

Svante Arrhenius and the theory of electrolytic and non-electrolytic dissociation

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Svante Arrhenius

Svante August Arrhenius (19 February 1859 – 2 October 1927) was a Swedish Scientist, originally a physicist, but often referred to as a chemist, and one of the founders of the science of physical chemistry. The Arrhenius equation, lunar crater Arrhenius and the Arrhenius Labs at Stockholm University are named after him.

Svante Arrhenius was one of several leading Swedish scientists actively engaged in the process leading to the creation in 1922 of The State Institute for Racial Biology in Uppsala, Sweden, which had originally been proposed as a Nobel Institute. Arrhenius was a member of the institute's board, as he had been in The Swedish Society for Racial Hygiene (Eugenics), founded in 1909.

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Arrhenius Theory of Electrolytic dissociation

In order to explain the properties of electrolytic solutions, Arrhenius put forth, in 1884, a comprehensive theory which is known as theory of electrolytic dissociation or ionic theory. The main points of the theory are:

- *An electrolyte, when dissolved in water, breaks up into two types of charged particles, one carrying a positive charge and the other a negative charge. These charged particles are called ions. Positively charged ions are termed cations and negatively charged as anions.*

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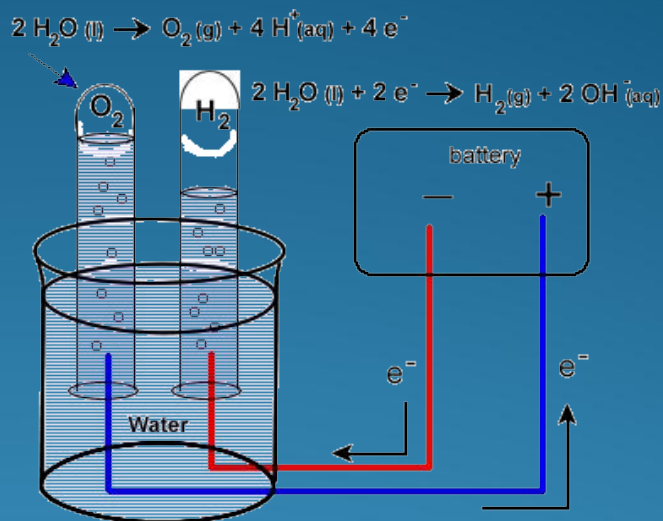
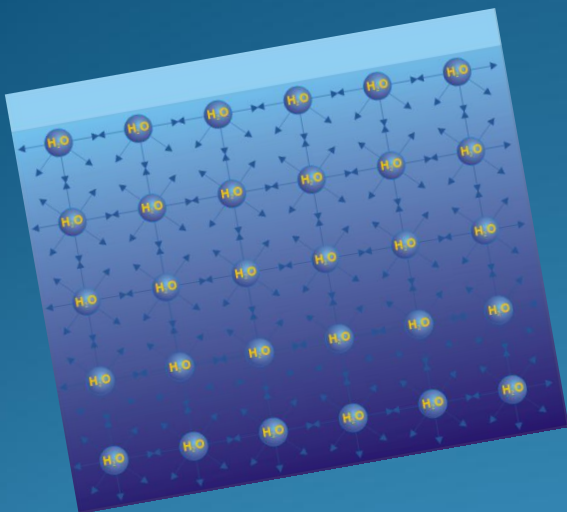
In its modern form, the theory assumes that solid electrolytes are composed of ions which are held together by electrostatic forces of attraction. When an electrolyte is dissolved in a solvent, these forces are weakened and the electrolyte undergoes dissociation into ions. The ions are solvated.



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● The process of splitting of the molecules into ions of an electrolyte is called ionization. The fraction of the total number of molecules present in solution as ions is known as degree of ionization or degree of dissociation. It is denoted by

$$\alpha = \frac{\text{Number of molecules dissociated into ions}}{\text{Total number of molecules}}$$

It has been observed that all electrolytes do not ionize to the same extent. Some are almost completely ionized while others are feebly ionized. The degree of ionization depends on a number of factors

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Applying the law of mass action to above equilibrium

- *Ions present in solution constantly re-unite to form neutral molecules and, thus, there is a state of dynamic equilibrium between the ionized and non-ionised molecules.*

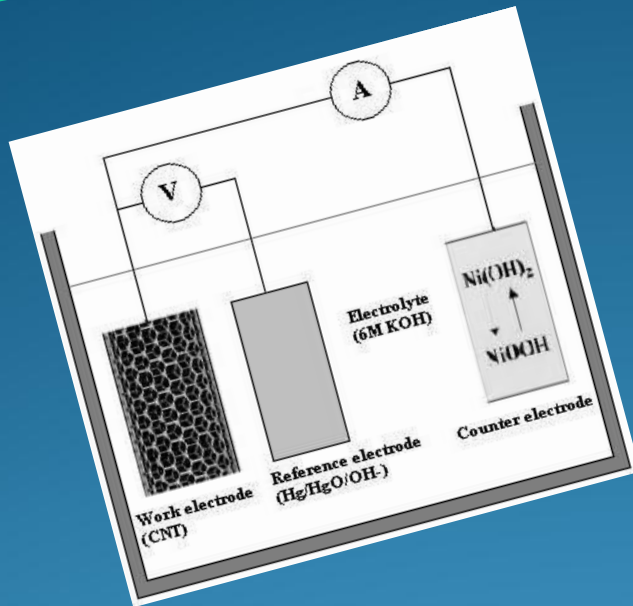
$$[A^+][B^-] / [AB] = K$$

K is known as ionization constant. The electrolytes having high value of K are termed strong electrolytes and those having low value of K as weak electrolytes

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- *When an electric current is passed through the electrolytic solution, the positive ions (cations) move towards cathode and the negative ions (anions) move towards anode and get discharged, i.e., electrolysis occurs.*

The ions are discharged always in equivalent amounts, no matter what their relative speeds are.

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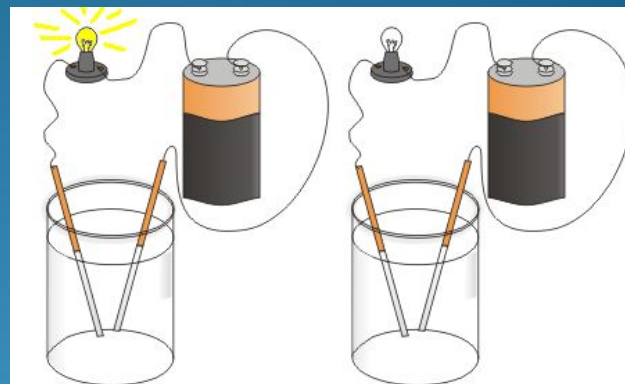
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Determination of the electrical conductivity of substances.

Determination of the electrical conductivity of substances. Distilled water, crystalline substances sodium chloride, copper sulphate, sugar or their aqueous solutions and diluted hydrochloric acid are consecutively put in beaker taking care that the graphite rods are well immersed in the samples.

When distilled water, crystalline substances NaCl, CuSO and sugar or sugar solution are examined the bulb does not light up. Therefore no current passes because there are no electrically charged particles. The lamp begins to burn if the electrodes are immersed in aqueous solutions of NaCl, CuSO and HCl. This means that the electric circuit is closed.



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Result of the experiments.

Tested substances			
NaCl	_____	solid	The lamp does not light up
CuSO ₄	_____	solid	The lamp does not light up
Sugar	_____	solid	The lamp does not light up
H ₂ O	_____	distilled water	The lamp does not light up
NaCl	_____	aqueous solution	The lamp lights up
CuSO ₄	_____	aqueous solution	The lamp lights up
HCl	_____	aqueous solution	The lamp lights up
Sugar	_____	aqueous solution	The lamp does not light up

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Changes in ionic substances in an aqueous solution or in a melt.

Sodium chloride crystals dissolve in water. This happens because of the electrostatic forces of attraction between Na^+ of the crystal lattice and the negative poles of the water molecules and between Cl^- and the positive poles of the water molecules. The result is that the sodium and chloride ions are detached from the crystal lattice and dissolve in the water. Aqueous solutions containing sodium and chloride ions are obtained. Such ions are called hydrated ions. They move randomly. Freely moving ions are released from disintegrating crystal lattice under the action of the polar water molecules in the process of dissolution.

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Changes in the substances with polar molecules upon dissolution.

The following changes take place on the dissolution in water of the polar hydrogen chloride molecules. Some water molecules orient their negative poles around the positive ones of the molecules of the hydrogen chloride, while other molecules direct orient their negative poles of the hydrogen chloride molecules. The result of this electrostatic interaction is that ions are formed.



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Electrolytes and non-electrolytes

- The electrolytic dissociation is observed only with substances having ionic crystal structure or strongly polar bonds. The aqueous solutions of these substance and the melts of the ionic compounds conduct electricity. They are called electrolytes. Acids, bases and salts re electrolytes.
- The substances with slightly polarized bonds or with non-polar bonds do not turn into ions in solution or in a melt. They do not conduct electric current and are termed non electrolytes.

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