For gases in the normal conditions of pressure and temperature the number of molecules in a unit volume is 2.68 x $10^{25}m^{-3}$ (Loschmidt number), therefore, ε of gases can be found from the formula

$$\varepsilon = 1 + \frac{2.68 \times 10^{25}\ m^{-3}}{8.854 \times 10^{-12}\ F/m}\alpha = 1 + 3.03 \times 10^{36}\ \alpha \qquad (1\text{-}41)$$

Where α is in $F.m^2$, or, in the non rationalized form is;

$$\varepsilon = 1 + 3.38 \times 10^{20}\ \alpha \qquad \text{where } \alpha \text{ is in } cm^3. \qquad (1\text{-}42)$$

1.1.9 Molecular Radius:

When a perfectly conducting sphere of radius r is placed in an electric field E the induced moment **p** is given by

$$p = r^3 E` \qquad (1.43)$$

But

$$p = \alpha E` \qquad (1.44)$$

By comparing these two equations one gets

$$\alpha = r^3 \qquad (1\text{-}45)$$

In case of cgs electrostatic units (without 4 $\pi\varepsilon_0$) therefore equation (1-24) becomes [11,24]

$$\frac{n^2-1}{n^2+2}\frac{M}{\rho} = \frac{4\pi}{3}N_A\alpha$$

$$= \frac{4}{3}\pi N_A r^3 \qquad (1\text{-}46)$$

This equation shows that the molar refraction is equal to the actual volume of the molecules in one mole.

1.2. Transport coefficients: -

1.2.1. Introduction:

The phenomena of diffusion, viscosity, and thermal conductivity are all physically similar in that they involve the transport of some physical property through the gas or liquid. Ordinary diffusion is the transfer of mass from one region to another because of a gradient in the concentration; viscosity is the transport of momentum through the gas because of a gradient in the velocity; and thermal conductivity is the transport of thermal energy resulting from the existence of thermal gradients in the gas. These properties are appropriately termed "transport phenomena." We present here a description of these phenomena in terms of an ultra-simplified kinetic theory. Although very crude arguments are used throughout, it is nevertheless possible to obtain expressions, which describe the primary dependence of the transport coefficients upon the temperature and pressure and also upon the mass and size of the molecules in the gas [25].

1.2.2. An ultra-Simplified Kinetic Theory of Dilute Gases:

In any real gas the molecules moves in all directions, and their velocities are distributed over a very wide range. When two molecules come close to one another they undergo very complex interactions, since real molecules attract one another at large distances and repel one another when the intermolecular separation is quite small. In spite of the complicated behavior of the molecules, surprisingly good descriptions of the transport properties may be obtained if we consider the following very unrealistic model for a gas containing N molecules per unit volume[25,26]:

(i) The molecules are rigid, non-attracting spheres with diameter σ.

(ii) All the molecules travel with the same speed; a reasonable choice for the molecular speed seems to be the arithmetic mean speed, $\Omega=(8kT/m\pi)^{1/2}$, which may be calculated from the velocity distribution function .

(iii) All the molecules travel in a direction parallel to one of the coordinate axes, that is, one-sixth of them are traveling in the (+x) direction one-sixth in the (-x)-direction, one-sixth in the (+y)-direction and so forth.

1.2.3. Rate of Molecular Collisions in a Gas:

Let us begin by examining the dependence of the rate of collisions,Γ, upon the size, number density, and average speed of the molecules. Consider a single molecule, which is moving in the (+z) – direction, and let us inquire as to the frequency with which it collides with the other molecules in the gas. Certainly it will undergo no collisions with the other molecules moving in the (+z)-direction, since they are all moving with the same speed, Ω. With respect to those molecules moving in the (-z)-direction, however, it has a relative velocity of $2\,\Omega$. This means that during a time interval Δt the molecules whose centers lie within a cylinder of cross-section $\pi\sigma^2$ and length $2\Omega\Delta t$

will undergo collisions with the molecule on which our attention has been focused (assuming that the latter is not deflected by the collisions).

Since there are N molecules per unit volume and since one-sixth of them are moving in the (-z)-direction there will be$(\frac{1}{3}\pi N \sigma^2 \Omega)$collision per unit time with these molecules. Similarly, the molecule moving in the (+z)-direction has a velocity of $(\sqrt{2}\ \Omega)$ relative to those molecules moving in the (+x)- direction; hence there are $(\frac{\sqrt{2}}{6}\pi N\sigma^2\Omega)$ collision per unit time with these molecules. The same result is obtained for molecules moving in the (-x)-, (-y) and (+y)-directions, so that altogether there are[25]:

$$\Gamma = \xi' N\pi\sigma^2 \Omega = \xi' p\sigma^2 \sqrt{8\pi / mkT} \qquad (1\text{-}47)$$

Collisions suffered by one molecule per unit time,

Where $\xi' = \frac{1}{3} + \frac{2}{3}\sqrt{2}.$

The second expression given in Eq. (1-47) for Γ was obtained by using p = N k T (ideal gas law) and $\Omega = \sqrt{8kT/m\pi}$. (If one were to assume that the molecular motion takes place in all directions and that the velocity distribution is Maxwellian, the same result is obtained, except that is, ξ'=1.414, as compared with the approximate 1.276).

1.2.4. The Mean Free Path:

Since the gas we are considering is composed of impenetrable elastic spheres, a collision between two molecules is well defined. This makes it possible to introduce a quantity known as the mean free path, which is the average distance traversed by a molecule between