Ionic Mobility

Ionic Mobility (U): It is the distance travelled by the ion per second under the potential gradient volt/cm.

Potential Gradient (P.G) or (E): It is the potential applied between two electrodes present at a distance.

If the distance between two electrodes is (x)

So

P.G or (E) = P.D/ x

Where

P.G or (E) = Potential Gradient (V/cm)

P.D = Potential Difference (V)

x = distance between two electrodes (cm)

U = Velocity of ion (cm sec^{-1}) / E (Vcm^{-1})

= ($V^{-1}cm^{2}$ sec^{-1})

Ionic Mobility depends on

1- The charge and size of ion
2- Electric field
3-The number of molecular of solvent.

The velocities of ion changed with electric field. Ionic velocities at field strength of E are known as absolute ionic velocities.

So

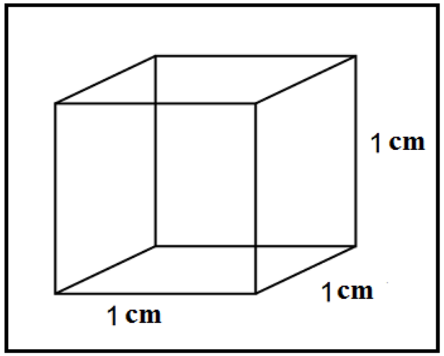
Velocity of ion = $\frac{X}{t}$

The ionic mobility is

$$U = \frac{X}{tE} \quad (v^{-1}\ cm^2\ s^{-1})$$

as

the resistance of the solution in cubic is



$$E = iR$$

as

$$R = \frac{1}{L}$$

$$i = \frac{I}{A}$$

So

$$E = \frac{I}{A} \cdot \frac{1}{L}$$

as

U= $\frac{X}{tE}$

So

U= $\frac{X}{t(\frac{I}{A.L})}$

U=($\frac{X.A}{tI}$).L

Where ($\frac{X}{t}$) is the velocity, ($\frac{X.A}{t}$) is unit of volume in unit of time, and ($\frac{X.A}{tI}$) is unit of volume in unit of time and current.

If we replace the value of $\left(\frac{X.A}{tI}\right)$ by volume (v) the equation becomes

U = vL

Where v = is the volume of solution in time and current unit.

Relationship between ionic mobility and limiting ionic conductance

According to ohm's low, the relationship between the current and the applied voltage is given by

$$R = \frac{E}{I}$$

$$I = \frac{E}{R} = \frac{E}{1/L}$$

as

$$E = 1 \text{ volt/cm}$$

$$\therefore I = \frac{1}{1/L} = L$$

$$\therefore I = L$$

For the solution contain (cation and anion) for 1-1 electrolyte

Strong electrolyte

$$C = C^{+} = C^{-}$$

$$U = U^{+} = U^{-}$$

Where

U^{+} = mobility of cation

U^{-} = mobility of anion

$C^{+}\ U^{+}$ =equivalent of cation which transfer to cathode

$C^{-}\ U^{-}$ = equivalent of anion which transfer to anode

Then

The total current is

$$I = L = F\,[C^+ U^+ + C^- U^-]$$

$$L = CF\,[U^+ + U^-]$$

$$\frac{L}{C} = F\,[U^+ + U^-]$$

As

$$\lambda = \frac{L}{C}$$

$$\lambda = \lambda_+ + \lambda_-$$

$$\lambda = F\,[U^+ + U^-]$$

So

$$\lambda_+ = FU^+$$

$$\lambda_- = FU^-$$

where

λ_+ and λ_- are limiting ionic conductance for cation and anion respectively.

Q1/ A potential of 9 volts is applied between two electrodes placed 0.15 cm apart. A dilute solution of ammonium chloride is placed between the electrodes and NH_4^+ ions is found to cover a distance of 1.6 x 10^{-2} cm in 1 hour. What is the ionic mobility of the NH_4^+ ion?

$$U = \frac{X}{t\,E}$$

$$\text{P.G or (E)} = \frac{P.D}{X} = \frac{9\ V}{0.15\ cm} = 60\ V\ cm^{-1}$$

$$U = \frac{1.6 \times 10^{-2}\ \text{cm}}{60 x 60\ Sec\ x\ 60\ \text{V cm}^{-1}} = 7.4 \times 10^{-8}\ \ V^{-1} cm^{2}\ sec^{-1}$$

Q2/ Calculate the specific conductance for 0.1 mole of 1L of sodium chloride solution in 25 C^o if you know: Ionic mobility of Na^+, Cl^- in this solution are 42.6×10^{-5} $V^{-1} cm^2 sec^{-1}$ and 68×10^{-5} $V^{-1} cm^2 sec^{-1}$ respectively.

$$C = \frac{0.1}{1000} = 0.0001 \text{ mol cm}^{-3}$$

$$L = CF [U^+ + U^-]$$

$$L = 0.0001 \text{ mol cm}^{-3}\ 96485 \text{ C mol}^{-1} \times [42.6 \times 10^{-5} + 68 \times 10^{-5}]\ V^{-1} cm^2 sec^{-1}$$

$$L = 0.01067 \text{ ohm}^{-1} \text{ cm}^{-1}$$

Q3/ Boundary method was carried to determine ionic mobility using a 0.1 N of potassium chloride solution. The applied potential and current was passed led to move a barrier to 4.64 cm through 67 minutes. If you know the current was 5.21 mA and a tube's area was 0.230 cm². The specific conductance of the potassium chloride solution at 25 ° C is 0.0129 ohm⁻¹cm⁻¹. Calculate ionic mobility of potassium ion.

$$U = \frac{X}{t\,E}$$

as

$$E = \frac{I}{A\,l}$$

$$E = \frac{5.21 / 1000\ A}{0.230\ \text{cm}^2\ x\ 0.0129\ \text{ohm}^{-1}\text{cm}^{-1}} = \mathbf{1.76\ Vcm^{-1}}$$

$$UK^+ = \frac{X}{t\,E}$$

$$UK^+ = \frac{4.64\ cm}{67\ x\ 60\ sec\ x\ 1.76\ v\ cm^{-1}} = 65.5 x\ 10^{-5}\ v^{-1}\ cm^2\ sec^{-1}$$

Q4/ what is the distance that ammonium ion was moved by one hour in a dilute solution of an ammonium salt at 25 C°. the distance between two electrodes was 9.8 cm and the applied potential was 5.6 volt. If you know the conductivity of infinity dilution of ammonium ion is73.4 ohm^{-1} cm^{2} mole^{-1}

$$U = \frac{X}{t\,E}$$

$$U = \frac{\lambda_+}{F} = \frac{73.4\ \text{ohm}^{-1}\,\text{cm}^2\,\text{mole}^{-1}}{96485\ C\ \text{mole}^{-1}} = 7.61 X\ 10^{-4}\ V^{-1}\ sec^{-1}\ cm^2$$

$$E = \frac{5.6\ V}{9.8\ cm} = 0.571\ V\ cm^{-1}$$

$$U = \frac{X}{t\,E}$$

$$7.61 X\ 10^{-4}\ V^{-1}\ sec^{-1}\ cm^2 = \frac{X}{60\ x\ 60\ x 0.571\ V\ cm^{-1}} = 1.56\ cm$$

Dr. Asmaa Kadim Ayal