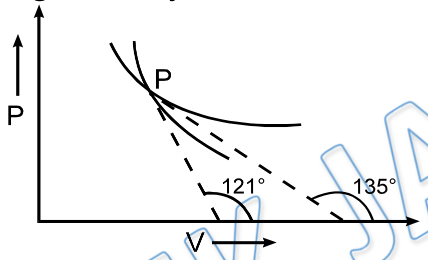
DPP – 3 (Thermodynamics)

Q 1. A gas undergoes an adiabatic process and an isothermal process. The two processes are plotted on a P-V diagram. The resulting curves intersect at a point P. Tangents are drawn to the two curves at P. These make angles of 135° & 121° with the positive V-axis. If tan 59° = 5/3, the gas is likely to be:



(A) monoatomic
(B) diatomic
(C) triatomic
(D) a mixture of monoatomic & diatomic gases

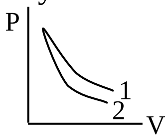
Q 2. A gas is compressed adiabatically till its pressure becomes 27 times its initial pressure. Calculate final temperature if initial temperature is 27^0C and the value of $\gamma = 3/2$?
(a) 300 K
(b) 600 K
(c) 900 K
(d) 1200 K

Q 3. An ideal gas (γ = 1.5) is expanded adiabatically; How. many times has the gas to be expanded to reduce the root mean square velocity of molecules 2.0 times :
(a) 4 times
(b) 16 times
(c) 8 times
(d) 2 times

Q 4. Three samples of the same gas A, B and C (γ = 3/2) have initially equal volume. Now the volume of each sample is doubled. The process is adiabatic for A isobaric for B and isothermal for C. If the final pressures are equal for all three samples, the ratio of their initial pressures are:
(a) $2\sqrt{2} : 2 : 1$
(b) $2\sqrt{2} : 1 : 2$
(c) $\sqrt{2} : 1 : 2$

(d) $2 : 1 : \sqrt{2}$

Q 5. P – V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to



(A) He and O_2 (B) O_2 and He
(C) He and Ar (D) O_2 and N_2

Q 6. Starting with the same initial conditions, an ideal gas expends from volume V_1 to V_2 in three different ways. The work done by the gas is W_1 if the process is isothermal, W_2 if isobaric and W_3 if adiabatic, then
(a) $W_2 > W_1 > W_3$ (b) $W_2 > W_3 > W_1$

(c) $W_1 > W_2 > W_3$ (d) $W_1 > W_3 > W_2$

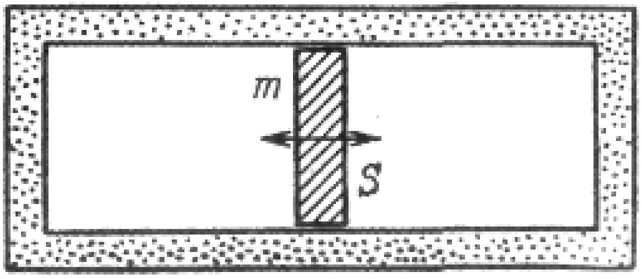
Q 7. A gas may expand either adiabatically or isothermally. A number of P-V curves are drawn for the two processes over different ranges of pressure and volume. It will be found that
(a) two adiabatic curves do not intersect
(b) two isothermal curves do not intersect
(c) an adiabatic curve and an isothermal curve may intersect
(d) the magnitude of the slope of an adiabatic curve is greater than the magnitude of the slope of an isothermal curve for the same values of pressure and volume

Q 8. Two gases have the same initial pressure, volume and temperature. They expand to the same final volume, one adiabatically and the other isothermally.
(a) The final temperature is greater for the isothermal process.
(b) The final pressure is greater for the isothermal process.
(c) The work done by the gas is greater for the isothermal process.
(d) All the above options are incorrect.

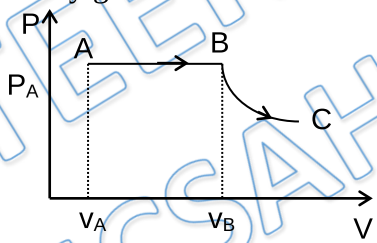
Q 9. Air ($\gamma = 1.4$) is filled in a motor car tube at 27^0C temperature and 2 atmosphere pressure. If the tube suddenly bursts then the final temperature will be (given $(1/2)^{2/7} = 0.82$)
(a) 642 K (b) 563 K
(c) 300 K (d) 246 K

Q 10. An ideal gas expands isothermally from a volume V_1 to V_2 and then compressed to original volume V_1 adiabatically. Initially pressure is P_1 and final pressure is P_3. The total work done is W. Then
(a) $P_3 > P_1, W > 0$
(b) $P_3 < P_1, W < 0$
(c) $P_3 > P_1, W < 0$
(d) $P_3 = P_1, W = 0$

Q 11. In a cylinder filled up with ideal gas and closed from both ends there is a piston of mass *m* and cross-sectional area *S*. In equilibrium the piston divides the cylinder into two equal parts, each with volume V_0. The gas pressure is p_0. The piston was slightly displaced from the equilibrium position and released. Find its oscillation frequency, assuming the processes in the gas to be adiabatic and the friction negligible



Q 12. Two moles of Helium gas ($\gamma = 5/3$) are initially at temperature 27°C and occupy a volume of 20 litres. The gas is first expanded at constant pressure until the volume is doubled. Then it undergoes an adiabatic change until the temperature returns to its initial value. Net work done by gas is

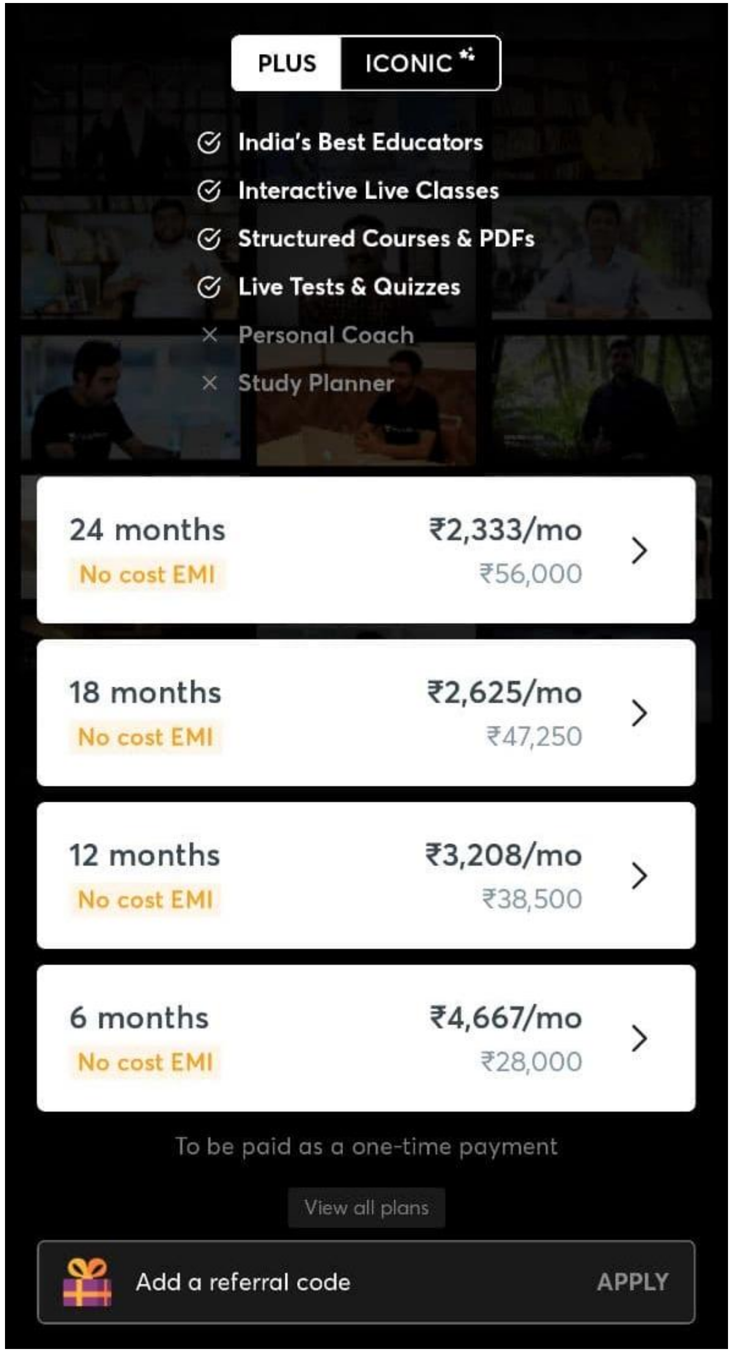


(a) 4980 J
(b) 7470 J
(c) 12450 J
(d) 8000 J

Answer Key

Q.1 a	**Q.2 c**	**Q.3 b**	**Q.4 b**	**Q.5 b**
Q.6 a	**Q.7 a,b,c,d**	**Q.8 a,b,c**	**Q.9 d**	**Q.10 c**

Q.11 $\frac{1}{2\pi}\sqrt{\frac{2\gamma P_0 S}{mV_0}}$	**Q.12** c



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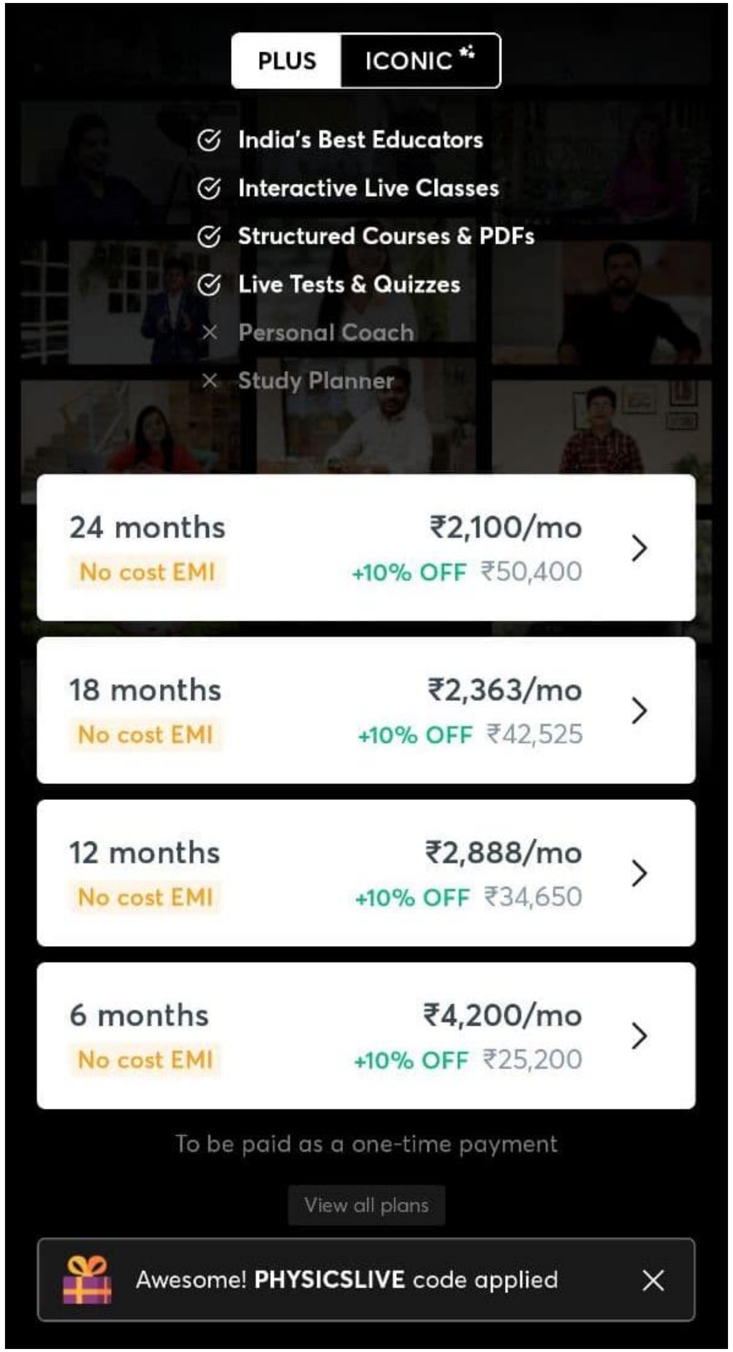


Written Solution

DPP- 3 Thermodynamics- Adiabatic process

By Physicsaholics Team

1)

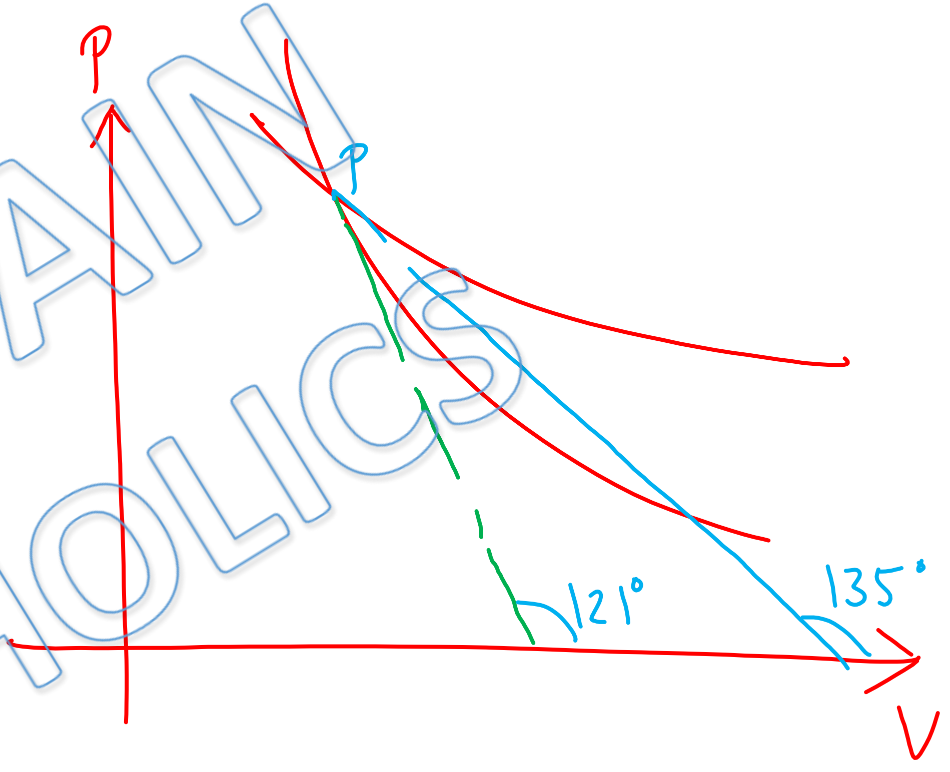
Slope of isothermal PV Curve

$= -\frac{P}{V} = \tan 135^\circ \Rightarrow \frac{P}{V} = 1$

Slope of adiabatic PV Curve

$= -\frac{\gamma P}{V} = \tan 121^\circ \Rightarrow \frac{\gamma P}{V} = 5/3$

$\Rightarrow \gamma = \frac{5}{3} \Rightarrow$ monoatomic gas



ANS (a)

2) $PV^{\gamma} = C \Rightarrow P\left(\frac{nRT}{P}\right)^{3/2} = C \Rightarrow \frac{T^{3/2}}{P^{1/2}} = C$

$\Rightarrow T^3 \propto P \Rightarrow \left(\frac{T_1}{T_2}\right)^3 = \frac{P_1}{P_2} \Rightarrow \left(\frac{300}{T}\right)^3 = \frac{1}{27}$

$\Rightarrow \frac{300}{T} = \frac{1}{3} \Rightarrow T = 900K$

ANS (C)

3) $PV^{\gamma} = C \Rightarrow \frac{nRT}{V} V^{\gamma} = c \Rightarrow T V^{3/2 - 1} = c$

$\Rightarrow T^2 V = c \Rightarrow V_{rms}^4 V = c$

on reducing V_{rms} to two times, V will increase to 16 times

ANS(b)

4) Let final pressure of each $= P_0$

for A :- $P_1 V_1^{3/2} = P_0 (2V_1)^{3/2} \Rightarrow P_1 = 2\sqrt{2}\, P_0$

for B :- $P_1 = P_f = P_0$

for C :- $P_1 V_1 = P_0 (2V_1) \Rightarrow P_1 = 2P_0$

Ratio $= 2\sqrt{2} : 1 : 2$

ANS (b)

5)

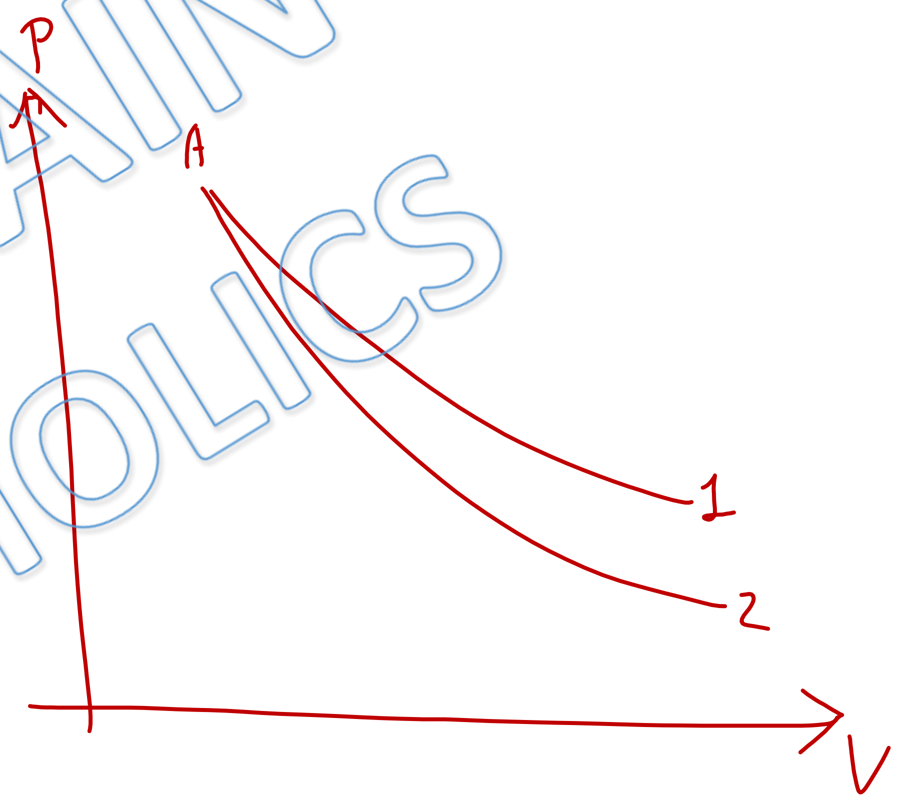
Slope of PV Curve in adiabatic $= \frac{-\gamma P}{V}$

At Point A, it has higher magnitude for 2

γ is higher for 2

$\Rightarrow f$ (degree of freedom) is higher for 1

$\Rightarrow$ option B is Correct

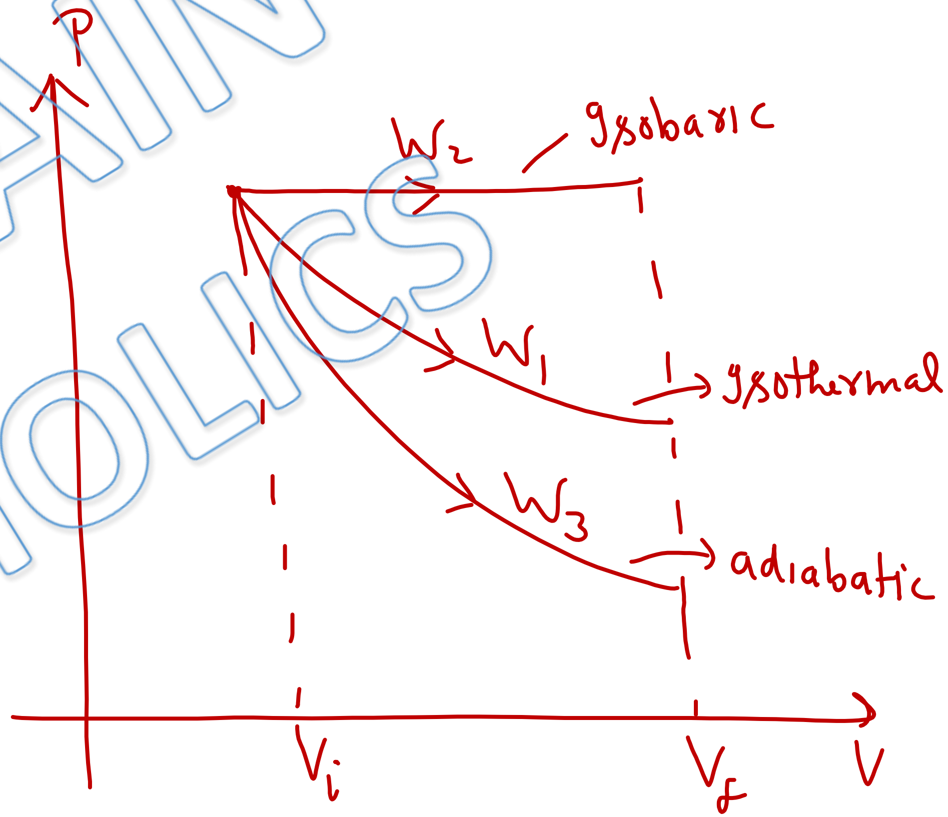


ANS(b)

6)

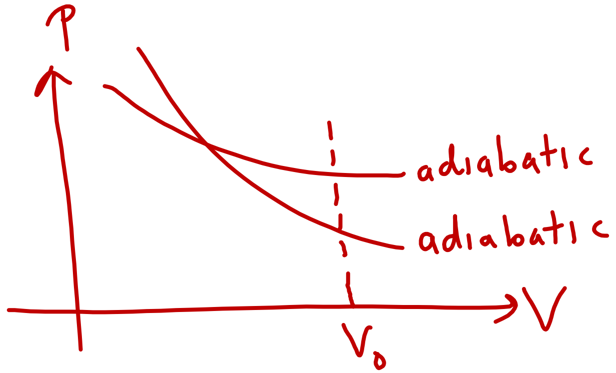
W = Area under Curve

$W_2 > W_1 > W_3$



ANS (a)

7)



for adiabatic $PV^{\gamma} = c$

$\Rightarrow$ for a given value of V_0, there are two values of pressure in graph which is not possible

$\Rightarrow$ we can give same logic for two isotherms

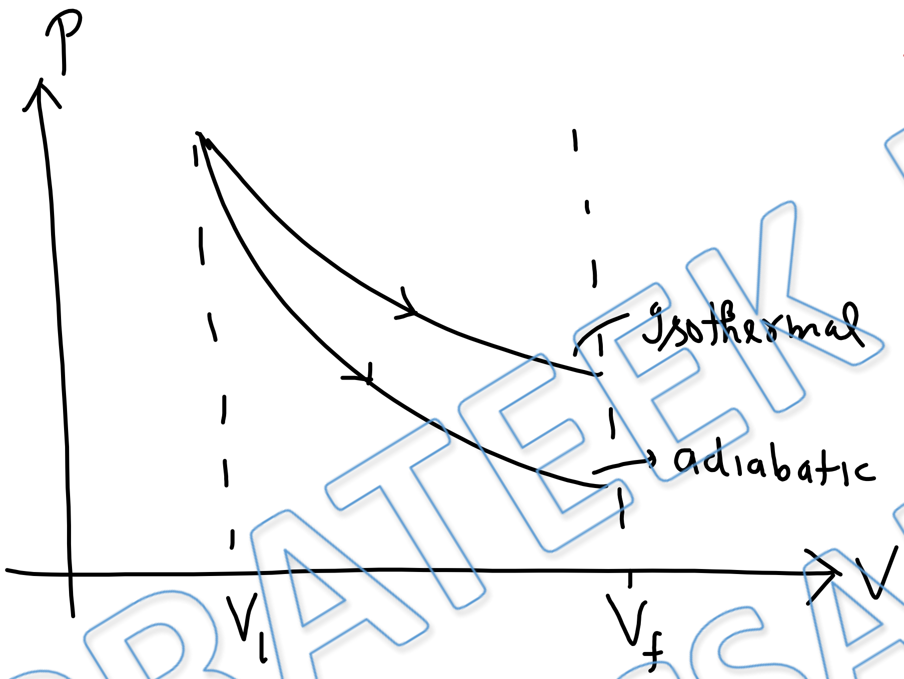
It is well known that an adiabatic & an isotherm may intersect

$$|\text{Slope in adiabatic P-V Curve}| = \frac{\gamma P}{V}$$

$$|\text{ ,, ,, isothermal ,, ,, }| = \frac{P}{V}$$

Ans (a, b, c, d)

8)



from graph it is clear that final value of PV is greater for isothermal

$\Rightarrow$ final temperature is greater for isothermal

final pressure is greater for isothermal (look graph)

W_{gas} = Area under curve

$\Rightarrow$ It is greater for isothermal

ANS (a, b, c)

9) Expansion of air in tube bursting is very fast, hence adiabatic Process

$$P^{1-\gamma} T^{\gamma} = C \Rightarrow T^{\gamma} = c P^{\gamma-1} \Rightarrow \left(\frac{T_1}{T_2}\right)^{\gamma} = \left(\frac{P_1}{P_2}\right)^{\gamma-1}$$

$$\Rightarrow \left(\frac{300}{T_2}\right)^{7/5} = \left(\frac{2}{1}\right)^{7/5 - 1} = (2)^{2/5}$$

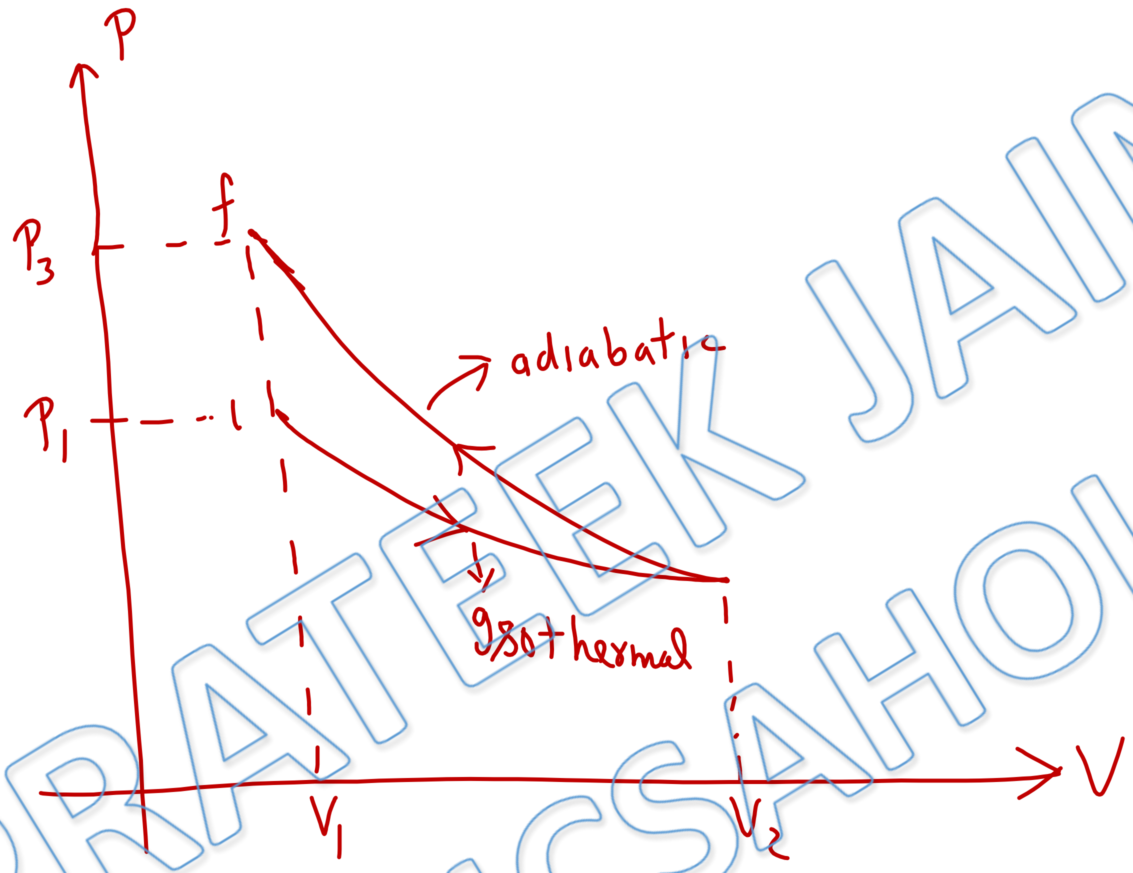
$$\Rightarrow \frac{300}{T_2} = (2)^{\frac{2}{5} \times \frac{5}{7}} = \frac{1}{.82}$$

$$\Rightarrow T_2 = 300 \times .82$$

$$= 246\ K$$

ANS(d)

10)



from graph it is clear that

$P_3 > P_1$

$W = -\Delta U$

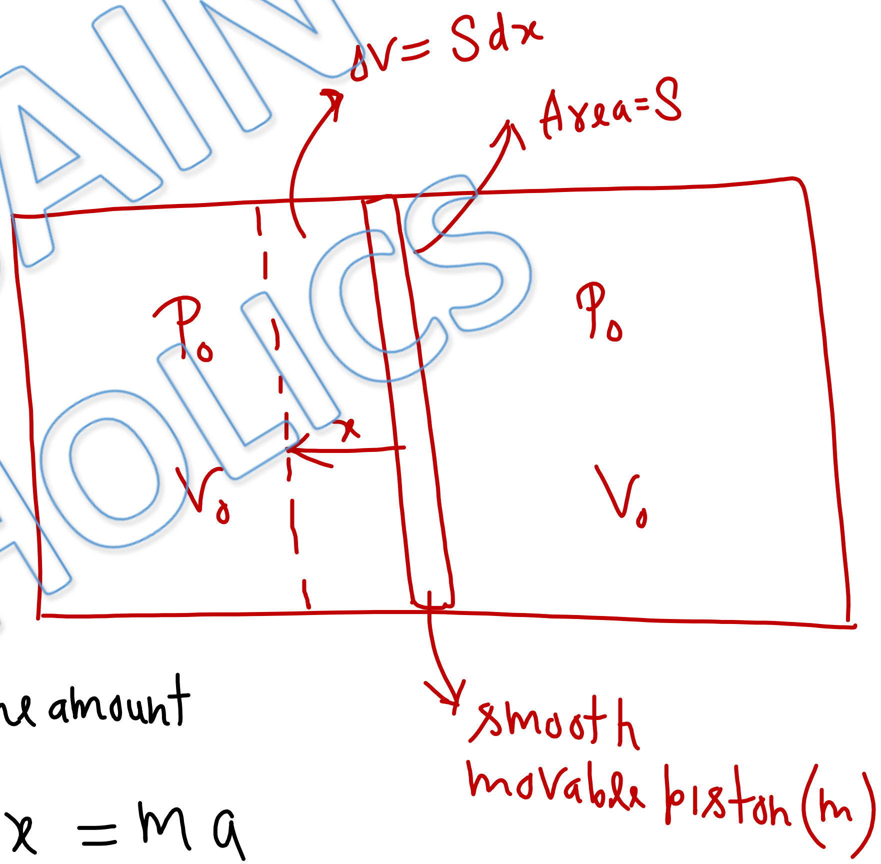
ANS (c)

11) for Left part

$$PV^{\gamma} = C$$

$$\Rightarrow \quad \frac{dP}{dV} = -\frac{\gamma P}{V} \Rightarrow dP = -\frac{\gamma P}{V} dV$$

$$\Rightarrow \quad \Delta P = \frac{\gamma P_0}{V_0} S x$$



Pressure of right part decreases by same amount

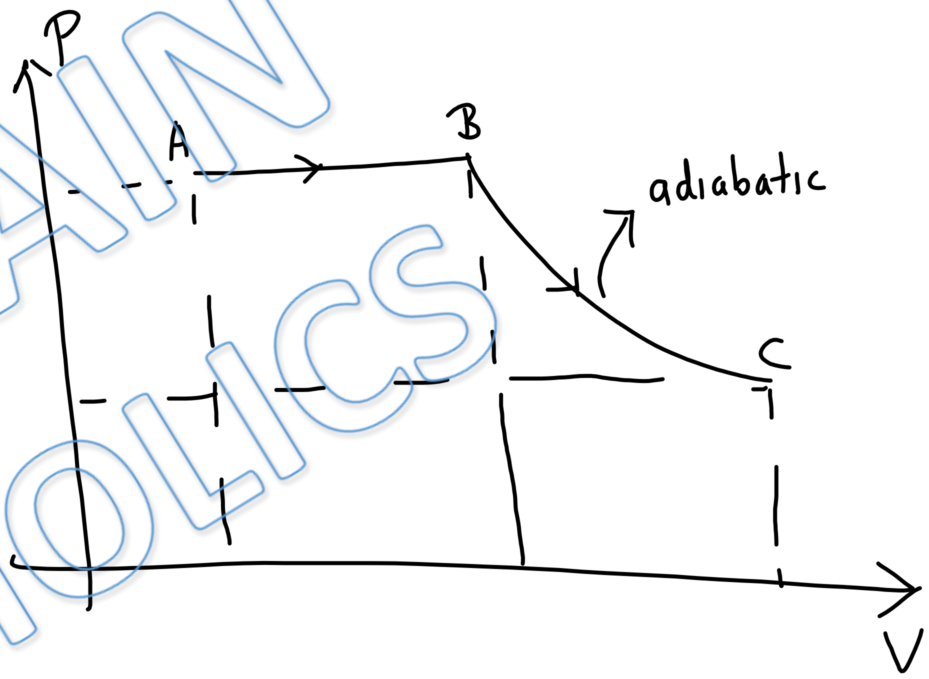
$\Rightarrow$ net restoring force on Piston $= \dfrac{2\gamma P_0 S^2 x}{V_0} = ma$

$$\Rightarrow \quad a = \frac{2\gamma P_0 S^2}{mV_0} x \qquad \Rightarrow \text{frequency} = \frac{1}{2\pi}\sqrt{\frac{2\gamma P_0 S^2}{mV_0}} = \frac{S}{2\pi}\sqrt{\frac{2\gamma P_0}{mV_0}}$$

12) $T_A = T_C = 300K$, $n = 2$ mole

$V_A = 20$ litre , $V_B = 40$ litre

for AB , $T \propto V \Rightarrow T_B = 600K$



$W_{AB} = nR\Delta T = 2 \times 8.3 \times 300$

$= 4980 J$

$W_{BC} = \frac{-nR\Delta T}{\gamma - 1} = \frac{-2 \times 8.3 \times (300-600)}{5/3 - 1} = \frac{2 \times 8.3 \times 300 \times 3}{2}$

$= 7470 J$

$W_{net} = 4980 + 7470 = 12450 J$

ANS (c)

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