DPP – 3 (KTG)

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Q 1. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is:
(a) 4 R T (b) 5 R T
(c) 15 R T (d) 11 R T

Q 2. The molecules of an ideal gas have 6 degrees of freedom. The temperature of the gas is T. The average translational kinetic energy of its molecules is:
(a) $\frac{3}{2}$k T (b) $\frac{6}{2}$ k T
(c) k T (d) $\frac{1}{2}$ k T

Q 3. The average translational kinetic energy of O_2 (molar mass 32) molecules at a particular temperature is 0.048 eV. The translational kinetic energy of N_2 (molar mass 28) molecules in eV at the same temperature is –
(a) 0.0015 (b) 0.003
(c) 0.048 (d) 0.768

Q 4. A gas sample is enclosed in a closed container, temperature of gas is continuously increasing. Match the correct options in column-ll corresponding to column-l

Column I		Column II
(a)Internal energy of gas	(P)	Increases
(b)Average momentum of gas molecules	(q)	Decreases
(c)Number of molecules moving with most probable speed	(r)	Zero
(d) $\frac{V_{avg}}{V_{rms}}$	(s)	Remains constant

Q 5. Temperature of an ideal gas is 300 K. The change in temperature of the gas when its volume changes from V to 2V in the process P = aV (Here, a is a positive constant) is:
(a) 900 K (b)1200 K
(c) 600 K (d) 300 K

Q 6. In the ρ-T graph shown in figure, match the following:

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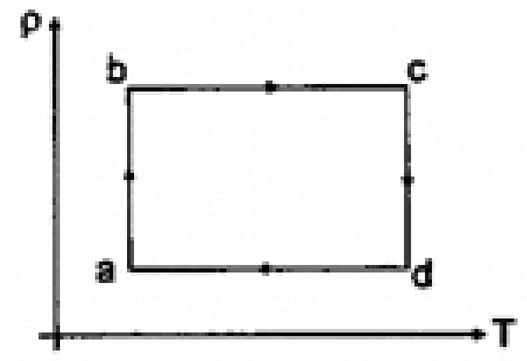

Table-1		Table-2	
(a)	Process a-b	(p)	Constant volume
(b)	Process b-c	(q)	$\Delta U = 0$
(c)	Process c-d	(r)	P increasing
(d)	Process d-a	(s)	P decreasing

Q 7. One mole of an ideal gas undergoes a process $P = \frac{P_0}{1+\left(\frac{V_0}{V}\right)^2}$. 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) $-\frac{2P_0V_0}{5R}$ (b) $\frac{11P_0V_0}{10R}$ (c) $-\frac{5P_0V_0}{4R}$ (d) P_0V_0

Q 8. Two containers of equal volume contain the same gas at pressures p_1 and p_2 and absolute temperatures T_1 and T_2 respectively. On joining the vessels, the gas reaches a common pressure p and a common temperature T. The ratio P/T is equal to

(a) $\frac{p_1}{T_1} + \frac{p_2}{T_2}$ (b) $\frac{1}{2}\left[\frac{p_1}{T_1} + \frac{p_2}{T_2}\right]$

(c) $\frac{p_1T_2+p_2T_1}{T_1+T_2}$ (d) $\frac{p_1T_2-p_2T_1}{T_1-T_2}$

Q 9. What is the ratio of pressures on the left and right sides?

(a) p_2T_2/p_1T_1 (b) p_1T_2/p_2T_1

(c) $\frac{p_1+p_2}{T_1+T_2}$ (d) $\frac{p_1T_1}{p_2T_2}$

Q 10. What is the final equilibrium temperature?

(a) $\frac{T_1T_2(p_1+p_2)}{p_1T_2+p_2T_1}$ (b) $\frac{p_1p_2(T_1+T_2)}{p_1T_2+p_2T_1}$

(c) $\frac{T_1T_2(p_1+p_2)}{p_1T_1+p_2T_2}$ (d) $\frac{T_1^2p_2^2}{p_1T_2+p_2T_1}$

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Answer Key

Q.1 d	**Q.2 a**	**Q.3 c**	**Q.4 a(p) , b(r, s) , c(q) , d(s)**	**Q.5 a**
Q.6 a(q, r) , b(p, r) , c(q, s) , d(p, s)	**Q.7 b**	**Q.8 b**	**Q.9 b**	**Q.10 a**

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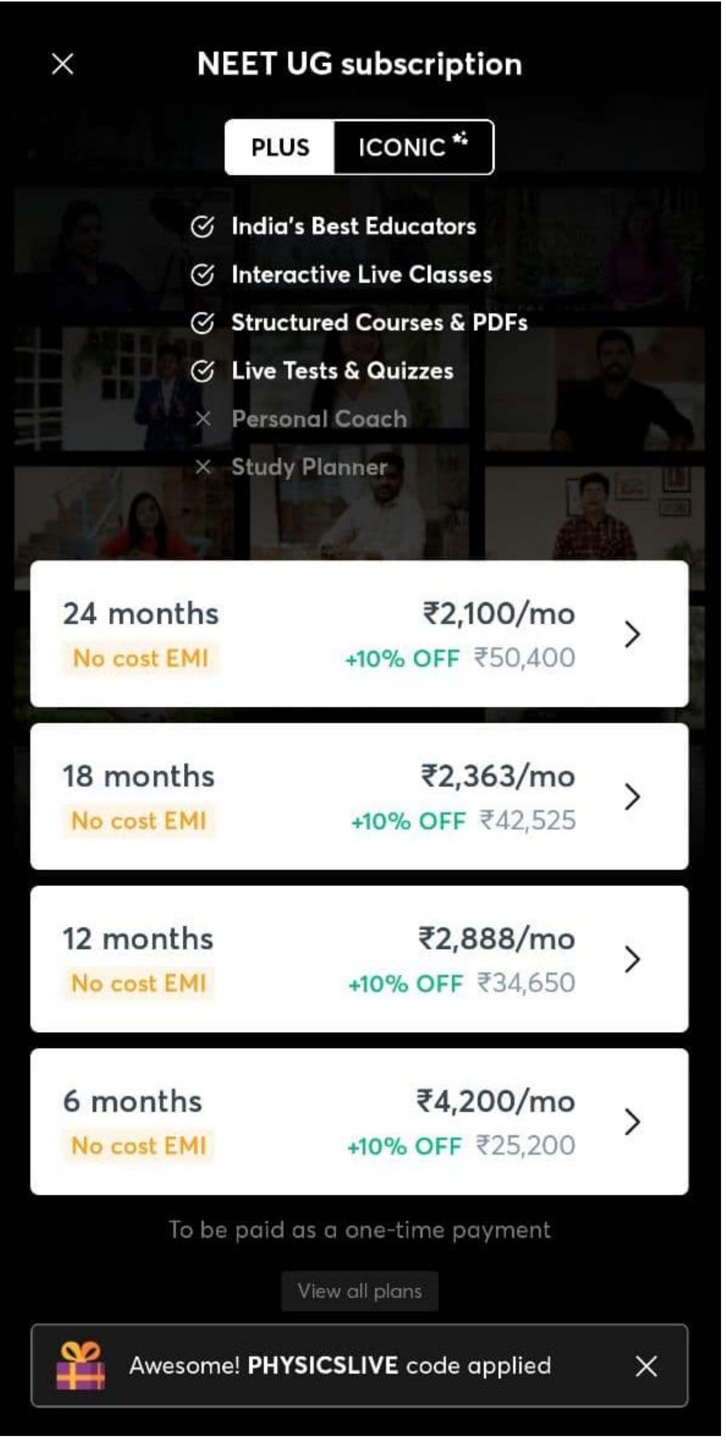

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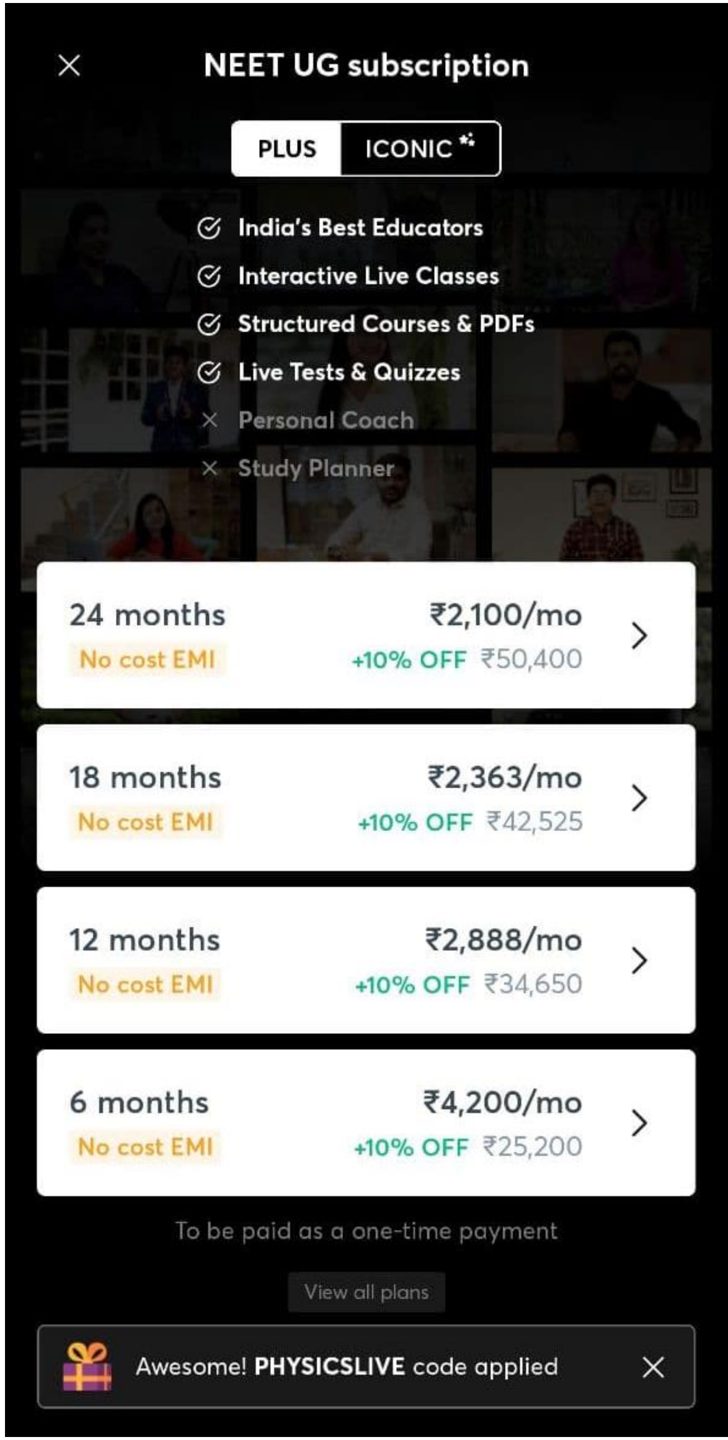

Written Solution

DPP- 3 KTG: Kinetic Energy of Gas, Degree of freedom of gas molecules

By Physicsaholics Team

Solution:1

Internal energy of a gas $U = \frac{f}{2} nRT$

$$U_{oxygen} = \frac{5}{2} \times 2RT = 5RT$$

$$U_{argon} = \frac{3}{2} \times 4RT = 6RT$$

$$U_{total} = 11RT$$

ANS (d)

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Solution:2

Av. energy associated with each degree of freedom $= \frac{1}{2}KT$

degree of freedom of K.E. $= 3$

average translational KE $= \frac{3}{2}KT$

Ans (a)

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Solution:3

Average translational KE of a molecule does not depend on molar mass. At same temperature It is same for all gases.

ANS (c)

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Solution: 4

(a) $U = \frac{f}{2} nRT$ → U increases on increasing T

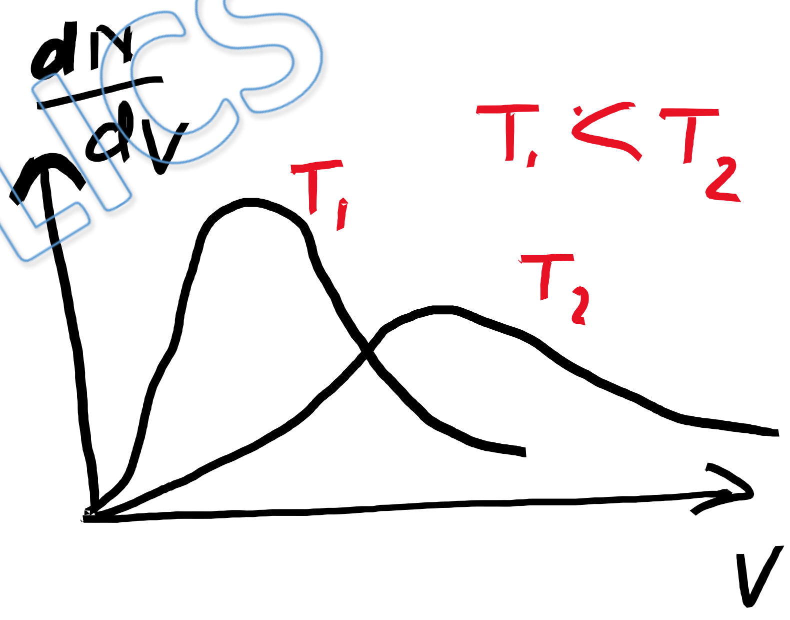
$a \rightarrow p$

(b) Since $\overrightarrow{V_{av}} = \vec{0} \Rightarrow \overrightarrow{P_{av}} = \vec{0}$

$b \rightarrow r\ \&\ s$

(c) maxima of graph shows no of molecules having most probable velocity.

It decreases on increasing temperature



$c \rightarrow q$

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(d) $\frac{V_{av}}{V_{rms}} = \frac{\sqrt{8RT/\pi M}}{\sqrt{3RT/M}} = \sqrt{\frac{8}{3\pi}}$

$= \text{Constant}$

$d \rightarrow s$

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Ans. A(p) b(r,s) C(q) d9s)

Solution:5

$$T = \frac{PV}{nR} = \frac{aV^2}{nR} \propto V^2$$

$V \rightarrow 2$ times

$\Rightarrow T \rightarrow 4$ times

final temperature $= 300 \times 4$

$= 1200\ K$

change in temperature $= 900\ K$

ANS (a)

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Solution: 6

(a) $T =$ Constant $\Rightarrow \Delta U = 0$; ρ is increasing

$$\rho = \frac{PM}{RT} \Rightarrow P = \frac{\rho RT}{M} \Rightarrow P \text{ is increasing}$$

Ans. $a \rightarrow q, r$

(b) $\rho =$ Constant, T is increasing

$$P = \frac{\rho RT}{M} \Rightarrow P \text{ is increasing}$$

$$\rho = \text{Constant} \Rightarrow \frac{P}{T} = \text{Constant} \Rightarrow V = \text{Constant}$$

Ans. $b \rightarrow p, r$

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(c) P is decreasing , T is Constant

$\Downarrow$ $\Downarrow$

P is decreasing $\Delta U = 0$

Ans. $C \rightarrow q, s$

(d) P is Constant , T is decreasing

$\Downarrow$ $\Downarrow$

V is Constant $\Delta U \neq 0$ & $P = \frac{\rho RT}{M}$

$\Downarrow$

P is decreasing

Ans. $d \rightarrow P, s$

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Solution:7

$$P = \frac{P_0}{1+\left(\frac{V_0}{V}\right)^2}$$

at $V = V_0$, $P = \frac{P_0}{1+1} = \frac{P_0}{2} \Rightarrow T_1 = \frac{P_0 V_0}{2R}$

at $V = 2V_0$, $P = \frac{P_0}{1+\frac{1}{4}} = \frac{4P_0}{5} \Rightarrow T_2 = \frac{4P_0 \times 2V_0}{5R}$

change in temperature

$$\Delta T = \frac{P_0 V_0}{R}\left[\frac{8}{5} - \frac{1}{2}\right] = \frac{11 P_0 V_0}{10 R}$$

ANS (b)

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Solution: 8

$V \rightarrow$ volume of one Container

n_1 & n_2 are no of moles in Containers.

$$n_1 = \frac{P_1 V}{R T_1} , \quad n_2 = \frac{P_2 V}{R T_2}$$

$$\frac{P}{T} = \frac{nR}{2V} = \frac{(n_1 + n_2) R}{2V} = \frac{n_1 R}{2V} + \frac{n_2 R}{2V}$$

$$= \frac{P_1}{2T_1} + \frac{P_2}{2T_2}$$

ANS (b)

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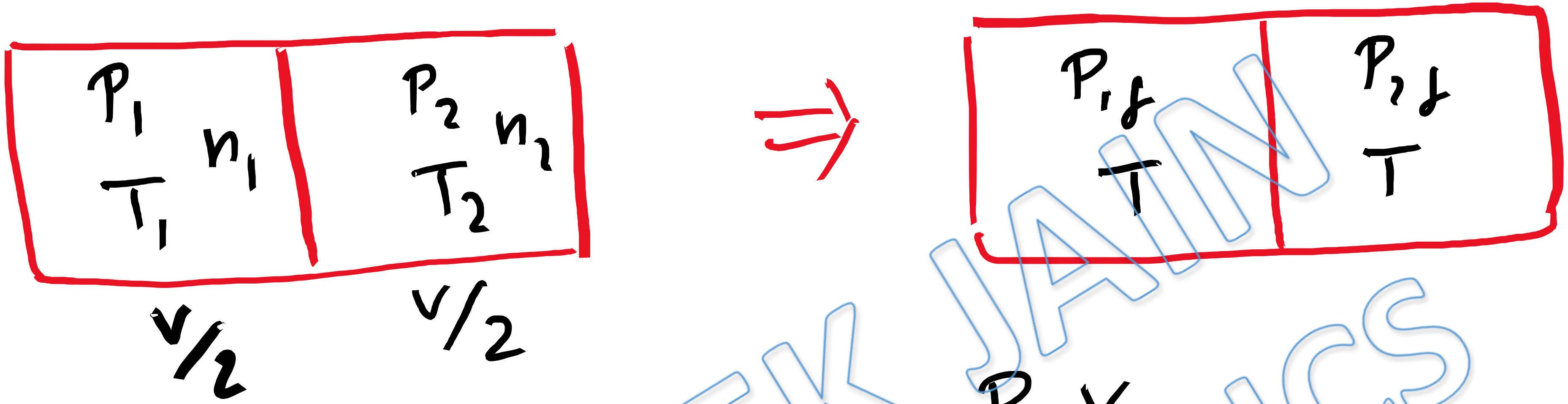
Solution:9



$$n_1 = \frac{P_1 V}{2RT_1}, \quad n_2 = \frac{P_2 V}{2RT_2}$$

$$\frac{P_{1f}}{P_{2f}} = \frac{n_1 RT/(V/2)}{n_2 RT/(V/2)} = \frac{n_1}{n_2} = \frac{P_1 T_2}{P_2 T_1}$$

Ans (b)

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Solution:10

Internal energy loss by left + Internal energy gain by right = 0

$$\Rightarrow \frac{f}{2} n_1 R (T - T_1) + \frac{f}{2} n_2 R (T - T_2) = 0$$

$$\Rightarrow \frac{n_1}{n_2} (T - T_1) + (T - T_2) = 0$$

$$\Rightarrow \frac{P_1 T_2}{P_2 T_1} (T - T_1) + (T - T_2) = 0$$

$$\Rightarrow T (P_1 T_2 + P_2 T_1) = P_1 T_1 T_2 + P_2 T_1 T_2$$

$$\Rightarrow T = \frac{(P_1 + P_2) T_1 T_2}{P_1 T_2 + P_2 T_1}$$

Ans (a)

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