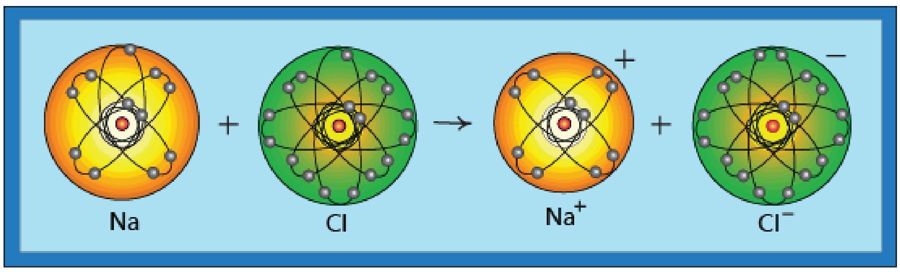
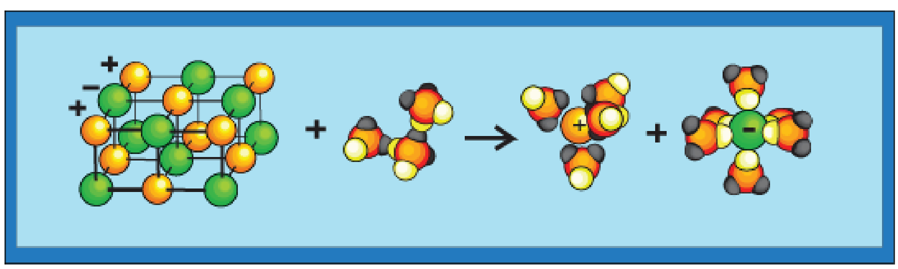
Ions and Surface Charge

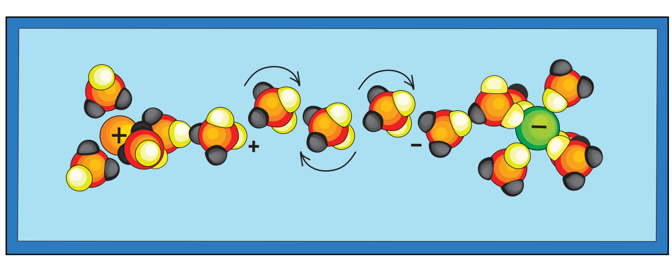
However, surface charge is another property which is extremely important for assembly and function. For example, the insulin molecule is charged positively on its upper surface with a negative charge on the lower tip. The receptor site which binds it has a net positive charge to attract the insulin molecule into it in the correct orientation and then bind it firmly in the site. But single atoms have charge as well. When sodium atoms come in contact with chlorine atoms, the lone electron on sodium moves into the open orbital of chlorine to form a pair – the sodium atom becomes a positively charged **Sodium Ion**; the chlorine becomes a negatively charged **Chlorine Ion**.



In the solid crystalline form, sodium and chloride ions are in a ridged lattice but, as they dissolve in water, both ions become surrounded by water molecules to delocalize and stabilize the charge.

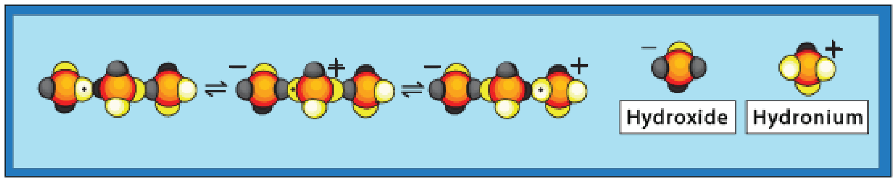


In this way, surrounding water molecules accept part of the positive charge of the sodium ion and those around the chloride ion, part of its negative charge.[32] In fact, small ions like sodium tightly bind four or six water molecules around them and have several additional layers of water molecules more loosely bond in a spherical form.[32] Even though these hydrating water molecules accept a portion of the charge, central charges are so strong that they continually draw a finite number of spinning, polarized water molecules between them.

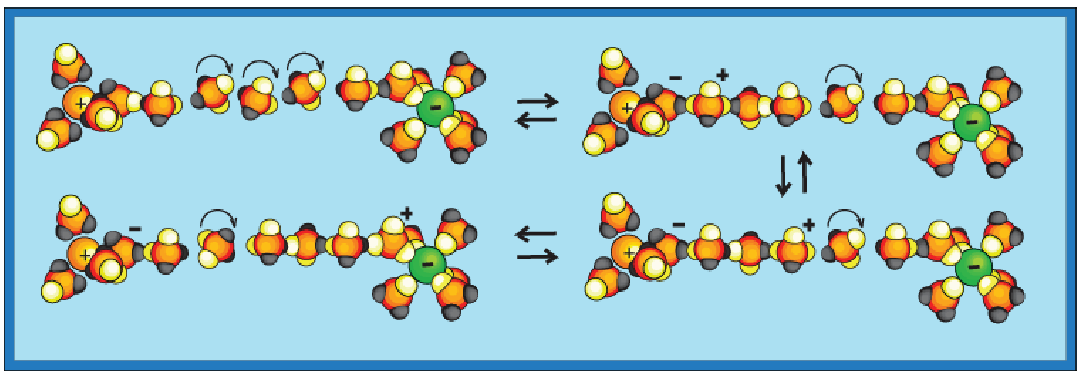


If the ions are far apart, water molecules between them simply orient their spins to help neutralize the charge. However, opposite charges on the ions continually draw them together and water molecules within hydrogen-bonding distances. When this happens, a unique type of **Charge-Transfer Reaction** occurs.[33]

Charge Transfer



In trimers, the small positively-charged proton nucleus of a hydrogen atom on one water molecule moves into the electron pair lobe of the adjacent molecule. This converts the acceptor molecule into a positively-charged **Hydronium Ion** and leaves the donor as a negatively-charged **Hydroxide Ion**. In pure water, only about one in a million (10^{-7}) molecules undergoes this spontaneous **Ionization Reaction** at any instant, but in water containing ions like sodium and chloride, it is another mechanism by which the charge potentials on ions and molecules are minimized and partly neutralized.[33]



By transferring protons from one hydrogen-bonded water molecule to the next, in cascade fashion, water molecules bound to each ion can assume an opposite charge and provide even broader neutralization of charge. Although the process appears complex, proton pulses resonate as quantized waves back and forth between the ions. By the above mechanisms, about 90% of the charge on an ion is transferred to water.[33]

It is important to point out that potassium ion and other large ions, produce entirely different effects on surrounding water. With a larger number of electrons around their central positively-charged core, they do not bind water molecules in spherical forms - they move rapidly through water and simply alter the rotation of water molecules as they pass - they increase the mobility and randomness of water rather than binding and decreasing it like sodium ions.[32] This difference in the effect of these two ions on local water is critical to the function of cells. A detailed description of the role of these two ions in nerve and muscle cells will be included in the Evolution Section.

Since ionization in pure water is extremely low, pure water is an insulator - but sea water, like water within cells, is a good conductor because it contains about 3% sodium chloride. At low external voltages, current is carried through salt water primarily by the ions but, if the voltage is high enough, water molecules align between the ions and pulses are transferred like lightning bolts by protons cascading through polarized linear segments of water molecules from one ionic center to the next. In the axons of nerve cells, this transfer of protonic charge along the inner surfaces of the membranes permits extremely rapid, almost superconductive, transfer of charge.[21]