11.9: Strong Acids and Bases

The most straight-forward examples involving acids and bases deal with *strong* acids and bases. **Strong acids**, like HCl or HNO_3, are such good proton donors that none of their own molecules can remain in aqueous solution. All HCl molecules, for example, transfer their protons to H_2O molecules, and so the solution contains only $H_3O^+(aq)$ and $Cl^-(aq)$ ions. Similarly, the ions of **strong bases**, like BaO or NaH, are such good proton acceptors that they cannot remain in aqueous solution. All O^{2-} ions, for example, are converted to OH^- ions by accepting protons from H_2O molecules, and the H_2O molecules are also converted to OH^-. Therefore a solution of BaO contains only $Ba^{2+}(aq)$ and $OH^-(aq)$ ions.

Table 11.9.1 lists molecules and ions which act as strong acids and bases in aqueous solution. In addition to those which react completely with H_2O to form H_3O^+ and OH^-, any compound which itself contains these ions will serve as a strong acid or base. Note that the strength of an acid refers only to its ability to donate protons to H_2O molecules and the strength of a base to its ability to accept protons from H_2O molecules. The acidity or basicity of a solution, on the other hand, depends on the concentration as well as the strength of the dissolved acid or base.

TABLE 11.9.1 Species Which Are Strong Acids and Bases in Aqueous Solution.

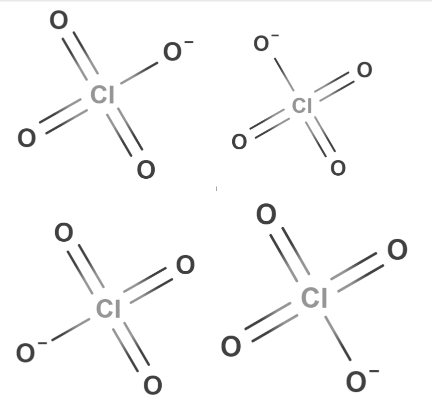
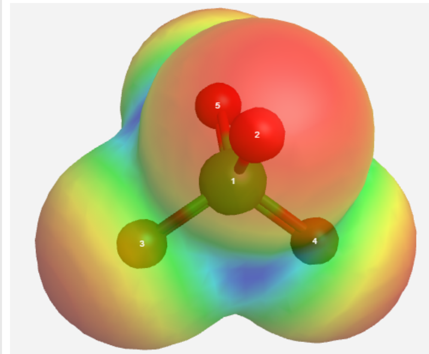
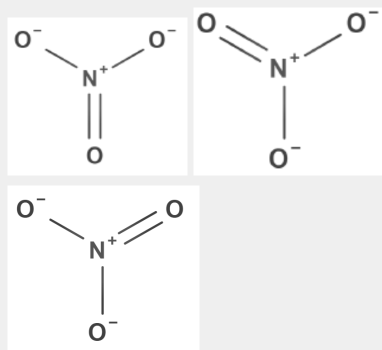
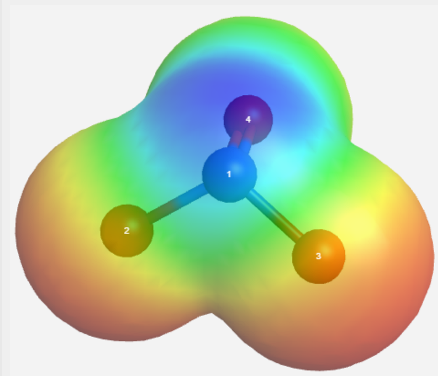
Strong Acids	Strong Bases
H_3O^+ (Only a few compounds like H_3OCl and H_3ONO_3 are known to contain hydronium ions.)	OH^- [Only LiOH, NaOH, KOH, RbOH, CsOH, $Ca(OH)_2$, $Sr(OH)_2$ and $Ba(OH)_2$ are sufficiently soluble to produce large concentrations of OH^-(aq).]
HCl, HBr, HI $HClO_4$	O^{2-} (Li_2O, Na_2O, K_2O, Rb_2O, Cs_2O, CaO, SrO, and BaO are soluble
HNO_3, H_2SO_4, $HClO_3$	H^-, S^{2-}, NH_2^-, N^{3-}, P^{3-}

Notice that the cations of the strong bases are also soluble in water, as seen in the table from 11.2 on solubility rules. For example, all the Group 1 cations form strong bases and all Group 1 cations are soluble in water. Therefore, you can use your prior understanding of solubility rules to guide your understanding of strong bases. As a general rules, if a cation is soluble in water, it can form a strong base.

As a general rule, strong proton donors are molecules in which a hydrogen is attached to a rather electronegative atom, such as oxygen or a halogen. Considerable electron density is shifted away from hydrogen in such a molecule, making it possible for hydrogen ions to depart without taking along any electrons. The strong acids in Table 11.9.1 fit this rule nicely. They are either hydrogen halides (HCl, HBr, HI) or oxyacids (whose general formula is H_nXO_m).

Below are the resonance structures for oxoacids after they donate a proton. The reason for the strength of the following acids is the stability of the anion, which is shown by the number of resonance structures and the distribution of the negative charge amongst all of the oxygen atoms. The distribution of the negative charge can be visualized in the 3D structure, with red being representing negative charge and blue representing positive charge. The 3D structure represents the average of the resonance structures shown to the left.

Name	Lewis Structure (Resonance)	3D Structure

Name	Lewis Structure (Resonance)	3D Structure
Perchloric Acid		
Nitric Acid		

The Lewis structures indicate a proton bonded to oxygen in each of the oxyacids, hence their general name. Note that for a strong oxyacid the number of oxygens is always larger by two or more than the number of hydrogens. That is, in the general formula H_nXO_m, $m \geq n + 2$.

The strength of a base depends on its ability to attract and hold a proton. Therefore bases often have negative charges, and they invariably have at least one lone pair of electrons which can form a coordinate covalent bond to a proton. The strong bases in Table 1 might be thought of as being derived from neutral molecules by successive removal of protons. For example, OH^- can be obtained by removing H^+ from H_2O, and O^{2-} can be obtained by removing H^+ from OH^-. When the strong bases are considered this way, it is not surprising that they are good proton acceptors.