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PHYSICS

BOOKS - SURA PHYSICS (TAMIL ENGLISH)

KINETIC THEORY OF GASES

Mcq

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

A. $\Delta p_x = -mu, \Delta p_y = 0$

B. $\Delta p_x = -2mu, \Delta p_y = 0$

C. $\Delta p_x = 0, \Delta p_y = mu$

D. $\Delta p_x = mu, \Delta p_y = 0$

Answer: A

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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 probable speed

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 by $\sqrt{10}$ times

C. remains same

D. increases by $\sqrt{7}$ 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. halves

D. quadruples

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. quadrapoled

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. $[3\mu_1 + 7\mu_2 + 6\mu_3]N_A$

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. Hydrogen

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. $\frac{PV}{kT}$

B. $\frac{kT}{PV}$

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

D. PV

Answer: A

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15. The following graph represents the pressure versus number density for ideal gas at two different temperatures T_1 and T_2. The graph implies

A. $T_1 = T_2$

B. $T_1 > T_2$

C. $T_1 < T_2$

D. Cannot be determined

Answer: B

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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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14. Derive an expansions for the work done in one cycle during adiabatic expansion.

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15. State and explain Boyle's law.

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16. State and explain Charle's law.

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17. State and derive the perfect or ideal gas equation.

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18. Define and derive Boltzmann constant.

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19. What is an ideal gas? Why do the real gases show deviations from ideal behaviour?

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

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21. Give the kinetic interpretation of temperature.

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22. List the factors affecting the mean free path.

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Long Answer Question

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

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2. Derive the expression pressure exerted by the gas on the walls of the container.

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3. Explain in detail the kinetic interpretation of temperature .

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4. Describe the total degrees of freedom for monoatomic molecule, diatomic molecule and triatomic molecule.

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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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9. Derive Mayer's relation for an ideal gas.

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10. State Newton's law of cooling verify with an experiment.

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11. Explain postulates of the kinetic theory of gases.

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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. 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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6. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature the ratio $\frac{C_p}{C_v}$ for the gas is

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7. 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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8. 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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9. 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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10. From a certain apparatus, the diffusion rate of hydrogen has an average value of $28.7cm^3/s$. The diffusion of another gas under the same condition is measured to have an average rate of $7.2cm^3/s$. Identify the gas.

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11. An air bubble of volume $1.0cm^3$ 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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12. One mole of a monoatomic gas is mixed with three moles of a diatomic gas. What is the molecules specific heat of the mixture at constant volume? $\left[8.31 / mol^{-1} K^{-1}\right]$

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13. Equal masses of O_2 and H_e gases are supplied equal amount of heat. Which gas will undergo a greater temperature rise and why?

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14. At what temperature the rms speed of oxygen atom equal to rms speed of helium gas atom at $-10^{\circ}C$?

Atomic mass of helium = 4

Atomic mass of oxygen = 32

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15. 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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16. Motor volume is occupied 1 mole of any (ideal) gas at standard temperature and pressure. Show that it is 22.4 litres.

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Additional Questions Multiple Choice Questions

1. Kinetic theory explains the behavior

A. of solids and liquid Based on the idea that the gas consists of rapidly vibrating atoms or molecules

B. of gases based on the idea that the gas consists of rapidly moving atoms or molecules

C. of solids based on the idea that the solid consists of rapidly vibrating atoms or molecules

D. of liquid based on the idea that the liquid consist of rapidly moving atoms or molecules

Answer: B

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2. Kinetic theory

A. Correctly explains specific heat capacities of many liquid

B. correctly explains specific heat capacities of many gases

C. correctly explains specific heat capacities of many solids

D. correctly explains specific heat capacities of many super cooled liquid

Answer: B

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3. The average distance a molecule can travel without colliding is called

A. mean free distance

B. mean free path

C. mean free length

D. mean free motion

Answer: B

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4. In dynamic equilibrium, molecules of gas collide and change their speeds during the collision

A. but the average properties vary

B. but the average properties constant

C. but the peak properties constant

D. but the rms properties constant

Answer: B

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5. The perfect gas equation can be written as

A. $PV = \mu RT$

B. $PV = \mu R$

C. $PV = RT$

D. $P = uRTV$

Answer: A

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6. According to Dalton's law of partial pressures:

A. total pressure of a mixture of gases is the sum of factors in virtual pressure

B. total pressure of a mixture of ideal gases is the difference partial pressure

C. total pressure of a mixture of gases is the sum of pressures

D. total pressure of a mixture of non reacting gases is the sum of partial pressure

Answer: D

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7. If there are n no. of molecules per unit volume and m is the mass of each, V_x is the x - component of velocity pressure can be written as,

A. $P = nmV_x^2$

B. $P = 2nmV_x^2$

C. $P = mV_x^2$

D. $P = nV_x^2$

Answer: A

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8. The average K.E of a molecule.

A. is inversely proportional to the molecular mass of the gas

B. is inversely proportional to the absolute temperature mass of the gas

C. is directly proportional to the absolute temperature mass of the gas

D. is not dependent on absolute temperature of the gas

Answer: B

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9. In ideal gas is expanding such that PT^2 = constant. The coefficient of volume expansion of the gas is.

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

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

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

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

Answer: C

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10. When the distance between the two atoms becomes γ_0, then the inter atomic force will be,

A. Zero

B. Infinity

C. Negative constant

D. Positive constant

Answer: A

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11. Moving with uniform speed. The temperature of the gas molecules inside will

A. increase

B. decrease

C. remains the same

D. decrease for some, while increases for others.

Answer: C

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12. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature the ratio $\frac{C_p}{C_v}$ for the gas is

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

B. 2

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

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

Answer: D

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

A. He (molecular mass 64)

B. O_2 (molecular mass 4)

C. M_2 (molecular mass 32)

D. CH_4 (molecular mass 16)

Answer: A

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14. The ratio of the vapour densities of two gases at a given temperature is $9:8$. The ratio of the r_{rms} velocity of their molecules is

A. $3:2\sqrt{2}$

B. $2\sqrt{2}:3$

C. $9:8$

D. $8:9$

Answer: B

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15. In an adiabatic change, the pressure and temperature of a monoatomic gas are related as $p \times T^C$, where C equals

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

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

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

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

Answer: B

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16. Gas exerts pressure on the walls of the container

A. gas has weight

B. gas molecules have momentum

C. gas molecule collide with each other

D. gas molecules collide with the walls of the container

Answer: D

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17. The slope at any point on the curve in PV graph for a gas is g_n involving the reaction

A. $\frac{dp}{p} = -\frac{dV}{V}$

B. $\frac{dp}{V} = -\frac{dV}{P}$

C. $\frac{dp}{p} = \frac{dV}{V}$

D. $\frac{dp}{V} = \frac{dV}{p}$

Answer: A

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18. The temperature is changed from $27^\circ C$ to $327^\circ C$. Find ratio of K.E. of molecules at two temperature.

A. $3:2$

B. $2:3$

C. $1:2$

D. $2:1$

Answer: C

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19. At which of the following temperature would be molecules of gas have twice the average K.E they have at $20^\circ C$?

A. $40^\circ C$

B. $80^\circ C$

C. $586^\circ C$

D. $313^\circ C$

Answer: D

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Match The Following

1.

(1)	Mono atomic molecules	(a)	Nitrogen
(2)	Diatomic molecules	(b)	Sulphur dioxide
(3)	Linear Triatomic molecules	(c)	Argon
(4)	Non-linear triatomic molecules	(d)	CO_2

A.

(1)	(2)	(3)	(4)
c	a	d	b

B.

(1)	(2)	(3)	(4)
d	a	b	c

C.

(1)	(2)	(3)	(4)
b	c	d	a

D.

(1)	(2)	(3)	(4)
b	d	c	a

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

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2.

(1)	Mono atomic molecule	(a)	1.33
(2)	Diatomic molecule (Normal temperature)	(b)	1.67
(3)	Linear triatomic molecule	(c)	1.40
(4)	Non-linear triatomic molecule	(d)	1.28

A.

(1)	(2)	(3)	(4)
b	d	c	a

B.

(1)	(2)	(3)	(4)
c	d	b	a

C.

(1)	(2)	(3)	(4)
b	c	d	a

D.

(1)	(2)	(3)	(4)
c	b	a	d

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

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3.

(1)	The rms speed of gas molecules	(a)	$1.41\sqrt{\frac{KT}{m}}$
(2)	The average speed of gas molecules	(b)	1.28
(3)	The most probable speed of gas molecules	(c)	$1.73\sqrt{\frac{KT}{m}}$
(4)	Diatomic molecules (High temperature)	(d)	$1.60\sqrt{\frac{KT}{m}}$

A.

(1)	(2)	(3)	(4)
b	d	c	a

B.

(1)	(2)	(3)	(4)
d	a	c	b

C.

(1)	(2)	(3)	(4)
b	c	d	a

D.

(1)	(2)	(3)	(4)
c	d	a	b

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

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Fill In The Blanks

1. Kinetic theory explains_____parameters like temperature, pressure.

A. microscopic

B. macroscopic

C. thermal

D. mechanical

Answer: B

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2. The pressure exerted on the walls of gas container is due to_____imparted by the gas molecule on the walls.

A. collision

B. momentum

C. kinetic energy

D. force

Answer: B

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3. Pressure, P =

A. $\frac{1}{3}m\overline{v^2}$

B. $\frac{1}{3}nm\bar{v}$

C. $\frac{1}{3}nm\overline{v^2}$

D. $\frac{1}{2}nm\overline{v^2}$

Answer: C

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4. The rms speed of gas molecules =_____.

A. $\sqrt{\frac{KT}{m}}$

B. $\sqrt{\frac{2KT}{m}}$

C. $1.73\sqrt{\frac{RT}{m}}$

D. $\sqrt{\frac{3KT}{m}}$

Answer: C

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5. The most probable speed of gas molecules is_____.

A. $\sqrt{\frac{KT}{m}}$

B. $\sqrt{\frac{3KT}{m}}$

C. $\sqrt{\frac{2KT}{m}}$

D. $\sqrt{\frac{5KT}{m}}$

Answer: C

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6. The mean free path is directly proportional to_____.

A. pressure

B. size of molecule

C. temperature

D. velocity

Answer: C

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7. The Brownian motion explained by Albert Einstein is based on_____.

A. Theory of relativity

B. Theory of gases

C. Kinetic theory

D. Prevost's theory

Answer: C

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8. The ratio of $C_P$and C_V for diatomic molecule at normal temperature is_____.

A. 1.4

B. 1.28

C. 1.33

D. 1.67

Answer: A

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9. For a triatomic molecule (non-liner type) Degree of freedom, 'f' is_____.

A. 7

B. 6

C. 3

D. 5

Answer: B

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10. The average kinetic energy of sample of gas is equally distributed to all the degrees of freedom. It is called_____.

A. Law of conservation of energy

B. Newton's law of colling

C. Law of equipartition of energy

D. Maxwell - Boltzmann distribution

Answer: C

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Choose The Odd One Out

1. CHOOSE THE ODD ONE OUT:

A. rms speed of gas molecules

B. mono atomic molecule

C. diatomic molecule

D. triatomic molecule

Answer: A

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2. CHOOSE THE ODD ONE OUT:

A. Helium

B. Neon

C. Argon

D. Iron

Answer: D

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3. CHOOSE THE ODD ONE OUT:

A. Brownian Motion

B. Robert Brown

C. Kinetic Theory

D. Avogadro Number

Answer: D

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4. CHOOSE THE CORRECT PAIR :

A. Rms speed of gas molecules - $1.41\sqrt{\frac{kT}{m}}$

B. Triatomic molecule - 1.40

C. Degree of freedom - $\frac{1}{2}kT$

D. Pressure - $\frac{1}{2}m\overline{v^2}$

Answer: c

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5. CHOOSE THE INCORRECT PAIR :

A. Robert Brown - Albert Einstern

B. Law of Equipartition of energy - $\frac{1}{2}kT$

C. Mean free path - $\frac{1}{n\pi\lambda^2}$

D. Brownian Motion - Zig-zag motion

Answer: c

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6. CHOOSE THE INCORRECT PAIR :

A. Kinetic Theory - Microscopic Origin

B. Mean free path - Proportional to temperature

C. Average K.E./ molecule - Independent of nature of molecule

D. Pressure - $\frac{3}{2}$ of Internal energy/unit volume

Answer: d

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Assertion Reason

1. Assertion : Brownian Motion explained by Albert Einstein is based on Kinetic theory.

Reason : Brownian motion proves the reality of atoms of molecules.

A. Assertion and Reason are correct and Reason is correct explanation of Assertion

B. Assertion and Reason are true but Reason is the false explanation of the Assertion

C. Assertion is true but Reason is false

D. Assertion is false but Reason is true

Answer: a

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2. Assertion : Since the Root mean square speed of hydrogen is much leaser than that of nitrogen, it escapes easily from Earth's atmosphere.

Reason : Internal energy of ideal gas. $U = \frac{1}{2}$ NkT.

A. Assertion and Reason are correct and Reason is correct explanation of Assertion

B. Assertion and Reason are true but Reason is the false explanation of the Assertion

C. Assertion is true but Reason is false

D. Assertion is false but Reason is true

Answer: d

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Choose The Correct Or Incorrect Statements

1. (I) The ratio of molar specific heat of constant pressure and constant volume of a gas is k.

(II) The mean free path is inversely proportional to the pressure of the molecule too.

Which one is incorrect statement?

A. I only

B. II only

C. Both are correct

D. None

Answer: A

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2. (I) The number of gas molecules in the range of speed V to V + dV is given by Brownian motion.

(II) For a mono atomic molecule degree of freedom f = 3.

Which one is incorrect statement?

A. I only

B. II only

C. Both are correct

D. None

Answer: A

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3. (I) The Brownian motion is explained by Albert Einstein based on Newton's law of cooling.

(II) Brownian Motion proves the reality of atoms and

molecules.

Which one is correct statement?

A. I only

B. II only

C. Both are correct

D. None

Answer: B

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4. (I) The rms speed of gas molecules is $1.60\sqrt{\frac{KT}{m}}$

(II) V_{rms} is largest and V_{mp} is the best.

Which one is incorrect statement?

A. I only

B. II only

C. Both are correct

D. None

Answer: A

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Very Short Answer Questions

1. Mention the different ways of increasing the number of molecular collision? Per unit time in a gas.

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2. On reducing the volume of the gas at constant temperature, the pressure of the gas increases. Explain on kinetic theory.

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3. What are the factors which effect Brownian motion?

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4. On which factors does the average K.E. of gas molecules depend?

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5. What type of motion is associated with the molecule of a gas?

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6. What is meant by rms speed of the molecules of a gas? Is rms speed same as the average speed?

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7. At what temperature does all molecular motion cease?

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8. At a g_n temperature equal masses of monoatomic & diatomic gases are supplied equal quantities of heat. Which of the two gases will suffer a larger temperature rise?

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9. Define evaporation

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10. Why does evaporation ause cooling?

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11. Although the velocity of air molecule is nearly 0.5 km/s, yet the smell of scent spreads at a much slower rate. Why?

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12. What is an ideal gas? (or) What is perfect gas?

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13. Define RMS speed.

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14. State Avogadro's law.

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15. Define the term degrees of freedom.

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Creative Questions Hots

1. When a gas is heated, its temperature increases. Explain it on the basis of kinetic theory of gases.

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2. A box contains equal number of molecules of hydrogen and oxygen. If there is a fine hole in the box, then which gas will

leak rapidly ? Why ?

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3. Mention the different ways of increasing the number of molecular collision? Per unit time in a gas.

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4. In the upper part of the atmosphere the kinetic temperature of air is of the order of 1000 K, even then one feels severe cold there. Why?

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5. 0.014 kg of ntirogen is enclosed in a vessel at a temperature of $27^{\circ} C$. How much heat has to be transferred to double the rms speed of its molecules.

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6. At what temperature is the rms Speed of an atom in an argon gas cylinder equal to the rms speed of a helium gas atom at $-20^{\circ} C$? [Atomic mass of Ar = 39.90, He = 4.04]

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Value Based Questions

1. Sameer and Rameez went to Thirupathi during holidy time. They found more crowd even though they have to wait to see God, in queue. Went the crowd started to move, the place was so hot and temperature does not fall. Every one was sweating and got caught in this congested situation. Why it is hot whenever we are in a crowd?

(i) What is internal energy of a system. Give an expression?

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2. Sameer and Rameez went to Thirupathi during holidy time. They found more crowd even though they have to wait to see God, in queue. Went the crowd started to move, the place was so hot and temperature does not fall. Every one was sweating and got caught in this congested situation. Why it is hot

whenever we are in a crowd?

(i) What is internal energy of a system. Give an expression?

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3. In a private school a physics teacher was asked by her student how to understand first law of thermodynamics in an easier way by using hints or any examples. The teacher was also thinking for a long time and when she was taking classes for 12^{th} standard students about Einstein's photoelectric equation, she was striked with an idea for clearing doubt of her 11^{th} std students. Can you guess her idea?

(i) Define degrees of freedom?

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4. In a private school a physics teacher was asked by her student how to understand first law of thermodynamics in an easier way by using hints or any examples. The teacher was also thinking for a long time and when she was taking classes for 12^{th} standard students about Einstein's photoelectric equation, she was striked with an idea for clearing doubt of her 11^{th} std students. Can you guess her idea?

(ii) Derive and Give expression for $C_P - C_V \& ' \gamma '$ for Monoatomic molecule.

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