QB365 Question Bank Software Study Materials

Kinetic Theory of Gases Important 2 Marks Questions With Answers (Book Back and Creative)

11th Standard

Physics

Total Marks : 60

2 Marks

30 x 2 = 60

1) A football at 27°C has 0.5 mole of air molecules. Calculate the internal energy of air in the ball.

Answer : The internal energy of ideal gas = $\frac{3}{2}$NKT

The number of air molecules is given in terms of number of moles so, rewrite the expression as follows

U = $\frac{3}{2}\mu$RT

Since Nk = μR. Here μ is number of moles.

Gas constant R = 8.31 $\frac{J}{molK}$

Temperature T = 273 + 27 =300K

U = $\frac{3}{2}\times 0.5\times 8.31\times 300$ = 1869.75J

This is approximately equivalent to the kinetic energy of a man of 57 kg running with a speed of 8 m s^{-1}.

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

Answer : The average speed

$\bar{v} = \frac{2+3+4+5+5+5+6+6+7+9}{10} = 5.2ms^{-1}$

To find the rms speed, first calculate the mean square speed $\bar{v^2}$

$\bar{v^2} = \frac{2^2+3^2+4^2+5^2+5^2+5^2+6^2+6^2+7^2+9^2}{10}$

= 30.6m^2s^{-2}

The rms speed

$v_{rms}\sqrt{\bar{v^2}} = \sqrt{30.6} = 5.53ms^{-1}$

The most probable speed is 5 m s^{-1} because three of the particles have that speed.

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

Answer : The hydrogen atom has one proton and one electron. The mass of electron is negligible compared to the mass of proton.

Mass of one proton = 1.67×10^{-27}kg.

One hydrogen molecule = 2 hydrogen

atoms = $2\times 1.67\times 10^{-27}$kg.

The average speed

$\bar{v} = \sqrt{\frac{8KT}{\pi m}} = 1.60\sqrt{\frac{KT}{m}} =$

$= 1.60\sqrt{\frac{(1.38\times 10^{-23})\times(300)}{2(1.67\times 10^{-27})}} = 1.78\times 10^3 ms^{-1}$

(Boltzmann Constant k = 1.38×10^{-23} J K^{-1})

The rms speed $v_{rms} = \sqrt{\frac{3KT}{m}} = 1.73\sqrt{\frac{kT}{m}}$

$= 1.73\sqrt{\frac{(1.38\times 10^{-23})\times(300)}{2(1.67\times 10^{-27})}} = 1.9\times 10^3 ms^{-1}$

Most probable speed $v_{mp} = \sqrt{\frac{2KT}{m}} = 1.41\sqrt{\frac{kT}{m}}$

$= 1.41\sqrt{\frac{(1.38\times 10^{-23})\times(300)}{2(1.67\times 10^{-27})}} = 1.57\times 10^3 ms^{-1}$

Note that $v_{rms} > \bar{V} > v_{mp}$

4) What is the microscopic origin of pressure?

Answer : Pressure arises due to momentum transfer to the wall of the container.

5) What is the microscopic origin of temperature?

Answer : The average kinetic energy of the molecule is directly proportional to the absolute temperature of the gas.

6) Why moon has no atmosphere?

Answer : The escape speed of gases on the surface of Moon is much less than the root mean square speeds of gases due to low gravity. Due to this all the gases escape from the surface of the Moon.

7) Define the term degrees of freedom.

Answer : The minimum number of independent coordinates needed to specify the position and configuration of a thermodynamic system in space is called degree of freedom of the system.

8) State the law of equipartition of energy.

Answer : Law of equipartition energy states that the average kinetic energy of system of molecules in thermal equilibrium at temperature T is uniformly distributed to all degrees of freedom (x or y or z) directions of motion so that each degree of freedom will get $\frac{1}{2}$kT of energy.

9) Define mean free path and write down its expression.

Answer : The average distance travelled by the molecule between two successive collisions is called mean free path

Mean free path $\lambda=\frac{kT}{\sqrt{2}\pi d^{2}P}$

Where K - Boltzmann's constant

T - Temperature

d - diameter of the molecule

P - Pressure

10) A fresh air is composed of nitrogen N_2(78%) and oxygen O_2(21%). Find the rms speed of N_2 and O_2 at 20°C.

Answer : Molar mass of nitrogen m = 0.028 kg/mol

Temperature T = 20 + 273 = 293 K

Universal gas constant $R=8.314\ \mathrm{J/mol/k}$

RMS speed of nitrogen (N_2),

$v_{rms}=\sqrt{\frac{3RT}{m}}$

$(\mathrm{N}_2), v_{ms}=\sqrt{\frac{3\times8.31\times273}{0.028}}$

$(\mathrm{N}_2), v_{rms}=\sqrt{2610\times10^{2}}=511\ \mathrm{m/s}$

Molar mass of Oxygen = 0.032 kg / mol

RMS speed of oxygen (O_2),

$v_{ms}=\sqrt{\frac{3RT}{m}}$

RMS speed of (O_2) $v_{ms}=\sqrt{\frac{3\times8.31\times293}{0.032}}$

$=\sqrt{2280\times10^{2}}$

RMS speed of $(\mathrm{O}_2), \quad v_{ms}=478\ \mathrm{m/s}$

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

Answer : Molar mass of methane gas $=16.04\times10^{-3}\ \mathrm{kg/mole}$

RMS speed of methane gas $v_{ms}=471.8\ \mathrm{ms}^{-1}$

Universal gas constant $\mathrm{R}=8.31\ \mathrm{J/mol/k}$

$v_{ms}=\sqrt{\frac{3RT}{m}}$

$\therefore$ Surface temperture of Jupiter

$\mathrm{T}=\frac{v_{rms}^{2}m}{3R}$

$=\frac{(471.8)^{2}\times16.04\times10^{-3}}{3\times8.31}$

$=\frac{3.549456\times10^{-3}}{24.93}$

$\therefore \mathrm{T}=143\ \mathrm{K}=143-273=-130^{\circ}\mathrm{C}$

12) Calculate the temperature at which the rms velocity of a gas triples its value at S.T.P. (Standard temperature T_1 = 273K).

Answer : RMS velocity $C = \sqrt{\frac{3RT}{M}}$

$T = T_1 = 273$ K

$\therefore C = \sqrt{\frac{3R \times 273}{M}}$

When the RMS velocity is tripled

$3C = \sqrt{\frac{3RT}{M}}$

Dividing equation is (2) by (1) we get

$\frac{3C}{C} = \sqrt{\frac{3RT/M}{3R \times 273/M}}$

$3 = \sqrt{\frac{T}{273}}$

$\therefore 9 = \frac{T}{273}$

$\therefore T = 273 \times 9 = 2457$ K

$\therefore$ Temperature $T_2 = 2457$ K, $T_1 = 273$ K

13) 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

Answer : One mole of an ideal gas at S.T.P occupies a volume of 22.4×10^{-3} m^3

$\therefore$ Number of moles $/\mathrm{m}^3 = \mathrm{n} = \frac{6.023 \times 10^{23}}{22.4 \times 10^{-3}}$

$\therefore n = 2.69 \times 10^{25}$ moles$/\mathrm{m}^3$

In terms of number of molecules and radius the mean free path at S.T.P can be written as

$\lambda = \frac{1}{4\pi\sqrt{2}r^2 n}$

Radius $r = \frac{3 \times 10^{-10}}{2} = 1.5 \times 10^{-6}$ m

$\therefore$ Mean free path, $\lambda = \frac{1}{4 \times 3.14 \times 1.414 \times (1.5 \times 10^{-10})^2 \times 2.69 \times 10^{25}}$

$\lambda = 0.0931 \times 10^{-6} = 9.31 \times 10^{-8}$ m

Mean free path, $\lambda \approx 9 \times 10^{-8}$ m

14) 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.

Answer : Since oxygen is a diatomic molecule with 5 degrees of freedom. Degrees of freedom of molecules in 2 moles of oxygen = f_1

$= 2\ \mathrm{N} \times 5 = 10\ \mathrm{N}$

Since argon is a mono atomic molecule with 3 degrees of freedom. Degrees of freedom of molecules in 4 moles of argon = f_2

$= 4\ \mathrm{N} \times 3 = 12\ \mathrm{N}$

$\therefore$ Total degrees of freedom of the mixture = f

$= f_1 + f_2 = 22\ \mathrm{N}$

According to the principle of law of equipartition energy, energy associated with each degree of freedom of a molecule

$= \frac{1}{2}kT$

$\therefore$ Total energy of the system $= \frac{1}{2}kT \times 22$

But k = R

$\therefore$ Total energy of the system $= \frac{1}{2}RT \times 22 = 11\mathrm{RT}$

15) On reducing the volume of a gas at constant temperature, the pressure of the gas increases. Explain it on the basis of kinectic theory.

Answer : (i) Oil reducing the volume the number of molecules per unit volume increases.

(ii) Hence a large number collide with the, walls of the vessel per second and a larger momentum is transferred to the wall per second. This increases the pressure of the gas.

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

Answer : The average K.E of a gas molecule depends only on the absolute temperature of the gas and is directly proportional to it.

17) What type of motion is associated with the molecule of a gas?

Answer : Brownian motion. In this motion any particular molecule will follow a zig - zag path due to be collision with the other molecule or with the walls of the container.

18) A box contains equal number of molecules of $H_{2\&O2}$. If there is a fine hole in the box, which gas will leave rapidly? Why?

Answer : $v_{rms} \times \frac{1}{\sqrt{M}}$ so H_2 will leak more rapidly. Because of its smaller molecular mass.

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

Answer : (i) The air molecule travel along a zig-zag path due to frequent collisions.

(ii) As a result their displacement per unit time is very small. Hence the smell of scent spreads very slowly.

20) What is an ideal gas?

Answer : An ideal gas is that gas which obeys the gas laws i.e. Charle's law, Boyle's law etc, at all values of temperature and pressure. Molecules of such a gas should be free from intermolecular attraction.

21) State Avogadro's law.

Answer : In 1812, Amadeo Avogadro stated that samples of different gases which contain the same number of molecule (any complexity, size, shape) occupy the same volume at the same temeperature and pressure.

$\frac{V}{n}$ = k = constant

22) When do the real gases obey more correctly the gas equation: PV = nRT?

Answer : An ideal gas is one whose molecules have zero volume and no mutual force between them. At low pressure, the volume of a gas is large and so the volume occupied by the molecules is negligible in comparison to the volume of the gas. At high temperature, the molecules have large velocities and so the intermolecular force has no influence on their motion. Hence at low pressure and high temperature, the behaviour of real gases approach the ideal gas behaviour

23) A cylinder of fixed capacity 44.8 litres contain helium gas at standard pressure and temperature. What is the amount of heat needed to raise the temperature of the gas by 15°C? (R = 8.31 J mol^{-1} K^{-1})

Answer : Volume of 1 mole of He at STP = 22.4 litres

Total volume of He at STP = 44.8 litres

∴ No. of moles of He, $n = \dfrac{44.8}{22.4} = 2$

Molar specific heat of He (monoatomic gas) at constant volume

$$C_V = \frac{3}{2}R = \frac{3}{2} \times 8.31 Jmol^{-1}k^{-1}$$

$$\Delta T = 15^o c$$

Heat required, $Q = nC_V\Delta T = 2 \times \dfrac{3}{2} \times 8.31 \times 15$

Q = 373.95 J

24) The temperature of a gas is raised from 27°C to 927°C. What is the rms molecular speed?

Answer : $v_{rms} \propto \sqrt{T}$

$$\frac{v_{rms} at\,(927^oC)}{v_{rms} at\,(27^oC)} = \sqrt{\frac{927+273}{27+273}} = \sqrt{\frac{1200}{300}} = 2$$

∴ v_{rms} at (927°C) = 2 v_{rms} at (27°C)

25) What are the different ways of increasing the number of molecular collision per unit time in a gas?

Answer : By

(i) increasing temperature (T) of the gas

(ii) increasing the number by molecule of the gas and

(iii) decreasing the volume (V) of the gas

26) How does the rms velocity of a gas molecules change with

(i) Temperature and

(ii) mass of molecule?

Answer : $v_{rms} = \sqrt{\frac{3kT}{m}}$

Hence the rms velocity of a gas molecule is :

(i) directly proportional to the square root of absolute temperature

(ii) inversely proportional to the square root of mass of the molecule.

27) How much volume does one mole of a gas occupy at N.T.P?

Answer : The volume of one mole of a gas $= 22.4 \times 10^{-3}\ \mathrm{m}^3$

28) Two vessels of same size we are the same temperature. One of them holds 1 kg of hydrogen gas and the other holds 1 Kg of nitrogen gas. Which of the vessels contains more number of molecules?

Answer : Now 2g of hydrogen contains N_A molecules where N_A is the Avogadro's number. Hence the number of molecules of hydrogen in

$1\ \mathrm{kg} = \frac{NA}{2} \times 1000 = 500 N_A$

The number of molecules of nitrogen in

$1\ \mathrm{kg} = \mathrm{N_A}/28 \times 1000$

$= 36\ \mathrm{N_A}$

Hence the vessel containing hydrogen will have more number of molecule.

29) What is perfect gas?

Answer : An ideal gas is that gas which obeys the gas laws i.e. Charle's law, Boyle's law etc, at all values of temperature and pressure. Molecules of such a gas should be free from intermolecular attraction.

30) Write the factors affecting Brownian motion.

Answer : Factors affecting Brownian Motion

1. Brownian motion increases with increasing temperature.
2. Brownian motion decreases with bigger particle size, high viscosity and density of the liquid (or) gas.