INDIAN SCHOOL AL WADI AL KABIR

Class: XI	**Department: SCIENCE- 2023 -2024** **PHYSICS**	**Date: 31/01/2024**
Worksheet No: 12	**CHAPTER: THERMODYNAMICS & KINETIC THEORY OF GASES**	**Note:** **A4 FILE FORMAT**
Name of the student:	**Class & Sec:**	**Roll No:**

1. A gas behaves as an ideal gas at

(a) low pressure and high temperature (b) low pressure and low temperature

(c) high pressure and low temperature (d) high pressure and high temperature

Ans; - (a)

2. The translational kinetic energy of gas molecules for 1 mol of gas is equal to

(a) $\frac{3}{2}RT$ (b) $\frac{2KT}{3}$

(c) $\frac{RT}{2}$ (d) $\frac{3KT}{2}$

Ans; - (a)

3. The work done by (or on) a gas per mole per kelvin is called

(a) Universal gas constant (b) Boltzmann's constant

(c) Gravitational constant (d) Entropy

Ans; - (a)

4. The root mean square speed of the molecules of a gas is

(a) independent of its pressure but directly proportional to its Kelvin temperature

(b) directly proportional to two square roots of both its pressure and its Kelvin temperature

(c) independent of its pressure but directly proportional to the square root of its Kelvin temperature.

(d) directly proportional to its pressure and its Kelvin temperature.

Ans; - (c)

5. The root mean square velocity of gas molecules is 10 km/s. The gas is heated till its pressure becomes four times. The velocity of gas molecules will be

(a)10 Km/s (b) 20 Km/s (c) 40 Km/s (d) 80 Km/s

Ans; - (b)

6. Dimensional formula for universal gas constant R is given by

(a) $[ML^2T^{-2}K^{-2}]$ (b) $[ML^2T^{-3}K^{-1}]$

(c) $[M^\circ L^2T^{-3}K^{-1}]$ (d) $[ML^2T^{-2}K^{-4}]$

Ans; - (a)

7. An ant is walking on the horizontal surface. The number of degrees of freedom of ant will be

(a)1 (b) 2 (c) 3 (d) 6

Ans; - (b)

8. The specific heat of a gas

(a) has only two values Cp & Cv (b) has a unique value of given temperature

(c) can have any values from O to ∝ (d) depends upon the mass of the gas

Ans; - (c)

ASSERTION - REASON BASED QUESTIONS

Direction: - In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not correct explanation of assertion.

(c) If assertion is true, but reason is false.

(d) If both assertion and reason are false.

1. Assertion: If a gas container in motion is suddenly stopped, the temperature of the gas rises.
Reason: The kinetic energy of ordered mechanical motion is converted into the kinetic energy of random motion of gas molecules.

(a)A (b) B (c) C (d)D

2. Assertion: 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.
Reason: The molecules of a gas collide with each other and the velocities of the molecules change due to collision.

(a)A (b) B (c) C (d)D

3. Assertion: Gases do not settle to the bottom of a container.
Reason: Gases have high kinetic energy.

(a)A (b) B (c) C (d)D

4. Assertion: A gas can be liquified at any temperature by increase of pressure alone.
Reason: On increasing pressure the temperature of gas decreases.

(a)A (b) B (c) C (d)D

5. Assertion: Equal masses of helium and oxygen gases are given equal quantities of heat. There will be a greater rise in the temperature of helium compared to that of oxygen.
Reason: The molecular weight of oxygen is more than the molecular weight of helium.

(a)A (b) B (c) C (d)D

CASE STUDY BASED QUESTIONS: -

CASE STUDY BASED QUESTIONS

The equipartition of kinetic energy was proposed initially in 1843 and more correctly in 1845, by John James Waterston. In 1859, James Clerk Maxwell argued that the kinetic heat energy of a gas is equally divided between linear and rotational energy. In 1876, Ludwig Boltzmann expanded on this principle by showing that the average energy was divided equally among all the independent components of motion in a system.

Boltzmann applied the equipartition theorem to provide a theoretical explanation of the Dulong-Petit law for the specific heat capacities of solids.

Law of Equipartition of Energy

According to this law, for any system in thermal equilibrium, the total energy is equally distributed among its various degree of freedom. And each degree of freedom is associated with energy $\frac{1}{2}$ kT (where k = 1.3 × l 0^{-23J}/K, T = absolute temperature of the system).

At a given temperature T; all ideal gas molecules no matter what their mass have th same average translational kinetic energy; namely, $\frac{3}{2}$ kT. When measure the temperature of a gas, we are also measuring the average translational kinetic energy of its molecules. At same temperature gases with different degrees of freedom (e.g., He and H) will have different average energy or internal energy namely $\frac{f}{2}$ kT. (F is different for different gases)

Answer the following questions

1. Relation between pressure P and average kinetic energy E per unit volume of a gas is

(a) $P = \frac{2E}{3}$ (b) $P = \frac{E}{3}$ (c) $P = \frac{3E}{2}$ (d) $P = 3E$

Ans; - (a)

2. At 0 K, which of the following properties of a gas will be zero?

(a) kinetic energy (b) potential energy

(c) vibrational energy (d) density

Ans; - (a)

3. The root mean square velocity of a gas molecule of mass m at a given temperature is proportional to

(a) m^0 (b) m (c) $\sqrt{m}$ (d) $m^{-1/2}$

Ans; - (d)

4. An ant is walking on the horizontal surface. The number of degrees of freedom of ant will be

(a) 1 (b) 2 (c) 3 (d) 6

Ans; - (b)

Or

5. The number of degrees of freedom for a diatomic gas molecule is

(a) 2 (b) 3 (c) 5 (d) 6

Ans; - (c)

1. (a) $P = \frac{2E}{3}$

2. (a) At 0 K, all molecular motion stops, so kinetic energy becomes zero.

3. (d) $V_{rms} = \sqrt{\frac{3K_3T}{m}}$ i.e. $V_{rms} \propto m^{-1/2}$

4. (b) As the ant can move on a plane, it has 2 degree of freedom.

5. (c) A diatomic molecule has 3 degree of freedom due to translatory motion and 2 degrees of freedom due to rotatory motion.

Numericals

1. An air bubble of volume 1.0 cm3 rises from the bottom of a lake 40 m deep at a temperature of 12ºC. To what volume does it grow when it reaches the surface which is at a temperature of 35ºC?

$V_1 = 10^{-6}\ m^3$

$$\begin{aligned} \text{Pressure on bubble } P_1 &= \text{Water pressure + Atmospheric pressure} \\ &= pgh + \text{Patm} \\ &= 4.93 \times 10^5 \text{ Pa} \\ T_1 &= 285\ k,\ T_2 = 308\ k \\ \frac{P_1V_1}{T_1} &= \frac{P_2V_2}{T_2} \\ V_2 &= \frac{4.93\times10^5\times1\times10^{-6}\times308}{285\times1.01\times10^5} = 5.3\times10^{-6}\,m^3. \end{aligned}$$

2. A vessel is filled with a gas at a pressure of 76 cm of mercury at a certain temperature. The mass of the gas is increased by 50% by introducing more gas in the vessel at the same temperature. Find out the resultant pressure of the gas.

According to kinetic theory of gases,

$$PV = \frac{1}{3}mv_{rms}^2$$

At constant temperature, v_{rms}^2 is constant. As v is also constant, so $P \propto m$.

When the mass of the gas increase by 50% pressure also increases by 50%,

$$\therefore \qquad \text{Final pressure} = 76 + \frac{50}{100}\times 76 = 114 \text{ cm of Hg.}$$

3. An oxygen cylinder of volume 30 liter has an initial gauge pressure of 15 atmosphere and a temperature of 27ºC. After some oxygen is withdrawn from the cylinder, the gauge pressure drops to 11 atmosphere and its temperature drop to17ºC. Estimate the mass of oxygen taken out of the cylinder.

(R = 8.31/mol^{-1} K^{-1}) (molecular mass of O2 = 32)

$$\begin{aligned} V_1 &= 30 \text{ litre} = 30 \times 10^3 \text{ cm}^3 = 3 \times 10^{-2} \text{ m}^3 \\ P_1 &= 15 \times 1.013 \times 10^5 \text{ N/m}^2 \\ T_1 &= 300 \text{ K} \\ \mu_1 &= \frac{P_1V_1}{RT_1} = 18.3 \\ P_2 &= 11 \times 1.013 \times 10^5 \text{ N/m}^2 \\ V_2 &= 3 \times 10^{-2}\ m^3 \\ T_2 &= 290\ k \\ \mu_2 &= \frac{P_2V_2}{RT_2} = 13.9 \end{aligned}$$

$$\mu_2 - \mu_1 = 18.3 - 13.9 = 4.4$$

Mass of gas taken out of cylinder

$$\begin{aligned} &= 4.4 \times 32 \text{ g} \\ &= 140.8 \text{ g} \\ &= 0.140 \text{ kg.} \end{aligned}$$

4. At what temperature the rms speed of oxygen atom equal to r.m.s. speed of helium gas atom at – 10ºC?, Atomic mass of helium = 4, Atomic mass of oxygen = 32.

$$v_{rms} = \left[\frac{3PV}{M}\right]^{1/2} = \left[\frac{3RT}{M}\right]^{1/2}$$

Let r.m.s. speed of oxygen is $(v_{rms})_1$ and of helium is $(v_{rms})_2$ is equal at temperature T_1 and T_2 respectively.

$$\frac{(v_{rms})_1}{(v_{rms})_2} = \sqrt{\frac{M_2 T_1}{M_1 T_2}}$$

$$\left[\frac{4T_1}{32\times263}\right]^{1/2} = 1$$

$$T_1 = \frac{32\times263}{4} = 2104k.$$

5. Estimate the total number of molecules inclusive of oxygen, nitrogen, water vapour and other constituents in a room of capacity 25.0 m^3 at a temperature of 27ºC and 1 atmospheric pressure.

As Boltzmann's constant,

$$k_B = \frac{R}{N}, \quad \therefore R = k_B N$$

Now $\quad PV = nRT = nk_B NT$

$\therefore$ The number of molecules in the room

$$= nN = \frac{PV}{Tk_B}$$

$$= \frac{1.013\times10^5\times25.0}{300\times1.38\times10^{-23}} = 6.117\times10^{26}.$$

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