Principles of Electro-Chemical Analysis

Analytical Chemistry or Chemical Analysis is the Part of Chemistry, which finds out ("determines") the Composition of substances.

Electro-Chemical Analysis uses Sensors, which deliver an electrical signal. The value of this signal is related to the quantity of a certain component within the substance, which is analysed ("Sample").

Our sensors and instruments determine components within liquid samples and samples with a liquid content (Meat, Fruits, Cheese, Plant tissue, Soil, Toothpaste, etc.).

- **Water**: Drinking Water, Surface Water (Lakes, Rivers), Wastewater, etc.
- **Beverages**: Beer, Wine, Fruit juices, Milk, etc.
- **Body liquids**: Saliva, Blood, Urine, Sweat, etc.
- **Food**: Fruits, Vegetables, Baby food, Meat, Cheese, Fish, etc.
- **Cosmetics**: Shampoo, Toothpaste, Lotions, Creams, etc.
- **Environmental Samples**: Water, Plants, Fruits, etc.
- **Pharmaceuticals**: Drugs, Herbals, etc.
- **Industrial**: Plating baths, chemicals, Acids, etc.

Most of the Samples are "Aqueous Solutions", that means Substances "dissolved" in water. These substances can be:

- **Salts**: NaCl (Table salt), CuSO4 (Copper sulphate), etc.
- **Acids**: HCl (Hydrochloric acid), H2SO4 (Sulphuric acid), etc.
- **Alkalines**: NaOH (Caustic Soda), NH4 (Ammonium), etc.
- **Gases**: O2 (Oxygen), Cl2 (Chlorine), NH3 (Ammonia), etc.

When substances dissolve in water another process takes place: many of the substances "dissociate", that means they split up in their ionic components.

For example when NaCl (Table salt) is dissolved in water, it splits up in a positive Ion Na+ and a negative Ion Cl-, or CuSO4 splits up in a bivalent, positive Cu+2 Ion and a bivalent negative SO4-2 Ion

Ions are "charged particles", that means they carry a positive or negative electric charge. They can carry a single charge unit (monovalent ions), a double charge (bivalent ions) or more charges.

Negative charged electrons carry electricity in metals or semiconductors; electricity in liquids is carried by positive or negative charged ions.

Usually multiple ions are present within a solution. It is important to determine (measure) the Concentration of one or more ions in a solution. The concentration can be expressed in various units:

- ppm (wt / vol) which means parts per million (weight in volume). That can be mg / L (milligram per litre) or µg / ccm.
- ppb which means parts per billion
- molarity, which means mol per litre. This is a unit used by chemists.

For the determination of a specific ion in a solution (or more precise expressed "the concentration of a specific ion in a solution"), an Ion-selective electrode (ISE) is a very useful tool.

An Electrode is an electrochemical sensor, which is immersed in a solution and delivers an electrical signal.

ISEs are available for various ions, for example the Potassium ISE delivers an mV (millivolt) signal, which is over a wide concentration range proportional to the logarithm of the Potassium concentration in the solution.

The function of an ion-selective electrode is based on Membrane Technology. A membrane is a component, which separates in this case two liquids with the special feature that the difference of the electrical potential (voltage in mV) on both sides of the membrane is related to the difference of the concentration of a specific ion on both sides of the membrane.

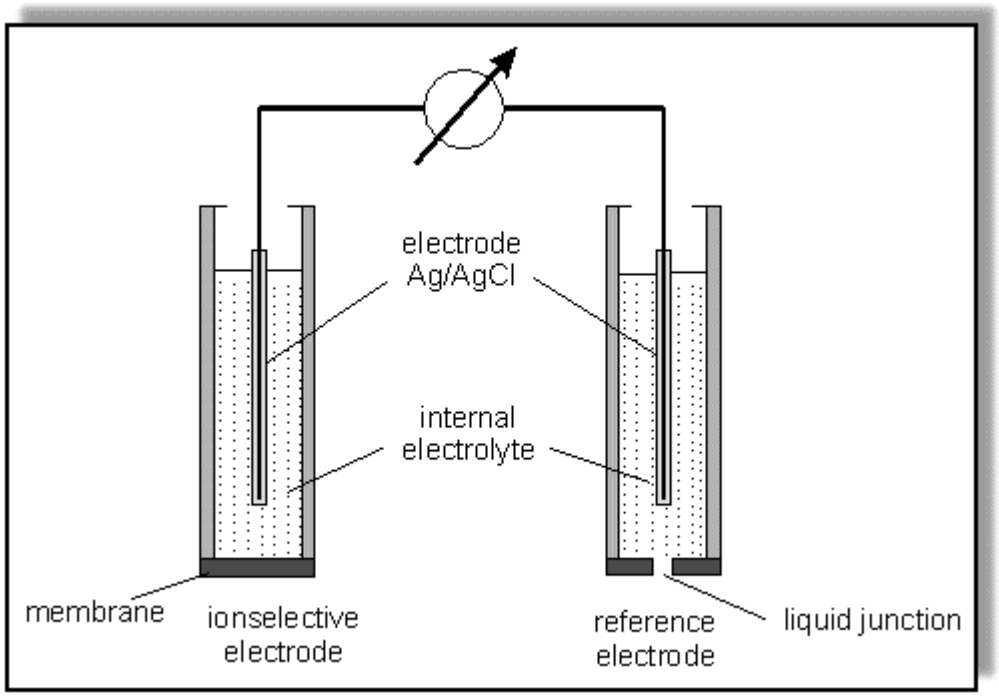
To measure the potential on both sides of the membrane, it is necessary to have an arrangement of electrodes as shown in the figure below. There are 2 electrodes, which are immersed in the sample: the ion-selective electrode and the Reference electrode.

Both electrodes are filled with a high concentrated solution (electrolyte) and two inner electrodes provide the connection to the measuring instrument (Ion meter).

While in case of the ISE the membrane separates the sample from the electrolyte, the electrolyte of the reference electrode is in direct contact with the sample via a so-called "Liquid junction".

The liquid junction has the function to provide a direct electrical contact of the liquids on both sides of the liquid junction, but prevents a fast mixing of the two liquids.

There are various types of liquid junctions: Capillaries (a hole with a very small diameter compared to the length of the hole), or small pieces of porous ceramic (this is the most common type)



The sample above demonstrates the principles of electro-analytical measurements.

It has to be mentioned that chemical processes are temperature dependent. Chemical processes run faster with higher temperatures. That means that higher temperatures create higher electrical signals.

Precise electro-analytical measurements have to be combined with a precise temperature measurement.