

Occurrence of plasma in nature:-

⇒ Often said that 99% of matter in Universe is in plasma state.

⇒ Plasma is ionized gas

⇒ Plasma can be found in stellar interiors, Gaseous nebulae, Van Allen radiation belts, Solar wind, flash of lightning bolt, Aurora Borealis etc.

⇒ It seems we only live in 1% of Universe without plasma.

The reason for this can be seen in "Saha-equation" which tells us about amount of ionization at thermal equilibrium.

$$\frac{n_i}{n_n} \approx 2.4 \times 10^{21} \frac{T^{3/2}}{n_i} e^{-U_i/kT} \text{ ---- } \textcircled{1}$$

Here,

n_i ⇒ density per m^3 of ionized atoms

n_n ⇒ " " " neutral "

T ⇒ Temperature of gas in K

$k \Rightarrow$ Boltzmann Constant

$U_i \Rightarrow$ is the ionization energy of the Gas i.e (exps require to remove outermost electron)

\Rightarrow For Ordinary gas (air) at room temperature

$$n_n \approx 3 \times 10^{25} \text{ m}^{-3}$$

$$T \approx 300 \text{ K}$$

$$U_i \approx 14.5 \text{ eV (For Nitrogen)} \because 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$\frac{n_i}{n_n} \approx 10^{-12.2} \text{ by (1)}$$

\Rightarrow As the temperature is raised, degree of ionization remain low.

\Rightarrow But when U_i is only a few times kT

$\frac{n_i}{n_n}$ rises abruptly.

\Rightarrow Further increase in temperature n_n is less than n_i and we say plasma is fully ionized gas.

\Rightarrow As ionization requires high temperature, this is the reason plasma only exist in astronomical bodies with millions of degree.

⇒ Therefore, life could not co-exist with plasma.

⇒ As plasma naturally occur at high temp.

So, for that reason plasma is designated as

"Fourth state of matter."

Physical Meaning of Saha Equation:

$$\frac{n_i}{n_n} \approx 2.4 \times 10^{21} \frac{T^{3/2}}{n_i} e^{-U_i/kT}$$

⇒ In Gas, atoms has different energies.

⇒ Atom can be ionized when by chance it suffer a collision of high energy to knock out of electrons.

⇒ Exponential factor $e^{-U_i/kT}$ in Saha equation express number of fast atoms decreases exponentially.

⇒ After ionization atoms will remain ionized until they meet with electrons.

⇒ Recombination rate depends upon density of electrons, which can take equal to n_i .

⇒ Therefore, equilibrium ion density will decrease with n_i . Therefore $\frac{1}{n_i}$ on right hand side of the equation

⇒ Since n_i in Interstellar medium is very low about 1 per cm^3 So recombination rate is low.

Definition of Plasma:-

⇒ Since every gas has small ionization therefore every ionized gas cannot called a plasma. A usefull definition is as follows:

Follows:

" A plasma is a quasineutral gas of charged and neutral particles which exhibits collective behaviour."