PHYSICS

BOOKS - FULL MARKS PHYSICS (TAMIL ENGLISH)

KINETIC THEORY OF GASES

In Text Solved Examples

1. A foolball at $25^{\circ}C$ has 0.5 mole air molecules . calculate the internal energy of air

in the ball.

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2. A room contains oxygen and hydrogen molecule in the ratio 3:1 . The temperature of the room is $27^{\circ}C$ .The molar mass of O_2 is 32 g mol^{-1} and for H_2 3 g mol^{-1} . The value of gas constant R is 8.32 J $mol^{-1}K^{-1}$

calculate:

(a) rms speed of oxygen and hydrogen molecule.

(b) Average kinetic energy per oxygen molecule and per hydrogen molecule.

(c) Ratio of average kinetic energy of oxygen molecules and hydrogen molecules.

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3. Ten particles are moving at the speed of of 2,3,4,5,5,5,6,6,7 and 9 and ms^{-1}. Calculate rms speed , average speed and most probable speed .

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4. Calculate the rms speed , average speed and the most probable speed of 1 mole of hydrogen molecules at 300K . Neglect the mass of electron.

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5. (i) Find the adiabatic exponent γ for mixture of μ_1 moles of monoatomic gas and μ_2 moles of a diatomic gas at normal temperature.

(ii) An oxygen molecule is travelling in air at

300 K and 1 atm , and the diameter of oxygen molecule is 1.2×10^{-10} m . Calculate the mean free path of oxygen molecule.

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6. (i) Find the adiabatic exponent γ for mixture of μ_1 moles of monoatomic gas and μ_2 moles of a diatomic gas at normal temperature.

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molecule is 1.2×10^{-10} m . Calculate the mean free path of oxygen molecule.

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Textual Evaluation Solved I Mcq

1. A particle or mass m is moving with speed u in a direction in a which makes 60° with respect to x axis to x axis . It undergoes elastic collision with the well . What is the change in momentum in x and y direction?

A. Δp_x=-mu ,Δp_y=0

B. Δp_x=-2mu, Δp_y=0

C. Δp_x=0,Δp_y==mu,Δp_y=0

D. Δp_x=mu,Δp_y=0

Answer: b

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2. A sample of ideal gas is at equilibrium. Which of the following quantity is zero?

A. rms speed

B. average speed

C. average velocity

D. most probabale

Answer: C

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3. An ideal gas is maintained at constant pressure. If the temperature of an ideal gas

increases from 100K to 1000K then the rms speed of the gas molecules

A. increases by 5 times

B. increases ny $\sqrt{10}$

C. remains same

D. increases by 7 times

Answer: b

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4. Two identically sized rooms A and B are connected by an open door. If the room A is air conditioned such that its temperature is 4° lesser than room B, which room has more air in it?

A. Room A

B. Room B

C. Both room has same air

D. cannot be determined

Answer: A

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5. The average translational kinetic energy of gas molecules depends on

A. number of moles and T

B. only on T

C. P and T

D. P only

Answer: A

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6. If the internal energy of an ideal gas U and volume V are doubled, then the pressure of the gas :

A. doubles

B. remains same

C. 0

D. quadriples

Answer: b

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7. The ratio $\gamma = \frac{C_P}{C_V}$ for a gas mixture consisting of 8 g of helium and 16 g of oxygen is

A. $\frac{23}{15}$

B. $\frac{15}{23}$

C. $\frac{27}{17}$

D. $\frac{17}{27}$

Answer: c

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8. A container has one mole of monoatomic ideal gas. Each molecule has f degrees of freedom. What is the ratio of $\gamma = \frac{C_P}{C_V}$

A. f

B. $\frac{f}{2}$

C. $\frac{f}{f+2}$

D. $\frac{f+2}{f}$

Answer: d

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9. If the temperature and pressure of a gas is doubled the mean free path of the gas molecules

A. remains same

B. doubled

C. tripled

D. quadruples

Answer: a

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10. Which of the following shows the correct relationship between the perssure and density of an ideal gas constant temperature ?

A. 

B. 

C. 

D. 

Answer: D

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11. A sample of gas consists of μ_1 moles of monoatomic molecules, μ_2 moles of diatomic molecules and μ_3 moles of linear triatomic molecules. The gas is kept at high temperature. What is the total number of degrees of freedom?

A. $[3\mu_1 + 7(\mu_2 + \mu_3)]N_A$

B. $[3\mu_1 + 7\mu_2 + \mu_3]N_A$

C. $[7\mu_1 + 3(\mu_2 + \mu_3)]N_A$

D. $[3\mu_1 + 6(\mu_2 + \mu_3)]N_A$

Answer: A

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12. If S_P and S_V denote the specific heats of nitrogen gas per unit mass at constant pressure and constant volume respectively, then

A. $S_P - S_V = 28R$

B. $S_P - S_V = R/28$

C. $S_P - S_V = R/14$

D. $S_P - S_V = R$

Answer: B

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13. Which of the following gases will have least rms speed at a given temperature?

A. Hydrogrn

B. Nitrogen

C. Oxygen

D. Carbon dioxide

Answer: D

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14. For a given gas molecule at a fixed temperature , the area under the Maxwell - Boltzmann distribution curve is equal to :

A. $\frac{PV}{k}T$

B. $\frac{kT}{P}V$

C. $\frac{P}{NkT}$

D. PV

Answer: A

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15. The following graph respresent the pressure versus number density for ideal gas

at two different temperature T_1 and T_2. The graph implies ..... .

A. $T_1 = T_2$

B. $T_1 > T_2$

C. $T_1 < T_2$

D. connot be determined

Answer: B

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Textual Evaluation Solved Ii Short Answer Question

1. What is the microscopic origin of pressure?

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2. What is the K.E per mircroscopic origin of temperature?

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3. Why moon has no atmosphere?

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4. Write the expression for rms speed, average speed and most probable speed of a gas molecule.

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5. What is the relation between the average kinetic energy and pressure?

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6. Define the term degrees of freedom.

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7. State the law of equipartition of energy.

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8. Define mean free path and write down its expression.

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9. Deduce Charles's law based on kinetic theory.

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10. Deduce Boyle's law based on kinetic theory.

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11. Deduce Avogadro's law based on kinetic theory.

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12. List the factors affecting the mean free path.

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13. What is the reason for Brownian motion?

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Textual Evaluation Solved Iii Long Answer Question

1. Write down the postulates of kinetic theory of gases.

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2. Gas exerts pressure on the walls of the container

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3. Explain in detail the kinetic interpretation of temperature .

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4. Define the term degrees of freedom.

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5. Derive the ratio of two specific heat capacities of monoatomic, diatomic and triatomic molecules.

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6. Explain in detail the Maxwell Boltzmann distribution function.

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7. Derive the expression for mean free path of the gas.

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8. Describe the Brownian motion.

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Textual Evaluation Solved Iv Numerical Problems

1. A fresh air is composed of ntirogen $N_2(78\,\%)$ and oxygen $O_2(21\,\%)$. Find the rms speed of N_2 and O_2 at $20^\circ C$.

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2. If the rms speed of methane gas in the Jupiter's atmosphere is $471.8ms^{-1}$, show that the surface temperature of Jupiter is sub-zero.

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3. Calculate the temperature at which the rms velocity of a gas triples its value at S.T.P. $[T_1 = 273K]$

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4. A gas is at temperature $80^\circ C$ and pressure $5 \times 10^{-10} Nm^{-2}$. What is the number of molecules per m^3 if Boltzmann's constant is $1.38 \times 10^{-23} JK^{-1}$

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5. From kinetic theory of gases, show that Moon cannot have atmosphere (Assume $k = 1.38 \times 10^{-23} JK^{-1}, T0^\circ C = 273K$).

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6. If 10^{20} oxygen molecules per second strike $4cm^2$ of wall at an angle of 30° with the normal when moving at a speed of $2 \times 10^3 ms^{-1}$, find the pressure exerted on the wall. (mass of $1O_2$ atom = $2.67 \times 10^{-26} kg$)

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7. During an adiabatic process, the the pressure of a mixture of monatomic and diatomic gases is found to be proportional to

the cube of the temperature . Find the value of

$\gamma = (C_P / C_V)$

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8. Calculate the mean free path of air molecules at STP. The diameter of N_2 and O_2 is about $3 \times 10^{-10} m$

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9. A gas made of a mixture of 2 moles of oxygen and 4 moles of argon at temperature T. Calculate the energy of the gas in terms of RT. Neglect the vibrational modes.

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10. Estimate the total number of air molecules in a room of capacity $25m^3$ at a temperature of $27^\circ C$.

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Additional Multiple Choise Questions

1. Oxygen and hydrogen gases are at the same temperature the ratio of the average K.E of an oxygen molecule and that of a hydrogen molecule is

A. 16

B. 4

C. 1

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

Answer: A::B::C

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2. According to kinetic theory of gases, molecules of a gas behave like .

A. the pressure of a gas is proprotional to the rms speed of the molecules .

B. the rms speed of the molecules of a gas is proprotional to the absolute

temperature.

C. the rms speed of the molecules of a gas is proprotional to the square root of the absolute temperature.

D. the pressure of a gas is proprotional to the square root of the rms speed of the molecules.

Answer: A::C::D

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3. Pressure exerted by a perfect gas is equal to ..... .

A. mean K.E . per unit volume.

B. half of mean K.E per unit volume.

C. one-third of mean K.E. per unit volume.

D. two-third of mean K.E. per unit volume.

Answer: A::B::C::D

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4. The temperature of an ideal gas is increased from $27 \circ C$ to $927 \circ C$. The root mean square speed of its molecules becomes.

A. 3 times

B. double

C. 4 times

D. 6 times

Answer: B

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5. Two gases are enclosed in a container at constant temperature. One of the gases , which is monoatomic. The ratio of the rms speed of the molecules of the monoatomic gas to that of the molecules of the diatomic gas is ..... .

A. 8

B. 4

C. $2\sqrt{2}$

D. 2

Answer: C

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6. If the absolute temperature of a gas is increased 3 times the rms velocity of the molecules will be ..... .

A. 3 times

B. 9 times

C. $\sqrt{3}$times

D. $\sqrt{6}$ times

Answer: C

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7. Which of the following animals possesses ink gland?

A. H_2

B. O_2

C. N_2

D. CO_2

Answer: A::B::C

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8. If the absolute temperature of a gas is increased 3 times the rms velocity of the molecules will be ..... .

A. equal to that of the helium molecules

B. twice that of the helium molecules

C. half that of the helium molecules

D. $\sqrt{2}$ times that of the helium molecules

Answer: B::D

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9. A gas is enclosed in a container which is then placed on a fast moving train . The temperature of the gas ..... .

A. rises

B. remains unchanged

C. falls

D. become unsteady

Answer: C

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10. The mean translational kinetic energy of a perfect gas molecule at the temperature Tk is :

A. $\frac{1}{2}kT$

B. kT

C. $\frac{3}{2}kT$

D. $\frac{5}{2}kT$

Answer: C

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11. A jar has mixture of hydrogen and oxygen gases in the ratio 1:5. The ratio of mean kinetic energies of hydrogen and Oxygen molecules is ..... .

A. $1:5$

B. $5:1$

C. $1:1$

D. $1:25$

Answer: A::C::D

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12. The perssure exerted on the walls of the container by a gas is due to the fact that the gas molecules ..... .

A. lose there K.E

B. Stick to the walls

C. are acceleration towards the wallls

D. change their momenta due to collision with the walls.

Answer: D

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13. Pressure exerted by a gas is ..... .

A. independent of the density of the gas

B. inversely proprotinal to the density of the gas

C. directly proproation to the density of the gas

D. directly proprotional to the square of the density of the gas .

Answer: C

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14. Four molecules have speed 2 km/s, 3 km/s. 4 km/s, 5 km/s The rms speed of these molecules in km/s is ..... .

A. $\sqrt{\frac{27}{2}}$

B. $\sqrt{27}$

C. $2\sqrt{27}$

D. $\sqrt{54}$

Answer: A

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15. A gas behaves as an ideal gas at :

A. low pressure and high temperature

B. high perssure and low temperature

C. low perssure and high temperature

D. high perssure and high temperature

Answer: A

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16. The kinetic theory of gases breaks down most at ..... .

A. low pressure and high temperature

B. high perssure and low temperature

C. low perssure and high temperature

D. high perssure and high temperature

Answer: B

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17. Two different ideal gases are enclosed in two defferent vessels at the same pressure . If ρ_1 and ρ_2 are their and ν_1 and ν_2 their rms their speed , respectively then - is equal to ..... .

A. $\frac{\rho_1^2}{\rho_2^2}$

B. $\frac{\rho_2^2}{\rho_2^1}$

C. $\sqrt{\frac{\rho_1}{\rho^2}}$

D. $\sqrt{\frac{\rho_2}{\rho^1}}$

Answer: A::B::C::D

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18. A cylinder of capacity 20 liters is filled with hydrogen gas . The total average K.E. of translatory motion of its molecules is $1.5 \times 10_5 J$. The perssure of hydrogen in the cylinder is ..... .

A. $2 \times 10^6 Nm^{-2}$

B. $3 \times 10^6 Nm^{-2}$

C. $4 \times 10^6 Nm^{-2}$

D. $5 \times 10^6 Nm^{-2}$

Answer: A::B::C::D

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19. The molecular weight of oxygen and hydrogen are 32 and 2, respectively .The rms velocities of their molecules at a given temperature , will be in the ratio

A. $4:1$

B. $1:4$

C. $1:16$

D. $16:1$

Answer: A::B::C::D

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20. The average energy of a molecules of a monoatomic gas at temperature T is (K=Boltzmann constant)

A. $\frac{1}{2}kT$

B. kT

C. $\frac{3}{2}kT$

D. $\frac{5}{2}kT$

Answer: C

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21. The temperature of an idea gas is increased from 120 K to 480 K. If at 120 K the root mean square velocity of the gas molecules is ν, at 480 K it becomes

A. $77^\circ C$

B. 350°

C. $273^\circ C$

D. $457^\circ C$

Answer: A

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22. The temperature of a gas is raise from $27^\circ C$ to $927^\circ C$. The root mean squre speed of its molecules..... .

A. become $\frac{\sqrt{927}}{27}$ times the earlier value

B. gets halved

C. remains the same

D. gets doubled

Answer: A::B::C::D

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23. The temperature at which the K.E. of a gas molecules is double its value at $27^{\circ}C$ is

A. $54^\circ C$

B. 300K

C. $327^\circ C$

D. $108^\circ C$

Answer: A::B::C

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24. The temperature of an idea gas is increased from 120 K to 480 K. If at 120 K the

root mean square velocity of the gas molecules is ν, at 480 K it becomes

A. 4ν

B. 2ν

C. $\frac{\nu}{2}$

D. $\frac{\nu}{4}$

Answer: B

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25. The average translational K.E. of O_2 (molar mass 32) molecules at a particular temperature is 0.048 eV. The translational K.E. of the 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

Answer: C

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26. The K.E. of one mole of a gas at normal temperature and perssure is $\left(R = 8.31 J mol^{-1} K^{-1}\right)$ ..... .

A. $0.56 \times 10^4 J$

B. $1.3 \times 10^2 J$

C. $2.7 \times 10^2 J$

D. $3.4 \times 10^3 J$

Answer: A::B::C::D

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27. The average K.E. of a hydrogen gas molecule at STP will be (Boltmann canstant $k_B = 1.38 \times 10^{-23} JK^{-1}$.....

A. $0.186 \times 10^{-28} J$

B. $0.372 \times 10^{20} J$

C. $0.56 \times 10^{-20} J$

D. $5.6 \times 10^{-20} J$

Answer: A::B::C

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28. Calculate the root mean square speed of smoking practices of mass 5×10^{-17} kg in their Brownian motion in air at S.T.P

A. $1.5ms^{-1}$

B. $3.0ms^{-1}$

C. $1.5cms^{-1}$

D. $3.0cms^{-1}$

Answer: C

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29. To what temperature should the hydrogen at room temperature $(27^\circ C)$ be heahted at constant perssure so that the RMS velocity of iths molecules becomes double its previous value?

A. $1200^\circ C$

B. $927^\circ C$

C. $600^\circ C$

D. $108^\circ C$

Answer: B

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30. A vessel constant oxygen at 400K . Another similar vessel constains an equal mass of hydrogen at 300K. The ration of the rms speed of molecules of hydrogen and oxygen is

A. $\frac{4}{3}$

B. $\frac{3}{4}$

C. $3\sqrt{2}$

D. $2\sqrt{3}$

Answer: D

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31. A chamber contains a mixture of helium gas (He) and hydrogen gas(H_2). The ration of the root-mean-square speed of the molecules of He and H_2 is ..... .

A. 2

B. $\sqrt{2}$

C. $\frac{1}{\sqrt{2}}$

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

Answer: C

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32. On colliding with the walls in a closed container , the ideal gas molecules.

A. transfer momentum to the walls

B. lose momentum completely

C. move with smaller speeds

D. perform Brownian motion.

Answer: A

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33. The speed of 5 molecules of a gas (in arbitrary units) are as follows:2,3,4,5,6 the root mean square speed for these molecule is

A. 2.91

B. 3.52

C. 4

D. 4.24

Answer: D

34. At absolute zero temperature ,the K.E. of the molecules becomes ..... .

A. zero

B. maximum

C. minimum

D. none of these

Answer: A

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35. If the rms speed of the molecules of a gas at 27° C is 141.4 m/s , the rms speed at 327° C will be nearly _____ .

A. $1000ms^{-1}$

B. $922ms^{-1}$

C. $520ms^{-1}$

D. $849ms^{-1}$

Answer: B

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36. The gas having average speed four times as that of SO_2 (molecular mass 64) is

A. He (molecular mass 4)

B. O_2 (molecular 32)

C. H_2 (molecular mass 2)

D. CH_4 (molecular mass 16)

Answer: A::C::D

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Additional 2 Mark Questions

1. State Avogadro's law.

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2. Define root mean square speed (v_{rms}). Write down its equations.

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3. Define the avogadro's number :

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4. Define Average speed. Write it equations.

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5. Define most probable speed of the gas. Write its expression.

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6. Write down the comparision of $v_{rms}, \bar{v}$ and v_{mp}.

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7. Why there is no hydrogen in earth's atmosphere ?

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8. What is Brownian motion?

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9. What does the universal gas constant R signify? Give its value.

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10. What is the Boltzmann's constant? Give its value.

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11. When do the real gases obey more correctly the gas equation : PV=nRT?

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Addtional Numerical Problems

1. If the rms speed of hydrogen molecules at 300K is $1930 ms^{-1}$. Then what is the rms speed of oxygen molecules at 1200K.

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2. The rms velocity of the molecules in a sample of helium is 5//7 times that of molecules in a sample of hydrogen . If the tempertaure of hydrogen is $0^{\circ}C$. Then, what is the temperature of helium?

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3. A cylinder of fixed capacity 44.8 litres contains helium gas at standard pressure at temperature . What is the amount of heat

need to rest that temperature of the gas by $15.00^{\circ}C$? $\left[R = 8.31 \ \ \mathrm{J\ mol^{-1}K^{-1}}\right]$

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4. An insulated container monoatomic gas of molar mass m is moving with a velocity ν_0. If the container is suddenly stopped. Find the change in temperature.

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5. Estimate the total number of molecules inclusive of oxygen, nitrogen, water vapour and other constituents in a room of capacity $30m^3$ at a temperature of $30^\circ C$ and 1 atmosphere pressure.

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6. Estimate the average energy of a helium atom at (i) room temperature $(27^\circ C)$ (ii) the temperature on the surface of the sun (6000K)

and (iii) the temperature of $10^7 K$. $\left(k_B 1.38 \times 10^{-23} JK^{-1}\right)$

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7. The molecules of a given mass of a gas have rms velocity of $200 ms^{-1}$ at $27^\circ C$ and $1.0 \times 10^5 Nm^{-2}$ perssure. What the temperature and perssure of the gas are respectively.

$127^\circ C$ and $0.05 \times 10^5 Nm^{-2}$

Find the rms velocity of its molecules in ms^{-1}

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8. At what temperature will the rms speed of oxygen molecules become just sufficient for escaping from the Earth's atmosphere? (Mass of oxygen molecules $(m) = 2.76 \times 10^{-26}$ kg Boltzmann's constant $(k_B) = 1.38 \times 10^{-23} JK^{-1}$)

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9. The temperature of a gas is raise from $27^{\circ} C$ to $927^{\circ} C$. The root mean squre speed of its molecules..... .

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10. A gaseous mixture consists of 16g of helium and 16g of oxygen the ratio of two specific heats of the mixture is

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