Problem 10-06 Absolute velocity of ions, molar conductivity, transference numbers

Molar conductivity of NH_4Cl solution with concentration 0.01 mol dm^{-3} at the temperature of 25 °C is 0.0129 S m^2 mol^{-1}. The transference number of the cation in this solution is 0.4907. What is the absolute velocity of the chloride ion in the conductivity cell where the distance of the electrodes is 5.5 cm and the voltage between the electrodes is 7 V

$[u_A = 8.67 \cdot 10^{-6}\ \text{m s}^{-1}]$

Solution:

$c = 0.01\ \text{mol dm}^{-3}$

$\lambda_{NH4Cl} = 0.0129\ \text{S m}^2\ \text{mol}^{-1}$

$t_C = 0.4907 \quad \Rightarrow \quad t_A = 1 - t_C = 1 - 0{,}4907 = 0{,}5093$

$U = 7\ \text{V}$

$\ell = 5.5\ \text{cm} = 0.055\ \text{m}$

$NH_4Cl = NH_4^+ + Cl^-$

$z_A = 1\ ,\ \nu_A = 1$

$$\left.\begin{aligned} t_A &= \nu_A \cdot \frac{\lambda_A}{\lambda} \\ \lambda_A &= u_A \cdot z_A \cdot F \end{aligned}\right\} \quad u_A = \frac{\lambda_A}{z_A \cdot F} = \frac{t_A \cdot \lambda}{\nu_A \cdot z_A \cdot F} = \frac{0.5093 \cdot 0.0129}{1 \cdot 1 \cdot 96485.3} = 6.8093 \cdot 10^{-8}\ \text{s m}^2\ \text{V}^{-1}$$

$$\left[\frac{\text{S m}^2\ \text{mol}^{-1}}{\text{C mol}^{-1}} = \frac{\text{s m}^2}{\text{V}}\right] \quad \left[\begin{matrix} I = Q/\tau = U/R \\ [\text{C} \cdot \text{s}^{-1} = \text{V} \cdot \text{S}] \end{matrix}\right]$$

$$u_A = \frac{v_A}{E}\ ,\ E = \frac{U}{\ell} \quad \Rightarrow \quad v_A = u_A \cdot E = u_A \cdot \frac{U}{\ell} = 6.8093 \cdot 10^{-8} \cdot \frac{7}{0.055} = 8.67 \cdot 10^{-6}\ \text{m s}^{-1}$$