# PHYSICS

# BOOKS - CHHAYA PHYSICS (BENGALI ENGLISH)

# KINETIC THEORY OF GASES

## Examples

**1.** The velocity of 10 gas molecules is a container are 2,3,3,4,4,4,5,5,7 and $10km.\,s^{-1}$

respectively. Find out the mean velocity and rms speed.

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**2.** Find out the rms speed of a gas of density $2g.\ L^{-1}$ at 76 cmHg pressure. Given density of mercury=$13.6g.\ cm^{-3}$ and $g = 980cm.\ s^{-2}$.

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**3.** Determine the rms speed of air molecules at STP Given density of mercury $= 13.6g.\,cm^{-3}$ density of air $= 0.00129g.\,cm^{-3}$.

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**4.** The rms speed of hydrogen molecules at STP is $1.85km.\,s^{-1}$ What is the density of hydrogen gas?

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**5.** Find out the rms speed of nitrogen gas molecules at $0^{\circ}C$. The density of nitrogen gas at STP=$1.25g.\ L^{-1}$

and density of mercury =$13.6g.\ cm^{-3}$

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**6.** Find out the ratio of the rms speeds of hydrogen and nitrogen molecules at STP?

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**7.** At what temperature will the rms speed of molecules of nitrogen gas be twice of that at $0^\circ C$?

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**8.** The temperature of a gas rises from $27^\circ C$ to $327^\circ C$. Show that the rms speed of the gas molecules would be $\sqrt{2}$ times its initial value at the final temperature.

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**9.** The rms speed of oxygen gas molecules at STP is $4.5 \times 10^4 cm.\ s^{-1}$. Find out the same for carbon dioxide gas molecules at STP. Given the molecular weights of oxygen and carbon dioxide are 32 and 44, respectively.

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**10.** Find out the kinetic energy of 2g of nitrogen gas at $27^\circ C$. Given $R = 8.3 \times 10^7 erg.\ mol^{-1} K^{-1}$.

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**11.** At what temperature the average kinetic energy of the molecules of a perfect gas be doubled than that at $20^\circ C$?

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**12.** Find out the temperature at which the molecular rms speed of a gas would be $\frac{1}{3}$rd its value at $100^\circ C$.

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**13.** The rms speed of the molecules of an ideal gas at STP is $0.5km.\ s^{-1}$. Find the density of the gas,what will be the density at $21^{\circ}C$ IF pressure remains the same? Given,atmospheric pressure =$10^{5}N.\ m^{-2}$.

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**14.** Find out the energy of 1 mol of a gas and its average molecular kinetic energy at $27^{\circ}C$.

Given, $R = 8.3 \times 10^{7} erg.\, mol^{-1}.\, K^{-1}$ and $N_A = 6.02 \times 10^{23} mol^{-1}$.

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**15.** The average kinetic energy of a molecule in a gas at STP is $5.6 \times 10^{-14} erg$. Find out the number of molecules per volume of the gas Given, density of mercury $= 13.6 g.\, cm^{-3}$.

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**16.** Find out the temperature at which the rms speed of nitrogen molecules will be equal to the escape velocity from the earth's gravity. Given,mass of a nitrogen atom = $23.24 \times 10^{-24} g$, average radius of the earth=6390 km,g=$980 cm.\ s^{-2}$, Boltzman constant $= 1.37 \times 10^{-16} erg.^{\circ} C^{-1}$

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**17.** Find out the temperature at which the average kinetic energy of a gas molecule will be

equal to the energy gained by an electron on acceleration across a potential difference of 1V, Given Boltzman constant=$1.38 \times 10^{-23} J.K^{-1}$, charge of an electron =$1.6 \times 10^{-19} C$.

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**18.** Find out the molecular kinetic energy of 1 mol of oxygen gas at STP, Given, molecular weight of oxygen=32, density of oxygen at STP = $1.43 g.L^{-1}$, density of mercury =$13.6 g.cm^{-3}$.

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**19.** At what temperature will the rms speed of a hydrogen molecules be equal to that of an oxygen molecule at $47^{\circ} C$?

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**20.** 0.76 g of a mixture of hydrogen and oxygen gases has a volume of 2L temperature of 300 K and pressure of $10^{5} N.m^{-2}$. Find out the individual masses of hydrogen and oxygen in the mixture.

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**21.** Find out the number of molecules in a gas of volume $20cm^3$ at a pressure of 76 cm of mercury. And at $27^\circ C$ Given average molecule kinetic energy at $27^\circ C = 2 \times 10^{-14} erg.$

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**22.** Find the temperature at which the average kinetic energy of a gas molecule will be equal to the energy of a photon to $6000 Angstrom$

radiation. Given,Boltzmann constant, $k = 1.38 \times 10^{-23} J.K^{-1}$ Planck's constant, $h = 6.625 \times 10^{-34} J.s.$

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**23.** Some amount of oxygen gas contained in a vessel has a density of $1.429 kg.m^{-3}$. At STP. The temperature is increased until the pressure is doubled Neglecting the change in volume of the vessel,find the rms speed of the oxygen molecules.

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**24.** Two ideal gases at absolute temperature $T_1$ and $T_2$ are mixed with each other. IF the molecular mass and the number of molecules are $m_1, n_1$ and $m_2, n_2$, respectively, find out the temperature of the mixture.

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**25.** 2 mol of a monatomic gas is mixed with 1 mol of a diatomic gas. Find out the value of $\gamma$

of the mixture.

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**26.** The mean free path for the collision of nitrogen molecules at STP is $6.44 \times 10^{-6} cm$. What is the mean time interval between collisions? Given, $R = 8.31 \times 10^{7} erg.\, mol^{-1}.\, K^{-1}$, molecular mass of nitrogen=28.

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**27.** The mass of a hydrogen molecule is $3.32 \times 10^{-27} kg$. $10^{23}$ such molecules hit every second on a rigid wall of area $2cm^2$ at an angle of $45^\circ$ with horizontal with a velocity of $10^3 m.\, s^{-1}$. If the molecules are reflected will the same velocity,then what is the pressure exerted on the wall?

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**28.** 22g of $CO_2$ gas at $27^\circ C$ is mixed with 16 g of $O_2$ gas at $37^\circ C$. What will be the

temperature of the mixture?

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**29.** A mixture of 8 g oxygen ,14 g nitrogen and 22g carbon dioxide is contained in a vessel of volume 4L What will be the pressure of the gas mixture if the temperature of the mixture is $27^{\circ} C$?

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**30.** 1 mol of He at $57^\circ C$ is mixed with 1 mol of Ar at $27^\circ C$. Find the temperature of the gas mixture .

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**31.** Find the minimum radius of the planet of density $5.5 \times 10^3 kg/m^3$ and temperature $427^\circ C$ which can hold $O_2$ in its atmosphere. [Given$G = 6.67 \times 10^{-11} N.m^{-2}.kg^{-2}$ and $R = 8.3 J.mol^{-1}.K^{-1}$]

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**32.** 1 mol $O_2$ at temperature $27^\circ C$ at STP $\left(1.01 \times 10^5 \frac{N}{m^2}\right)$ is kept in a vessel.Find the number of collisions the molecules experience(in SI) per second per unit area with the wall of the vessel.

[Given Boltzmann constant k= $1.38 \times 10^{-23} J/K$]

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**33.** 0.014 kg $N_2$ gas at $27^\circ C$ is kept in a closed vessel. How much heat is required to double the rms speed of the $N_2$ molecules?

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**34.** IF 2 mol of a gas at constant pressure, requires 70 cal heat to increase its temperature from $30^\circ C$ to $35^\circ C$, then find its degrees of freedom.

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## Higher Order Thinking Skills Hots Questions

**1.** Will the rms speed of molecules of different gases at the same temperature be the same?

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**2.** $1cm^3$ of hydrogen gas and $1cm^3$ of oxygen gas are both at STP. Which one contains more number of molecules?

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**3.** How does kinetic theory explain the increase of temperature of a gas when heat is supplied from outside?

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**4.** A porous container is filled with a gas mixture. Which gas would leak faster from the container when it is placed in vaccum?

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**5.** Equal number of molecules of an ideal monatomic and an ideal diatomic gas are at the same temperature. Which gas will be more heated if equal amount of heat is supplied from outside?

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**6.** The motion of gas molecules ceases at the temperature of absolute zero .Explain.

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**7.** The velocity of a gas molecule is comparable to that of a rifle bullet. Yet, a gas molecule spends a much longer time than a bullet does to travel equal distances .Explain.

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**8.** How would the rms speed of an ideal gas change if temperature increases.

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**9.** How would the rms speed of an ideal gas change if density increases at constant pressure,

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**10.** How would the rms speed of an ideal gas change if density increases at constant temperature.

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**11.** Why does a real gas obey Boyle's law and Charle's law at high temperature.

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**12.** Why does a real gas obey Boyle's law and Charle's law at low pressure.

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**13.** A gas mixture contains 1 mol each of two different gases, Would the average molecular kinetic energy of the two gases be equal? Would the rms speed be equal?

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**14.** State the condition in which a real gas behaves as an ideal gas.

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**15.** For a fixed mass of a gas at constant temperature the pressure falls when the volume increases, and vice versa. Explain according to the kinetic theory?

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**16.** For a fixed mass of a gas at constant volume, pressure rises when temperature increases,and vice versa Explain from the kinetic theory.

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**17.** Find out the molecular kinetic energy of 1 mol of an ideal gas . Is it equal for all gases?

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**18.** In a closed container ,the gas molecules have a highly random motion. Yet the pressure throughout the container is uniform at constant temperature.

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**19.** Why does a place of wood floating on water have no Brownian motion?

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**20.** Light gases like hydrogen and helium are very rare in the earth's atmosphere why?

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**21.** IF n is the number of degrees of freedom of the molecules of an ideal gas, show that the ratio $\frac{C_p}{C_v}$ is $1+\frac{2}{n}$.

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**22.** 1 mol of an ideal monatomic gas $\left(\gamma=\frac{5}{3}\right)$ is mixed with 1 mol of an ideal diatomic gas $\left(\gamma=\frac{7}{5}\right)$. Find the value of $\gamma$ for the mixture.

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**23.** The ratio between the specific heats of an ideal gas is $\gamma$. Show that the number of degrees of freedom of the gas molecules is $n = \frac{2}{\gamma - 1}$.

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**24.** IF the absolute temperature of a perfect gas rises to four times its initial value estimate the changes of molecular rms speed.

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**25.** IF the absolute temperature of a perfect gas rises to four times its initial value estimate the changes of total kinetic energy.

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**26.** Some gas cylinders are kept on the running vehicle . What will be the change it temperature of the gas molecules inside the cylinder?

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**27.** Find the dimension of the constant a in the van der Waals equation $\left(p+\frac{a}{V^2}\right)(V-b)=RT.$

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**28.** Find the dimension of the constant b in the van der Waals equation $\left(p+\frac{a}{V^2}\right)(V-b)=RT.$

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**29.** We have a sample of a gas characterised by p,V,T and another sample by $2p$, $\frac{V}{4}$, $2T$. What is the ratio of the number of molecules in the two samples?

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**30.** Find out the ratio between the absolute temperature of two samples of hydrogen and oxygen gases, if their molecules rms speed are equal.

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**31.** At equilibrium the volume pressure and temperature of a gas are V,p and T respectively. IF the gas is divided into two parts by a equation, what will be the value of these quantities in each part?

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**32.** In a gas -filled container, a molecule of speed $200m/s$ collides at an angle of $30^\circ$ with the horizontal face of this container, and

rebounds with the same speed. Is the collision elastic or inelastic? In this momentum conserved in this collision?

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**33.** While considering the motion of gas molecules in a container,why do we use rms speed instead of average speed of molecules?

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## Exercise Multiple Choice Questions

**1.** IF the volume of a body Is $V_1$ and total volume of the molecules of the body is $V_2$, then

A. $V_1 = V_2$

B. $V_1 < V_2$

C. $V_1 > V_2$

D. $V_1 < V_2$ or $V_1 > V_2$ for different bodies

**Answer: C**

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**2.** The molecules of all solids

A. are relatively closer than those of liquids or gases

B. are relatively farther than those of liquids or gases

C. move faster than those of liquids or gases

D. are stationary as they cannot move inside the solid

**Answer: A**

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**3.** Which of the following statements is inconsistent with the characteristic of Brownian motion?

A. the velocity of a particle increases as its size decreases

B. the velocity of the particles increases as the temperature increases

C. the velocity of the particles increases as the viscosity of the medium decreases

D. the velocity of the particles increases when the container is shaken.

**Answer: D**

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**4.** A piece of wood floating on water does not have any Brownian motion, because

A. a part of the wooden piece is above water

B. the resultant of the applied forces by the water molecules is zero

C. an adhesive force acts between the molecules of wood and water

D. the viscosity of water is comparatively less

**Answer: B**

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**5.** The velocities of two particles moving towards east to $4m.s^{-1}$ and $6m.s^{-1}$, respectively The velocities of three other particles moving towards west are $2m.s^{-1}, 3m.s^{-1}$ and $5m.s^{-1}$ respectively. The root mean square speed of these 5 particles is

A. 0

B. $4m.s^{-1}$

C. $1.667m.s^{-1}$

D. $4.242m.\ s^{-1}$

**Answer: D**

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**6.** the pressure and density of hydrogen gas, kept in a vessel are $1.013 \times 10^6 dyn.\ cm^{-2}$ and $0.089g.\ L^{-1}$, respectively, The rms speed of the gas molecules will be

A. $18.5m.\ s^{-1}$

B. $185m.\ s^{-1}$

C. $1.85km.\ s^{-1}$

D. $18.5km.\ s^{-1}$

**Answer: C**

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**7.** IF the mean velocity rms speed and maximum probable velocity of a gas are $c^{-}$, $c$ and $c_m$, respectively then

A. $c_m < \bar{c} < c$

B. $\bar{c} < c < c_m$

C. $c_m > \bar{c} > c$

D. None of these

**Answer: A**

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**8.** There is a mixture of hydrogen and oxygen gases in a vessel. The root mean square speed of the oxygen molecules is

A. 4 times that of hydrogen molecules

B. 16 times that of hydrogen molecules

C. $\frac{1}{4}$ times of hydrogen molecules

D. $\frac{1}{16}$ times of hydrogen molecules

**Answer: C**

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**9.** A mixture of 2moles of helium gas (atomic mass=4 amu) and 1 mole of argon gas (atomic

mass=40 amu) is kept at 300 K in a container. The ratio of the rms speeds is

A. 0.32

B. 0.45

C. 2.24

D. 3.16

**Answer: D**

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**10.** At room temperature the rms speed of the molecules of a certain diatomic gas is found to be $1930 m / s$. The gas is

A. $H_2$

B. $F_2$

C. $O_2$

D. $Cl_2$

**Answer: A**

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**11.** IF the volume of a container is V, the pressure on the walls of the container by a gas is p and internal energy of the gas is U, then

A. U=pV

B. $U = \frac{1}{3}pV$

C. $U = \frac{2}{3}pV$

D. $U = \frac{3}{2}pV$

**Answer: D**

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**12.** A certain amount of gas is at $27^\circ C$. The rms speed of the gas molecules becomes double at

A. $327^\circ C$

B. $600^\circ C$

C. $927^\circ C$

D. $1200^\circ C$

**Answer: C**

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**13.** If a gas of particular mass is expanded at constant temperature ,the variable which undergoes a change is

A. pressure of the gas

B. internal energy of the gas

C. rms speed of the gas molecules

D. kinetic energy of the gas molecules

**Answer: A**

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**14.** At equilibrium condition,volume,pressure and temperature of a gas kept in a closed container are V,p and T respectively. IF the container is divided into two equal parts by a partition, the value of these quantities for each part will be

A. $\frac{V}{2}, \frac{p}{2}, \frac{T}{2}$

B. $\frac{V}{2}, \frac{p}{2}, T$

C. $\frac{V}{2}, p, \frac{T}{2}$

D. $\frac{V}{2}, p, T$

**Answer: D**

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**15.** According to the kinetic theory of gases, there are no intermolar attractions, so these molecules do not have

A. linear momentum

B. kinetic energy

C. potential energy

D. mechanical energy

**Answer: C**

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**16.** IF k is Boltzmann constant and T is temperature, the average kinetic energy of each molecule of a gas will be

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

B. $\sqrt{\frac{2}{3}}kT$

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

D. $\sqrt{\frac{3}{2}}kT$

**Answer: C**

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**17.** The rms speed of oxygen molecules at $47^\circ C$ will be equal to the rms speed of hydrogen molecules at

A. 80 K

B. $-83K$

C. 3K

D. 20 K

**Answer: D**

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**18.** The pressure volume and temperatuere in two samples of a gas are p,V,T and 2p $\frac{v}{4}$,2T respectively The ratio of the number of molecules in the two samples is

A. $2:1$

B. $4:1$

C. $8:1$

D. $16:1$

**Answer: B**

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**19.** The rms speed of gas molecules at $0^\circ C$. Will be reduced to half at

A. $0^\circ C$

B. $273^\circ C$

C. $32^\circ C$

D. $204^\circ C$

**Answer: D**

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**20.** A container of 5 L contains $10^{26}$ number of molecules of a gas. IF the mass and rms speed of each molecule are$2.4 \times 10^{25} g$ and $3.5 \times 10^{4} cm.\ s^{-1}$ respectively, the pressure of the gas will approximately be

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

B. $10^{6} dyn.\ cm^{-2}$

C. $3 \times 10^6 dyn.\, cm^{-2}$

D. $5 \times 10^6 dyn.\, cm^{-2}$

**Answer: A**

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**21.** Air is filled in two heat insulated vessels 1 and 2 having pressure volume and temperature $p_1, V_1, T_1$ and $p_2, V_2, T_2$ respectively IF the intermediate valve between the two vessels is

opened the temperature of air at equilibrium will be

A. $T_1 + T_2$

B. $\frac{T_1 + T_2}{2}$

C. $\frac{T_1 T_2 (p_1 V_1 + p_2 V_2)}{p_1 V_1 T_2 + p_2 V_2 T_1}$

D. $\frac{T_1 T_2 (p_1 V_1 + p_2 V_2)}{p_1 V_1 T_1 + p_2 V_2 T_2}$

**Answer: C**

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**22.** A vessel contains a mixture of one moles of oxygen and two moles of nitrogen at 300 K. the ratio of the average rotational kinetic energy per $O_2$ molecule to per $N_2$ molecule is

A. $1:1$

B. $1:2$

C. $2:1$

D. depends on the moment of inertia of the two molecules

**Answer: A**

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**23.** 70 cal of heat is required to raise the temperature of 20 moles of an ideal diatomic gas at constant pressure from $30^{\circ}C$. The amount of heat required (in cal) to raise the temperature of the same gas through the same range ($30^{\circ}C$ to $35^{\circ}C$) at constant volume is

A. 30

B. 50

C. 70

D. 90

**Answer: B**

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**24.** Three closed vessels A,B and C at the same temperature T and contain gases which obey the Maxwellian distribution of velocities. Vessel A contains only $O_2$, B only $N_2$ and C a mixture of equal quantities of $O_2$ and $N_2$. IF the

average velocity of the $O_2$ molecules in vessel A is $v_1$ that of the $N_2$ molecules in vessel B is $v_2$, the average velocity of the $O_2$ molecules in vessel C is

A. $\frac{(v_1 + v_2)}{2}$

B. $v_1$

C. $(v_1 v_2)^{\frac{1}{2}}$

D. $\sqrt{\frac{3kT}{M}}$

**Answer: B**

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## Exercise Very Short Answer Type Questions

**1.** What is the name of the smallest entity of matter that exhibits all the properties of that matter?

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**2.** Which one of the following has the highest intermolecular force-solid,liquid or gas?

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**3.** If a gas jar filled with a light gas like hydrogen is held upside down on another gas jar filled with carbon dioxide,it is observed that the two gases produce a homogenous mixture in the jars. What is the name of this process?

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**4.** How does the velocity of Brownian particles change due to movement of the vessel?

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**5.** What is the direction of velocities of of gas molecules according to the kinetic theory of gases?

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**6.** Gas molecules collide with each other and with the walls of the container. What is the type of these collisions.

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**7.** What do you call the straight line path described by a gas molecule between two successive collisions?

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**8.** Both vaporisation and vapour pressure prove the___of molecules of a liquid.[Fill in the blanks].

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**9.** Brownian motion supports the _____of the matter [Fill in the blanks]

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**10.** In Brownian motion in a medium, if the particles decrease in size,how does their velocity vary?

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**11.** Does the velocity of the particles increase or decrease when the velocity increases in Brownian motion in a medium?

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**12.** Which gases obey the basic assumptions of the kinetic theory?

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**13.** According to the kinetic theory of gases,every gas molecule behaves as a _____[Fill in the blanks]

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**14.** According to the kinetic theory of gases the velocity of gas molecules vary from____to _____[Fill in the blanks]

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**15.** Which is greater -rms speed or mean velocity?

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**16.** Does the pressure of a gas increase or decrease when the velocity of the gas molecules increases?

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**17.** On which other factor does the pressure of a gas depend,besides the number of molecules per unit volume and the temperature of the gas?

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**18.** Is the most probable velocity of gas molecule higher or lower than the mean velocity ?

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**19.** Will the rms speed of oxygen and hydrogen gas molecules be the same at equal temperature?

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**20.** What is the ratio of the rms speed of $O_3$ and $O_2$ at a certain temperature?

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**21.** By how times will the pressure of a gas kept in a gas container of constant volume increase to double the rms speed of the gas molecules?

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**22.** The velocity of three gas molecules are $4cm.\ s^{-1}, 8cm.\ s^{-1}$ and $12cm.\ s^{-1}$ respectively. Calculate their rms speed.

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**23.** What is the relation between rms speed and molecular mass of a gas?

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**24.** Hydrogen and oxygen gases are kept in two vessels at the same temperature and pressure. What is the ratio of the rms speed of their molecules?

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**25.** IF a gas molecule of a mass m and velocity u collides perpendicularly with a wall of container, what will be the value of momentum of the molecule after the collision?

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**26.** IF n number of molecules, each having mass m and velocity u, perpendicular hit the walls of a container in every second what will be the value of the applied force?

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**27.** In the kinetic theory of gases____is more important than mean velocity. [Fill in the blanks]

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**28.** What is the name of the force acts among the molecules of matter?

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**29.** Under which conditions do real gases behave as ideal gases?

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**30.** Which property of a gas is proportional to the net internal energy of the gas molecule?

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**31.** At which temperature does the kinetic energy of gas molecules become zero?

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**32.** To which gases is the van der Waals equation applicable?

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**33.** If the temperature of a gas is increased at constant volume,how will the number of collisions of the molecules per unit time change?

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**34.** What is the dimensions of a in van der Waals's equation $\left(p+\frac{a}{V^2}\right)(V-b)=RT$?

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**35.** What is the dimensions of b in van der Waals's equation $\left(p+\frac{a}{V^2}\right)(V-b)=RT$?

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**36.** What is the relation between pressure p of a gas and its energy density u?

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**37.** According to the kinetic theory of gases, there is no attractive force between the gas

molecules , the entire energy of them is _____[Fill in the blanks]

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## Exercise Short Answer Type Questions I

**1.** What is the difference between real gas and ideal gas?

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**2.** $1cm^3$ of hydrogen gas and $4cm^3$ of oxygen gas are both at STP. Which one contains more number of molecules?

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**3.** A porous container is filled with a mixture of hydrogen and oxygen gas. Which gas will leak faster and why?

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**4.** Explain the relation between pressure and volume of a gas confined in a closed vessel at a constant temperature,according to the kinetic theory of gases.

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**5.** Explain the relation between pressure and temperature of a gas confined is a close inextensible vessel, according kinetic theory of gases.

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**6.** Why do real gases not obey Boyle's law ? When will they obey?

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**7.** Why does moon have no atmosphere?

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**8.** The motion of real gas molecules ceses at absolute zero temperature -Explain. What will be in case of ideal gases?

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## Exercise Short Answer Type Questions Ii

**1.** IF the number of gas molecules in a container in doubled, how will the pressure

and the total kinetic energy of the gas molecules of that container change?

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**2.** How will the rms speed and the total kinetic energy of the gas molecules change, if its absolute temperature is decreased 4 times?

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**3.** Why do real gases behave an ideal gases at low pressure?

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**4.** We know that the velocity of a gas molecule is approximately equal to the velocity of a rifle bullet,Yet,a gas molecule spends much longer time than a bullet does to travel equal distance Explain.

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**5.** A gas mixture contains 2mol each of helium and oxygen gas. What will be the ratio of their (i) average kinetic energy, (ii) rms speed?

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**6.** Write down the expansion for pressure of an ideal gas according to kinetic theory of gases. Given that at absolute temperature T, the average kinetic energy of a molecule of an ideal gas is $\frac{3}{2}\left(\frac{R}{N}\right)T$, where R is the universal gas constant and N is the Avogadro number

Determine the equation for ideal gases from his.

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## Exercise Problem Set I

**1.** IF the density of hydrogen gas is $0.00009 g . cm^{-3}$ determine the value of rms speed of hydrogen molecules at STP.

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**2.** IF the density of helium gas is $0.178g.\ L^{-1}$ what will be the rms speed of helium molecules at STP?

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**3.** A container having volume 1L contains $10^{25}$ number of oxygen molecules If the mass and the rms speed of oxygen molecules are $2.7 \times 10^{-25}g$ and $4 \times 10^{4}cm.\ s^{-1}$, respectively what will be the pressure of that gas?

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**4.** In a hydrogen filled balloon, the pressure of the gas is $\frac{11}{2}$ times the atmospheric pressure and its density is $83.\, g.\, m^{-3}$. Determine the roots mean square speed of hydrogen molecules.

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**5.** The velocities of four molecules are $1km.\, s^{-1}, 3km.\, s^{-1}, 5km.\, s^{-1}$ and $7km.\, s^{-1}$

respectively Determine the difference between the values of mean velocity and rms speed of these molecules.

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**6.** IF the density of nitrogen at STP is $1.25g.\,L^{-1}$, determine the rms speed of nitrogen molecules.

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**7.** IF the rms speed of oxygen at STP is $4.6 \times 10^4 cm.\, s^{-1}$ What will be its density at STP?

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**8.** Determine the rms speed of gas molecules at $27^\circ C$ $[R = 8.3 \times 10^7 erg.\, mol^{-1}.\, K^{-1},$ atomic weight of oxygen=16].

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**9.** Determine the rms speed of air at STP Density of mercury = $13.6g.\,cm^{-3}$, $g = 980cm.\,s^{-2}$ density of air = $0.00129g.\,cm^{-3}$.

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**10.** Determine the rms speed of carbon dioxide molecules at $0^{\circ}C$ Universal gas constant, $R = 8.31 \times 10^{7} erg.\,mol^{-1}, K^{-1}$ and molecule mass of $CO_2 = 44$.

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**11.** The temperature of a gas is increased from $77^{\circ} C$ to $277^{\circ} C$ . What will be the ratio of the initial and final kinetic energies of the gas molecules?

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**12.** At which temperature will the value of root mean square speed of molecules be zero?

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**13.** Find the temperature at which the value of rms speed of hydrogen molecules will be equal to that of carbon dioxide molecules at $27^{\circ} C$. Carbon dioxide molecules are 22 times heavier than hydrogen molecules.

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**14.** Estimate the average thermal energy of helium atom at (i) the temperature on the surface of the sun 6000K (ii) the temperature

of 10 million Kelvin (typical core temperature in case of star).

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**15.** Calculate the molecular kinetic energy of 1 g helium gas at $127^{\circ}C$ Molecular weight of helium=4 and $R = 8.3 \times 10^{7} erg.\, Mol^{-1}.\, K^{-1}$ .

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**16.** Calculate the temperature at which the average translational kinetic energy of the molecules of a gas will be $\frac{1}{3}$rd of that at $180^{\circ}C$?

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**17.** IF the rms sped of hydrogen molecules is $1.84km.\ s^{-1}$ at STP, what will be the rms speed of oxygen molecules at STP? The molecular mass of hydrogen and oxygen and 2 and 32 respectively.

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**18.** If the density and rms speed of a gas are $1.25 \times 10^{-3} g.\, cm^{-3}$ and $5 \times 10^{4} cm.\, s^{-1}$ respectively then determine (i) kinetic energy of the gas per unit volume and (ii) pressure of the gas

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**19.** Calculate the rms speed of oxygen gas molecule at 300 K.

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**20.** The temperature of an ideal gas is increased from 120K to 480 K. IF a 120 K the rms speed of the gas molecules is v then find out the rms speed at 480K.

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**21.** Determine the average energy of a gas molecule at 3940 K. $R = 8.31 \times 10^7 erg.\, mol^{-1}.\, K^{-1}$ and $N = 6.025 \times 10^{23}$.

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**22.** Mean free path of benzene molecule is $2.2 \times 10^{-6} cm$ and number of molecules per unit volume is $2.79 \times 10^{19} cm^{-3}$. Determine the diameter of a benzene molecule.

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**23.** An air bubble of volume $1.0 cm^3$ rises from the bottom of a lake 40 m deep at a temperature of $12^\circ C$. To What volume does it grow when it reaches the surface. Which is at a temperature of $35^\circ C$?

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Exercise Problem Set Ii

**1.** Three vessels of equal capacity have gases at the same temperature and pressure. The first vessel contains neon (monatomic) the second contains chlorine (diatomic) and the third contains uranium hexafluoride(polyatomic). Do the vessels contain equal number of respective molecules? Is the root mean square speed of molecules are same in the three cases in $v_{rms}$ the largest?

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**2.** From a certain appartus the diffusion rate of hydrogen has an average value of $28.7cm^2.\ s^{-1}$ The diffusion of another gas under the same conditions is measured to have an average rate of $7.2cm^3.\ s^{-1}$ Identify the gas.

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**3.** The mean kinetic energy of the molecules of an ideal gas is given by $E = 2.07 \times 10^{-23} TJ.\ mol^{-1}$ where T is

temperature of the gas. Calculate the number of molecules to 1 litre of the gas at STP. What will be the average distance between the molecules?[Given standard atmosphere = $1.01 \times 10^5 N.m^{-2}$]

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**4.** A jar contains a gas and few drops of water at $T_1 K$. The pressure of the jar is 830mm of mercury. The temperature of the jar is reduced by 1% The saturated vapour pressure at the

two temperatures are 30 mm and 25 mm of mercury calculate the new pressure in the jar.

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**5.** A gaseous mixture consists of 16 g of helium and 16 g of oxygen. Obtain the ratio of $\frac{C_p}{C_v}$ of the mixture.

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**6.** A container of volume $0.166m^3$ contains a mixture of $1.60g$ oxygen and 2.80 g nitrogen at constant temperature 300 K. Find the pressure of the mixture.

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**7.** The mean square speed of the molecules of a fixed mass of a gas is $6.8 \times 10^4 m^2 . s^{-2}$ calculate the mean square speed of the molecules when the gas has been compressed adiabatically to half of its original , volume The

ratio of the specific heat capacity of the gas at constant pressure to that at constant volume is 1.30.

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**8.** One mole of an ideal gas $(\gamma = 1.4)$ performs 80 J of work while undergoing isobaric expansion. Find the amount of heat absorbed by the gas in the process and change in its internal energy.

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**9.** A barometer tube is 1 m long and $2cm^2$ in cross section. Mercury stands up to height of 75 cm in the tube. When a small amount of oxygen is introduced in the space above the mercury level,the level falls by 5 cm. Calculate the mass of the oxygen introduced. Room temperature $= 27^\circ C g = 10m.\, s^{-2}$ and density of mercury = $13600kg.\, m^{-3}$

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## Exercise Hot Numerical Problems

**1.** The area of one of the walls of container is $3cm^2$. $10^{23}$ Number of molecules are incident on it every second at an angle of $45^\circ$. What is the pressure exerted on the wall if the velocity of each molecule is $10^5 cm.\ s^{-1}$ and it mass is $3.32 \times 10^{-24} g$?

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**2.** A container of volume 1 L contains $2.5 \times 10^{23}$ number of nitrogen molecules. The mass of each molecule is $4.65 \times 10^{23}$ and the rms speed of the molecule is $5 \times 10^{4} cm.\, s^{-1}$. Determine the pressure and the total kinetic energy of the gas.

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**3.** Calculate the number of molecules is $1 cm^{3}$ of an ideal gas at $27^{\circ} C$. Temperature and 20 mmHg pressure. The average kinetic energy of

one molecule of the gas at $27^{\circ} C = 4 \times 10^{-14} erg$, density of mercury = $13.6 g.\, cm^{-3}$

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**4.** The mass of one molecule of hydrogen gas is $3.2 \times 10^{-24} g$ The root mean square speed of the molecules of another gas is 4 times that of hydrogen molecule at the same temperature.Determine the mass of each molecule of that gas.

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**5.** A dust particle present in air is $10^{12}$ times heavier than a molecule of air. The rms speed of a dust particle is n times that of a molecule of air. What is the value of n?

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**6.** Estimate the total number of air molecules (inclusive of $O_2, N_2$ and water vapour and

other constituents) in a room of capacity $25m^3$ at a temperature of $27^\circ C$ and 1 atm pressure.

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**7.** Calculate the mean free path for the collision of nitrogen molecules at $0^\circ C$ temperature at 1 standard atmosphere pressure. The mean time interval between two successive collisions = $1.9 \times 10^{-10} s$,

$R = 8.31 \times 10^7 erg.\, mol^{-1}.\, K^{-1}$ molecular mass of nitrogen =28.

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**8.** The average kinetic energy of a hydrogen molecule at $0^{\circ}C$ is $5.64 \times 10^{-14} erg$ and the universal gas constant $R = 8.32 \times 10^{7} erg.\, mol^{-1}.\, K^{-1}$. Find out the value of the avogadro number.

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**9.** The radius of a completely evacuated bulb is 20 cm. The bulb is filled with 2g hydrogen and 3

g helium gas. What is the pressure exerted on the wall of the bulb at $22^{\circ} C$?

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**10.** Determine the number of molecules is $20 cm^3$ of a gas at $27^{\circ} C$ and 76 cmHg pressure. Average kinetic energy per molecule at $27^{\circ} C = 4 \times 10^{-14} erg$ and $g = 980 cm.\ s^{-2}$.

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**11.** An insulated box containing a mono-atomic gas of molar mass M moving with a speed $v_0$ is suddenly stopped. Find the increment is gas temperature as a result of stopping of the box.

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**12.** Given below are densities of some solids and liquids given rough estimates of the size of their atoms:

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**13.** Find out the temperature at which the average translational kinetic energy of a gas molecule will be equal to the energy gained by an electron on acceleration across a potential difference of 5V, Boltzmann constant, $k = 1.38 \times 2.^{-23} J.K^{-1} 1ev = 1.6 \times 10^{-19} J.$

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**14.** Nuclear fusion occurs among deuterium nuclei when the average kinetic energy of a nucleus is 0.72 MeV. At what temperature can this nuclear fusion occur?

$1ev = 1.6 \times 10^{-19} J, k = 1.38 \times 10^{-23} J.\ K^{-1}$

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**15.** Calculate the translational kinetic energy and net kinetic energy of an oxygen molecule at $27^{\circ} C$, where Avogadro number ,

$N = 6.023 \times 10^{23}$ and Boltzmann constant $k = 1.38 \times 10^{-23} J.K^{-1}$

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**16.** A cylinder of volume 10L contains nitrogen gas at $27^{\circ}C$, and 50 standard avogadro pressure. The cylinder is kept in vaccum and a $1cm^2$ hole is made on it. Calculate the time after which the cylinder will be empty. $k = 1.38 \times 10^{-23} J.K^{-1}$, $N = 6.023 \times 10^{23}$ and molecular mass of nitrogen =28.

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**17.** The mean free path of oxygen gas molecules at STP is $9.5 \times 10^{-6} cm$ What is the time interval between two successive collisions of a molecule? Atomic weight of oxygen=32 and $R = 8.3 \times 10^{7} erg.\, mol^{-1}.\, K^{-1}$

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**18.** A gas is equilibrium has uniform density and pressure throughout its volume. This is strictly

true only if there are no external influences. A gas column under gravity for example does not have uniform density (and pressure). As you might expect, its density decreases with height. The precise independence is given by the so called law of atmospheres

$$n_2 = n_1 \exp[-mg(h_2 - h_1)/K_B T]$$

where $n_2$, $n_1$ refer to number density at heights $h_2$ and $h_1$ respectively. Use this relation to derive the equation for sedimentation equilibrium of a suspension in a liquid column:

$$n_2 = n_1 \exp[-mgN_A(p - p')(h_2 - h_1)/(pRT)]$$

where p is the density of the suspended particle and p' that of the surrounding medium [$N_A$ is Avogadro's number and R the universal gas constant ]

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**19.** The velocity of a nitrogen molecule on the earth surface is equal to its rms speed at $0^\circ C$ IF the molecule moves straights upwards without any collisions with other molecules, determine the height up to which the molecule

would rise. The mass of a nitrogen molecule $m = 4.65 \times 10^{-26} kg$ and $k = 1.38 \times 10^{-23} J.K^{-1}$

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**20.** Two non-reactive monoatomic ideal gases have their atomic masses in the ratio 2:3 the ratio of their partial pressures, when enclosed in a vessel kept a constant temperature is 4:3 Calculate the ratio of their densities.

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**21.** Two mole of ideal helium gas is in a rubber balloon at $30^{\circ}C$. The balloon is fully expandable and an be assumed to required no energy in its expansion. The temperature of the gas balloon is slowly charged to $35^{\circ}C$. Taking $R = 8.31J.mol^{-1}.K^{-1}$ calculate the amount of heat required to raise that temperature.

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**22.** A closed container of volume $0.02m^3$ contains a mixture of neon and argon gases at a temperature of $27^\circ C$ and pressure of $1 \times 10^5 N.m^{-2}$ The total mass of the mixture is 28 g. IF the molar masses of neon and argon are20 and $40g/mol$ respectively . find the masses of the individual gases in the container assuming then to be ideal. $[R = 8.314J.mol^{-1}.K^{-1}]$

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## Entrance Corner Assertion Reason Type

**1.** Statement I: The root mean square speeds of the molecules of different ideal gases at the same temperature are the same.

Statement II: The average translational kinetic energy of molecules of different ideal gas are same at the same temperature.

A. Statement I is true,statement II is true, statement II is a correct explanation for statement I

B. Statement I si true,statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true,

**Answer: C**

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**2.** Statement I: The rms speed of oxygen molecules $(O_2)$ at an absolute temperature T is c. IF the temperature is doubled and oxygen gas dissociates into atomic oxygen, the rms speed remains unchanged.

Statement II: The rms speed of the molecules of a gas is directly proportional to $\sqrt{T/M}$

A. Statement I is true,statement II is true, statement II is a correct explanation for statement I

B. Statement I si true,statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true,

**Answer: A**

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**3.** Statement I: The total translation kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume.

Statement II: The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

A. Statement I is true,statement II is true, statement II is a correct explanation for statement I

B. Statement I si true,statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true,

**Answer: B**

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**4.** Statement I: Mean free path of gas molecules,varies inversely with density of the gas

Statement II: Mean free path of gas molecule is defined as the average distance travelled by a molecule between two successive collisions.

A. Statement I is true,statement II is true, statement II is a correct explanation for statement I

B. Statement I si true,statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true,

**Answer: B**

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**5.** Statement I: For an ideal gas at constant temperatures the product of the pressure and the volume is constant.

Statement II: The mean square velocity of the molecules is inversely proportional of mass.

A. Statement I is true,statement II is true, statement II is a correct explanation for statement I

B. Statement I si true,statement II is true, statement II is not a correct explanation

for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true,

**Answer: B**

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**6.** Statement I: The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume.

Statement II: The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

A. Statement I is true,statement II is true, statement II is a correct explanation for statement I

B. Statement I si true,statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true,

**Answer: B**

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## Entrance Corner Multiple Correct Answer Type

**1.** From the following statements concerning ideal gas at any given temperature T, select correct one(s).

A. the coefficient of volume expansion at constant pressure is the same for all ideal gases

B. the average translational kinetic energy per molecule of oxygen gas is 3kT, K being the Boltzmann constant

C. the mean free path of molecules increases with decrease in pressure

D. in a gaseous mixture,the average translational kinetic energy of the

molecules of each component is different.

**Answer: A::C**

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**2.** Let $\bar{v}, v_{rms}$ and $v_p$ respectively denote the mean velocity,root mean square speed and most probable velocity of the molecules in an ideal monatomic gas at absolute temperature T. The mass of a molecule is m . Then

A. no molecule can have a speed greater than $\sqrt{2}v_{rms}$

B. no molecule can have speed less than $\frac{v_p}{\sqrt{2}}$

C. $v_p < \bar{v} < v_{rms}$

D. the average kinetic energy of a molecule is $\frac{3}{4}mv_p^2$

**Answer: B::C**

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**3.** For a jar containing $H_2$ and He gases which of the following statements are correct?

A. Both the gas molecules have same average energy

B. Both the gas molecules have same average translational kinetic energy

C. Hydrogen molecules have greater average energy than helium molecules

D. Both the molecules have same average velocity

**Answer: A::B::C**

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**4.** The root mean square speed of the perfect gas molecules will be doubled if

A. pressure is doubled at constant volume

B. pressure is made 4 times at constant volume

C. volume is made 4 times at constant pressure

D. volume is increased by 41.1% at constant pressure

**Answer: C::D**


**5.** According to kinetic theory of gases, Which of the following statements are true?

A. real gas behaves as ideal gas at high temperature and low pressure

B. liquid state of ideal gas impossible

C. at any temperature and pressure,ideal gas obeys Boyle's law and Charle's law

D. The molecules of a real gas do not exert any force or one another

**Answer: B::C**

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## Entrance Corner Comprehension Type

**1.** The pressure exerted by an ideal gas is p= $\frac{1}{3}\frac{M}{V}c^2$ where the symbols have their usual meanings. Using standard gas equation, pV=nRT we find that $c^2 = \frac{3RT}{M}$ or $C^2 \propto T$. Average kinetic energy of translation of 1 mol of gas=$\frac{1}{2}Mc^2 = \frac{3RT}{2}$

Average thermal energy of a helium atom at room temperature $(27^\circ C)$ is (given Boltzmann constant $k = 1.38 \times 10^{-23} J.K^{-1}$)

A. $2.16 \times 10^{21} J$

B. $6.21 \times 10^{21} J$

C. $6.21 \times 10^{-21} J$

D. $6.21 \times 10^{-23} J$

**Answer: C**

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**2.** The pressure exerted by an ideal gas is p= $\frac{1}{3}\frac{M}{V}c^2$ where the symbols have their usual meanings. Using standard gas equation, pV=nRT we find that $c^2 = \frac{3RT}{M}$ or $C^2 \propto T$.

Average kinetic energy of translation of 1 mol of gas=$\frac{1}{2}Mc^2 = \frac{3RT}{2}$

Average thermal energy of 1 mol of helium at $27^0C$ temperature is (given constant for 1 mol= $8.31J.mol^{-1}.K^{-1}$)

A. $3.74 \times 10^3 J$

B. $3.74 \times 10^{-3} J$

C. $3.74 \times 10^6 J$

D. $3.74 \times 10^{-6} J$

**Answer: A**

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**3.** The pressure exerted by an ideal gas is p= $\frac{1}{3}\frac{M}{V}c^2$ where the symbols have their usual meanings. Using standard gas equation, pV=nRT we find that $c^2 = \frac{3RT}{M}$ or $C^2 \propto T$. Average kinetic energy of translation of 1 mol of gas=$\frac{1}{2}Mc^2 = \frac{3RT}{2}$

At what temperature when pressure remains unchanged, will the rms speed of hydrogen be double its value at STP?

A. 819 K

B. $819^\circ C$

C. 1000 K

D. $1000^\circ C$

**Answer: B**

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**4.** The pressure exerted by an ideal gas is p= $\frac{1}{3}\frac{M}{V}c^2$ where the symbols have their usual meanings. Using standard gas equation, pV=nRT we find that $c^2 = \frac{3RT}{M}$ or $C^2 \propto T$.

Average kinetic energy of translation of 1 mol of gas=$\frac{1}{2}Mc^2 = \frac{3RT}{2}$

At what temperature, when pressure remain unchanged , will the rms speed of a gas be half its value at $0^\circ C$?

A. $204.75K$

B. $204.75^\circ C$

C. $-204.75K$

D. $-204.75^\circ C$

**Answer: D**

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**5.** IF $c_1, c_2, c_3$.....are random speeds of gas molecules at a certain moment then average velocity $c_{av} = \frac{c_1 + c_2 + c_3 + \ldots\ldots c_n}{n}$ are root mean square speed of gas molecules

$$c_{rms} = \sqrt{\frac{c_1^2 + c_2^2 + c_3^2 + \ldots\ldots + c_n^2}{n}} = c$$

Further $c^2 \propto T$ or $c \propto \sqrt{T}$

At0K, c=0 i.e.,molecular motion stops.

IF three molecules have velocities $0.5km.\ s^{-1}$, $1km.\ s^{-1}$ and $2km.\ s^{-1}$ the ratio of rms speed and average velocity is

A. 0.134

B. 1.34

C. 1.134

D. 13.4

**Answer: B**

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**6.** IF $c_1, c_2, c_3$.....are random speeds of gas molecules at a certain moment then average velocity $c_{av} = \frac{c_1 + c_2 + c_3 + \ldots\ldots c_n}{n}$ are root

mean square speed of gas molecules

$$c_{rms} = \sqrt{\frac{c_1^2 + c_2^2 + c_3^2 + ..... + c_n^2}{n}} = c$$

Further $c^2 \propto T$ or $c \propto \sqrt{T}$

At0K, c=0 i.e.,molecular motion stops.

Temperature of a certain mass of a gas is doubled,The rms speed of its molecules becomes n times where n is

A. $\sqrt{2}$

B. 2

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

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

**Answer: A**

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**7.** IF $c_1, c_2, c_3$.....are random speeds of gas molecules at a certain moment then average velocity $c_{av} = \frac{c_1 + c_2 + c_3 + \ldots\ldots c_n}{n}$ are root mean square speed of gas molecules

$$c_{rms} = \sqrt{\frac{c_1^2 + c_2^2 + c_3^2 + \ldots\ldots + c_n^2}{n}} = c$$

Further $c^2 \propto T$ or $c \propto \sqrt{T}$

At0K, c=0 i.e.,molecular motion stops.

KE per molecule of the gas in the above question becomes x times where x is

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

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

C. 4

D. 2

**Answer: C**

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**8.** IF $c_1, c_2, c_3$.....are random speeds of gas molecules at a certain moment then average velocity $c_{av} = \frac{c_1 + c_2 + c_3 + ..... c_n}{n}$ are root mean square speed of gas molecules

$$c_{rms} = \sqrt{\frac{c_1^2 + c_2^2 + c_3^2 + ..... + c_n^2}{n}} = c$$

Further $c^2 \propto T$ or $c \propto \sqrt{T}$

At0K, c=0 i.e.,molecular motion stops.

KE per mole of hydrogen at $100^\circ C$ (given $R = 8.31 J.\, mol^{-1}, K^{-1}$) is

A. 4946J

B. 4649J

C. 4496J

D. 4699J

**Answer: C**

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**9.** IF $c_1, c_2, c_3$.....are random speeds of gas molecules at a certain moment then average velocity $c_{av} = \frac{c_1 + c_2 + c_3 + \ldots\ldots c_n}{n}$ are root mean square speed of gas molecules

$$c_{rms} = \sqrt{\frac{c_1^2 + c_2^2 + c_3^2 + \ldots\ldots + c_n^2}{n}} = c$$

Further $c^2 \propto T$ or $c \propto \sqrt{T}$

At0K, c=0 i.e.,molecular motion stops.

At what temperature when pressure remains constant, will the rms speed of the gas molecules be increased by 10% of the rms speed at STP?

A. $57.3K$

B. $57.3^\circ C$

C. $557.3K$

D. $-57.3^\circ C$

**Answer: A**

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**10.** A cubical box of side 1 m contains helium gas (atomic weight=4) at pressure $100N.m^{-2}$ During an observation time of 1s, an atom travelling with rms speed parallel to one of the edges of the cube was found to make 500 hits with a perpendicular wall without any collisions with other atoms.

Evaluate the temperature of the gas

A. 125K

B. 160K

C. 181K

D. 185K

**Answer: D**

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**11.** A cubical box of side 1 m contains helium gas (atomic weight=4) at pressure $100N.m^{-2}$ During an observation time of 1s, an atom travelling with rms speed parallel to one of the

edges of the cube was found to make 500 hits with a perpendicular wall without any collisions with other atoms.

Evaluate the average kinetic energy per atom.

A. $3.31 \times 10^{-21} J$

B. $3.75 \times 10^{6} J$

C. $3.81 \times 10^{-15} J$

D. $3.22 \times 10^{3} J$

**Answer: B**

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**12.** A cubical box of side 1 m contains helium gas (atomic weight=4) at pressure $100N.m^{-2}$ During an observation time of 1s, an atom travelling with rms speed parallel to one of the edges of the cube was found to make 500 hits with a perpendicular wall without any collisions with other atoms.

Evaluate the total mass of the helium gas in the box.

A. $9 \times 10^{-4} kg$

B. $5 \times 10^{-3} kg$

C. $3 \times 10^{-4} kg$

D. $7 \times 10^{-3} kg$

**Answer: B**

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## Entrance Corner Integer Answer Type

**1.** Two identical cylinder contain helium at 3.5 standard atmosphere and argon at 2.5 standard atmosphere respectively. IF both

these gases are filled in one of the cylinders, what would be the pressure of the mixture?

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**2.** The rms speed of molecule of a gas at $-73^{\circ}C$ and 1 standard atmosphere pressure is $100m.s^{-1}$ . The temperature of the gas is increased to $527^{\circ}C$ and pressure is doubled. The rms speed becomes k times what is the value of k?

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**3.** The density of gas is $6 \times 10^{22} kg.\, m^{-3}$ and the root mean square speed of the gas molecules is $500 m.\, s^{-1}$ The pressure exerted by the gas on the walls of the vessel in $n \times 10^{3} N.\, m^{-2}$ Find the value of n.

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**4.** A gas has molar heat capacity $c = 37.55 J.\, mol^{-1}.\, K^{-1}.$ In the process

pT=constant . Find the number of degrees of freedom of the molecules of the gas.

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**5.** A vessel has 6g of hydrogen at pressure p and temperature 500k. A small hole is made in it so that hydrogen leaks out. How much hydrogen (in g) leaks out if the final pressure is $\frac{p}{2}$ and temperature falls to 300K?

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## Examinations Archive With Solutions Wbchse

**1.** Use kinetic theory of gases to show that the average kinetic energy of a molecule of an ideal gas is directly proportional to the absolute temperature of the gas.

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**2.** What is mean free path of a gas molecule? On What factors does it depend?

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**3.** Which one of the following is not true for an ideal gas ?

A. The molecule of an ideal gas move randomly

B. The molecule of an ideal gas attract one another

C. The volume of the molecules of an ideal gas is negligible

D. The pressure of an ideal gas increases with increase in the velocity of its molecules.

**Answer: D**

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**4.** From the relation $p = \frac{1}{3}mnc_{rms}^2$ show that the mean kinetic energy of a molecule is the same for all types of gases.

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**5.** From the relation $C_p - C_v = R$ show that the ratio of two specific heats $(\gamma)$ of an ideal gas is given by $\gamma = 1 + \frac{2}{f}$ where f is the degrees of freedom of the molecule.

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**6.** A monatomic ideal gas is heated at constant pressure. How much fraction of heat is used to increase internal energy?

A. $\frac{2}{5}$

B. $\frac{3}{5}$

C. $\frac{3}{7}$

D. $\frac{3}{7}$

**Answer:**

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**7.** From kinetic theory prove that pressure of a gas $p = \frac{2E}{3v}$ (where v=1 molar volume, E=kinetic energy).

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**8.** What will be the effect on rms velocity of a gas particle when (i) Temperature of the gas is increased (ii) density of the gas is decreased?

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**9.** The degrees of fraction of a molecular gas is n. Show that the ratio of gas $\frac{C_p}{C_v} = 1 + \left(\frac{2}{n}\right)$

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**10.** In thermal equilibrium the rms velocity of a gas molecule is

A. proportional to $T^3$

B. proportional to $T^2$

C. proportional to $\sqrt{T}$

D. zero

**Answer: C**

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**11.** Write the expression for mean free path.

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**12.** The mean free path of oxygen molecule at NTP is $9.5 \times 10^{-6} cm$ What will be the time between two consecutive collisions of an oxygen molecule?( $R = 8.3 \times 10^{7} erg.\, mol^{-1}.\, K^{-1}$)

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**13.** From kinetic theory of gases prove that the pressure of a gas p=$2E/3V$, where V=1 molar volume E=kinetic energy.

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**14.** State two fundamental postulates of kinetic theory of ideal gases.

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**15.** The temperature of a gas in increased from $27^\circ C$ to $327^\circ C$. Show that the rms velocity of the gas molecules at higher temperature is $\sqrt{2}$ times the velocity at the initial temperature.

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**16.** The volume and pressure of two moles of an ideal gas and V and p respectively Another 1mol ideal gas having volume 2V also exerts the same pressure p. Molecular mass of the second

gas is 16 times that of the first gas. Compare the rms velocities of the two gases.

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**17.** The perfect gas equation for 4g of hydrogen gas is

A. pV=RT

B. pV=2RT

C. $pV = \frac{1}{2}RT$

D. $pV = 4RT$

**Answer: B**

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**18.** From the relation $p = \frac{1}{3}mnc_{rms}^2$ show that the mean kinetic energy of a molecule is the same for all types of gases.

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**19.** Define degrees of freedom Write down the principle of equipartition of energy. Find the

value of $\gamma = (C_p / C_v)$ of a diatomic gas.

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## Examinations Archive With Solutions Wbjee

**1.** The rms speed of oxygen is v at a particular temperature. IF the temperature is doubled and oxygen molecules dissociate into oxygen atoms the rms speed becomes

A. v

B. $\sqrt{2}v$

C. 2v

D. 4v

**Answer: C**


**2.** IF the rms velocity of hydrogen gas at certain temperature is c, then the rms velocity of oxygen gas at the same temperature is

A. $\frac{c}{8}$

B. $\frac{c}{10}$

C. $\frac{c}{4}$

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

**Answer: C**

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**3.** Temperature of an ideal gas initially at $27^\circ C$ is raised by $6^\circ C$, The rms velocity of the gas molecule will

A. increase by nearly 2%

B. decrease by nearly 2%

C. increase by nearly 1%

D. decrease by nearly 1%

**Answer: C**

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Examinations Archive With Solutions Jee Main

**1.** An open pipe made up of glass is immersed in mercury in such a way that a length of 8 cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46 cm. What will be length of the air column above mercury in the tube now?(atm pressure =76 cm of HG)

A. 16cm

B. 22cm

C. 38cm

D. 6cm

**Answer: A**

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**2.** Consider an ideal gas confined in an isolated closed chamber. As the gas undergoes an adiabatic expansion the average time of collision between molecules increases as $V^q$ where V is the volume of the gas. The value of q is $\left(\gamma = \frac{C_p}{C_v}\right)$

A. $\frac{3\gamma + 5}{6}$

B. $\frac{3\gamma - 5}{6}$

C. $\frac{\gamma + 1}{2}$

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

**Answer: C**

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**3.** An ideal gas undergoes a quasistatic, reversible process in which its molar heat capacity C remains constant. It during this

process the relation the pressure p and volume V is given by $pV^n$=constant, then n is given by (here $C_p$ and $C_v$ are molar specific heat at constant pressure and constant volume respectively).

A. $n = \frac{C_p}{C_v}$

B. $n = \frac{C - C_p}{C - C_v}$

C. $n = \frac{C_p - C}{C - C_v}$

D. $n = \frac{C - C_v}{C - C_p}$

**Answer: B**

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**4.** The mass of a hydrogen molecule is $3.32 \times 10^{-27} kg$. $10^{23}$ such molecules hit every second on a rigid wall of area $2cm^2$ at an angle of $45^\circ$ to the normal and rebound elastically with a speed of $10^3 m/s$ then the pressure on the wall is nearly

A. $2.35 \times 10^2 N/m^2$

B. $4.70 \times 10^2 N/m^2$

C. $2.35 \times 10^3 N/m^2$

D. $4.70 \times 10^3 N/m^2$

**Answer:**

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## Examinations Archive With Solutions Aipmt

**1.** The mean free path of molecules of a gas (radius r) is inversely proportional to

A. $r^3$

B. $r^2$

C. r

D. $\sqrt{r}$

**Answer: B**

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**2.** The ratio of the specific heats $\frac{C_p}{C_v} = \gamma$ in terms of degrees of freedom(n) is given by

A. $\left(1 + \frac{1}{n}\right)$

B. $\left(1+\frac{n}{3}\right)$

C. $\left(1+\frac{2}{n}\right)$

D. $\left(1+\frac{n}{2}\right)$

**Answer: C**

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## Examinations Archive With Solutions Neet

**1.** The molecules of a given mass of a gas have rms velocity of $200m.s^{-1}$ at $27^{\circ}C$ and

$1.0 \times 10^5 N.\, m^{-2}$ pressure. When the temperature and pressure of the gas are respectively. $127^\circ C$ and $0.05 \times 10^5 N.\, m^{-2}$ the rms velocity of its molecules in $m.\, s^{-1}$ is

A. $\frac{400}{\sqrt{3}}$

B. $\frac{100\sqrt{2}}{3}$

C. $\frac{100}{3}$

D. $100\sqrt{2}$

**Answer: A**

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**2.** When the temperature of a gas is raised from $30^{\circ} C$ to $90^{\circ} C$ the percentage increase in the rms velocity of the molecules will be

A. 0.6

B. 0.1

C. 0.15

D. 0.3

**Answer: B**

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**3.** At what temperature will the rms speed of oxygen molecules become just sufficient for escaping from the earth's atmosphere? [Given:mass of oxygen(m)= $2.76 \times 10^{-26} kg$ Boltzmann constant $k_B = 1.38 \times 10^{-23} J.\, K^{-1}$]

A. $5.016 \times 10^4 K$

B. $8.360 \times 10^4 K$

C. $2.508 \times 10^4 K$

D. $1.254 \times 10^4 K$

**Answer: B**

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## Cbse Scanner

**1.** What would be the effect on the rms speed of gas molecules if the temperature of the gas is increased by a factor of 4?

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**2.** State law of equiparition of energy.

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**3.** Find the ratio of two molar specific heats for a diatomic gas .

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**4.** The absolute temperature of a gas is increased to four times . What will be the

change in its root mean square speed.

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**5.** Define degrees of freedom. What is the degrees of freedom of a monatomic and diatomic gas?

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**6.** A flask contains Argon and chloring in the ratio of $2:1$ by mass. The temperature of the

mixture is $27^{\circ} C$ Obtain the ratio of averagae kinetic energy per molecule and root mean square speed $v_{rms}$ of the molecules of the two gases. Given atomic mass of argon=39.9 u and molarcular mass of chlorine.=70.9 u.

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**7.** State the law of equipartition of energy.

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**8.** Prove that the average kinetic energy of a molecule of an ideal gas is direcly proportional to the absolute temperature of the gas.

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**9.** The absolute temperature of a gas is increased to 3 times. What will be the increase in root mean square velocity of the gas molecule.

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