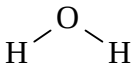
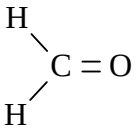
CHEM 0094 **MOLECULAR AND IONIC COMPOUNDS**

All compounds are either **molecular** or **ionic**. A molecular compound consists of **molecules** whose formula represents the actual number of atoms **bonded** together in the molecule. The atoms are joined to give a definite **shape** which is defined by the angles between the bonds and by the bond lengths. Some examples are shown below.

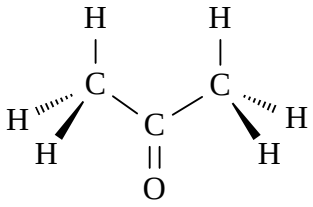


water (H_2O)

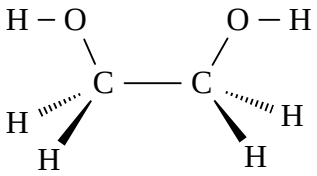
carbon dioxide (CO_2)



formaldehyde (CH_2O)



acetone (C_3H_6O)



ethylene glycol ($C_2H_6O_2$)

Ionic compounds exist as aggregations of **ions** such that the total charge on the positive ions (**cations**) is equal to the total charge on the negative ions (**anions**). The formula of an ionic compound is the simplest whole number ratio of the cations and anions. For example, a sodium chloride (NaCl) crystal contains billions of Na^+ ions and Cl^- ions in a 1:1 ratio. Each Na^+ ion is surrounded by *six* Cl^- ions and each Cl^- ion is surrounded by *six* Na^+ ions. Hence, no Cl^- ion *belongs* to any Na^+ ion and *vice versa*. In calcium chloride ($CaCl_2$), there are *two* Cl^- ions for each Ca^{2+} ion. **Notice that for ethylene glycol (above) the formula is $C_2H_6O_2$ and <u>not</u> CH_3O (the simplest ratio of C, H and O atoms)**.

NaCl and $CaCl_2$ contain only **monatomic** ions (ions derived from single atoms) but many ionic compounds contain **polyatomic** ions (ions containing two or more atoms bonded together). Examples are $CaCO_3$ (Ca^{2+} and CO_3^{2-} ions) and NaOH (Na^+ and OH^- ions).

Because of the strong attraction between cations and anions, a lot of energy is needed to separate anions from cations and hence ionic compounds are all *solids with high melting points*. However, the forces of attraction *between* molecules are much smaller and molecular compounds are *gases, liquids or solids with low melting points.*

Metals tend to form cations and hence most ionic compounds contain a metal. Exceptions are compounds of Sn and Pb with *four* halogen atoms. Thus, $SnCl_4$ and $PbCl_4$ (both liquids) are molecular compounds. Most compounds *without* a metal are molecular. Exceptions are compounds containing the ammonium ion (NH_4^+). Thus, NH_4Cl and $(NH_4)_2SO_4$ (both solids) are ionic compounds.