Q1/ From the ideal gas law $PV = nRT$, calculate how many molecules in a cubic centimeter ($cm^3$) of air at a pressure of 1013.25 mb and a temperature of 15°C? ($R = 8.3145$ J/mol K°) $N_A = 6.022 \times 10^{23}$ molecules/mol.

Sol

$$PV = nRT \Longrightarrow n = \frac{PV}{RT}$$

① P in Pascal

② V in $m^3$

$P = 1013.25$ mb or hPa

$\therefore P = 1013.25 \times 100$

$P = 101325$ Pascal

$V = 1\ cm^3$

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

③ $R = 8.3145$ J/mol K°

④ T in Kelvin

$T = 15 + 273$

$T = 288$ K°

$$\therefore n = \frac{101325 \times 10^{-6}}{8.3145 \times 288}$$

$n = 42.3 \times 10^{-6}$ no. of moles

$$N_A = \frac{\text{no. of molecules}}{\text{no. of moles}} \Longrightarrow \text{no. of molecules} = N_A * n$$

$\Longrightarrow$ no. of molecules $= 6.022 \times 10^{23} \times 42.3 \times 10^{-6}$

$= 2.55 \times 10^{19}$ molecules

Q2/ How many Oxygen molecules are there in a $cm^3$ of air at a pressure of 1013.25 mb and a temperature of 15°C ?

SI

$$PV = nRT \Longrightarrow n = \frac{PV}{RT}$$

P in Pascal , $P = 1013.25\ hPa$ | ×100 → Pa ← hPa

$P = 101325\ Pa$

V in $m^3$

$V = 1\ cm^3$

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

$R = 8.3145\ J/mol.K^\circ$

T in Kelvin $\Longrightarrow T = 15 + 273$

$T = 288\ K^\circ$

$$\therefore n = \frac{101325 * 10^{-6}}{8.3145 \times 288} = 42.3 \times 10^{-6} \rightarrow \text{no. of moles}$$

no. of molecules $N = N_A * n$ (no. of moles)

$N = 6.022 \times 10^{23} \times 42.3 \times 10^{-6} = 2.55 \times 10^{19}$ molecules

This is the no. of molecules of air, but we need to find the no. of molecules of oxygen.

Oxygen has 21% of the volume of air

$$\therefore \text{no. of molecules of } O_2 = \frac{21}{100} \text{ of air} = \frac{21}{100} \times 2.55 \times 10^{19} = 5.35 \times 10^{18} \text{ molecules}$$