THE CONDUCTANCE OF SOLUTIONS OF POTASSIUM CHLORIDE

THESIS FOR THE DEGREE OF M. S.

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THE CONDUCTANCE OF SOLUTIONS

OF

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INTRODUCTION

Very precise measurements have been made of the conductance of solutions of potassium chloride by several investigators, the most notable of whom are: Kohlrausch and Maltby (Kohlrausch and Maltby, Wiss. Abh. Phys.- Tech. Reichsanst 3, 180 -1900), Kraus and Parker (Kraus and Parker, J. Am. Chem. Soc. 44, 2422 - 1922), and Parker and Parker (Parker and Parker, J. Am. Che. Soc. 46, 312 - 1924).

Kohlrausch and Malby have done the most exact work, possibly, of any of the investigators. However, in the work done by them, the assumption of 74.6 for the molecular weight of potassium chloride, was made. These workers also assumed that 1000 cc. were equivalent in volume to 1 liter, which we know to be not true. The accepted value for the molecular weight of KCL is 74.553 (International Critical Tables, Vol. 1, Page 155), and it is also accepted that 1 liter is equivalent to 1000.027 cc. (International Critical Tables, Vol. 1, Page 2, Table A). The difference in the accepted values mentioned, and those used by Kohlrausch and Maltby, necessarily makes the values of conductance, obtained by them, wrong.

Kraus and Parker (Kraus and Parker, J. Am. Chem. Soc. 44, 2422 (1922) have interpreted the results obtained by Kohlrausch and Maltby in terms of the value 1000.027 cc. equivalent to 1 liter. They have not attempted to correct these values for the accepted value for the molecular weight of KCl.

Parker and Parker (Parker and Parker, J. Am. Chem. Soc. 46 312-1924) believe that it is more convenient to use the cubic decimeter as a standard rather than the liter. As a result of this they have adopted the cubic decimeter as the standard of volume, and in place of the "Normal" system, have introduced the "demal" system. A 1.0 "Demal" solution contains an equivalent weight of substance per cubic decimeter of solution. However, the equivalent conductance of a solution is obtained by multiplying the specific conductivity by the number of cubic centimeters ot the solution which contain one equivalent. In this latter respect the "Demal" system is much more convenient to work with.

The Normal system is generally accepted, whereas the "Demal" system, whatever advantages it may have, is not as generally accepted at the present time.

The purpose of this investigation has been to redetermine the conductance of solutions of KCl in the Normal system. The value of 74.553 for the molecular weight of KCl has been used throughout the work, and also the fact that 1000.027 cc. are equivalent to 1 liter, has been taken into consideration and employed.

It is much more convenient to make solutions up by weight rather than by volume, and in order to determine accurately how these solutions may be so made, it was necessary to determine the densities of the various solutions under investigation.

APPARATUS AND MATERIALS

Measuring Apparatus:- The apparatus used in measuring the conductance of the solutions, consisted of: a resistance box having a capacity range of one of ten thousand ohms, a Leeds and Northrup Microphone Hummer of 1000 cycles frequency, a Leeds and Northrup Student Type Potentiometer, and a pair of Stromberg Carlson headphones. The wiring diagram is shown in Fig. 1 . Page 10.

Conductivity Cell:- The cell used in this experiment was of the Kohlrausch and Maltby type, of about thirty millilietrs volume. A sketch of the cell is shown in Fig. 2, Page 11.

Thermostat:- A constant temperature bath of approximately 20 liters capacity was used, and kept at 25 (plus or minus 0.04) degrees Centigrade. The thermometer used in the bath was of the Beckman type and was previously set by means of comparison with a Bureau of Standards thermometer.

Preparation of Materials:- The salt used in making the solutions was Baker's Analyzed KCl (Special Crystal). The analysis of the salt was

given as:

Fe	0.001%	MgO	0.001%
CuO	0.001%	SO_2	0.001%

The salt was allowed to dry for 48 hours in a constant temperature oven at 135 degrees Centigrade. The salt was cooled in a dessicator, so that it would remain dry.

Conductivity Water:- The conductivity water used in these measurements was prepared by re-distilling laboratory-distilled water, direct from the still, over alkaline permanganate in a block tin condenser. The first and last quarter portions were discarded, and the water used had a specific conductance of 1.8 x 10-6.

Calibration of weights:- The weights used in this work were standardized as described by T. W. Richards (T. W. Richards J. Am. Chem. Soc. 22, 144 - 1900). The weight used as a standard was a 1 g. piece from a Ruprect set, which had been standardized by the U. S. Bureau of Standards.

METHOD OF PROCEDURE

Making up Solutions:- A liter of 1.0 Normal KCl contains 74.553 g. KCl (weights in vacuum) per liter of solution. The factor for reducing weights in vacuum to weights in air, is given (Landolt-Bornstein "Physikalisch-Chemische Tabellen" Springer, Berlin Page 15 (1912) as 1.00106. Dividing by this factor we obtain 74.4740 g. (brass weights in air) KCl per liter of solution.

The graduated flasks used (Nos. 1580 & 101826) bore Bureau of Standards certificates of 1927. These had been calibrated at 20 degrees C. To change the values given at 20 degrees to the corresponding values at 25 degrees, 0.12 ml./ 1000 ml. must be added (Circular of Bureau of Standards No. 19, Table 31, Page 48). It then becomes necessary to increase the amount of KCl to terms of KCl per 1000.12 ml. solution. Setting up a simple proportion and solving we find that it requires 74.4829 g. KCl (brass weights in air) per 1000.12 ml. solution. The various concentrations were made up after calculating, in the same manner, the proportional amount of KCl necessary per 1000.12 ml. solution.

In each case the KCl was weighed, and by means of a clean glass funnel, transferred to the calibrated flask. The vial, as well as the funnel, was washed with conductivity water, the rinsing allowed to run into the flask. Conductivity water was then put into the flask until the maniscus was slightly below the graduation mark. The flask was then placed in the constant temperature bath, at 25 degrees, and allowed to come to equilibrium at that temperature. This required about one hour. By using a 10 ml. pipette, conductivity water was then added until nearly to the graduation mark. The last few drops of water were added by using a capillary tube as a pipette, and when finally filled, the top part of the lower maniscus was on a level with the mark.

Determination of Densities:- As soon as the solution was made up, it was taken from the constant temperature bath, and wiped dry and weighed. This weight is the weight of the flask plus 1000.12 ml. of solution at 25 degrees. The weight of the flask, being previously determined, is subtracted from the weight of the flask plus the 1000.12 ml. of solution. This is the weight of 1000.12 ml. of solution at 25 degrees. By dividing the weight of the 1000.12 ml. of solution by 1000.12, the density, in g./ml. (brass weights in air) is obtained. If this value for the density is multiplied by 1.00106, the factor for converting weights

in air to weights in vacuum, the density of the solution will be obtained in terms of g. / ml. in vacuum. A table of densities, of the various solutions dealt with, is given on page 13. The densities in that table are based on the weight of 1000.12 ml. of solution.

Another method was employed in determining the densities of these solutions. This method involved the use of pycnometers. If a pycnometer, of approximately 25 ml. capacity, is cleaned well and filled with conductivity water and allowed to come to a constant temperature of 25 degrees in a bath kept at that temperature, it will contain an exact volume of the water. The time required for this equilibrium of temperature to be reached, is about one hour. The weight of the pycnometer, and contained water, is then obtained. If this same pycnometer is then cleaned and rinsed well with a certain concentration of KCl solution, filled and allowed to come to equilibrium temperature at 25 degrees, for the same length of time, the volume of the solution will be the same as obtained as in the case of the water. The weight of the pycnometer plus this volume of KCl solution is then obtained. Assuming that the weight of the pycnometer does not vary, which is the case, the weights obtained will be proportional to the densities of the water and KCl solution. By dividing the weight of the pycnometer and solution, by the weight of the pycnometer and conductivity water, a value is obtained which is density of the solution relative to the density of water. The density of water at 25 degrees is 0.9904 g./ml. (weights in vacuum) (Bulletin of Bureau of Standards Vol. 4, No. 4, Page 600, Table No. 19). To convert this density of water to terms of g./ ml. brass weights in air, it is necessary to multiply by 1.00106. This gives a value of 0.996066 for the density of water in g. / ml. brass weights in air. By multiplying the relative value of the density of the solution by the actual density of water at 25 degrees, the density of the solution is obtained in terms of g./ml. brass weights in air. If desired to interpret this value for the density of the solution in terms of g./ml. in vacuum the density, in terms of g./ml. brass weights in air, must be multiplied by 1.00106. A table of densities so determined is given on Page 13.

Determination of the Cell Constant:- Kraus and Parker (Kraus and Parker, J. Am. Chem. Soc. 44, 2422 - 1922), give data for the conductivity of 0.1 Normal KCl, at 25 degrees. "0.1 Normal KCl solution made by dissolving 7.455 g. KCl in one liter of solution." To transpose this weight to brass weights in air, it is necessary to divide by 1.00106, which

gives a value of 7.4474 g. KCL per liter of solution. As has been stated, the flask used contained 1000.12 ml. at 25 degrees. By multiplying 7.4474 by 1.00012, the value 7.4483 g. is obtained. Thus in order to make up this solution it was necessary to weigh 7.4483 g. KCL (brass weights in air), in order to have a 0.1 Normal KCL solution at 25 degrees. Nine solutions were so made, and three separate determinations of conductivity were made for each of the nine solutions. Kraus and Parker give a value of 0.0129014 for the specific conductance of that solution. If the conductance of the solution is calculated, which is the reciprocal ohms resistance of the cell, and divided into the specific oonductance, the cell constant is obtained. Taking the average of all determinations, the value of 0.5971 was accepted as the cell constant. Great care was taken in the handling of the cell, and it was assumed that the value 0.5971 did not change throughout the entire investigation.

<u>Conductance Measurements</u>:- The conductance of a solution, as is stated above, is the reciprocal ohms resistance of the solution. If a cell is inserted in a circuit, as is shown in Fig.1, Page 10 , and the slide wire adjusted so that minimum sound is heard

through the headphones, the unknown resistance of the cell is balanced by the outside resistance R. The cell resistance is then calculated by use of the formula;

$$X = R \times \frac{1000 - \text{Bridge Reading}}{\text{Bridge Reading}}.$$

To calculate the conductance of the solution, then it is necessary to divide this value of X into 1. In order to get the specific conductance of the solution, which is the conductance of 1 cc. of the solution, the value X must be multiplied by the cell Constant, K. The equivalent conductance of the solution is then determined by multiplying the specific conductance of the solution by the number of cubic centimeters which contain one equivalent. This value for 1.0 Normal KCl, is 1000.027, since there are that many ccs. in one liter. For each concentration below the 1.0x Normal, this must necessarily be taken into consideration.

In preparing the cell for conductance measurements, the cell was rinsed thoroughly, with the solution under investigation, three times. The electrodes were also rinsed with the same solution three times. The cell was then filled, and the electrodes carefully inserted. It was then placed in the constant temperature bath, kept at 25 degrees, and allowed to come to equilibrium at that temperature. This required about half an hour. After equilibrium was obtained, the measurements were taken. Measurements were taken for three five-minute

intervals, and the results tabulated. This was repeated twice, so that for each and every solution made up, there were three separate determinations of the conductivity. Calculating the specific and equivalent conductance for every reading of the bridge, and averaging them, gives the same result as averaging all the bridge readings and then calculating the specific and equivalent conductances. This latter method was the one used in determining the conductivity values found in Table 2, Page 20.

WIRING DIAGRAM

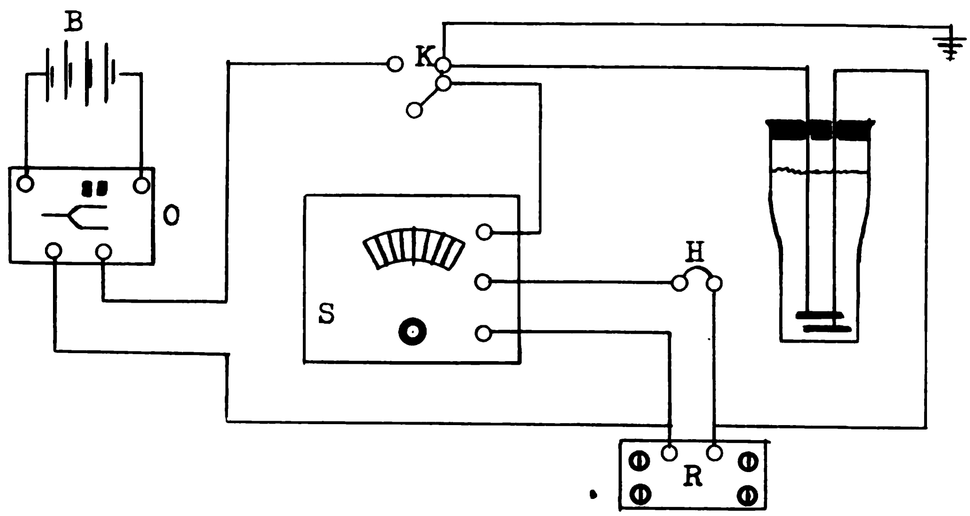

FIG. -1-

B - Battery.

O - Microphone hummer.

K - Key.

S - Slide wire, or bridge.

H - Headphones.

R - Outside resistance.

CONDUCTIVITY CELL

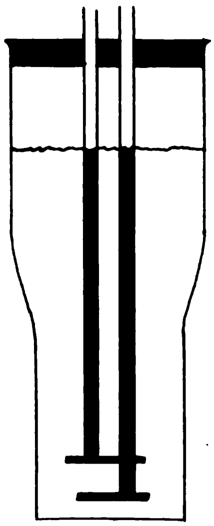

FIG. -2-

DETERMINATION OF CELL CONSTANT

0.1 Normal KCl solution. 7.455g. (vacuum)

per liter of solution.

Specific Conductivity - 0.0129014

Solution	R	Bridge	Ratio	X	L	-L	K
1	50	320	0.9305	46.525	0.02149	0.01290	0.6002
2	50	307	0.9257	46.285	0.02149	0.01290	0.5971
3	50	307	0.9257	46.285	0.02149	0.01290	0.5971
4	50	307	0.9257	46.285	0.02149	0.01290	0.5971
5	50	307	0.9257	46.285	0.02149	0.01290	0.5971
6	50	307	0.9257	46.285	0.02149	0.01290	0.5971
7	50	307	0.9257	46.285	0.02149	0.01290	0.5971
8	46	515	1.0061	46.281	0.02160	0.01290	0.5971
9	45	570	1.0285	46.283	0.02161	0.01290	0.5971
					Average		0.5971

R Outside resistance.

X Resistance of the cell.

L Conductance of solution.

$\bar{L}$ Specific Conductance of solution.

K Cell Constant.

The values tabulated are the result of three determinations of conductance of each solution.

DENSITY TABLE

Density of 1.0 Normal KCl Solution at 25 Degrees, C.

Table "A"- Densities as calculated from pycnometer determinations.

Table "B"- Densities as calculated from the weight of 1000.12 ml. of solution.

	-A-		-B-	
Soln.	(air)	(Vacuum)	(air)	(vacuum)
1	1.0271	1.0282		
	1.0272	1.0283		
	1.0271	1.0282		
	1.0271	1.0282		
Av.	1.0271	1.0282	1.0270	1.0281
11	1.0272	1.0283		
	1.0271	1.0282		
	1.0271	1.0282		
	1.0271	1.0282		
Av.	1.0271	1.0282	1.0270	1.0281
111	1.0272	1.0283		
	1.0271	1.0282		
	1.0271	1.0282		
	1.0271	1.0282		
Av.	1.0271	1.0282	1.0270	1.0281
Average	1.0271	1.0282	1.0270	1.0281

All values of densities are given in terms of grams per milliliter.

DENSITY TABLE

Density of 0.5 Normal KCl Solution at 25 Degrees, C.

Table "A" - Densities as calculated from Pycnometer Determinations.

Table "B" - Densities as calculated from the weight of 1000.12 ml. solution.

	-A-		-B-	
Soln.	(air)	(vacuum)	(air)	(vacuum)
1	1.0108	1.0119		
	1.0108	1.0119		
	1.0108	1.0119		
	1.0108	1.0119		
Av.	1.0108	1.0119	1.0103	1.0114
11	1.0110	1.0121		
	1.0110	1.0121		
	1.0110	1.0121		
	1.0111	1.0122		
Av.	1.0110	1.0121	1.0111	1.0122
111	1.0111	1.0122		
	1.0110	1.0121		
	1.0109	1.0119		
	1.0111	1.0122		
Av.	1.0111	1.0122	1.0110	1.0121
Average	1.0110	1.0121	1.0110	1.0121

All values for densities given in terms of grams per milliliter.

DENSITY TABLE

Density of 0.2 Normal KCl Solution at 25 Degrees, C.

Table "A" - Densities as calculated from pycnometer determinations.

Table "B" - Densities as calculated from the weight of 1000.12 ml. solution.

Solution	-A- (air)	-A- (vacuum)	-B- (air)	-B- (vacuum)
1	1.0024	1.0034		
	1.0024	1.0034		
	1.0024	1.0034		
	1.0024	1.0034		
Av.	1.0024	1.0034	1.0024	1.0034
11	1.0024	1.0034		
	1.0024	1.0034		
	1.0024	1.0034		
	1.0024	1.0034		
Av.	1.0024	1.0034	1.0024	1.0034
111	1.0024	1.0034		
	1.0024	1.0034		
	1.0024	1.0034		
	1.0024	1.0034		
Av.	1.0024	1.0034	1.0024	1.0034
AVERAGE	1.0024	1.0034	1.0024	1.0034

All values for densities given in terms of grams per milliliter.

DENSITY TABLE

Density of 0.1 Normal KCl Solution at 25 Degrees, C.

Table "A" - Densities as calculated from pycnometer determinations.

Table "B" - Densities as determined from the weight of 1000.12 ml. solution.

	-A-		-B-	
Solution	(air)	(vacuum)	(air)	(vacuum)
1	0.9992	1.0002		
	0.9992	1.002		
	0.9992	1.0002		
	0.9992	1.0002		
Av.	0.9992	1.0002	0.9991	1.0002
11	0.9989	1.9999		
	0.9991	1.0002		
	0.9992	1.0002		
	0.9991	1.0002		
Av.	0.9991	1.0002	0.9991	1.0002
111	0.9991	1.0002		
	0.9992	1.0002		
	0.9992	1.0002		
	0.9990	1.0000		
Av.	0.9991	1.0002	0.9991	1.0002
AVERAGE	0.9991	1.0002	0.9991	1.0002

All values for densities given in terms of grams per milliliter.

DENSITY TABLE

Density of 0.02 Normal KCl Solutions at 25 Degrees, C.

Table "A" - Densities as calculated from pycnometer determinations.

Table "B" - Densities as calculated from the weight of 1000.12 ml. of solution.

	-A-		-B-	
Solution	(air)	(vacuum)	(air)	(vacuum)
1	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
Av.	0.9967	0.9977	0.9966	0.9977
11	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
Av.	0.9967	0.9977	0.9967	0.9977
111	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
Av.	0.9967	0.9977	0.9967	0.9977
AVERAGE	0.9967	0.9977	0.9967	0.9977

All values for densities are in terms of grams per milliliter.

DENSITY TABLE

Density of 0.02 Normal KCl Solutions at 25 Degrees, C.

Table "A" - Densities as calculated from pycnometer determinations.

Table "B" - Densities as calculated from the weight of 1000.12 ml. of solution.

	-A-		-B-	
Solution	(air)	(vacuum)	(air)	(vacuum)
1	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
Av.	0.9967	0.9977	0.9966	0.9977
11	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
Av.	0.9967	0.9977	0.9967	0.9977
111	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
	0.9967	0.9977		
Av.	0.9967	0.9977	0.9967	0.9977
AVERAGE	0.9967	0.9977	0.9967	0.9977

All values for densities are in terms of grams per milliliter.

DENSITY TABLE

0.01 Normal KCl Solution - 25 Degrees, C.

Table "A" - Densities calculated from pycnometer determinations.

Table "B" - Densities calculated from the weight of 1000.12 ml. of solution.

Solution	-A- (air)	-A- (vacuum)	-B- (air)	-B- (vacuum)
1	0.9963	0.9974		
	0.9962	0.9973		
	0.9962	0.9973		
	0.9963	0.9974		
Av.	0.99625	0.99735	0.9964	0.9975
11	0.9962	0.9973		
	0.9962	0.9973		
	0.9963	0.9974		
	0.9963	0.9974		
Av.	0.99625	0.99735	0.9963	0.9974
111	0.9963	0.9974		
	0.9963	0.9974		
	0.9963	0.9974		
	0.9962	0.9973		
Av.	0.9963	0.9974	0.9963	0.9974
AVERAGE	0.9963	0.9974	0.9963	0.9974

All densities given in terms of grams per milliliter.

CONDUCTANCE TABLE

1.0 Normal KCl Solution - 25 Degrees, C.

74.4829 g. KCl/ liter of solution.(air wgts)

78.1932 g. KCl/ 1000g. water. (air weights.)

R - Outside Resistance.
Ratio - Bridge ratio.
X - Resistance of solution.
L - Conductance of solution.
$\bar{L}$ - Specific Conductance of solution.
Λ - Equivalent Conductance of solution.

Soln.	R	Bridge	Ratio	X	L	$\bar{L}$	Λ
1	5	742	1.1017	5.5085	0.1815	0.1084	108.4
11	5	740	1.1008	5.504	0.1817	0.1085	108.5
111	5	741	1.1013	5.5065	0.1816	0.1084	108.4
				Average		0.1084	108.4
1V	5	738	1.0999	5.4995	0.1818	0.1086	108.6
V	5	739	1.1004	5.502	0.1817	0.1085	108.5
				Average		0.1085	108.5

Solutions, 1, 11, 111, were made up volumetrically at 25 Degrees, C.

Solutions 1V, and V, were made up by weight, after determining weight of KCl per 1000 g. water.

The tabulated results are the averages of three determinations.

CONDUCTANCE TABLE

0.5 Normal KCl Solution - 25 Degrees, C.

37.2415 g. KCl/ liter of solution(air wghts.)

38.2432 g. KCl/ 1000g. water(air weights.)

R - Outside Resistance.
Ratio - Bridge Ratio.
X - Resistance of Solution.
$\underline{L}$ - Conductance of solution.
$\bar{L}$ - Specific Conductance of solution.
Λ - Equivalent Conductance of solution.

Soln.	R	Bridge	Ratio	X	L	$\bar{L}$	Λ
1	10	586	1.0351	10.351	0.0966	0.05769	115.4
11	10	591	1.0370	10.370	0.0964	0.0576	115.2
111	10	588	1.0358	10.358	0.0965	0.0577	115.3
					Average	0.0577	115.3
1V	10	588	1.0358	10.358	0.0965	0.0577	115.3
V	10	589	1.0362	10,362	0.965	0.0576	115.2
					Average	0.0576	115.3

Solutions 1, 11, and 111, were made up at 25 degrees, volumetrically.

Solutions 1V, and V, were made up by weight, after calculating weight of KCl per 1000 g. water.

The tabulated results are the averages of three determinations.

CONDUCTANCE TABLE

0.2 Normal KCl Solution - 25 Degrees, C.

14.8966 g. KCl/ liter of solution (air wgts.)

15.0852 g. KCl/ 1000g. water (air weights)

R - Outside Resistance.
Ratio - Bridge ratio.
X - Resistance of solution.
$\underline{L}$ - Conductance of solution.
$\bar{L}$ - Specific Conductance of solution.
Λ - Equivalent conductance of solution.

Soln.	R	Bridge	Ratio	X	L	$\bar{L}$	Λ
1	24	531	1.0125	24.3	0.0412	0.0246	122.9
11	24	529	1.0117	24.28	0.0412	0.0246	122.9
111	24	530	1.0121	24.29	0.0412	0.0246	122.9
				Average		0.0246	122.9
1V	24	529	1.0117	24.28	0.0412	0.0246	122.9
V	24	530	1.0121	24.29	0.0412	0.0246	122.9
				Average		0.0246	122.9

Solutions 1, 11, and 111 were made up volumetrically at 25 degrees, C.

Solutions 1V, and V, were made up by weight, after determining weight of KCl per 1000g. water.

The tabulated results are the averages of three determinations.

CONDUCTANCE TABLE

0.1 Normal KCl Solution - 25 Degrees, C.

7.4483 g. KCl/ liter of solution (air wgts.)

7.5107 g. KCl. 1000g. water (air weights).

R - Outside Resistance.
Ratio - Bridge Ratio.
X - Resistance of solution.
L - Conductance of solution.
$\bar{L}$ - Specific conductance of solution.
Λ - Equivalent conductance of solution.

Soln.	R	Bridge	Ratio	X	L	$\bar{L}$	Λ
1	45	579	1.0321	46.44	0.0215	0.01286	128.6
11	45	582	1.0333	46.50	0.0215	0.01286	128.6
111	45	580	1.0325	46.46	0.0215	0.01285	128.5
					Average	0.01285	128.6
1V	45	580	1.0325	46.46	0.0215	0.01285	128.5
V	45	580	1.0325	46.46	0.0215	0.01285	128.5
					Average	0.01285	128.5

Solutions 1, 11, and 111, were made up volumetrically at 25 degrees, C.

Solutions 1V, and V, were made up by weight, after determining weight of KCl/ 1000g. water.

The tabulated results are the averages of three determinations.

CONDUCTANCE TABLE

0.05 Normal KCL Solution - 25 Degrees C.

3.7242 g. KCL / liter of solution. (air wgts.)

3.7470 g. KCL / 1000 g. water (air wgts.)

R - Outside resistance.
Ratio - Bridge ratio.
X - Resistance of solution.
L - Conductance of solution.
$\bar{L}$ - Specific Conductance of Solution.
Λ - Equivalent Conductance of solution.

Soln.	R	Bridge	Ratio	X	L	$\bar{L}$	Λ
I	87	577	1.0313	89.72	0.0111	0.00665	133.1
II	87	577	1.0313	89.72	0.0111	0.00665	133.1
III	87	577	1.0313	89.72	0.0111	0.00665	133.1
				Average		0.00665	133.1
IV	87	579	1.0321	89.79	0.0111	0.00665	133.1
V	87	578	1.0317	89.76	0.0111	0.00665	133.1
				Average		0.00665	133.1

Solution I, II, and III were made up volumetrically at 25 degrees, C.

Solutions IV, and V, were made up by weight, after determining weight of KCL per 1000 g. water.

The tabulated results are the averages of three determinations.

CONDUCTANCE TABLE

0.02 Normal KCl Solution - 25 Degrees, C.

1.4897 g. KCl/ liter of solution (air wgts.)

1.4969 g. KCl/ 1000g. water (air weights)

R - Outside resistance.
Ratio - Bridge ratio.
X - Resistance of solution.
L - Conductance of solution.
$\bar{L}$ - Specific Conductance of solution.
Λ - Equivalent conductance of solution.

Soln.	R	Bridge	Ratio	X	L	$\bar{L}$	Λ
1	214	518	1.0073	215.6	0.0046	0.00277	138.5
11	214	519	1.0077	215.6	0.0046	0.00277	138.5
111	214	518	1.0073	215.6	0.0036	0.00277	138.5
				Average		0.00277	138.5
1V	214	516	1.0065	215.4	0.0046	0.00277	138.5
V	214	518	1.0073	215.6	0.0046	0.00277	138.5
				Average		0.00277	138.5

Solutions 1, 11, and 111 were made up volumetrically at 25 degrees, C.

Solutions 1V, and V, were made up by weight, after determining weight of KCl per 1000 g. water.

The tabulated results are the averages of three determinations.

CONDUCTANCE TABLE

0.01 Normal KCl Solution - 25 Degrees, C.

0.7448 g. KCl/liter of solution (air weights).

0.7522 g. KCl/1000 g. water (air weights).

R - Outside resistance.
Ratio - Bridge Ratio.
X - Resistance of solution.
L - Conductance of solution.
$\bar{L}$ - Specific conductance of solution.
Λ - Equivalent conductance of solution.

Soln.	R	Bridge	Ratio	X	L	$\bar{L}$	Λ
1	410	573	1.0293	422.013	0.0024	0.0014	141.5
II	410	571	1.0289	421.849	0.0024	0.0014	141.5
III	410	570	1.0285	421.685	0.0024	0.0014	141.5
				Average		1.0014	141.5
IV	410	571	1.0289	421.849	0.0024	0.0014	141.5
V	410	571	1.0289	421.849	0.0024	0.0014	141.5
				Average		0.0014	141.5

Solutions 1, II and III were made up at 25 degrees, C., volumetrically.

Solutions IV and V were made up by weight, after determining the density of the solution.

All tabulated results are the averages of three determinations.

Conc. (1)	Density - 25 deg.C. g./ml.(air)	Density - 25 deg.C. g./ml.(vac.)	g. KCl 1000g. water(air wts.)	Conc.(2)	$\bar{L}$	Λ
1.0 (n)	1.0271	1.0282	78.1927	1.0499(f)	0.1084	108.4
0.5	1.0110	1.0121	38.2432	0.5135	0.0577	115.3
0.2	1.0023	1.0034	15.0852	0.2026	0.0246	122.9
0.1	0.9991	1.0002	7.5107	0.1008	0.0129	128.6
0.05	0.9976	0.9987	3. 7470	0.0503	0.0067	133.1
0.02	0.9966	0.9977	1.4969	0.0210	0.0028	138.5
0.01	0.9963	0.9974	0.7522	0.0101	0.0014	141.5

(1) Concentration of solution, expressed in Normality.

(2) Concentration of solution, expressed in Formality.

$\bar{L}$ Specific Conductance of solution.
Λ Equivalent Conductance of solution.

DISCUSSION

The densities of the various solutions, of KCl in the Normal system, were determined accurately by two methods. It was found that the densities so determined checked very well.

It was found that 1 drop of water weighed 0.1206 g. By using a length of capillary tubing, the amount of water admitted to the vessel, was diminished. The average amount of water admitted, by means of the capillary, was found to be 0.0418 g. This is approximately the weight of a quarter of a drop. In making up a solution which will contain 500 g. of water, the error introduced by weighing is of the order of 0.008%, which is less than the error commonly made in making solutions up volumetrically.

Conductivity measurements served as a check on the density determinations. It may be seen, from the Conductance Tables, that these values checked.

SUMMARY

1. - The conductivity of solutions of KCl, in the normal system, has been measured.

2. - The densities of these same solutions have been determined.

3. - The weight of materials (brass weights in air), necessary to make these solutions, has been calculated.

4. - Solutions in the normal system have been made by weight, and the conductivity of them has been measured.