Question

Resistance of a conductivity cell filled with 0.1 mol L^{-1} KCl solution is 100 Ω. If the resistance of the same cell when filled with 0.02 mol L^{-1} KCl solution is 520 Ω. Calculate the conductivity and molar conductivity of 0.02 mol L^{-1} KCl solution. The conductivity of 0.1 mol L^{-1} KCl solution is 1.29 $S m^{-1}$.

Answer

0.1 M KCl solution

$R = 100\ \Omega$

$\kappa = 1.29\ S m^{-1}$

Cell constant (G)

$= \text{Conductivity}(\kappa) \times \text{Resistance}$

$= 1.29\ \frac{S}{m} \times 100\ \Omega$

$= 129\ m^{-1}$

$= 1.29\ cm^{-1}$

0.02 M KCl solution

$R = 520\ \Omega$

$\kappa = ?$

$\Lambda_m = ?$

$\kappa = \frac{G}{R}$

$= \frac{1.29\ cm^{-1}}{520\ \Omega}$

$= 2.48 \times 10^{-3}\ S cm^{-1}$

$\Lambda_m = \frac{1000 \times \kappa}{M}$

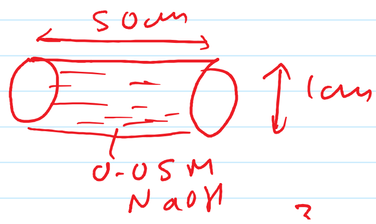
$= \frac{1000 \times 2.48 \times 10^{-3}}{0.02}$

$= 124\ S cm^2 mol^{-1}$

Question

The electrical resistance of a column of 0.05 mol L^{-1} NaOH solution of diameter 1 cm and length 50 cm is $5.55 \times 10^3\ \Omega$. Calculate its resistivity, conductivity and molar conductivity.

Answer:



$\text{Area}(A) = \pi r^2 = \pi (0.5\ cm)^2$

$= 0.785\ cm^2$

$= 0.785\ cm^2$

0.05 M NaOH

$R = 5.55 \times 10^3\ \Omega$

Cell constant $(G) = \frac{\text{length}(l)}{\text{Area}(A)}$

$= \frac{50\ cm}{0.785\ cm^2}$

$= 63.69\ cm^{-1}$

Conductivity $(\kappa) = \frac{G}{R} = \frac{63.69\ cm^{-1}}{5.55 \times 10^3\ \Omega}$

$= 0.01148\ S\,cm^{-1}$

Resistivity $(\rho) = \frac{1}{\kappa} = \frac{1}{0.01148} = 87.1\ \Omega\,cm$

Molar conductivity $(\Lambda_m) = \frac{1000 \times \kappa}{M} = \frac{1000 \times 0.01148}{0.05}$

$= 229.6\ S\,cm^2\,mol^{-1}$

Question

The conductivity of $0.001028\ mol\ L^{-1}$ acetic acid is $4.95 \times 10^{-5}\ S\,cm^{-1}$. Calculate its dissociation constant if Λ_m^∞ for acetic acid is $390.5\ S\,cm^2\,mol^{-1}$.

Answer:

$\Lambda_m = \frac{1000 \times \kappa}{M} = \frac{1000 \times 4.95 \times 10^{-5}}{0.001028} = 48.15\ S\,cm^2\,mol^{-1}$

$\alpha = \frac{\Lambda_m}{\Lambda_m^\infty} = \frac{48.15}{390.5} = 0.1233$

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

$t=0$ $\quad c$

$t=\infty$ $\quad c(1-\alpha) \quad c\alpha \quad c\alpha$

$K_a = \frac{[CH_3COO^-][H^+]}{[\ldots]} = \frac{c\alpha\, c\alpha}{c(1-\alpha)} = \frac{c\alpha^2}{1-\alpha}$

$[CH_3COOH]$

$$K_a = \frac{0.001028 \times (0.1233)^2}{(1 - 0.1233)} = 1.78 \times 10^{-5} mol\ L^{-1}$$

Question

Why does the conductivity of a solution decrease with dilution?

Answer

The conductivity of a solution at any given concentration is the conductance of one unit volume of solution. With dilution i-e decrease in concentration number of charge carriers per unit volume decreases, thus conductivity decreases

Question

Define conductivity and molar conductivity for the solution of an electrolyte. Discuss their variation with concentration.

Answer

Conductivity:

The conductivity of a solution at any given concentration is the conductance of one unit volume of solution kept between two platinum electrodes with unit area of cross section and at a distance of unit length.

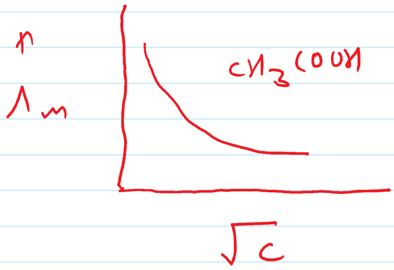
Molar conductivity:

Molar conductivity of a solution at a given concentration is the conductance of the volume V of solution containing one mole electrolyte kept between two electrodes.

Variation with concentration

For strong as well as weak electrolytes, conductivity decreases with dilution i.e decrease in concentration because, number of ions per unit volume decrease with dilution.

For strong as well as weak electrolytes, molar conductivity increases with dilution. For weak electrolytes, degree of dissociation increases on dilution, thus charge carriers increase, hence molar conductivity increases.



For strong electrolytes, solute-solute interaction decreases on dilution, thus resistance decreases and molar conductivity increases.

$$\Lambda_m = \Lambda_m^{\infty} - A\sqrt{c}$$

Question

The conductivity of 0.20 M solution of KCl at 298K is 0.0248 $S cm^{-1}$. Calculate its molar conductivity.

Answer

$$\Lambda_m = \frac{1000\,\kappa}{c} = \frac{1000 \times 0.0248}{0.2} = 124\ S\,cm^2\,mol^{-1}$$

Question

The resistance of a conductivity cell containing 0.001M KCl solution at 298 K is 1500Ω. What is the cell constant if conductivity of 0.001M KCl solution at 298K is 0.146×10^{-3} $S cm^{-1}$

Answer:

Cell constant (G) = Conductivity (κ) × Resistance (R)

$= 0.146 \times 10^{-3} \times 1500$

$= 0.219\ cm^{-1}$

Question

Conductivity of 0.00241M acetic acid is $7.896 \times 10^{-5}\ S\,cm^{-1}$. Calculate its molar conductivity if Λ_m° for acetic acid is $390.5\ S\,cm^2\,mol^{-1}$, what is its dissociation constant?

Answer:

i) $\Lambda_m = \frac{1000\,\kappa}{M} = \frac{1000 \times 7.896 \times 10^{-5}}{0.00241} = 32.76\ S\,cm^2\,mol^{-1}$

ii) $\alpha = \frac{\Lambda_m}{\Lambda_m^\circ} = \frac{32.76}{390.5} = 0.084$

$K = \frac{C\alpha^2}{1-\alpha} = \frac{0.00241\,(0.084)^2}{(1-0.084)} = 1.86 \times 10^{-5}\ \frac{mol}{L}$