PHYSICAL CHEMISTRY LABORATORY II

EXPERIMENT NUMBER: 1

NAME OF THE EXPERIMENT: Cell Constant and Determination of Molar Conductivity of $MgSO_4$

DATE OF THE EXPERIMENT:18/5/2023

NAME OF THE ASSISTANT: Kübra

GROUP NUMBER: 5

STUDENT NAME SURNAME: Elif Nazenin GİRAY

GROUP MEMBERS:Berkay Yapıcı & Alper İrez

SECTION: Thursday Afternoon

CALCULATIONS

1) **Table.**1 Contacted values for KCl

Conc. (M)	Temp (K)	Conductance (S)						
		#1	#2	#3	#4	#5	Mean	Sd
0,10	299,45	0,01299	0,01312	0,01308	0,01315	0,01316	0,01310	6,89202 x 10^{-5}

Mean = $\frac{\Sigma X_i}{N} = \frac{0{,}01299+\cdots+0{,}01316}{5}$ = 0,01310

Standard deviation = $\frac{\Sigma(x-x_i)^2}{N-1}$ = 6,89202 x 10^{-5}

G = $\kappa\frac{A}{l} = \frac{\kappa}{B}$

κ: Specific Conductance = 0,01289 S/cm
B: Electrode Cell Constant
A: Electrode area
l: length of column

B = $\frac{0{,}01289 \text{ S/cm}}{0{,}01310\ S} = 0{,}9840\ cm^{-1}$

2)

Table 2. Conductance Values for Mg_2SO_4

Conc. (M)	Temperature (K)	Conductance (S)						
		1	2	3	4	5	Mean	Sd
0,20	298,15	0,01715	0,01738	0,01741	0,01740	0,01742	0,01735	0,000114
0,1	298,75	0,01016	0,01001	0,00999	0,00998	0,00997	0,010022	7,85x10^{-5}
0,05	297,95	0,00625	0,00611	0,00623	0,00616	0,00612	0,006174	6,35 x10^{-5}
0,025	298,15	0,00363	0,00359	0,00357	0,00356	0,00356	0,003582	2,95 x10^{-5}
0,0125	298,55	0,00215	0,00213	0,00212	0,00211	0,00213	0,002128	1,48 x10^{-5}

Kelvin = ℃ + 273.15
G = $\frac{\kappa}{B}$ $\kappa = G\ x\ B$
molar conductivity: $\Lambda = \frac{\kappa}{C}$ **C: concentration**

For Specific conductance for solution 1,

$$\kappa = G \times B = 0{,}01735 \text{ S} \times 0{,}9840 \text{ cm}^{-1} = 0{,}01707 \text{ S cm}^{-1}$$

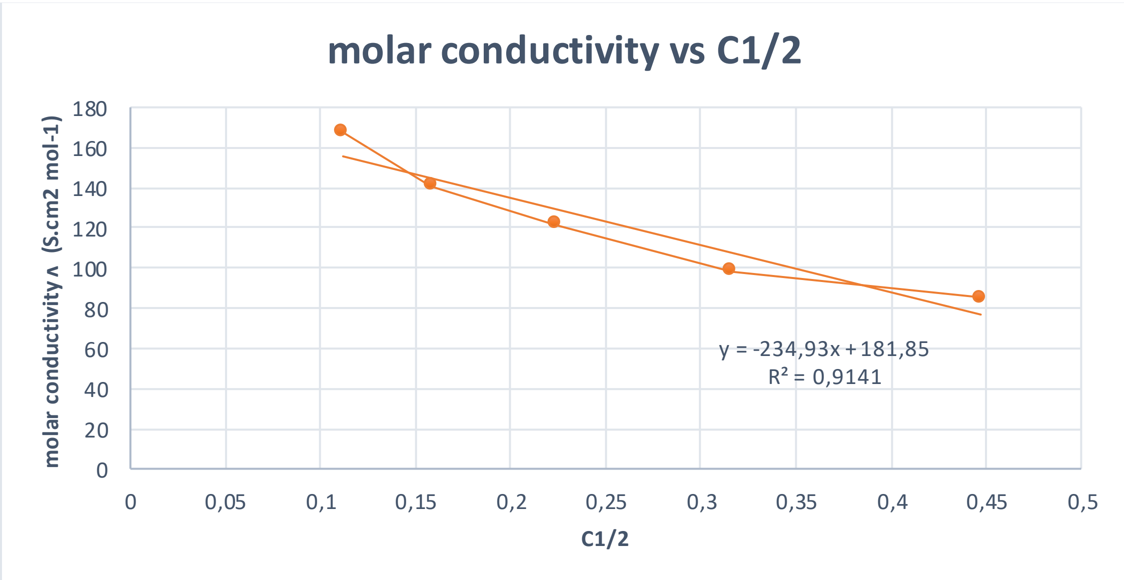
Molar conductivity for solution 1,

$$\Lambda = \frac{0{,}01707 \text{ S cm}^{-1}}{0{,}20\ mol/L} \times \frac{1000 \text{ cm}^3}{1\ L} = 85{,}36 \text{ S.cm}^2\text{mol}^{-1}$$

Table 3. Specific conductance and molar conductivity of Mg_2SO_4

Conc. (M)	Specific Conductance κ ($S.cm^{-1}$)	molar conductivity ʌ ($S.cm^2$ mol^{-1})
0,20	0,017074	85,3692
0,1	0,009861	98,6134
0,05	0,006075	121,501
0,025	0,003525	140,983
0,0125	0,002094	167,511

Graph 1. Molar conductivity vs $\sqrt{c}$ graph for $MgSO_4$



From Graph y = -234,93x + 181,85 then

$\Lambda = \Lambda_0 - \kappa\sqrt{c}$ y = ʌ 234,93 = κ $\Lambda_0 = 181{,}85$ S.cm^2 mol^{-1}

Conc. (M)	Temp (K)	Conductance (S)						
		1	2	3	4	5	Mean	Sd
0,10	298,35	0,00512	0,00511	0,00511	0,00510	0,00510	0,00511	8,37 x 10^{-6}
0,05	298,55	0,00297	0,00297	0,00296	0,00297	0,00297	0,002968	4,47 x 10^{-6}
0,03	298,65	0,001897	0,001891	0,001888	0,001892	0,001892	0,001892	3,24 x 10^{-6}
0,02	298,85	0,00138	0,001373	0,001365	0,001365	0,001362	0,001369	7,38 x 10^{-6}
0,01	298,95	0,000781	0,000778	0,000778	0,000777	0,000773	0,000777	2,88 x 10^{-6}
0,005	298,15	0,000503	0,000495	0,000493	0,000491	0,000495	0,000495	4,56 x 10^{-6}

Table 4. Measured conductance values of Monochloroacetic acid with varying concentrations.

Specific conductance for solution 1

$\kappa = G\ x\ B$ = 0,00511 S x 0,9840 cm^{-1} = 0,005026 S cm^{-1}

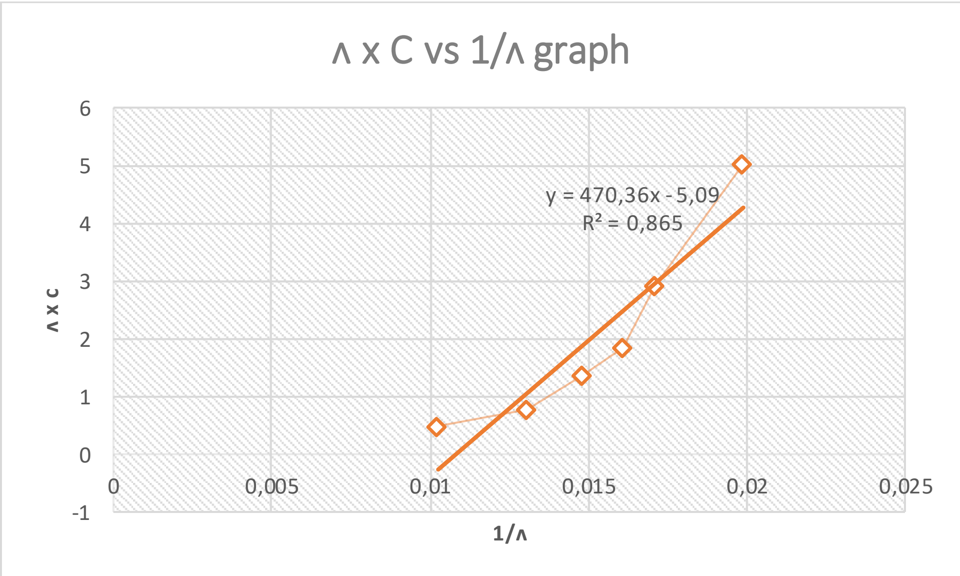
Molar conductivity for solution 1

$\wedge = \frac{0,00511\ \mathrm{S\,cm^{-1}}}{0,10\ mol/L} \times \frac{1000\ \mathrm{cm^3}}{1\ L}$ = 50,26116 S.cm^{2}mol^{-1}

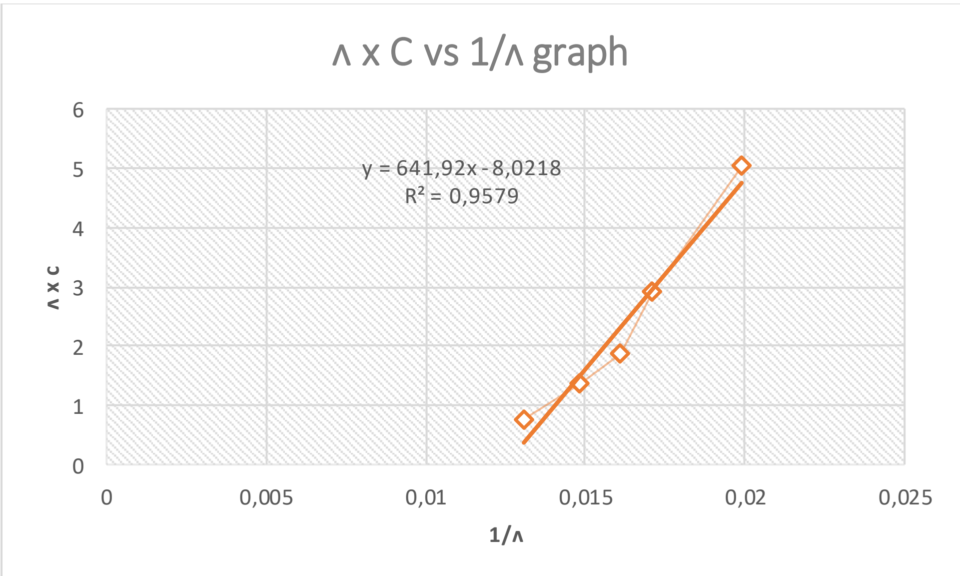
Table 5. Specific conductance, Molar conductivity, ∧ x C, 1/∧ values calculated for $MgSO_4$

Conc. (M)	Specific Conductance κ (S.cm^{-1})	molar conductivity ∧ (S.cm^2 mol^{-1})	∧ x C	1/∧
0,10	0,005026	50,2612	5,026116	0,019896
0,05	0,002920	58,4084	2,920421	0,017121
0,03	0,001862	62,0557	1,86167	0,016115
0,02	0,001347	67,3527	1,347054	0,014847
0,01	0,000765	76,4938	0,764938	0,013073
0,005	0,000487	97,4917	0,487458	0,010257

Graph 2. ∧ x c vs 1/∧ graph of monochloroacetic acid



Graph 3. ∧ x c vs 1/∧ graph of monochloroacetic acid



$$\Lambda C = K_d\left(\frac{\Lambda_0^{\ 2}}{\Lambda} - \Lambda_0\right)$$

Λ = Molar Conductivity

Λ_0 = Molar Conductivity at Infinite Dilution

C = Concentration

K_d = Dissociation constant then

y = 236.47x – 0.438

y = ΛC

x = 1 / Λ

$K_d\Lambda_0^{\ 2}$ = 641,92

$K_d\Lambda_0$ = 8,0218

Thus,

K_d = 0.100245

Λ_0 = 80,0294 $S.cm^2.mol^-$

For 0.1 M Monochloroacetic acid

$$\alpha = \frac{\Lambda}{\Lambda_0}$$

$\Lambda = 50{,}2612$ S.cm^2.mol^{-1} and Λ_0 = 80,0218 S.cm^2.mol^{-1}

$$\alpha = \frac{50{,}2612}{80{,}02194} = 0{,}628092$$

$$K_d = \frac{\Lambda C}{\left(\frac{{\Lambda_0}^2}{\Lambda} - \Lambda_0\right)}$$

$$K_d = \frac{5{,}026116}{\left(\frac{80{,}02194021^2}{50{,}2612} - 80{,}02194021\right)} = 0{,}106075$$

Table 6. **Λ, Λo, α, ΛC and K_d values for $MgSO_4$**

Conc. (M)	Λ	Λ_0	α	ΛC	K_d
0,10	50,2612	80,02194021	0,628092	5,026116	0,106075
0,05	58,4084	80,02194021	0,729905	2,920421	0,098625
0,03	62,0557	80,02194021	0,775483	1,86167	0,080356
0,02	67,3527	80,02194021	0,841678	1,347054	0,089491
0,01	76,4938	80,02194021	0,95591	0,764938	0,207251
0,005	97,4917	80,02194021	1,218312	0,487458	-0,03399

QUESTIONS

1) This law is valid for weak electrolytes. Ostwald's rule of dilution says that the degree of dissociation of weak electrodes is inversely proportional to the square root of the concentration in molars. It can also be used for a weak electrolyte as it is directly proportional to the square root of the volume that can hold one mole of solute. [5]

2) Conductivity is done by ions in solutions, so the increase or decrease in conductivity may vary according to some properties of the ions. The type of ions and their concentration affect the conductivity. In addition, the solution's temperature also affects the conductivity. As a result, the conductivity of the solutions decreases. [6]

3) Due to measure the conductivity of solutions, it is necessary to calibrate the two probes of the conductivity meter. The solution used for this purpose is 0.1 M KCl. The reason for using KCl is that because of the high diffusion coefficient of potassium and chloride ions in the structure of KCl, the transmission of ions becomes easier, and it has an easily soluble structure. In this experiment, KCl was used as the reference solution. Alternatively, NaCl or KNO3 can be used. [7]

4) The electrode potential will vary depending on the activity and concentration of the salts used in the experiment. Molar conductivity (Λ_0) and specific conductivity (k) depend on the concentration of salts, and they are terms associated with concentration. Concentration-dependent values are required in calculating the electric potential. Therefore, molar conductivity and specific conductivity are used instead of conductivity (G) because the specific conductivity varies depending on the electrolyte concentration. On the other hand, conductivity depends on the physical properties of the electrodes, such as their length. [7]

5)

$$\frac{Experimental\ Value - Theoretical\ Value}{Theoretical\ Value} \times 100 = Percent\ Error$$

Theoreticel conductance value of 0.1 M of KCl at 25 °C = 12.88 mS [1]

Then,

$$\frac{(0{,}013105 - 0{,}01288)}{0{,}01288} \times 100 = 1{,}7\%$$

Theoretical K_d for Monochloroacetic acid equal to $1{,}3\text{x}10^{-3}$ M[2]
Theoretical Λ_0 for Monochloroacetic acid equal to 362 $S.cm^2mol^{-1}$[3]
Theoretical Λ_0 for $MgSO_4$ $1{,}3\text{x}10^{-3}$186,9 $S.cm^2mol^{-1}$[4]

Same calculations for other solutions then,
Percent error for
K_d percent error for Monochloroacetic acid equal to -15,38%

Λ_0 percent error for Monochloroacetic acid equal to -31,6%
Λ_0 percent error for Monochloroacetic acid equal to -85,1%

DISCUSSION

This experiment aims to maesure the conductivity, molar conductivity, and cell constant of strong and weak electrolytes. The conductivity of the strong reference electrolyte KCl, the strong electrolyte MgSO4, and the weak electrolyte mono-chloroacetic acid were measured with a conductometer. It was observed that the dilution process changed the conductivity of temperature and ion types. . Ions provide conduction in solutions. This experiment aims to measure the conductivity, molar conductivity, and cell constant of strong and weak electrolytes. The conductivity of the strong reference electrolyte KCl, the strong electrolyte MgSO4, and the weak electrolyte mono-chloroacetic acid were measured with a conductometer. It was observed that the dilution process changed the conductivity of temperature and ion types. . Ions provide conduction in solutions. As a result of the calculations in the experiment, it is seen that errors have been obtained. If the errors have a negative value, this indicates that an experimental value less than the theoretical value is obtained. If the errors are positive, the practical value is accepted due to data higher than the theoretical value. It may not be at the desired temperature for the experiment, or the water bath may not have reached the thermal balance. On the other hand, during the measurement with the conductometers, the pomts touching the glass may not be kept at the optimum level, or errors may have been obtained due to incorrect readings. Finally, the dilution process may not have been performed as desired.

REFERENCES

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