Variation of Conductance with Temperature in Electrolytes

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Certificate

This is to certify that **Eric Cartman**, student of Class XII A, **South Park Elementary School** has completed the project titled *Variation of Conductance with Temperature in Electrolytes* during the academic year 2008-2009 towards partial fulfillment of credit for the Chemistry practical evaluation of AISSCE 2009, and submitted satisfactory report, as compiled in the following pages, under my supervision.

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Acknowledgements

"There are times when silence speaks so much more loudly than words of praise to only as good as belittle a person, whose words do not express, but only put a veneer over true feelings, which are of gratitude at this point of time."

I would like to express my sincere gratitude to my chemistry mentor **Mrs Janet Garrison**, for her vital support, guidance and encouragement - without which this project would not have come forth. I would also like to express my gratitude to the staff of the Department of Chemistry at South Park Elementary for their support during the making of this project.

Aim

To find the variation of conductance with temperature in electrolytes

Apparatus

Glass beaker, $CuSO_4$ solution, Cu electrodes, $ZnSO_4$ solution, Zn electrodes, rheostat, battery eliminator, water, burner, thermometer, flask, ammeter, voltmeter

Important Terms

- **Conductance**: The property of ease of flow of electric current through a body is called conductance.

- **Resistance**: The obstacle offered to the flow of electric current is called resistance.

- **Electrolysis**: The operation in which electricity causes a chemical reaction is called electrolysis.

- **Ohm's Law**: This law states that the current flowing through a resistance is directly proportional to the potential difference applied across it's ends, at constant temperature and pressure.

$$V = I \times R$$

- **Faraday's Laws**:
  - First Law: The mass of a substance produced or consumed in electrolysis is directly proportional to the quantity of charge passing through it.

    $$m \propto Q$$
    $$\text{or, } m = Z \times I \times t$$

    where, Z is electrochemical equivalent; I is current; t is time in seconds; Q is charge.

  - Second Law: The mass of substance produced in electrolysis directly proportional to its equivalent mass.

    $$W1 / E1 = W2 / E2 = W3 / E3...$$

  - Third Law: The mass of a substance produced in electrolysis is directly proportional to the number of electrons per mole needed to cause desired change in oxidation state.

Conductivity

When voltage is applied to the electrodes immersed into an electrolyte solution, ions of electrolyte move, and thus, electric current flows through the electrolytic solution. The electrolytic solution and the metal conductors exhibit resistance to the passage of the current; both of which obey Ohm's law.

The reciprocal of resistance is called electrical conductance. The unit of electrical conductance is *Siemens (S)* or ohm-1 or mho.

If a solution is placed between two parallel electrodes having cross sectional area *A* and distance *L* apart then the resistance is given by

$$R = 1 / C$$

ρ (called '*rho*') is known as resistivity. Its reciprocal gives the conductivity of the solution, which is denoted by κ (called '*kappa*'). Its unit is *Siemens/meter*.

$$K = 1 / R * L / A$$

L / A is a fixed quantity for a cell and is called the 'cell constant'.

Factors Affecting Electrical Conductivity

The factors which affect the electrical conductivity of the solutions are:

- **Inter-ionic attraction**: It depends on solute- solute interactions.
- **Solvation of ions**: It depends on solute-solvent interactions.
- **Viscosity of the solvent**: It depends on solvent-solvent interactions.

Procedure

1. The electrolyte chosen is $ZnSO_4$ and the electrodes are of Zn.
2. Readings for the measurement of conductance are taken at intervals of 3 ☐C.
3. Proper precautions are taken to avoid evaporation and to keep other factors constant.
4. The vessel and electrodes are removed and the vessel is cleaned and filled with $ZnSO_4$ solution.
5. The electrodes are refitted in their original place so that the distance between them does not change.
6. Current is passed and when the voltmeter and ammeter show steady readings, they are noted.
7. The current is switched off.
8. It is seen that while the ammeter reading returns at once to 0 position. The voltmeter needle pauses for a while at a particular reading which is noted down.
9. This reading indicates the back EMF in the electrolyte.
10. Similarly, more sets of reading are taken, and resistance is calculated.
11. Thus, the value of conductance is calculated.
12. The switched on circuit readings in voltmeter and ammeter are taken.
13. The current through the electrolyte is changed by adjusting the rheostat and more sets of readings are taken.
14. Thus, the mean value of resistance is calculated.
15. Above steps are repeated for $CuSO_4$ as electrolyte with electrodes made of Cu.

Physical Constants

For the purpose of accuracy and convenience, some important aspects of the electrolyte process are kept constant in the experiment as their variation might affect the conductivity of the electrolyte. They are:

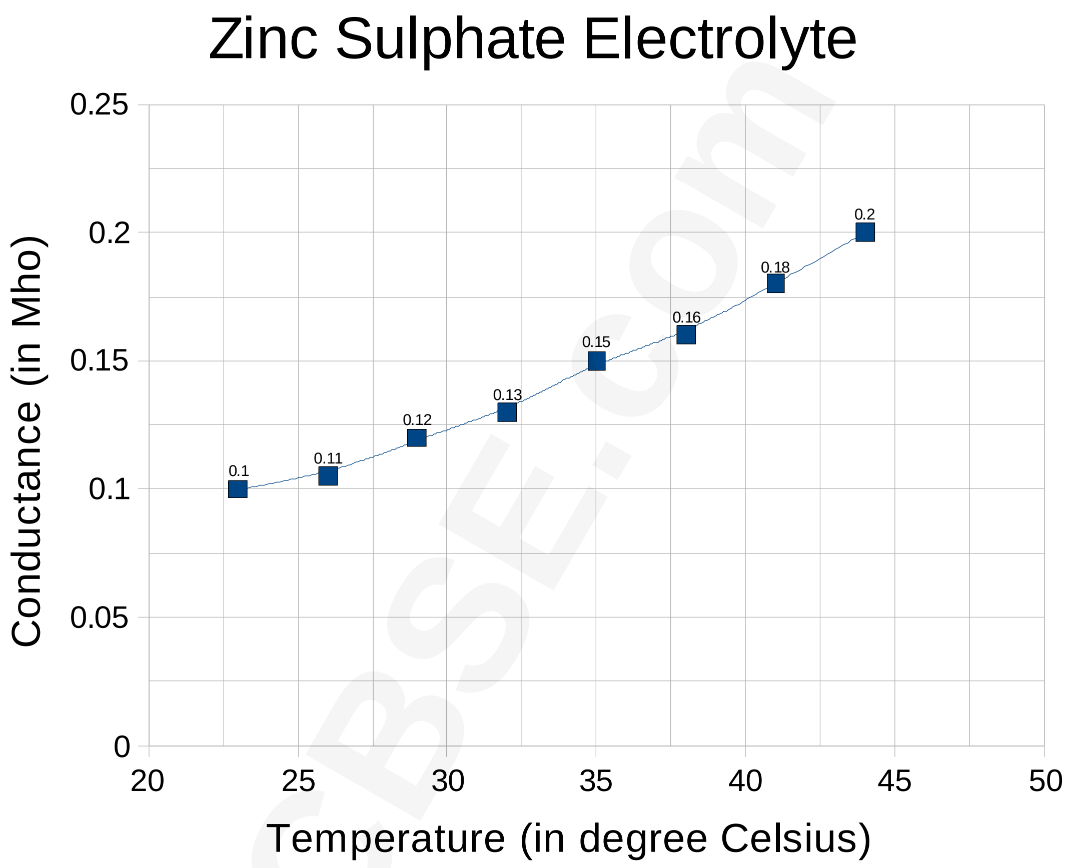
- Voltage
- Nature of electrodes
- Size of electrodes
- Separation between the electrodes
- Concentration of the electrolytes
- Nature of the electrolytes
- Resistance in the circuit

Observation Set 1

For $ZnSO_4$ electrolyte with Zn electrodes

S No	Temperature	Reading of Ammeter *I*	Reading of Voltmeter *V*	Resistance *R = V / I*	Conductance *C = 1 / R*
1	23 □C	100 mA	1.0 V	10 Ω	0.100 Ω^{-1}
2	26 □C	100 mA	0.95 V	9.5 Ω	0.105 Ω^{-1}
3	29 □C	110 mA	0.89 V	8.09 Ω	0.120 Ω^{-1}
4	32 □C	110 mA	0.84 V	7.63 Ω	0.130 Ω^{-1}
5	35 □C	120 mA	0.80 V	6.66 Ω	0.150 Ω^{-1}
6	38 □C	125 mA	0.75 V	6.00 Ω	0.160 Ω^{-1}
7	41 □C	130 mA	0.71 V	7.6 Ω	0.180 Ω^{-1}
8	44 □C	130 mA	0.65 V	5.00 Ω	0.200 Ω^{-1}

Graph of Observation Set 1

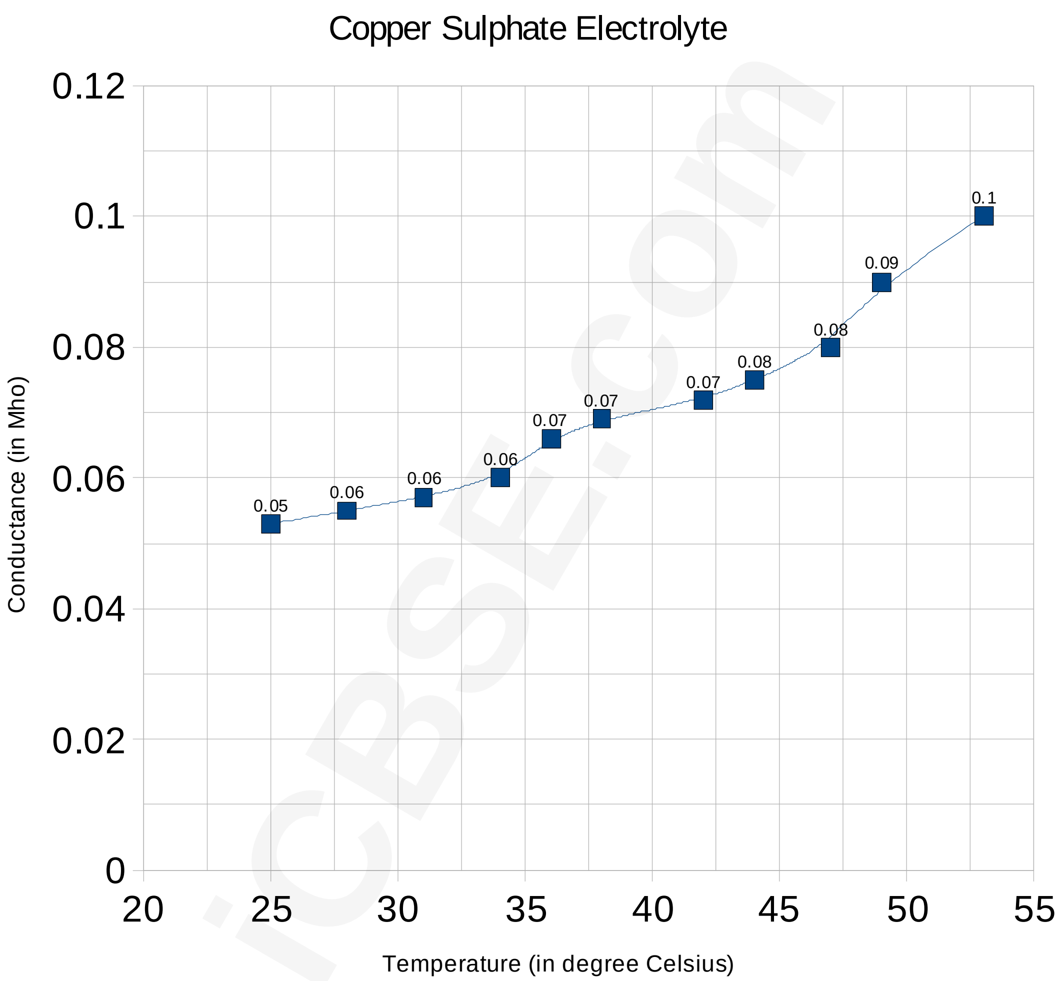


Observation Set 2

For $CuSO_4$ electrolyte

S No	Temperature	Reading of Ammeter *I*	Reading of Voltmeter *V*	Resistance *R = V / I*	Conductance *C = 1/R*
1	25 ☐C	75 mA	1.4 V	18.67 Ω	0.053 Ω^{-1}
2	28 ☐C	75 mA	1.35 V	18.00 Ω	0.055 Ω^{-1}
3	31 ☐C	75 mA	1.3 V	17.33 Ω	0.057 Ω^{-1}
4	34 ☐C	75 mA	1.25 V	16.67 Ω	0.060 Ω^{-1}
5	36 ☐C	80 mA	1.2 V	15.00 Ω	0.066 Ω^{-1}
6	38 ☐C	80 mA	1.15 V	14.38 Ω	0.069 Ω^{-1}
7	42 ☐C	80 mA	1.10 V	13.75 Ω	0.072 Ω^{-1}
8	44 ☐C	85 mA	1.10 V	12.94 Ω	0.075 Ω^{-1}
9	47 ☐C	85 mA	1.05 V	12.35 Ω	0.080 Ω^{-1}
10	49 ☐C	90 mA	1.10 V	11.11 Ω	0.090 Ω^{-1}
11	53 °C	90 mA	1.90 V	10.00 Ω	0.100 Ω^{-1}

Graph of Observation Set 2



Result

The relevant graph shows that the *1 / Resistance* of an electrolyte increases at a steady rate as the temperature increases.

Conclusion

On heating a solution, it is known that viscosity gradually decreases, with decrease in viscosity, the speed and movement of the ions increases. In other words, the conductance of the electrolyte increases with increases in temperature. Hence, the result of the experiment agrees with reasoning.

Precautions

- Variation of resistance due to one of the factors should be kept constant.
- The electrodes used in each case should always be kept parallel to each other.
- The solution should be kept undisturbed throughout the experiment.
- For each observation, three readings are taken and the mean value is considered.

Bibliography

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