q_2 = 0 + W_2$

In process 1 →

$\Delta Q_1 = \Delta U_1 + W_1$

ΔU_1 → +ve

W_1 → greater than W_2

$\Rightarrow \Delta Q_1 > \Delta Q_2 > \Delta Q_3$

Ans. a

7) When vessel will stop, all Kinetic energy will Convert into internal energy

$$\frac{1}{2} m V^2 = \frac{f}{2} nR\Delta T$$

(m → mass of gas)

but $\gamma = 1 + \frac{2}{f} \Rightarrow \frac{2}{f} = \gamma - 1$

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

$$\Delta T = \frac{mV^2}{nRf}$$

$$= \frac{(\gamma-1) m V^2}{2nR}$$

$$= \frac{(\gamma-1) MV^2}{2R}$$

Ans. b

8)

$$2\,dU + 3\,dW = 0$$

$$\Rightarrow 2 \times \frac{3}{2} nR\,dT + 3P\,dV = 0$$

$$\Rightarrow 3\left[P\,dV + V\,dP + P\,dV\right] = 0$$

$$\Rightarrow 2P\,dV = -V\,dP$$

$$\Rightarrow 2\int \frac{dV}{V} = -\int \frac{dP}{P}$$

$$\Rightarrow 2\ln V = -\ln P + C$$

$$\Rightarrow \ln V^2 + \ln P = C$$

$$\Rightarrow \ln PV^2 = C$$

$$\Rightarrow PV^2 = C$$

Ans. d

9)

In adiabatic expansion

$\Delta Q = 0 \Rightarrow \Delta U + W_{gas} = 0$

$\Rightarrow \Delta U = -ve \Rightarrow T$ decreases

In adiabatic process

$PV^{\gamma} = c$

$\Rightarrow \frac{T}{V} V^{\gamma} = c$

$\Rightarrow TV^{\gamma-1} = c$

$\Rightarrow T \propto \frac{1}{V^{\gamma-1}}$

statement 1 is correct
& " 2 " wrong

Ans. c

10) $T = KV^2 \Rightarrow \frac{PV}{nR} = KV^2 \Rightarrow PV^{-1} = C \rightarrow$ Polytropic process

$$W_{gas} = \frac{-nR\Delta T}{x-1} = \frac{-nR(4T_0 - T_0)}{-1-1} = \frac{3nRT_0}{2}$$

$$\Delta U = \frac{f}{2}nR\Delta T = \frac{3}{2}nR(4T_0 - T_0) = \frac{9}{2}nRT_0$$

$$\Delta Q = \Delta U + W_{gas}$$

$$= \frac{12nRT_0}{2} = 6nRT_0$$

Ans(c)

11)

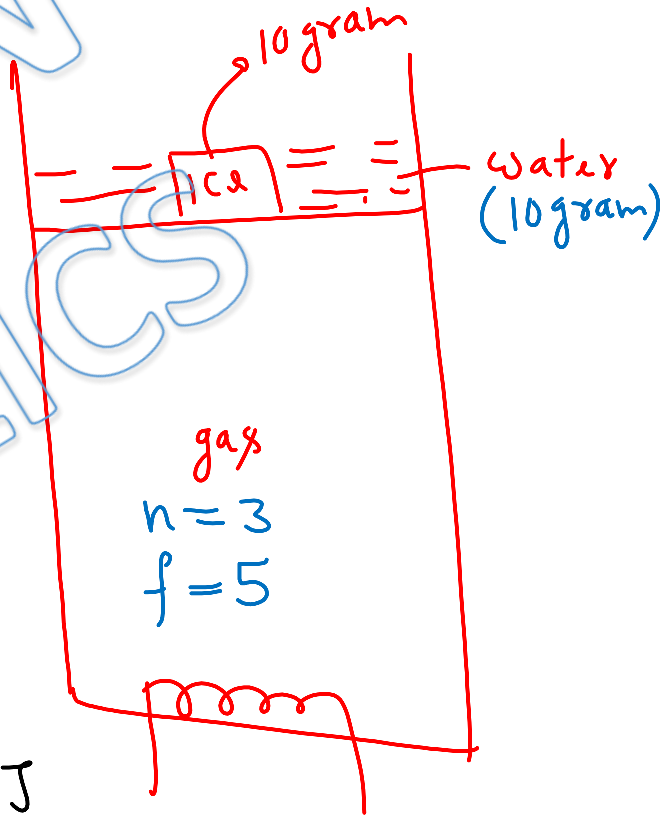
1) $P_{gas} = P_0 + \frac{mg}{A} = \text{Constant}$

Since gas is in equilibrium with (ice + water)

$T = \text{Constant}$

$\Rightarrow \quad V = \text{Constant}$

$\Rightarrow$ work done by gas $= 0$



II) Increment in temperature $= 100\,C$

$$\Delta U = \frac{f}{2} nR\Delta T = \frac{5}{2} \times 3 \times 8.314 \times 100 \simeq 6250\,J$$

III) work done by gas

$= nR\Delta T = 3 \times 8.314 \times 100 = 2500\ J$

IV) Heat supplied up to boiling of water

$\Delta Q = \Delta U + W_{gas} + mL + m's\Delta T$

$= 6250 + 2500 + (10 \times 80 \times 4.2) + (20 \times 4.2 \times 100)$

$= 8750 + 3360 + 8400$

$= 20510\ J$

Ans. I – C, II – A, III – B, IV – D

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