CHEMICAL SCIENCES

EMPIRICAL EQUATION FOR THE DEPENDENCE OF THE EQUIVALENT ELECTRICAL CONDUCTIVITY OF AN AQUEOUS SALT SOLUTION ON CONCENTRATION

Perelygin Yu.,
Doctor of Engineering Sciences, Professor, Department of Chemistry, Penza State University, Russia, Penza
Kolchugina I.
PhD of Engineering Sciences, Associate Professor, Department of Chemistry, Penza State University, Russia, Penza
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Abstract
The relevance and goals are due to the need to obtain an equation of the dependence of the equivalent electrical conductivity on the salt concentration in the solution. An equation is proposed for calculating the equivalent electrical conductivity depending on the salt concentration in the solution. The resulting equation is sufficiently well observed when the salt concentration in the solution is up to 5 g-eq/l.

Keywords: electrical conductivity of solutions, salt concentrations.

Introduction

Several equations are known [1, p.175], [2, p.96] that establish the dependence of the equivalent electrical conductivity of a solution (λ) on the salt concentration, including the Kohlrausch equations, the Fuoss-Onsager equation, the Shedlovsky formula, the Robinson-Stokes equation and the Falkenhagen formula, are performed in solutions with a salt concentration not more than 0.1 g-eq / l.

In [3, p.24], it is proposed to describe the dependence of specific electrical conductivity (EC) on concentration using the reduced values of electrical conductivity (the ratio of the specific electrical conductivity to its maximum value) and the reduced concentration value (the ratio of the concentration to its value at the maximum of the electrical conductivity). The proposed equation is not linear, which makes it difficult to use.

Thus, obtaining a linear equation that will allow one to determine the equivalent electrical conductivity at higher salt concentrations is of both theoretical and practical interest.

The dependence of λ on dilution ν = 1/c (c–is the concentration of the dissolved substance, g-eq/l) [4, p.244] has the same form as the dependence of the enzymatic reaction rate on the substrate concentration (Michaelis-Menten equation) [5, p.54]. This suggests the possibility of using the Michaelis–Menten equation

$$v = \frac{v_{max}c}{c+K}$$

(where c – is the substrate concentration, K – is the Michaelis-Menten constant) to establish the dependence of the equivalent electrical conductivity of the solution on the concentration of the substance in the solution in the following form:

$$\lambda = \frac{\lambda_o v}{K+v} \qquad (1)$$

where λ_o is the limiting equivalent electrical conductivity (Ohm^{-1} $g\text{-}eq^{-1}$ cm^2), K– is a constant which, apparently, depends on the type of solvent, solute and temperature.

Let us divide unity on the left and right parts of the last equation, similar to that adopted in [5 p.84], we obtain the following equation:

$$\frac{1}{\lambda} = \frac{1}{\lambda_0} + \frac{\mathrm{K}c}{\lambda_0} \qquad (2)$$

It follows from this equation that a linear relationship between 1/λ and c must be observed. At the same time, on the y-axis, at a concentration of a dissolved substance equal to zero, the segment is equal to $1/\lambda_o$, and the tangent of the slope of the straight line is equal to $K/(\lambda_o)$. This allows you to determine λ_o and K.

Experimental part

Table 1 shows the values of equivalent electrical conductivity (λ, Ohm^{-1}g-eq-1cm^2) versus concentration (c, g-eq/l) for solutions of sodium chloride, calcium nitrate and aluminum chloride, which are borrowed from [6, p.445].

Table 1

Values of equivalent electrical conductivity (λ, $Ohm^{-1}g\text{-}eq^{-1}cm^2$) from salt concentration (c, g-eq/l)

c	0.001	0.01	0.1	1.0	2.0	3.0	4.0	5.0
λ, (NaCl)			106,7	85,76	74,71	65.57	57.23	49.46
λ, ($Ca(NO_3)_2$)		115.8	95.76	66.7	50.2	38.9	30	23.28
λ, ($AlCl_3$)	138	106.9		56.2	43.7		25.4	

The figure shows the dependences of 1/λ on c for solutions of sodium chloride (3), calcium nitrate (2) and aluminum chloride (1), which are straight lines, which indicates the feasibility of equation (2). As can be seen from the figure, equation (2) and, consequently, equation (1), are observed quite well up to the concentration of sodium chloride, calcium nitrate up to 5 g-eq/l and aluminum chloride up to 4 g-eq/l.

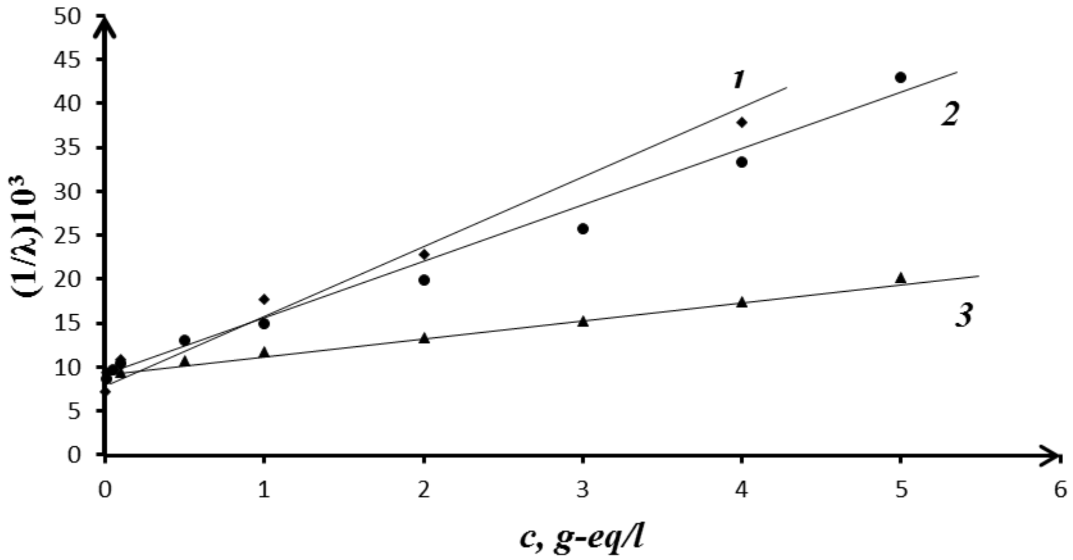

Figure. Dependences of 1/λ on the concentration of a solution (c) of sodium chloride(3), calcium nitrate(2), and aluminum chloride(1).

As calculations performed using the least squares method show, the dependence, 1/λ on c for solutions of sodium chloride, calcium nitrate and aluminum chloride (at a temperature of 25 ° C) are described respectively by the following equations, which correspond to equation (2):

$$\frac{1}{\lambda} = 0{,}00934 + 0{,}0021c$$

$$\frac{1}{\lambda} = 0{,}0089 + 0{,}00633c$$

$$\frac{1}{\lambda} = 0.0088 + 0.0073c.$$

The correlation coefficient of these equations is equal to 0.993 - 0.997, which indicates a fairly high convergence of the above equations with the results of experimental data.

Table 2 shows the values of the parameters λ_o and K calculated from the data from the last three equations and tabular values of λ_o from [6, p. 445].

Table 2: The values of the parameters λ_o and K.

Solution	Limiting equivalent conductivity λ_o ($Ohm^{-1}g\text{-}eq^{-1}cm^2$)		Constant, *K*
	Experimental	Tabular	
NaCl	107	108.8	0,226
$Ca(NO_3)_2$	112,4	131	0,71
$AlCl_3$	114,4	139	0,83

Table 2 shows that the calculated values of the limiting equivalent electrical conductivity correlate fairly well with the known values [6 p. 445], and the constant, K, depends on the type of salt and, obviously, temperature. The dimension of the constant K, as can be seen from equation (2), is equal to l/g-eq.

Conclusion

Thus, the above equations (1) or (2) can be used to calculate the equivalent electrical conductivity of salt solutions in a fairly wide range of concentrations, up to 5 g-eq/l, which depends on the type of salt, obviously, temperature and on those processes which can take place in solution, such as hydrolysis.

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