COUNTER IONS

Compounds are mixtures of elements bonded together to make one material. Compounds can contain two or more elements. Those elements have to be found in a specific ratio. Two materials that contain the same two elements bonded together, but in different ratios, are two different compounds. Two materials that contain two different pairs of elements bonded together, but in the same ratio, would still be different compounds.

In nature, elements are found bound up in compounds more often than not. One common way for elements to be bound together is to form a salt. Salts are found very frequently in the earth's crust. A salt contains both anions and cations. Cations are not generally found alone. Anions are not generally found alone. They need counterions to balance out their charges.

Imagine two atoms get together to form a salt. A sodium atom comes together with a fluorine atom. The sodium atom lets one of its electrons go, and the fluorine atoms snatches it up. Now there is a sodium cation and a fluoride anion. The two ions are held together by the attractive forces between their opposite charges. They have formed a salt.

- Anions and cations are always found together.
- The charges on the cations must balance the charges on the anions.

For example, sodium chloride is a very common ionic compound. It is the main component of table salt, used in cooking. Sodium chloride contains sodium ions, each with a +1 charge, and chloride ions, each with a -1 charge. Overall, the compound has no charge, because the positive sodiums balance out the charge on the negative chlorides, and vice versa.

$Na^+ + Cl^- = NaCl$ (no overall charge) (equation IC2.1)

In a similar way, other ionic compounds form so that there is no overall charge on the compound. Magnesium oxide forms in a ratio so that the positive charges on the magnesium balance the negative charges on the oxygen.

$Mg^{2+} + O^{2-} = MgO$ (no overall charge) (equation IC2.2)

However, sodium oxide would need to form in a different ratio in order to keep the positive and negative charges balanced. Instead of forming in a one-to-one ratio, there would need to be double the number of sodium ions as oxygen ions in order to have the charges cancel each other exactly.

$2\ Na^{+} + O^{2-} = Na_2O$ (no overall charge) (equation IC2.3)

The two positive charges on the two sodium cations balance out the two negative charges on the oxide anion.

<u>Problem IC2.1.</u>

What would be the ratio of elements if each of the following ions formed a salt with chloride ions, Cl^{-}?

a) K^{+} b) Fe^{3+} c) Mo^{6+} d) Zr^{4+}

<u>Problem IC2.2.</u>

What would be the ratio of elements if each of the following ions formed a salt with oxide ions, O^{2-}?

a) Li^{+} b) Fe^{3+} c) Cr^{6+} d) Ti^{4+}

<u>Problem IC2.3.</u>

What would be the ratio of elements if each of the following ions formed a salt with nitride ions, N^{3-}?

a) Li^{+} b) Ta^{3+} c) W^{6+} d) Co^{2+}

<u>Problem IC2.4.</u>

Some compounds are more complicated. In the following polyoxoanions, the metal and oxide charges do not quite cancel. Given the charge on the metal, and assuming oxide has a 2- charge, what would be the overall charge on the polyoxoanion? Suggest the right ratio of counterion(s) that could balance the charge in each case (e.g. 3 Li^{+} ions, etc).

a) WO_4^{n-} (W^{6+}) b) $V_4O_{12}^{n-}$ (V^{5+}) c) $Mo_4O_{14}^{n-}$ (Mo^{6+}) d) $Cr(OH)_6Mo_6O_{18}^{n-}$ (OH^{-}, Cr^{4+}, Mo^{6+})

Ionic compounds have no overall charge. Instead, they consist of anions and cations found together to balance charge. The number of positive charges in an ionic compound equal the number of negative charges. Overall, the charge is balanced out.

Why does the charge need to be balanced out? Imagine a bottle of sodium cations. There are a few problems with the cations in that bottle. First of all, the cations will all repel each other. You'd better stand back when you take the lid off. The repulsion between the sodium atoms will make them erupt out of the bottle like a volcano.

By the way, what happened to all of the electrons when somebody made that bottle of sodium ions? Did they also make a jar of electrons with the leftovers? Did the two bottles sit on their shelves in a factory in Milwaukee until someone in Cleveland ordered a bottle of sodium ions and somebody in Tampa ordered a bottle of electrons?

The problem with that story lies in Coulomb's law, the mathematical relationship that talks about the force of attraction between two charges. A transformation of Coulomb's law deals with the energy needed to separate opposite charges. It would take a lot of energy to separate a whole bottle of electrons from a whole bottle of sodium cations, and even more energy to send one bottle to Cleveland and another to Tampa. You would need a power station to generate a bazillion gigawatts of energy to get the job done.

On the other hand, people really can generate cations or anions in instruments such as mass spectrometers. They can even keep those ions for a while in "ion traps". They would only do this with extremely small numbers of ions, though (nowhere near a visible amount), and it does take a generous amount of power. Once they switch the mass spectrometer off, the ions won't stick around for long.

Source : http://employees.csbsju.edu/cschaller/Principles%20Chem/ionics/ioncounter.htm