Minerals and salts consist of positive ions (cations) and negative ions (anions). For instance, the chemical formula for table salt is sodium chloride (NaCl). Sodium is the cation (Na^+) and chloride is the anion (Cl^-). In normal solutions both positive and negative ions exist in equal proportions to ensure electrical neutrality. Pure water, H_2O, also consists of equal amounts of hydrogen cations (H^+) and hydroxyl anions (OH^-).

In certain critical applications like superconductor wafers and scientific glassware manufacturing it is important to use absolutely pure water (H_2O) with no dissolved minerals whatsoever. In such cases deionization (DI) is used to remove all cations and anions from water. The process does not remove bacteria and organic contaminants, and DI is commonly used after water pretreatment.

The DI process has two stages: the first stage removes all positive cations from the water and exchanges them with hydrogen ions (H^+). The process is similar in principle to ion exchange in water softeners, yet hydrogen ions are added instead of sodium. As the water passes through the first stage, all positive ions are completely replaced with (H^+) while negative ions remain.

Water then enters the second stage of deionization, where all the negative ions are replaced with OH^- ions, thereby maintaining electric neutrality. By the time water completes the second stage, all the positive and negative ions are replaced with (H^+) and (OH^-), the very ions that comprise water!

DI results in pure water that is very reactive and not suitable for drinking. It is kept in contained environments to avoid exposure to air or other chemicals.

Pure deionized water is used in critical applications like silicon wafers.