$$\lambda_D = \sqrt{\frac{\varepsilon_0 k T_e}{n_e q_e^2}}$$

although this is only valid when the ions are much colder than the electrons.

Debye length in an electrolyte

In an electrolyte, the Debye length is

$$\lambda_D = \sqrt{\frac{\varepsilon_0 \varepsilon_r k T}{2 N_A e^2 I}}$$

where

I is the ionic strength of the electrolyte,

ε_0 is the permittivity of free space,

ε_r is the dielectric constant,

k is the Boltzmann's constant,

T is the Temperature,

N_A is Avogadro's Number.

e is the elementary charge,

or when the solute is mono-monovalent and symmetrical,

$$\lambda_D = \sqrt{\frac{\varepsilon_0 \varepsilon_r RT}{2F^2 C_0}}$$

where

R is the gas constant,

F is the Faraday constant,

C_0 is the molar concentration of the electrolyte.

$\mu_0 \qquad \mu_0 c^2$

Q. 5. What do you mean by Debye potential ? Explain Debye length and characteristic time.

Or, Discuss the conditions for the existence of plasma.

Ans. Debye Potential : The potential corresponding to mean potential energy between the neighbouring particles of plasma is called the Debye potential

We know that electrons are generally bound into atoms and for producing plasma, these electrons require to be free. The binding energies of many elements vary from several electrons volts (eV) to a few tens of eV. These energies may be added to an atomic system to caused ionisation by a number of means . A convenient method is to import the energy by collision events of one sort or another. On the addition of the ionisation energy to a fraction of atoms of a neutral gas, an ionised gas is formed. If sufficient total energy can be added, the gas may be completely ionsed with no neutral particles existing.

One of the most powerful influences upon plasma behaviour is the electromagnetic interaction of the charged particles. Even a partically inoised gas can be effected by externally applied electric and magnetic fields and conduct electric current. The ions and electrons serve as the charge carriers. Since the coulombs electric fields of charged particles fall off only as the inverse of square of distance, the electrostatic forces are of long range and can act upon a considerable number of other particles. This interaction of substantial number of particles causes them to react in a collective manner to other forces and the collective behaviour constitutes the prime characteristic of a plasma.

Expression for Debye length and Potential : Let us assume a large number of neighbouring particles so that the electric field can be taken as the continuous function of distance. Then the electric field satisfies the Poisson's equation

$$div \ \vec{E} = \rho / \varepsilon_0 \qquad \ldots(1)$$