D. Essays

1. State the important postulates of kinetic theory of gases. Derive an expression for the pressure exerted by a gas.
2. Derive expressions for (a) *rms* velocity and (b) kinetic energy of a molecule of a gas.
3. Discuss briefly the Maxwellian speed distribution. From this obtain expression for mean velocity, *rms* velocity and most probable velocity of the molecules of a gas.

E. Problems

1. Calculate the rms velocity of methane molecules present in the atmosphere of Jupiter whose atmospheric temperature is $-130°C$. Molecular mass of methane $= 16$; $R = 8.3\,J\,mol^{-1}K^{-1}$.

   [Ans: $471.8\,ms^{-1}$]

2. If the rms velocity of hydrogen molecule at STP is $1.84 \times 10^3\ ms^{-1}$, calculate the rms velocity of oxygen at STP [Molecular mass of hydrogen and oxygen are 2 and 32 respectively].

   [Ans: $460\ ms^{-1}$]

3. Calculate the kinetic energy of 0.002 kg of helium at 200 K. $R = 8.3\ J\ mol^{-1}\ K^{-1}$.

   [Ans: 1.245×10^3 J]

4. At what temperature, the pressure remaining constant, will the r.m.s. velocity of a gas be half its value at 273 K?

   [Ans: 68.25 K]

5. The mean kinetic energy of a molecule of hydrogen at 0°C is 5.64×10^{-21} J and R $= 8.3\,J\,mol^{-1}K^{-1}$. Calculate Avogadro number.

   [Ans: $6.023 \times 10^{23}\ mol^{-1}$]

6. At what temperature will the average speed of oxygen molecules be sufficient to escape from the earth? Given escape velocity of earth $= 11.1\,kms^{-1}$, mass of oxygen molecule $= 5.34 \times 10^{-26}$ kg, $k = 1.38 \times 10^{-23}\,JK^{-1}$.

   [Hint: $(3/2)\,kT = \frac{1}{2}\,mv_e^2$]

   [Ans: 1.6×10^5 K]

7. Calculate the temperature at which the rms velocity of gas molecules is double the value at 27°C, pressure remaining constant.

   [Ans: 927°C]

8. Given Boltzmann's constant $= 1.38 \times 10^{-23}\,JK^{-1}$, calculate the kinetic energy of translation of an oxygen molecule at 300 K

   [Ans: 6.21×10^{-21} J]

9. At what temperature is the *rms* speed of an atom of argon gas equal to the *rms* speed of a helium gas atom at $-20°C$? (Atomic mass of $Ar = 39.9$ u, of $He = 4.04$)

   Hint: $\sqrt{T_1/M_1} = \sqrt{T_2/M_2}$

   [NCERT]

   [Ans: 2.52×10^3 K]