CONDUCTIVITY OF ELECTROLYTIC SOLUTIONS

References: See `References to Experiments'

Background:

Study the cited references carefully.

Know definitions of the following and their interrelations:

- cell constant
- specific conductance \( \kappa \), and specific resistance \( \rho \)
- equivalent conductance at a given concentration, \( \Lambda \) and at infinite dilution, \( \Lambda_0 \)
- dissociation constant \( K_a \) and degree of dissociation, \( \alpha \).

Know the principle of the Wheatstone-bridge.

Objectives:

Measurements of

1) the cell constant
2) the specific conductance of deionized (conductance) and tap water
3) the conductance of an electrolyte as a function of concentration for

   a) strong electrolyte: HCl or KNO₃
   b) weak electrolyte: succinic acid or acetic acid

Chemicals:

0.02 N KCl (specific conductance, \( \kappa \), at 25°C: 0.002767 ohm⁻¹cm⁻¹)
0.02 N HCl
succinic acid \((\text{HOOC})_2(\text{CH}_2)_4\) (Although it is a dibasic acid, it is considered a weak electrolyte with an ionization constant)
\( K_1 = 6.4 \times 10^{-5} \) at 25°C
Experiment II-7a

Physical Chemistry Laboratory

**Apparatus:**

- Conductance cell
- Beckman Conductivity Bridge
- Barnsted Water Purity Meter
- Deionizing Column

**Remarks on procedure:**

Satisfactory and reproducible results demand the utmost care and cleanliness in the preparation of solutions and their transfer. Glassware should be cleaned thoroughly with cleansing acid, rinsed repeatedly with tap water, distilled water and finally with conductance water. **Do not use organic solvents for drying,** use a drying oven.

The electrodes of the conductance cell must be immersed in conductance water whenever the cell is not in use. Never touch the electrodes.

All solutions should be prepared using conductance water.

In making conductivity measurements, allow the cell to remain in the constant temperature bath for at least fifteen minutes before balancing the bridge for the final reading.

**Procedure:**

A. Before making up solutions measure the specific conductance of the conductance water. (A special conductance cell of known cell constant and a Serfass Conductance Bridge should be used.) Obtain such a cell from the instructor. The specific conductance of conductance water should be $5 \times 10^{-6}$ ohm$^{-1}$cm$^{-1}$ or less. (This corresponds to a resistance of about 200,000 ohms in a cell of unit cell constant.)

B. Determine the cell constant of a conductivity cell using 0.02 N KCl.

C. By successive dilutions, prepare the following
solutions:

1) 0.01, 0.005, 0.0025, and 0.00125 N HCl from 0.02N HCl

2) M/32, M/64, M/128, M/256, M/512, and M/1024 solutions from M/16, (1/16) molar, succinic acid obtained by weighing the proper amount using an analytical balance and dissolve in conductance water using 100-ml volumetric flask.

D. Measurements: Measure the resistance of conductivity water in the special cell. Refill the cell and repeat.

Measure the resistance of distilled water and tap water in the cell used in B.

Measure the resistance of all HCl and succinic acid solutions in the cell from B. Use the Beckman Conductivity Bridge for all measurements unless the conductivity water exceeds the maximum resistance of the bridge. The figure is a sketch of the conductivity bridge.

Results and calculations:

1) Calculate the cell constant. Give the identification number of the cell used and the temperature.

2) Calculate the specific conductance of the conductivity, distilled and tap water.

3) Tabulate the calculated concentrations, square root of concentration, resistance, specific conductance, and equivalent conductance for each solution. In the case of the weak electrolyte, include in the table the degree of ionization and the ionization constant. For succinic acid use $\Lambda_o = 381 \text{ ohm}^{-1}\text{cm}^2\text{ equiv}^{-1}$.

4) Plot the equivalent conductance (ordinate) against the square root of concentration (abscissa).

5) By extrapolation, obtain the limiting equivalent
conductance of HCl.

6) Calculate the propagated error in the equivalent conductance of 0.005 N HCl solution.

7) Plot \( \frac{1}{\Lambda} \) (y) vs. \( \Lambda c \) (x) for succinic acid to obtain \( \Lambda_o \) and \( K_a \) from the linear equation (c is the molar concentration)

\[
\frac{1}{\Lambda} = \frac{1}{\Lambda_o} + \frac{\Lambda c}{K_a} (\Lambda_o)^2
\]

Compare these experimental values to those given in this description of the experiment.

8) Give an alternate method of determining the \( \Lambda_o \) of a weak electrolyte. Discuss briefly what measurements should be made and how such measurements are used to derive \( \Lambda_o \).