Chemistry 201

Ionic solutes

NC State University

Dissociation of ionic solutes

Ionic solutes dissociate in water. Therefore, the molality must be calculated based on the total number of ions. In the simplest case of a monovalent cation and anion, there are two equivalents of solute for each mole of salt dissolved. Examples of this are NaCl, KCl, CsCl, NaBr, NH_4OH and so on. Rather than create a new formula (as Wertz does in the book) we can simply keep track of a dissociation number for calculation of the colligative properties.

Dissociation of equivalent solutes

Thus, in the case of monovalent salt,

$$m_{solute} = m_{Na^+} + m_{Cl^-}$$

which means that

$$m_{solute} = 2\, m_{NaCl}$$

The same relationship holds for divalent salts, in which both ions have the same charge. Examples include $CaSO_4$, $CaCO_3$, $MgSO_4$, $CuSO_4$, and so on. In each of these cases

$$m_{solute} = 2\, m_{MX}$$

Dissociation of solutes in water

For salts containing two monovalent and one divalent ion the dissociation of one mole of salt leads to three equivalents in solution. Salts such as Na_2SO_4, Na_2CO_3, K_2SO_4, $(NH_4)_2SO_4$, and so on have two cations for each anion.

$$m_{solute} = 2\, m_{M^+} + m_{X^{2-}}$$

Therefore,

$$m_{solute} = 3\, m_{MX}$$

for these ions. The same holds for salts such as $CaCl_2$, $MgCl_2$, $Ca(NO_3)_2$ and so on.

Dissociation of solutes in water

For salts containing three monovalent and one trivalent ion the dissociation of one mole of salt leads to four equivalents in solution. Salts such as Na_3PO_4, K_3PO_4, $(NH_4)_3PO_4$, and so on have three cations for each anion.

$$m_{solute} = 3\, m_{M^+} + m_{X^{3-}}$$

Therefore,

$$m_{solute} = 4\, m_{MX}$$

for these ions. The same holds for salts such as $FeCl_3$, $EuCl_3$, $Tb(NO_3)_3$ and so on.

Dissociation of solutes in water

The most complicated case involves salts containing two trivalent and three divalent ions. For these salts the dissociation of one mole of salt leads to five equivalents in solution. Salts such as $Ca_3(PO_4)_2$, $Mg_3(PO_4)_2$ and so on obey

$$m_{solute} = 3\, m_{M^{2+}} + 2\, m_{X^{3-}}$$

Therefore,

$$m_{solute} = 5\, m_{MX}$$

for these ions.