JEE Mains Previous Years Questions
Gaseous State 2024

January 31, 2025

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1 Ideal Gas Laws

Question 1 (JEE Main 2024 January 29 - Shift 1) Two vessels A and B are of the same size and are at same temperature. A contains 1 g of hydrogen and B contains 1 g of oxygen. P_A and P_B are the pressures of the gases in A and B respectively, then $\frac{P_A}{P_B}$ is:

(1) 16

(2) 8

(3) 4

(4) 32

Solution: Using the ideal gas law: $P = \frac{nRT}{V}$, $\frac{P_A}{P_B} = \frac{n_A}{n_B} = \frac{1/2}{1/32} = 16$ **Answer:** (1)

Question 2 (JEE Main 2024 January 29 - Shift 2) The temperature of a gas having 2.0×10^{25} molecules per cubic meter at 1.38 atm (Given, k = $1.38 \times 10^{-23} \text{JK}^{-1}$) is :

(1) 500 K

(2) 200 K

(3) 100 K

(4) 300 K

Solution: $PV = NkT$ which gives $T = \frac{PV}{Nk} = \frac{1.38 \times 1.01 \times 10^5}{2 \times 10^{25} \times 1.38 \times 10^{-23}} = \frac{1.01 \times 10^5}{2 \times 10^2} = 504K \approx 500K$ **Answer:** (1)

2 Kinetic Theory of Gases

2.1 Postulates of KTG

2.2 Mean free path

Question 3 (JEE Main 2024 April 05 - Shift 1) If the collision frequency of hydrogen molecules in a closed chamber at $27°C$ is Z, then the collision frequency of the same system at $127°C$ is :

(1) $\frac{2}{3}Z$

(2) $\frac{4}{3}Z$

(3) $\frac{3}{2}Z$

(4) $\frac{3}{4}Z$

Solution: Assuming mean free path is constant, $f \propto v \propto \sqrt{T}$ $\frac{f_1}{f_2} = \frac{\sqrt{T_1}}{\sqrt{T_2}} \implies \frac{f_1}{f_2} = \frac{\sqrt{300}}{\sqrt{400}} \implies \frac{f_2}{f_1} = \frac{2}{\sqrt{3}} \implies f_2 = \frac{2}{\sqrt{3}} f_1 \implies f_2 = \frac{2}{\sqrt{3}} Z$ **Answer:** (2)

Question 4 (JEE Main 2024 April 05 - Shift 2) If n is the number density and d is the diameter of the molecule, then the average distance covered by a molecule between two successive collisions (i.e. mean free path) is represented by :

(1) $\sqrt{2}n\pi d^2$

(2) $\frac{1}{\sqrt{2}n\pi d^2}$

(3) $\frac{1}{2n\pi d^2}$

(4) $\frac{1}{\sqrt{2}n^2\pi d^2}$

Solution: The mean free path is given by $\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$ **Answer:** (2)

2.3 Speed of gas molecules

Question 5 (JEE Main 2024 January 01 - Shift 2) If the root mean square velocity of hydrogen molecule at a given temperature and pressure is 2 km/s, the root mean square velocity of oxygen at the same condition in km/s is :

(1) 2.0

(2) 0.5

(3) 1.5

(4) 1.0

Solution: $V_{rms} = \sqrt{\frac{3RT}{M}}$, $\frac{V_1}{V_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{32}{2}} = \sqrt{16} = 4$. So, $V_2 = \frac{V_1}{4} = \frac{2}{4} = 0.5$ km/s. **Answer:** (2)

Question 6 (JEE Main 2024 January 30 - Shift 1) At which temperature the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at $47°C$?

(1) 80 K

(2) -73 K

(3) -4 K

(4) 20 K

Solution: $v_{rms} = \sqrt{\frac{3RT}{M}}$, $v_{H_2} = v_{O_2}$, $\frac{3RT}{2} = \frac{3R(320)}{32}$, $T = \frac{320}{16} = 20K$ **Answer:** (4)

Question 7 (JEE Main 2024 April 06 - Shift 1) A sample contains a mixture of helium and oxygen gas. The ratio of root mean square speed of helium and oxygen in the sample, is:

(1) $\frac{1}{\sqrt{32}}$

(2) $2\sqrt{2}$

(3) $\sqrt{\frac{3}{2}}$

(4) $\frac{1}{4}$

Solution: $v_{rms} = \sqrt{\frac{3RT}{M}}$ $\frac{v_{He}}{v_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{He}}} = \sqrt{\frac{32}{4}} = \sqrt{8} = 2\sqrt{2}$ **Answer:** (2)

2.4 Degree of freedom

Question 8 (JEE Main 2024 January 29 - Shift 2) N moles of a polyatomic gas (f = 6) must be mixed with two moles of a monoatomic gas so that the mixture behaves as a diatomic gas. The value of N is :

(1) 6

(2) 3

(3) 4

(4) 2

Solution: $f_{eq} = \frac{n_1 f_1 + n_2 f_2}{n_1 + n_2}$, Given $f_{eq} = 5$. So $5 = \frac{6N+2(3)}{N+2} \Rightarrow 5N + 10 = 6N + 6 \Rightarrow N = 4$. **Answer:** (3)

Question 9 (JEE Main 2024 April 04 - Shift 2) The translational degrees of freedom (f_t) and rotational degrees of freedom (f_r) of CH_4 molecule are:

(1) $f_t = 2$ and $f_r = 2$

(2) $f_t = 3$ and $f_r = 3$

(3) $f_t = 3$ and $f_r = 2$

(4) $f_t = 2$ and $f_r = 3$

Solution: Since CH_4 is a polyatomic non-linear molecule, its degrees of freedom are: Translational DOF = 3 Rotational DOF = 3

Answer: (2)

2.5 Internal Energy of Gas

Question 10 (JEE Main 2024 January 27 - Shift 1) The average kinetic energy of a monatomic molecule is 0.414eV at temperature : (Use $K_B = 1.38 \times 10^{-23}$ J/mol - K)

(1) 3000 K

(2) 3200 K

(3) 1600 K

(4) 1500 K

Solution: For monatomic molecule, degrees of freedom = 3. $K_{avg} = \frac{3}{2} k_B T$ $T = \frac{2 \times 0.414 \times 1.6 \times 10^{-19}}{3 \times 1.38 \times 10^{-23}} \approx 3200K$ **Answer:** (2)

Question 11 (JEE Main 2024 January 27 - Shift 2) The total kinetic energy of 1 mole of oxygen at $27°C$ is : [Use universal gas constant (R) = 8.31 J/moleK]

(1) 6845.5 J

(2) 5942.0 J

(3) 6232.5 J

(4) 5670.5 J

Solution: Kinetic energy $= \frac{f}{2}nRT = \frac{5}{2} \times 1 \times 8.31 \times 300 = 6232.5J$. **Answer:** (3)

Question 12 (JEE Main 2024 January 31 - Shift 2) A gas mixture consists of 8 moles of argon and 6 moles of oxygen at temperature T. Neglecting all vibrational modes, the total internal energy of the system is

(1) 29RT

(2) 20RT

(3) 27RT

(4) 21RT

Solution: $U = nC_vT = n_1C_{v_1}T + n_2C_{v_2}T$. So $U = 8 \times \frac{3}{2}RT + 6 \times \frac{5}{2}RT = 12RT + 15RT = 27RT$ **Answer:** (3)

Question 13 (JEE Main 2024 April 06 - Shift 2) Energy of 10 non-rigid diatomic molecules at temperature T is :

(1) 70 K_BT

(2) 35 K_BT

(3) $\frac{7}{2}RT$

(4) 35RT

Solution: Degree of freedom for non-rigid diatomic molecule $= 5 + 2(3N - 5) = 5 + 2(3 \times 2 - 5) = 7$

Energy of one molecule $= \frac{f}{2}k_BT$

Energy of 10 molecules $= 10(\frac{7}{2}k_BT) = 35k_BT$ **Answer:** (2)

Question 14 (JEE Main 2024 April 09 - Shift 2) The temperature of a gas is $-78°C$ and the average translational kinetic energy of its molecules is K. The temperature at which the average translational kinetic energy of the molecules of the same gas becomes 2 K is :

(1) $127°C$

(2) $117°C$

(3) $-39°C$

(4) $-78^{\circ}C$

Solution: $KE = \frac{f}{2}RT$. $T_1 = -78 + 273 = 195K$ $KE \propto T$ To double the KE energy, the temperature must also double. $T_f = 2 \times 195 = 390K$ $T_f = 390 - 273 = 117^{\circ}C$ **Answer:** (2)

2.6 Molar specific heat

Question 15 (JEE Main 2024 January 01 - Shift 1) Two moles a monoatomic gas is mixed with six moles of a diatomic gas. The molar specific heat of the mixture at constant volume is :

(1) $\frac{9}{4}R$

(2) $\frac{13}{6}R$

(3) $\frac{5}{2}R$

(4) $\frac{11}{4}R$

Solution: $C_{V_{mix}} = \frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2} = \frac{2 \times \frac{3}{2}R + 6 \times \frac{5}{2}R}{2+6} = \frac{3R+15R}{8} = \frac{18R}{8} = \frac{9}{4}R$ **Answer:** (1)

Question 16 (JEE Main 2024 January 30 - Shift 2) If three moles of monoatomic gas ($\gamma = \frac{5}{3}$) is mixed with two moles of a diatomic gas ($\gamma = \frac{7}{5}$), the value of adiabatic exponent γ for the mixture is:

(1) 1.75

(2) 1.40

(3) 1.52

(4) 1.35

Solution: $n_1 = 3, \gamma_1 = \frac{5}{3}, n_2 = 2, \gamma_2 = \frac{7}{5}$
We know that for mixture of gases,
$\frac{n_1+n_2}{\gamma-1} = \frac{n_1}{\gamma_1-1} + \frac{n_2}{\gamma_2-1}$
$\frac{3+2}{\gamma-1} = \frac{3}{\frac{5}{3}-1} + \frac{2}{\frac{7}{5}-1}$
$\frac{5}{\gamma-1} = \frac{19}{2}$
$\gamma = 1 + \frac{10}{19} = \frac{29}{19} \approx 1.52$ **Answer:** (3)

Question 17 (JEE Main 2024 April 08 - Shift 1) A mixture of one mole of monoatomic gas and one mole of a diatomic gas (rigid) are kept at room temperature ($27^{\circ}C$). The ratio of specific heat of gases at constant volume respectively is:

(1) $\frac{7}{5}$

(2) $\frac{5}{3}$

(3) $\frac{5}{2}$

(4) $\frac{3}{2}$

Solution: $\frac{(C_v)_{mono}}{(C_v)_{dia}} = \frac{\frac{3}{2}R}{\frac{5}{2}R} = \frac{3}{5}$ **Answer:** (2)

3 Calculation of heat for Gas

4 Miscellaneous Questions

Question 18 (JEE Main 2024 January 31 - Shift 1) The parameter that remains the same for molecules of all gases at a given temperature is :

(1) kinetic energy

(2) momentum

(3) mass

(4) speed

Solution: The average translational kinetic energy depends only on the temperature. $KE = \frac{3}{2}kT$. **Answer:** (1)

Question 19 (JEE Main 2024 April 08 - Shift 2) Given below are two statements :

Statement (I) : The mean free path of gas molecules is inversely proportional to square of molecular diameter. Statement (II) : Average kinetic energy of gas molecules is directly proportional to absolute temperature of gas.

In the light of the above statements, choose the correct answer from the options given below :

(1) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are false

(3) Both Statement I and Statement II are true

(4) Statement I is false but Statement II is true

Solution: Statement I: The mean free path is given by $\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$, So, $\lambda \propto \frac{1}{d^2}$, thus statement I is true.

Statement II: $KE = \frac{f}{2}RT$, KE is directly proportional to temperature. Thus, statement II is also true. **Answer:** (3)