Kinetic Theory Of Gases JEE Main PYQ - 1

Total Time: 25 Minute **Total Marks:** 40

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Kinetic Theory Of Gases

1. A $15\,g$ mass of nitrogen gas is enclosed in a vessel at a temperature $27°C$. Amount of heat transferred to the gas, so that rms velocity of molecules is doubled, is about : [Take R = 8.3 J/ K mole] **(+4, -1)**

[9 Jan. 2019 II]

a. 10 kJ

b. 0.9 kJ

c. 6 kJ

d. 14 kJ

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2. Two gases - argon (atomic radius $0.07\,nm$, atomic weight 40) and xenon (atomic radius $0.1\,nm$, atomic weight 140) have the same number density and are at the same temperature. The ratio of their respective mean free times is closest to : **(+4, -1)**

[9 Jan 2020 II]

a. 4.67

b. 2.3

c. 1.83

d. 1.09

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3. A vertical closed cylinder is separated into two parts by a frictionless piston of mass m and of negligible thickness. The piston is free to move along the length of the cylinder. The length of the cylinder above the piston is ℓ_1, and that below the piston is ℓ_2 , such that $\ell_1 > \ell_2$. Each part of the cylinder contains n moles of an ideal gas at equal temperature T. If the piston is stationary, its mass, m, will be given by : (R is universal gas constant and g is the acceleration due to gravity) **(+4, -1)**

[12 Jan. 2019 II]

a. $\frac{nRT}{g}\left[\frac{1}{\ell_2}+\frac{1}{\ell_1}\right]$

b. $\frac{nRT}{g}\left[\frac{\ell_1-\ell_2}{\ell_1\ell_2}\right]$

c. $\frac{RT}{g}\left[\frac{2\ell_1+\ell_2}{\ell_1\ell_2}\right]$

d. $\frac{RT}{g}\left[\frac{\ell_1-3\ell_2}{\ell_1\ell_2}\right]$

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4. An ideal gas occupies a volume of $2\,m^3$ at a pressure of $3\times10^6\,Pa$. The energy of the gas is: **(+4, -1)**

[12 Jan. 2019 I]

a. $3\times10^6 J$

b. $10^8 J$

c. $6\times10^4 J$

d. $9\times10^{-6} J$

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5. Consider two ideal diatomic gases A and B at some temperature T. Molecules of the gas A are rigid , and have an mass m. Molecules of the gas B have an additional vibrational mode, and have a mass $\frac{m}{4}$. The ratio of the specific heats $(C_V^A$ and $C_V^B)$ of gas A and B, respectively is : **(+4, -1)**

[9 Jan 2020 I]

a. 5:09

b. 7:09

c. 3:05

d. 5:07

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6. If 10^{22} gas molecules each of mass 10^{-26} kg collide with a surface (perpendicular to it) elastically per second over an area $1\,m^2$ with a speed 10^4 m/s, the pressure exerted by the gas molecules will be of the order of : **(+4, -1)**

[13-Apr-2023 shift 2]

a. $10^8\ N/m^2$

b. $10^4\ N/m^2$

c. $10^3\ N/m^2$

d. $10^{16}\ N/m^2$

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7. In a process, temperature and volume of one mole of an ideal monoatomic gas are varied according to the relation $VT = K$, where K is a constant. In this process the temperature of the gas is incresed by ΔT. The amount of heat absorbed by gas is (R is gas constant) : **(+4, -1)**

[11 Jan. 2019 II]

a. $\frac{1}{2}R\Delta T$

b. $\frac{3}{2}R\Delta T$

c. $\frac{1}{2}KR\Delta T$

d. $\frac{2K}{3}\Delta T$

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8. In an ideal gas at temperature T, the average force that a molecule applies on the walls of a closed container depends on T as T^q. A good estimate for q is : **(+4, -1)**

[Online April 10,2015]

a. 2

b. 1

c. $\frac{1}{2}$

d. $\frac{1}{4}$

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9. Modern vacuum pumps can evacuate a vessel down to a pressure of $4.0 \times 10^{-15}\,atm$ at room temperature $(300\,K)$. Taking $R = 8.3\,JK^{-1}\,mole^{-1}, 1\,atm = 10^5\,Pa$ and $N_{\text{Avogadro}} = 6 \times 10^{23} mole^{-1}$, the mean distance between molecules of gas in an evacuated vessel will be of the order of : **(+4, -1)**

[Online April 9, 2014]

a. $0.2\,\mu m$

b. $0.2\,mm$

c. $0.2\,cm$

d. $0.2\,nm$

10. The temperature of an open room of volume $30\, m^3$ increases from $17^\circ C$ to $27^\circ C$ due to the sunshine. The atmospheric pressure in the room remains $1 \times 10^5\, Pa$. If n_i and n_f are the number of molecules in the room before and after heating, then $n_f - n_i$ will be : **(+4, -1)**

[29-Jan-2024 Shift 2]

a. -1.61×10^{23}

b. 1.38×10^{23}

c. 2.5×10^{25}

d. -2.5×10^{25}

Answers

1. **Answer: a**

Explanation:

$Q = nC_v\Delta T$ as gas in closed vessel
$Q = \frac{15}{28} \times \frac{5\times R}{2} \times (4T - T)$
$Q = 10000\,J = 10\,kJ$

Concepts:

1. **Kinetic Molecular Theory of Gases:**

Postulates of Kinetic Theory of Gases:

- Gases consist of particles in constant, random motion. They continue in a straight line until they collide with each other or the walls of their container.
- Particles are point masses with no volume. The particles are so small compared to the space between them, that we do not consider their size in ideal gases.
- Gas pressure is due to the molecules colliding with the walls of the container. All of these collisions are perfectly elastic, meaning that there is no change in energy of either the particles or the wall upon collision. No energy is lost or gained from collisions. The time it takes to collide is negligible compared with the time between collisions.
- The kinetic energy of a gas is a measure of its Kelvin temperature. Individual gas molecules have different speeds, but the temperature and kinetic energy of the gas refer to the average of these speeds.
- The average kinetic energy of a gas particle is directly proportional to the temperature. An increase in temperature increases the speed in which the gas molecules move.
- All gases at a given temperature have the same average kinetic energy.
- Lighter gas molecules move faster than heavier molecules.

$$PV = \frac{1}{3}Nm(c_{rms})^2$$

From given formula's questions on kinetic theory can be solved.

Kinetic energy:

$$KE = \frac{1}{3}mn\bar{v}^2$$

---

2. **Answer: d**

Explanation:

$$\lambda = \frac{1}{\sqrt{2}\pi n_v d^2}$$

$$\tau = \frac{\lambda}{v} = \frac{1}{\sqrt{2}\pi n_v d^2 v} = \frac{1}{\sqrt{2}\pi n_v d^2}\sqrt{\frac{M}{3RT}}$$

$$\frac{\tau_1}{\tau_2} = \sqrt{\frac{M_1}{M_2}}\frac{d_2^2}{d_1^2}$$

$$= \sqrt{\frac{40}{140}}\frac{(0.1)^2}{(0.07)^2}$$

$$= 1.09$$

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3. **Answer: b**

Explanation:

$$P_2 A = P_1 A + mg$$

$$\frac{nRT.A}{A\ell_2} = \frac{nRT.A}{A\ell_2} + mg$$

$$nRT\left(\frac{1}{\ell_2} - \frac{1}{\ell_1}\right) = mg$$

$$m = \frac{nRT}{g}\left(\frac{\ell_1 \ell_2}{\ell_1.\ell_2}\right)$$

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4. **Answer: d**

Explanation:

$$\text{Energy} = \frac{1}{2}nRT = \frac{f}{2}PV$$
$$= \frac{f}{2}\left(3 \times 10^6\right)(2)$$
$$= f \times 3 \times 10^6$$

Considering gas is monoatomic i.e. $f = 3$

$E. = 9 \times 10^6 J$

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5. **Answer: d**

Explanation:

Degree of freedom of a diatomic molecule if vibration is absent $= 5$
Degree of freedom of a diatomic molecule if vibration is present $= 7$
$\therefore C_v^A = \frac{f_A}{2}R = \frac{5}{2}R \,\&\, C_v^B = \frac{f_B}{2}R = \frac{7}{2}R$
$\therefore \frac{C_v^A}{C_v^B} = \frac{5}{7}$

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6. **Answer: c**

Explanation:

Magnitude of change in momentum per collision = 2 mv

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{N(2mv)}{1}$$

$$= \frac{10^{22} \times 2 \times 10^{-26} \times 10^4}{1}$$

$$= 2N/m^2$$

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7. **Answer: a**

Explanation:

$VT = K$

$\Rightarrow V\left(\frac{PV}{nR}\right) = k \Rightarrow PV^2 = K$

$\because C = \frac{R}{1-x} + C_V$ (For polytropic process)

$C = \frac{R}{1-2} + \frac{3R}{2} = \frac{R}{2}$

$\therefore \Delta Q = nC\Delta T$

$= \frac{R}{2} \times \Delta T$

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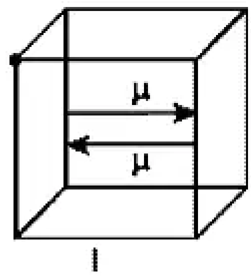
8. **Answer: b**

Explanation:



Time interval between two successive collisions at a face $= \frac{2l}{u}$
Number of collisions/s $= \frac{u}{2l}$
Change of momentum/collision $= 2mu$
Therefore, change of momentum/s $= \frac{u}{2l} \times 2mu = \frac{mu^2}{l} = F$
Therefore, $F \propto u^2 \propto T \Rightarrow q = 1$

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9. **Answer: b**

Explanation:

$$\lambda = \frac{kT}{\sqrt{2}\pi d^2 P} = \frac{1.38\times10^{-23}\times300}{\sqrt{2}\pi\times10^{-20}\times4\times10^{-10}} = \frac{1.38\times3}{\sqrt{2}\times4\pi}\times10^{-9} = 0.2\,nm$$

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10. **Answer: d**

Explanation:

n_1 = initial number of moles $n_1 = \frac{P_1V_1}{RT_1} = \frac{10^5\times30}{8.3\times290} \approx 1.24\times10^3$ n_2 = final number of moles $= \frac{P_2V_2}{RT_2} = \frac{10^5\times30}{8.3\times300} \approx 1.20\times10^3$ Change of number of molecules : $n_f - n_i = (n_2 - n_1)\times 6.023\times10^{23} \approx -2.5\times10^{25}$