The international volt is defined as the potential difference required to send a current of one ampere through a resistance of one ohm.

The quantity of electricity is measured in *international coulomb*. It is the quantity of electricity passing through a conductor when a current of one ampere flows in one second. Hence the quantity of electricity is given by the relation.

$$Q = I \times t \quad (9.2)$$

Another unit to measure the quantity of electricity is the *Faraday* (F). It is equal to 96,500 coulombs. The main significance of F is that it is the amount of charge that produces one equivalent of chemical change.

The electrical work (W) performed when a current of strength I passes for t second through a resistance across which the potential difference is V, is given by

$$W = VIt = VQ \quad (9.3)$$

where W is expressed in joules. The Joule is the electrical unit of energy and is defined as the amount of work performed by a current of one ampere flowing for one second under a potential difference of one volt.

$$1J = 1 \times 10^7 \text{ ergs} = 0.2390 \text{ cal}$$

Finally, the rate at which work is being done by an electric current is expressed in watt. A *watt* is worked performed at the rate of 1 Joule per second, and is a unit of electrical power.

9.4 ELECTROLYTIC CONDUCTANCE

Electrolytes or ionic conductors are good conductors of electricity. The electrical conductance of an electrolyte is due to the ions it contains. The greater the concentration of the ions, the higher will be the conductance. The interesting feature of electrolytic solutions is not that they resist the flow of electricity, but that they allow it to flow. Consequently, the important value in electrochemistry is conducting power. The conductance (L) of a system is reciprocal of its resistance (R). Thus conductance is defined as

$$L = \frac{1}{R} \quad (9.4)$$

The SI unit of conductance is Siemen (symbol S). Since resistance (R) is measured in ohms (symbol Ω, omega), its reciprocal, the conductance is defined with the units of reciprocal ohm, ohm^{-1} or mho and denoted as Ω^{-1} (omega inverse). Following the SI system of units, we shall use S to define the conductance.

To compare the conductivity of different solutions, the size of the electrodes and the distance between the electrodes must be standardized. It has been found that the resistance offered by a solution is directly proportional to the distance between the electrode and inversely proportional to the area of the cross section of solution between the electrodes

$$R \propto \frac{l}{A}$$

$$R = \rho \frac{l}{A} \qquad (9.5)$$

where l is the difference between the electrodes, A is the area of cross section and ρ(rho) is the constant of proportionality known as the *specific resistance* or *resistivity*. If in the above equation $l = 1m$, $A = 1m^2$, then $R = \rho$. Hence the specific resistance is the resistance of a conductor of unit length and of a unit area of cross section. In other words, specific resistance is the resistance of a meter cube of the material. The SI units of the specific resistance is ohm.m or Ω.m.

The *specific conductance* or *conductivity* of any conductor is defined as the reciprocal of the specific resistance. It is represented by Ls.

Since $Ls = \frac{1}{\rho}$

Equation (9.5) becomes

$$\rho = R \cdot \frac{A}{l}$$

$$\frac{1}{\rho} = \frac{1}{R} \cdot \frac{l}{A}$$

Hence $Ls = \frac{1}{R} \cdot \frac{l}{A}$ $\qquad \left(\therefore L = \frac{1}{R}\right)$

$$Ls = L \cdot \frac{l}{A} \qquad (9.6)$$

Now if $l = 1m$, and $A = 1m^2$, then

$$Ls = L \qquad (9.7)$$

Hence the specific conductance is the conductance of a material of unit length and unit area of cross section.

Alternatively, specific conductance is the conductance of a one meter cube of the material. For electrolytic solutions, it is the conductance of a meter cube of the solution. Since the specific resistance is measured in ohm × m, the units of the specific conductance will be $ohm^{-1} \cdot m^{-1}$ or mho m^{-1} or S m^{-1}.

Conductance (L) and specific conductance (Ls) are additive properties. If a number of electrolytes are present together in a dilute solution, the total conductivity is equal to the sum of Ls values of individual electrolytes.

$$Ls = \sum_i Ls_i + Ls_{H_2O}$$

Likewise $L = \sum_i L_i + L_{H_2O}$

where $\sum_i Ls_i$ denotes the sum of the conductivities of all the electrolytes present in the solution and Ls_{H_2O} is the conductivity of water. By repeated distillation of water with small amounts of $KMnO_4$ added to it (to oxidize organic impurities) specific conductance of water (Ls_{H_2O}) can be reduced to minimum. Water prepared in this manner is called conductivity water ($LsH_2O = 1 \times 10^{-8}\ S\ m^{-1}$). Conductivity water is used for preparing solutions of electrolytes for conductivity measurements.

9.5 EQUIVALENT AND MOLAR CONDUCTANCE

At any fixed temperature, the conductivity of a solution depends partly on the number of charges per unit volume, which for different solutions may contain different amounts of electrolytic charges. Since the point of interest is to compare the current carrying ability of a given number of electrolytic charges at different concentrations, it is not much rewarding to consider the conductivity/specific conductance as a fundamental quantity. In order to compare the conductance of an electrolyte with another electrolyte, the fundamental weight of an electrolyte must be dissolved in the same volume of the solution. This weight is either the equivalent weight or the molecular weight.

The equivalent conductance of an electrolyte is defined as the conductance of a volume of the solution containing one gram equivalent of dissolved substance when placed between two parallel electrodes 1m apart, and large enough to contain between them all of the solution. It is represented by Λ (lambda) and never determined directly, but is calculated from the specific conductance. It represents the conductivity power of all the ions produced by dissolving one gr-m equivalent of the electrolyte at a given dilution and temperature.

$$\Lambda = Ls \times V \tag{9.8}$$

If C represents the concentration of a solution in gram equivalent per litre, ... lectrolyte is $\frac{10^{-3}}{C}$ m^3. If Ls