DPP – 5 (Thermodynamics)

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Q 1. Sixty per cent of given sample of oxygen gas when raised to a high temperature dissociates into atoms. Ratio of its initial heat capacity (at constant volume) to the final heat capacity (at constant volume) will be:

(a) $\frac{8}{7}$ (b) $\frac{25}{26}$

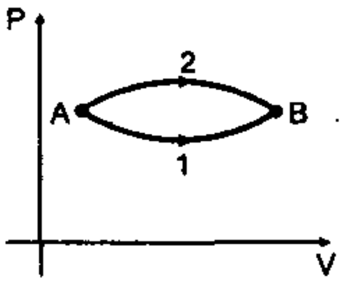
(c) $\frac{10}{7}$ (d) $\frac{25}{27}$

Q 2. P-V diagram of a diatomic gas is a straight line passing through origin. The molar heat capacity of the gas in the process will be:

(a) 4R (b) 2.5R

(c) 3 R (d) $\frac{4R}{3}$

Q 3. The figure shows two paths for the change of state of a gas from A to B. The ratio of molar heat capacities in path 1 and path 2 is:



(a) >1

(b)<1

(c) 1

(d) data insufficient

Q 4. The molar heat capacity in a process of a diatomic gas if it does a work of $\frac{Q}{4}$ when a heat of Q is supplied to it is :

(a) $\frac{2}{5}$R (b) $\frac{5}{2}$R

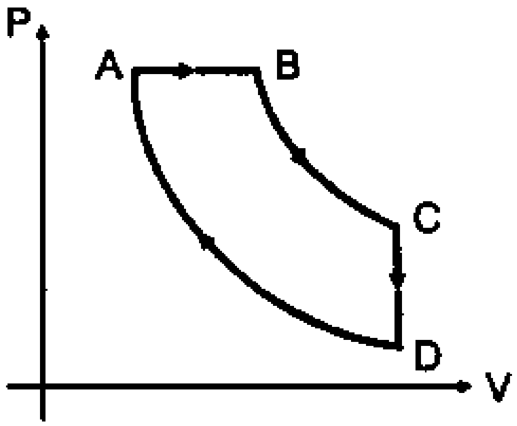
(c) $\frac{10}{3}$R (d) $\frac{6}{7}$R

Q 5. Ideal monoatomic gas is taken through a process dQ = 2dU. The molar heat capacity for the process is: (where dQ is heat supplied and dU is change in internal energy)

(a) 5 R (b) 3 R

(c) R (d) None

Q 6. n moles of a monoatomic gas undergo a cyclic process ABCDA as shown in figure. Process AD is isobaric, BC is adiabatic, CD is isochoric and DA is isothermal. The maximum and minimum temperature in the cycle are $4T_0$ and T_0 respectively. Then:



(a) $T_B > T_C > T_D$
(b) heat is released by the gas in the process CD
(c) heat is supplied to the gas in the process AB
(d) total heat supplied to the gas is $2nRT_0 \ln(2)$

Q 7. At ordinary temperatures, the molecules of an ideal gas have only translational and rotational kinetic energies. At high temperatures they may also have vibrational energy. As a result of this at higher temperatures : (C_V = molar heat capacity at constant volume)
(a) $C_V = 3/2R$ for a monoatomic gas
(b) $C_V > 3/2$ R for a monoatomic gas
(c) $C_V < \frac{5}{2}$R for a diatomic gas
(d) $C_V > \frac{5}{2}$R for a diatomic gas

Q 8. An ideal gas with adiabatic exponent (γ = 1.5) undergoes a process in which work done by the gas is same as increase in internal energy of the gas. The molar heat capacity of gas for the process is:
(A) C = 4R (B) C = 0
(C) C= 2R (D) C = R

Q 9. A mixture of ideal gasses N_2 and He are taken in the mass ratio of 14 : 1 respectively. Molar heat capacity of the mixture at constant pressure is.
(a) $\frac{19R}{6}$ (B) $\frac{6R}{19}$
(C) $\frac{13R}{6}$ (D) $\frac{6R}{13}$

Q 10. The molar heat capacity for an ideal gas
(a) cannot be negative
(b) must be equal to either C_V or C_p
(c) must lie in the range $C_V \leq C \leq C_p$
(d) may be zero

Q 11.

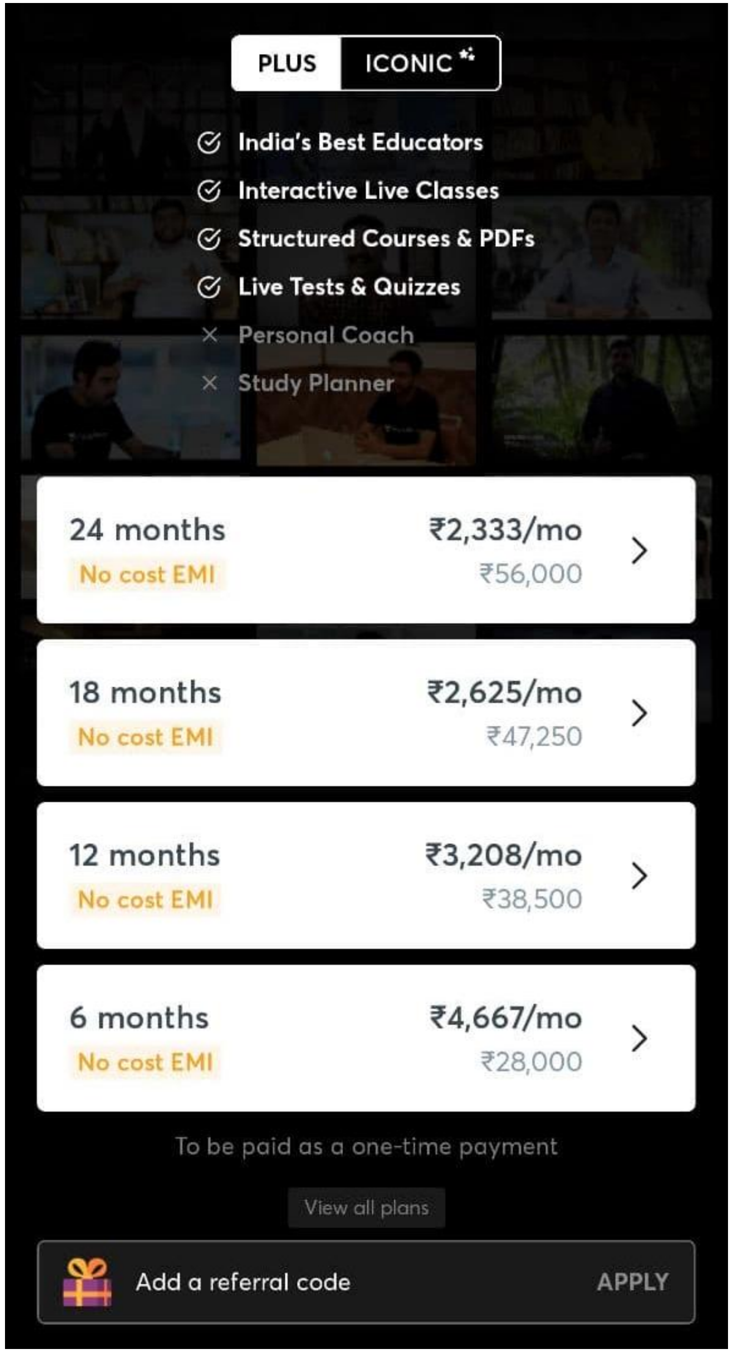
STATEMENT–1: The specific heat of a monatomic gas has value between 0 and ∞.

because

STATEMENT–2: $c_P = \frac{5}{2}R$ and $c_V = \frac{3}{2}R$ for a monoatomic gas.

Answer Key

Q.1 c	**Q.2 c**	**Q.3 b**	**Q.4 c**	**Q.5 b**
Q.6 a,b,c	**Q.7 a,d**	**Q.8 a**	**Q.9 a**	**Q.10 d**
Q.11 d				



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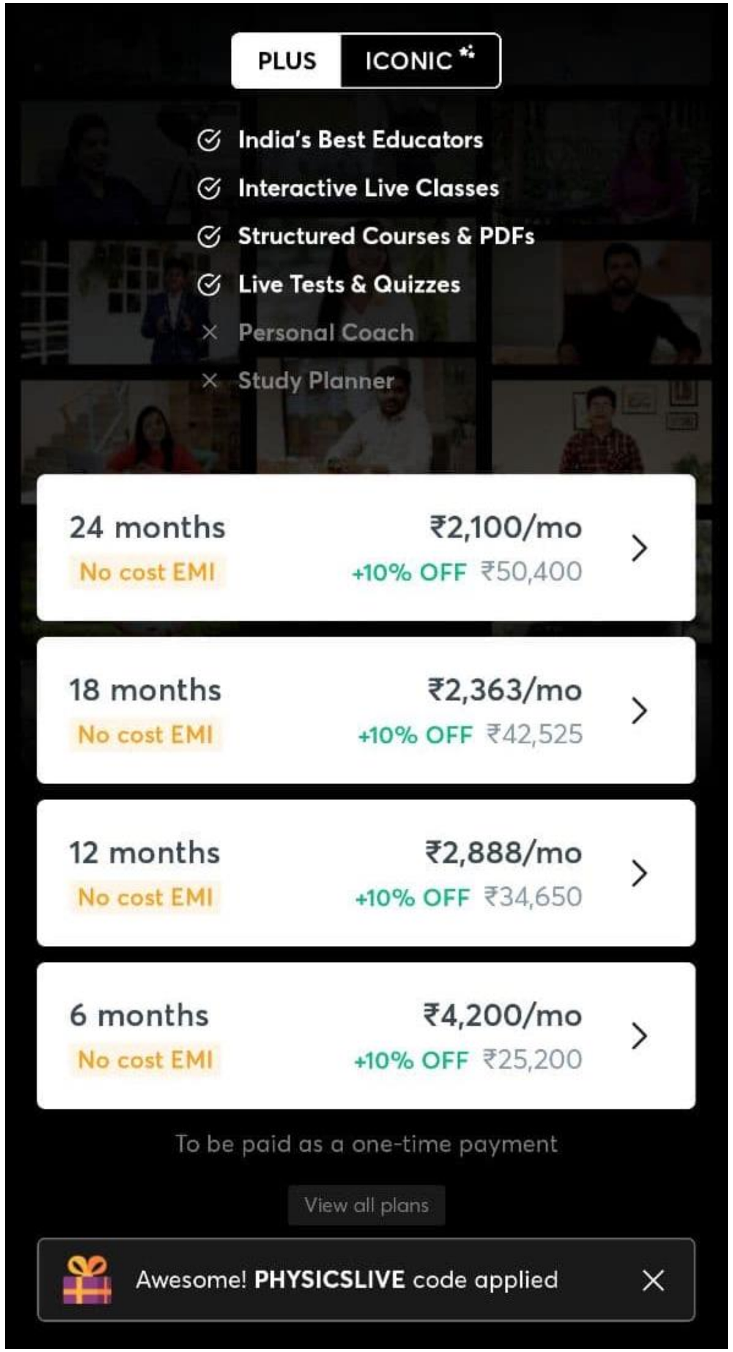

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Written Solution

DPP- 5 Thermodynamics- Molar heat capacity

By Physicsaholics Team

1) Initial $C_v = \frac{f}{2}R = \frac{5}{2}R$

Let there are n moles of Oxygen

At high temperature →

no of moles of $O_2 = .4n$, no of moles of $O = 1.2n$

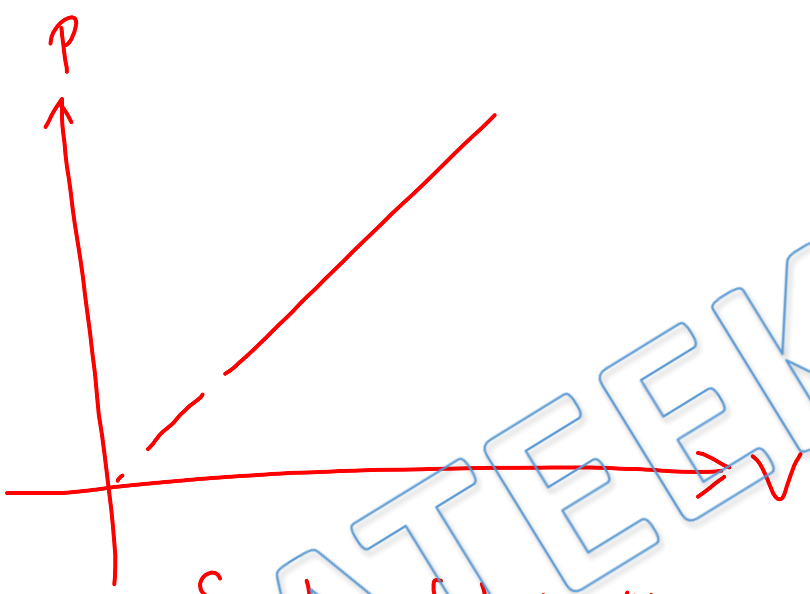
$$C_v' = \frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2} = \frac{.4n\left[\frac{5}{2}R\right] + 1.2n\left[\frac{3}{2}R\right]}{.4n + 1.2n} = \frac{2.8nR}{1.6n}$$

$$= \frac{7R}{4}$$

$$\frac{C_v}{C_v'} = \frac{5R \times 4}{2 \times 7R} = \frac{10}{7}$$

Ans (c)

2)



Equation of process

$$\frac{P}{V} = \text{Constant}$$

$$\Rightarrow PV^{-1} = C$$

Polytropic process

$$C = \frac{f}{2}R - \frac{R}{x-1}$$

$$= \frac{5}{2}R - \frac{R}{-1-1}$$

$$= \frac{5R}{2} + \frac{R}{2}$$

$$= \frac{6R}{2}$$

$$= 3R$$

ANS(C)

3)

$$\Delta Q_1 = \Delta U + W_1 \qquad \text{where } W_2 > W_1$$

$$\Delta Q_2 = \Delta U + W_2$$

$$\Rightarrow \Delta Q_1 < \Delta Q_2$$

$$\Rightarrow n C_1 \Delta T < n C_2 \Delta T$$

$$\Rightarrow \frac{C_1}{C_2} < 1$$

Ans (b)

4)

$W = Q/4$

$\Rightarrow \Delta U = \Delta Q - W = Q - Q/4 = 3Q/4$

$\Rightarrow \frac{f}{2} nR\Delta T = \frac{3}{4} nC\Delta T$

$\Rightarrow \frac{5}{2}R = \frac{3C}{4}$

$\Rightarrow C = \frac{20}{6}R = \frac{10R}{3}$

Ans (c)

5)

$$dQ = 2\,dU$$

$$\Rightarrow \; n C\, dT = 2 \times \frac{f}{2} n R\, dT$$

$$C = fR = 3R$$

ANS - B

b)

AB is isobaric with increasing volume

$\Rightarrow T_B > T_A$

DA is isothermal $\Rightarrow T_D = T_A$

CD is isochoric with decreasing pressure

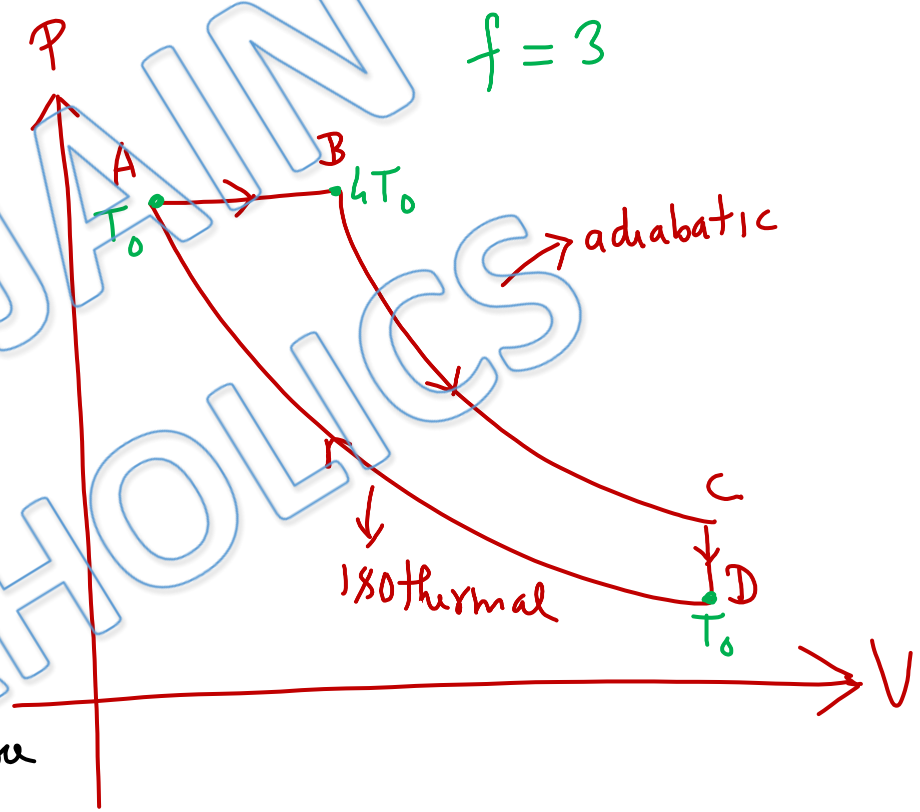
$\Rightarrow T_C > T_D$

BC is adiabatic with increasing volume

$\Rightarrow T_B > T_C$

T_B is highest & T_D is lowest temperature

$\Rightarrow T_B = 4T_0 \quad , T_D = T_0$



$\Delta Q_{CD} = nC_V \Delta T = -ve \Rightarrow$ Heat is released by gas in CD

(nC_V: +ve, ΔT: -ve)

$\Delta Q_{AB} = n C_p \Delta T$ = +ve ⇒ Heat is absorbed by gas

(n → +ve, ΔT → +ve)

$$\Delta Q_{AB} = n C_p \Delta T = n\left(\frac{5}{2}R\right)(4T_0 - T_0) = \frac{15}{2} nRT_0$$

$$\Delta Q_{BC} = 0$$

$$\Delta Q_{CD} = n C_v \Delta T = n\left(\frac{3}{2}R\right)(T_0 - T_C)$$

$$\Delta Q_{DA} = nRT_0 \ln\left(\frac{V_A}{V_D}\right)$$

⇒ net heat supplied depends on T_C option (d) is wrong

7)

Monoatomic gas has translational KE only $\Rightarrow f = 3$

$$C_V = \frac{3}{2}R$$

Diatomic gas has $f = 7$ at high temperature

3 terms of T.K.E
2 ,, ,, R K.E
2 ,, ,, V E

$$C_V = \frac{7}{2}R > \frac{5}{2}R$$

Ans (a, d)

8)

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

$$\Rightarrow \quad \Delta Q = W_{gas} + \Delta U = 2\,\Delta U$$

$$\Rightarrow \quad n\,C\,\Delta T = 2 \times n\,C_v\,\Delta T$$

$$\Rightarrow \quad C = 2C_v = \frac{2R}{\gamma - 1} = \frac{2R}{1.5 - 1}$$

$$= 4R$$

ANS(a)

9)

mass Ratio = 14 : 1

$\Rightarrow$ mole Ratio $= \frac{14}{28} : \frac{1}{4} = \frac{1}{2} : \frac{1}{4} = 2 : 1$

$\Rightarrow$ 2 mole N_2 + 1 mole He

$$C_{P_{mix}} = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 + n_2} = \frac{2\left(\frac{7}{2}R\right) + 1\left(\frac{5}{2}R\right)}{2+1}$$

$$= \frac{19R}{2 \times 3} = \frac{19R}{6}$$

ANS(a)

10) In Polytropic process $PV^{\delta} = c$

$$C = \frac{R}{\gamma-1} - \frac{R}{\delta-1}$$

$C = -ve$

for $1 < \delta < \gamma$

$C = 0$

for $\delta = \gamma$ (adiabatic process)

Ans (d)

11) C may be $-ve$

Ex!

In polytropic Process ($PV^\delta = c$)

$$C = \frac{R}{\gamma - 1} - \frac{R}{\delta - 1}$$

for $1 < \delta < \gamma$

$$C = -ve$$

Statement 1 is wrong & 2 is correct

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