Class XI

Kinetic Theory of Gases worksheet 3

1. Given Samples of 1 cm^3 of Hydrogen and 1 cm3 of oxygen, both at N. T. P. which sample has a larger number of molecules? 1

Ans. Acc. to Avogadro's hypothesis, equal volumes of all gases under similar conditions of temperature and pressure contain the same number of molecules. Hence both samples have equal number of molecules.

2. Find out the ratio between most probable velocity, average velocity and root Mean square Velocity of gas molecules? 1

Ans.

$$v_{mps} = \sqrt{\frac{2kT}{m}}$$

$$v_{av} = \sqrt{\frac{8kT}{\pi m}}$$

$$v_{mps} = \sqrt{\frac{3kT}{m}}$$

$$v_{mps} : v_{av} : v_{mps} = \sqrt{\frac{2kT}{m}} : \sqrt{\frac{8kT}{\pi m}} : \sqrt{\frac{3kT}{m}} = \sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$$

3. What is Mean free path? 1

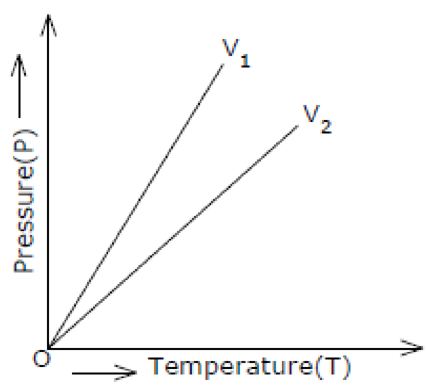
Ans. Mean free path (λ) is defined as the average distance a molecule travels between collisions.

4. What happens when an electric fan is switched on in a closed room? 1

Ans. When electric fan is switched on, first electrical energy is converted into mechanical energy and then mechanical energy is converted into heat. The heat energy will increase the Kinetic energy of air molecules; hence temperature of room will increase.

5. If a certain mass of gas is heated first in a small vessel of volume V_1 and then in a large vessel of volume V_2. Draw the P – T graph for two cases? 2

Ans.



From Perfect gas equation; $P = \frac{RT}{V}$

For a given temperature, $P \; \alpha \; \frac{1}{V}$ so when the gas is heated in a small vessel (Volume V_1) , the pressure will increases more rapidly than when heated in a large vessel (Volume V_2). As a result, the slope of P – T graph will be more in case of small vessel than that of large vessel.

6. Derive the Boyle's law using kinetic theory of gases? 2

Ans. Total pressure exerted by gas molecules is

$$P = \frac{1}{3}\rho C^2 = \frac{1}{3}\frac{M}{V}C^2$$

$$PV = \frac{1}{3}MC^2$$

$$At\ const.tem.$$

$$PV = const.$$

$$or, \quad P\alpha\ \frac{1}{V}$$

7. At what temperature is the root mean square speed of an atom in an argon gas cylinder equal to the r.m.s speed of a helium gas atom at- 20^{0}C? Given Atomic Mass of Ar = 39.9 and of He = 4.0? 2

Ans.

$$M_{Ar} = 39.9$$

$$M_{He} = 4$$

$$T_{He} = -20\ {}^0C = -20 + 273 = 253K$$

$$T_{Ar} = ?$$

$$\left(v_{rms}\right)_{He} = \left(v_{rms}\right)_{Ar}$$

$$\sqrt{\frac{3RT_{He}}{M_{He}}} = \sqrt{\frac{3RT_{Ar}}{M_{Ar}}}$$

$$\frac{253}{4} = \frac{T_{Ar}}{39.9}$$

$$T_{Ar} = 2523.6K$$

8. Show that at constant temperature bulk modulus K of an ideal gas is the pressure P of the gas? 3

Ans. The bulk modulus is given by $K = \dfrac{\Delta P}{-\dfrac{\Delta V}{V}}$

In case of an ideal gas at constant temp. before compression, $PV = nRT \longrightarrow (1)$

In case of an ideal gas at constant temp. after compression, $\left(P + \Delta P\right)\left(V + \Delta V\right) = nRT \longrightarrow (2)$

From (1) and (2)

$$PV=(P+\Delta P)(V+\Delta V)$$
$$PV=PV+P\Delta V+V\Delta P+\Delta P\Delta V$$
$$-P\Delta V=V\Delta P+\Delta P\Delta V$$
$$\frac{-P\Delta V}{V}=\Delta P+\frac{\Delta P\Delta V}{V}$$
$$\frac{-P\Delta V}{V}=\Delta P\left(1+\frac{\Delta V}{V}\right)$$
$$\frac{-P\Delta V}{V}=\Delta P \quad \left[\because \frac{\Delta V}{V}<<1 \ \ so\ neglected\right]$$
$$P=-\frac{\Delta P}{\frac{\Delta V}{V}}$$
$$P=K$$

9. If Nine particles have speeds of 5, 8, 12, 12, 12, 14, 14, 17 and 20 m/s. find : 3

1) the average speed

2) the Most Probable speed

3) the r.m.s. Speed of the particles?

Ans. 1) $v_{av}=\frac{C_1+C_2+C_3+C_4+C_5+C_6+C_7+C_8+C_9}{9}=\frac{5+8+12+12+12+14+14+17+20}{9}=12.7ms^{-1}$

2) $v_{rms}=\sqrt{\frac{C_1^2+C_2^2+C_3^2+C_4^2+C_5^2+C_6^2+C_7^2+C_8^2+C_9^2}{9}}=\sqrt{\frac{5^2+8^2+12^2+12^2+12^2+14^2+14^2+17^2+20^2}{4}}=$

3) Three of particles have a speed of 12m|s; two have a speed of 14m|s and the remaining have different speeds. Therefore, the most probable speed, V_{mP} = 12 m /s.

10. Establish the relation between $\gamma=\frac{C_P}{C_V}$ and degrees of freedom (n)? 3

Ans. Total energy associated with a gram molecule of the gas $E=n\times\frac{1}{2}\times kT\times N=\frac{1}{2}nRT$

Specific heat at constant volume, $C_V=\frac{dE}{dT}=\frac{d}{dT}\left(\frac{1}{2}nRT\right)=\frac{1}{2}nR$

Specific heat at constant pressure, $C_P=C_V+R=\frac{1}{2}nR+R=\left(\frac{n}{2}+1\right)R$

$$Now,\ \gamma = \frac{C_P}{C_V}$$

$$= \frac{\left(\frac{n+2}{2}\right)R}{\frac{n}{2}R}$$

$$= \frac{n+2}{n}$$

$$= 1 + \frac{2}{n}$$

11. The earth without its atmosphere would be inhospitably cold. Explain Why? 1

Ans. The lower layers of earth's atmosphere reflect infrared radiations from earth back to the surface of earth. Thus the heat radiations received by the earth from the sun during the day are kept trapped by the atmosphere. If atmosphere of earth were not there, its surface would become too cold to live.