Kinetic Theory of Gases & Radiation Numericals

Formulae :

$$P = \frac{1}{3}\frac{mNC^2}{V} \qquad P = \frac{1}{3}\rho C^2 \qquad C = \sqrt{\frac{3P}{\rho}} \qquad P = HDg$$

1. Calculate number of molecules per cm^3 (Per C.C.) of a gas at 760 mm of mercury, when mass of each molecule of gas is 6.8×10^{-26} kg & R.M.S. velocity of gas molecule is 420 m/sec.
Given : Density of mercurty D = 13.6×10^3 kg/m^3 and Acceleration due to gravity, g = 9.8 m/sec^2. (Ans : $N = 2.531\times10^{19}$)

2. Calculate RMS velocity of oxygen molecule at NTP. Density of oxygen at NTP is 1.43 gm/lit
Given : H = 0.76 m of Hg D = $13.6\times10^3\ kg/m^3$ g = $9.8 m/\sec^2$
(Ans : $C = 4.609\times10^2\ m/\sec$)

3. The kinetic energy of 1 kg of oxygen at 300 K is $1.356\times10^6\ J$, Find the kinetic energy of 4 kg of oxygen at 400 k. (Ans : $E_2 = 7.232\times10^6\ J$)

Formulae : $C_{rms} = \sqrt{\frac{3RT}{M}}$

4. Calculate the rms speed of oxygen molecule at 225^{0}C Density of oxygen at $NTP = 1.42 kg/m^3$ and one atomsphere = 1.013×10^5 N/m^2 (Ans : $C_T = 624.51\ m/\sec$)

5. Find the temperature at which RMS speed of gas molecule is four times its value at NTP
(Ans : $T = 4368K$ or $T = 4095^0 C$)

6. If RMS speed of Hydrogen molecule at NTP is $1.84 \times 10^3 m/\sec$, find the RMS speed of oxygen molecule at NTP molecular weight of hydrogen is 2 and that of oxygen is 32.
(Ans : $C_{O_2} = 460\ m/\sec$)

7. RMS velocity of oxygen molecule at NTP is 460.9 m/sec. Find the RMS velocity of hydrogen molecule at same temperature. (Ans : $C_{H_2} = 1843.6\ m/\sec$)

8. Two tanks of equal volume contain equal mases of oxygen and nitrogen at 127^0C. Find the ratio of i) number of molecules in two tanks. ii) Pressure in two tanks (Ans : i) 7/8 ii) 7/8)

Type -II : Stefan's Law of radiation :

Formulae : $R = \sigma T^4$, $R = A\sigma T^4$, $R = A\sigma\left[T^4 - T_0^4\right]$

9. Compare rate of radiation of metal sphere at 627^0C and 327^0C
(Ans : $R_1 : R_2 = 5.0625 : 1$)

10. Compare rates of emission of heat by black body maintained at 727^0C and 227^0C
(Ans : $R_1 : R_2 = 16 : 1$)

11. Compare rate of emission of heat by a black body maintained at 727^0C with 227^0C, if black body is surrounded by an endosure 27^0C. What would be ratio of their rate of loss of heat ?
[Ans : i) $R_1 : R_2 = 16 : 1$, ii) 1]

12. At what temperature will black body radiates heat at the rate of $5.67\times10^{4}\,watt/m^{2}$. Stefan's constant = $\sigma = 5.67\times10^{-8}$ SI unit (Ans : $T = 727^{0}C$)

13. A 40 watt filament lamp losses all its power by radiation when it is heated to 2500 K. If the surface emissivity is 0.5 & its radius of cross section is 0.1 mm, Calcuate its length. $\sigma = 5.67\times10^{-8}$ watt / m^2k^4. (Ans : $l = 5.748cm$)

14. Show that rms velocity of an oxygen molecule is $\sqrt{2}$ times that of a sulfur dioxide molecule at S.T.P. Ans : $\boxed{C_1 = \sqrt{2}C_2}$

15. At what teperature will oxygen molecules have same rms speed as helium molecules at S.T.P.? (Molecular masses of oxygen and helium are 32 and 4 respectively) Ans : $T_1 = \boxed{2184K}$

16. Compare the rms speed of hydrogen molecules at 127^{0}C with rms speed of oxygen molecules at 27^{0}C given that molecular mases of hydrogen and oxygen are 2 and 32 respectively.

Ans : $\boxed{C_1 : C_2 = 8\sqrt{3}}$

17. Find kinetic energy of 5 litre of a gas at S.T.P. given standard pressure is $1.013\times10^{5}\,N/m^{2}$.

Ans : $\boxed{E = 7.5975\times10^{+2}\,J}$

18. Calculate the average molecular kinetic energy (i) per kmol (ii) per kg (iii) per molecule of oxygen at 127^{0}C, given that molecular weightof oxygen is 32, R is 8.31 J mol^{-1} K^{-1} and Avogadro's number N_A is 6.02×10^{23} molecules mol^{-1}. Ans : = $8.28\times10^{-21}\,J$

19. Calcuclate the energy radiated in one minute by a blackbody of surfacce area $100\,cm^{2}$ when it is maintained at 227^{0}C Ans : $\boxed{Q = 2126J}$

20. Energy is emitted from a hole in an electric furnace at the rate of 20 W, when the temperature of the furnace is 7270C. What is the area of the hole ? (Take Stefan's constant σ to be $5.7\times10^{-8}\,Js^{-1}m^{-2}K^{-4}$ Ans : $\boxed{A = 3.52\times10^{-4}\,m^{2}}$

21. The emissive power of a sphere of area 0.02 m^2 is $0.5\,kcal\,s^{-1}m^{-2}$. What is the amount of heat radiated by the spherical surface in 20 second ? Ans : $\boxed{Q = 0.2K\,cal}$

22. Compare the rates of emission of heat by a blackbody maintained at 727^0C and at 227^0C, if the blackbodies are surrounded by an enclosure (black) at 27^0C. What would be the ratio of their rates of loss of heat ? Ans : $\boxed{R_1 : R_2 = 18.23 : 1}$

23. Earth's mean temperature can be assumed to be 280 K. How will the curve of blackbody radiation look like for this temperature ? Find out λ_{max} . In which part of the electromagnetic spectrum, does this value lie ? Ans : $\boxed{\lambda = 1.035 \times 10^{-5} m}$

24. A small-blackened solid copper sphere of radius 2.5 cm is placed in an evacuated cchamber. The temperature of the chamber is maintained at 100^0C. At what rate energy must be supplied to the copper sphere to maintain its temperature at 110^0C ? (Take Stefan's constant σ to be $5.76 \times 10^{-8}\, Js^{-1}m^{-2}K^{-4}$ and treat the sphere as blackbody) Ans : $\boxed{P = 0.96 Watt}$

25. Find the temperature of a blackbody if its spectrum has a peak at $(a)\,\lambda_{max} = 700\text{nm}(\text{visible})$, (b) $\lambda_{max} = 3\text{cm}(\text{microwave region})$ and (c) $\lambda_{max} = 3\text{m}(\text{FM radio waves})$ (Take Wien's constant b = 2.897×10^{-3}mK)Ans : a) $\boxed{T_1 = 4138K}$ b) $\boxed{T_2 = 0.0966K}$ c) $\boxed{T_3 = 0.966 \times 10^3 K}$