DPP – 5

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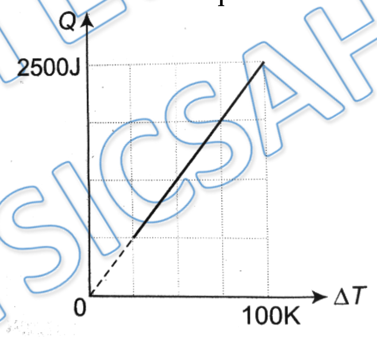
Q 1. Two moles of helium are mixed with n moles of hydrogen. If $\frac{C_p}{C_v} = \frac{3}{2}$ for the mixture, then the value of n is:

(a) 1 (b) 2
(c) 3 (d) 3/2

Q 2. Five moles of helium are mixed with two moles of hydrogen to form a mixture. Take molar mass of helium $M_1 = 4g$ and that of hydrogen $M_2 = 2g$. The equivalent of γ is:

(a) 1.49 (b) 1.63
(c) 1.56 (d) None

Q 3. One mole of a gas mixture is heated under constant pressure, and heat required Q is plotted against temperature difference acquired. Find the value of γ for mixture



(a) $\frac{3}{4}$ (b) $\frac{1}{4}$
(c) $\frac{3}{2}$ (d) $\frac{2}{3}$

Q 4. When 1 mole of monoatomic gas is mixed with 2 moles of diatomic gas, then find C_p, C_v, f and γ for the resulting mixture
(symbols have their usual meaning)

(a) $\frac{19}{6}R, \frac{13}{6}R, \frac{13}{3}, \frac{19}{13}$ (b) $\frac{13}{6}R, \frac{19}{6}R, \frac{19}{3}, \frac{13}{19}$
(c) $\frac{19}{3}R, \frac{13}{3}R, \frac{13}{3}, \frac{19}{13}$ (d) $\frac{19}{6}R, \frac{13}{6}R, \frac{13}{6}, \frac{19}{13}$

Q 5. The molar heat capacity of a gas at constant volume is C_v. If n moles of the gas undergo ΔT change in temperature, its internal energy will change by $nC_v\Delta T$

(a) only if the change of temperature occurs at constant volume
(b) only if the change of temperature occurs at constant pressure

(c) in any process which is not adiabatic
(d) in any process

Q 6. When one mole of monatomic gas is mixed with one mole of a diatomic gas, then the equivalent value of γ for the mixture will be (vibration mode neglected)
(a) 1.33 (b) 1.40
(c) 1.50 (d) 1.60

Q 7. The ratio $\frac{C_p}{C_v} = \gamma$ for a gas. Its molar mass is M. Its specific heat capacity at constant pressure is
(a) $\frac{R}{\gamma-1}$ (b) $\frac{\gamma R}{\gamma-1}$
(c) $\frac{\gamma R}{M(\gamma-1)}$ (d) $\frac{\gamma RM}{\gamma-1}$

Q 8. Each molecule of a gas has f degrees of freedom. The ratio $\frac{C_p}{C_v} = \gamma$ for the gas is
(a) $1 + \frac{f}{2}$ (b) $1 + \frac{1}{f}$
(c) $1 + \frac{2}{f}$ (d) $1 + \frac{(f-1)}{3}$

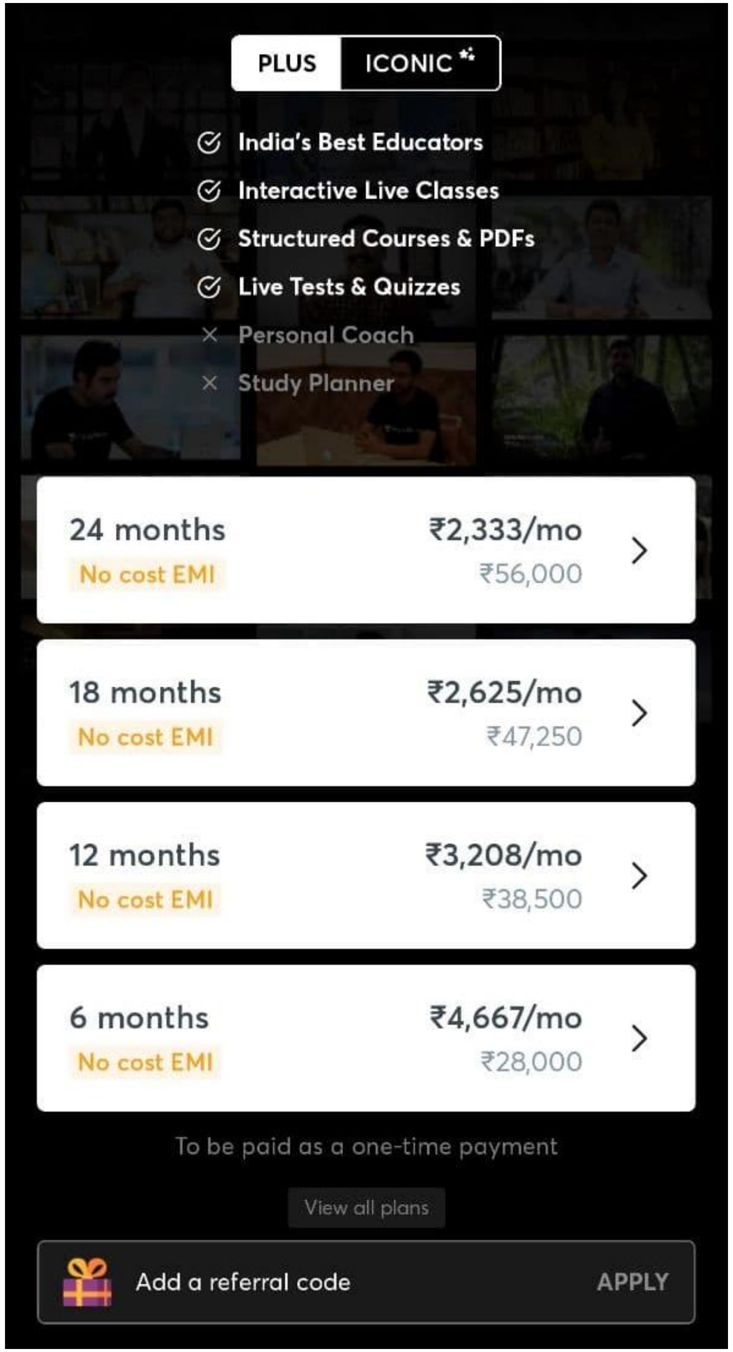
Q 9. A mixture of n_1 moles of mono atomic gas and n_2 moles of diatomic gas has $\frac{C_p}{C_v} = \gamma = 1.5$
(a) $n_1 = n_2$ (b) $2n_1 = n_2$
(c) $n_1 = 2n_2$ (d) $2n_1 = 3n_2$

Q 10. Find the specific heat capacity c_v (in J/gm-K) for a gaseous mixture consisting of 7.0 g of nitrogen and 20 g of argon. The gases are assumed to be ideal
(a) 0.22 (b) 15.2
(c) 0.42 (d) 23.55

Q 11. One mole of an ideal gas whose adiabatic exponent equals γ undergoes a process P = $P_o + \frac{\alpha}{V}$, where P_o and α are positive constants. Find molar heat capacity of the gas as a function of its volume
(a) $\frac{\gamma R}{\gamma-1} + \frac{\alpha V}{P_o R}$ (b) $\frac{R}{\gamma-1} + \frac{R}{P_o V}$
(c) $\frac{\gamma R}{\gamma-1} + \frac{\alpha R}{P_o V}$ (d) $\frac{(\gamma-1)R}{\gamma} + \frac{VR}{P_o \alpha}$

Answer Key

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



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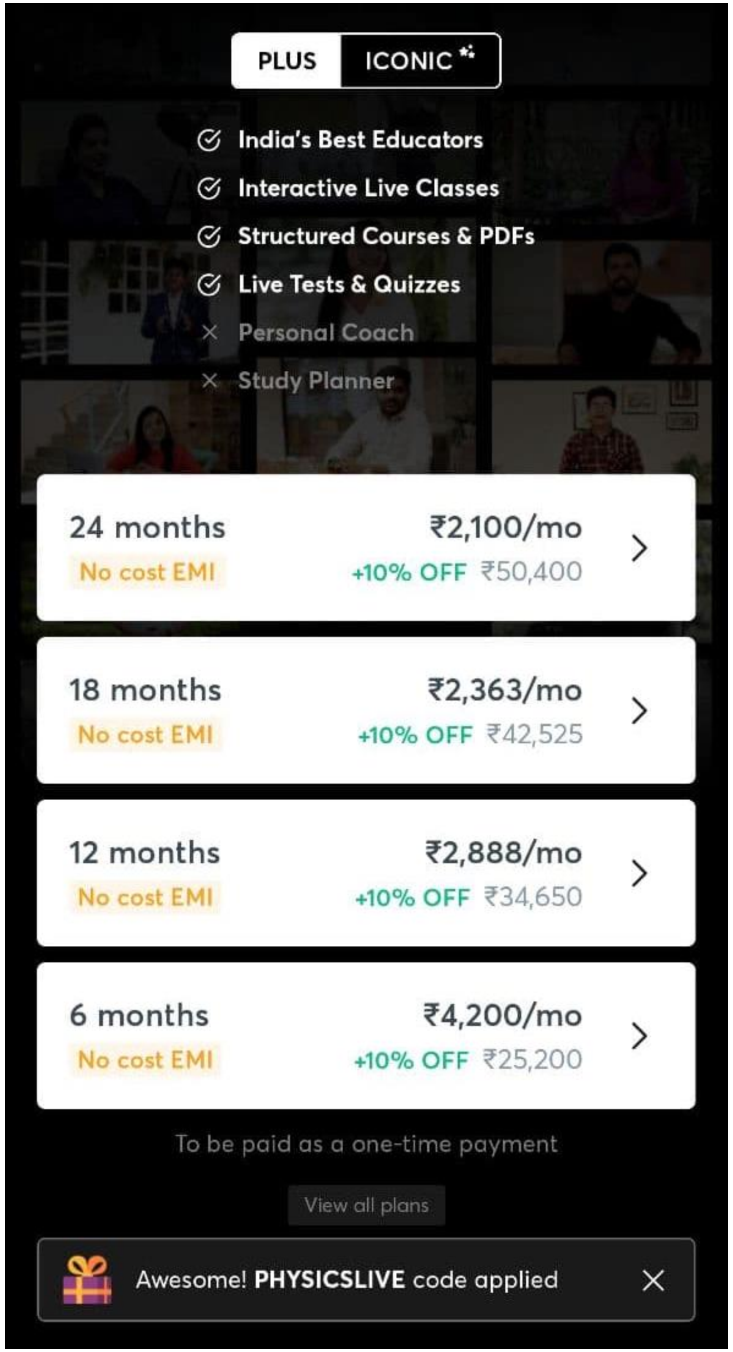

NEET & JEE Main
Physics DPP- Solution

DPP- 5 Thermodynamics- Calculation of Specific & Molar heat Capacity, Mixing of gases

By Physicsaholics Team

Solution 1:

given; $\left(\frac{C_p}{C_v}\right)_{mix} = 3/2$

And for mixture of gases

$$\frac{C_p}{C_v} = \frac{n_1 C_{p_1} + n_2 C_{p_2}}{n_1 C_{v_1} + n_2 C_{v_2}}$$

For He gas

$C_{p_1} = \frac{5}{2}R$; $C_{v_1} = \frac{3}{2}R$; $n_1 = 2$ moles

For H_2 gas

$C_{p_2} = \frac{7}{2}R$; $C_{v_2} = \frac{5}{2}R$; $n_2 = n$

so;

$$\frac{3}{2} = \frac{2\times\frac{5}{2}R + n\frac{7}{2}R}{2\times\frac{3}{2}R + n\times\frac{5}{2}R}$$

$$\frac{3}{2} = \frac{10 + 7n}{6 + 5n}$$

$18 + 15n = 20 + 14n$

$\boxed{n = 2}$ Ans.

Ans. b

Solution 2:

$$\gamma_{mix} = \frac{(C_p)_{mix}}{(C_v)_{mix}} = \frac{n_1 C_{p_1} + n_2 C_{p_2}}{n_1 C_{v_1} + n_2 C_{v_2}}$$

For He gas

$n_1 = 5$ mole, $C_{p_1} = \frac{5}{2}R$, $C_{v_1} = \frac{3}{2}R$

For H_2 gas

$n_2 = 2$ moles, $C_{p_2} = \frac{7}{2}R$, $C_{v_2} = \frac{5}{2}R$

$$\gamma_{mix} = \frac{\left(5 \times \frac{5}{2}R\right) + \left(2 \times \frac{7}{2}R\right)}{\left(5 \times \frac{3}{2}R\right) + \left(2 \times \frac{5}{2}R\right)}$$

$$\gamma_{mix} = \frac{25 + 14}{15 + 10} = \frac{39}{25}$$

$$\boxed{\gamma_{mix} = 1.56} \text{ Ans.}$$

Ans. c

Solution 3:

From given graph

$Q = 2500\ J$

$\Delta T = 100\ K$

$Q = nC_p \Delta T$

$2500 = 1\ C_p (100)$

$\boxed{C_p = 25}$

From $C_p - C_v = R$

$C_v = C_p - R$

$C_v = 25 - 8.3$

$\boxed{C_v = 16.7}$

$\gamma = \frac{C_p}{C_v} = \frac{25}{16.7} \simeq 1.5$

$\boxed{\gamma = \frac{3}{2}}$ Ans.

or

From given graph

$\Delta T = 100\ K$

$Q = 2500\ J$

given; $P =$ constant

so; $W = P(\Delta V)$ or $nR\Delta T$

and $\Delta U = n\left(\frac{f}{2} R\Delta T\right)$

$dQ = \Delta U + dW$

$2500 = \frac{f}{2} nR\Delta T + nR\Delta T$

$\left(\frac{f}{2} + 1\right) nR\Delta T = 2500$

$\left(\frac{f}{2} + 1\right) = \frac{2500}{nR\Delta T} = \frac{2500}{1 \times 8.3 \times 100} \simeq 3$

$\frac{f}{2} = 2 \rightarrow \boxed{f = 4}$

as $\gamma = 1 + \frac{2}{f}$

$\gamma = 1 + \frac{2}{4} = 1 + \frac{1}{2}$

$\boxed{\gamma = \frac{3}{2}}$ Ans.

Ans. c

Solution 4:

Monoatomic gas

$n_1 = 1$ mole

$C_{V_1} = \frac{3}{2}R$; $C_{P_1} = \frac{5}{2}R$

Diatomic gas

$n_2 = 2$ mole

$C_{V_2} = \frac{5}{2}R$; $C_P = \frac{7}{2}R$

$$C_{P\,mix} = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 + n_2} = \frac{1 \times \frac{5}{2}R + 2 \times \frac{7}{2}R}{1+2}$$

$$\boxed{C_{P\,mix} = \frac{19}{6}R}$$

$$C_{V\,mix} = \frac{n_1 C_{V_1} + n_2 C_{V_2}}{n_1 + n_2} = \frac{1 \times \frac{3}{2}R + 2 \times \frac{5}{2}R}{1+2}$$

$$\boxed{C_{V\,mix} = \frac{13}{6}R}$$

$$\gamma_{mix} = \frac{(C_P)_{mix}}{(C_V)_{mix}} = \frac{19/6\,R}{13/6\,R}$$

$$\boxed{\gamma_{mix} = \frac{19}{13}}$$

$$\because C_{V\,mix} = \frac{f_{mix}}{2}R$$

$$\frac{13}{6}\cancel{R} = \frac{f_{mix}}{2}\cancel{R}$$

$$\boxed{f_{mix} = \frac{13}{3}}$$

Ans. a

Solution 5:

change in Internal Energy

$\Delta U = nC_v\Delta T$

Internal energy is state function; it only depends on initial and final state.

So; ΔU will be same in all process

Ans. d

Solution 6:

$$\gamma_{mix} = \frac{n_1 C_{p_1} + n_2 C_{p_2}}{n_1 C_{v_1} + n_2 C_{v_2}}$$

$$\gamma_{mix} = \frac{1 \times \frac{5}{2} R + 1 \times \frac{7}{2} R}{1 \times \frac{3}{2} R + 1 \times \frac{5}{2} R}$$

$$\gamma_{mix} = \frac{\frac{12}{2} R}{\frac{8}{2} R} = \frac{3}{2}$$

$$\boxed{\gamma_{mix} = 1.5}$$

Ans. c

Solution 7:

$\because$ Sp. heat capacity $[C_s]$ = $\frac{\text{Molar heat capacity}}{\text{Molecular mass}}$

$$C_s = \frac{C}{M}$$

at constant pressure

$$C = C_p$$

$\because \frac{C_p}{C_v} = \gamma$ (given)

Then, from $C_p - C_v = R$

$$C_p - \frac{C_p}{\gamma} = R$$

$$C_p\left(\frac{\gamma - 1}{\gamma}\right) = R$$

$$\boxed{C_p = \frac{\gamma R}{\gamma - 1}}$$

So; at constant pressure

$$C_s = \frac{C_p}{M}$$

$$\boxed{C_s = \frac{\gamma R}{M(\gamma - 1)}}$$ Ans.

Ans. c

Solution 8:

$$\frac{C_p}{C_v} = \gamma = 1 + \frac{2}{f}$$

Ans

Ans. c

Solution 9:

For mono atomic gas

$n = n_1$, $C_{P_1} = \frac{5}{2}R$, $C_{V_1} = \frac{3}{2}R$

For diatomic gas

$n = n_2$, $C_{P_2} = \frac{7}{2}R$, $C_{V_2} = \frac{5}{2}R$

$\frac{C_P}{C_V} = \gamma = 1.5$ (given, for mixture)

$$\gamma = 1.5 = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 C_{V_1} + n_2 C_{V_2}} = \frac{n_1\left(\frac{5}{2}R\right) + n_2\left(\frac{7}{2}R\right)}{n_1\left(\frac{3}{2}R\right) + n_2\left(\frac{5}{2}R\right)}$$

$$\gamma = \frac{5n_1 + 7n_2}{3n_1 + 5n_2} \Rightarrow 1.5 = \frac{3}{2} = \frac{5n_1 + 7n_2}{3n_1 + 5n_2}$$

$$\Rightarrow 9n_1 + 15n_2 = 10n_1 + 14n_2$$

$$\Rightarrow \boxed{n_2 = n_1}$$ Ans.

Ans. a

Solution 10:

$\because$ Sp. heat Capacity $[C_s] = \dfrac{\text{Molar heat Capacity}}{\text{Molecular mass}}$

$$C_s = \frac{C}{M}$$

For Nitrogen gas (N_2)

$m_1 = 7\text{ gm}$, $M_1 = 28\text{ gm}$

$n_1 = \frac{7}{28} = \frac{1}{4}$ mole ; $C_{p_1} = \frac{7}{2}R$, $C_{v_1} = \frac{5}{2}R$

For Argon gas (Ar)

$m_2 = 20\text{ gm}$, $M_2 = 40\text{ gm}$

$n_2 = \frac{20}{40} = \frac{1}{2}$ mole, $C_{p_2} = \frac{5}{2}R$; $C_{v_2} = \frac{3}{2}R$

$$(C_v)_{mix} = \frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2} = \frac{\frac{1}{4}\times\frac{5}{2}R + \frac{1}{2}\times\frac{3}{2}R}{\frac{1}{4}+\frac{1}{2}}$$

$$\boxed{(C_v)_{mix} = \frac{11}{6}R}$$

So;

$$(C_s)_v = \frac{(C_v)_{mix}}{M}$$

$$M = \frac{n_1 M_1 + n_2 M_2}{n_1 + n_2} = \frac{\frac{1}{4}\times 28 + \frac{1}{2}\times 40}{\frac{1}{4}+\frac{1}{2}}$$

$$M = \frac{7+20}{3} = \frac{108}{3} = 36$$

$$(C_s)_v = \frac{\frac{11}{6}R}{36} = 0.42$$

$$\boxed{(C_s)_v = 0.42\ \text{J/gm-k}}$$ Ans.

Ans. c

Solution 11:

$$C = C_V + \frac{P\,dV}{n\,dT}$$

$$P = P_0 + \frac{\alpha}{V} \quad ; n = 1 \text{ mole}$$

$$\Rightarrow C = C_V + \frac{P\,dV}{dT}$$

$$P = P_0 + \frac{\alpha}{V}$$

$$\frac{nRT}{V} = \frac{RT}{V} = P_0 + \frac{\alpha}{V}$$

$$RT = P_0 V + \alpha$$

$$R\,dT = P_0\,dV + 0$$

$$\frac{dV}{dt} = \frac{R}{P_0}$$

Hence; $C = C_V + \left(P_0 + \frac{\alpha}{V}\right)\left(\frac{R}{P_0}\right)$

$$\boxed{C = C_V + R + \frac{\alpha R}{P_0 V}} \quad \text{—(1)}$$

given; $\frac{C_P}{C_V} = \gamma$

$$\frac{C_V + R}{C_V} = \gamma \Rightarrow 1 + \frac{R}{C_V} = \gamma$$

$$\frac{R}{C_V} = \gamma - 1 \Rightarrow \frac{C_V}{R} = \frac{1}{\gamma - 1}$$

$$\boxed{C_V = \frac{R}{\gamma - 1}}$$

Put value of C_V in eq^n (1)

$$C = \frac{R}{\gamma - 1} + R + \frac{\alpha R}{P_0 V}$$

$$C = \frac{R + \gamma R - R}{\gamma - 1} + \frac{\alpha R}{P_0 V}$$

$$\boxed{C = \frac{\gamma R}{\gamma - 1} + \frac{\alpha R}{P_0 V}} \quad \text{Ans.}$$

Ans. c

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Chalo Niklo