Experiment 8 - Double Displacement Reactions

A double displacement reaction involves two ionic compounds that are dissolved in water. In a double displacement reaction, it appears as though the ions are "trading places," as in the following hypothetical reaction:

 $AB_{(aq)} + CD_{(aq)} \rightarrow AD + CB$ Where AB exists as A^+ and B^- ions in solution and CD exists as C^+ and D^- ions in solution. As the ions come in contact with each other, there are six possible combinations that might conceivably cause a chemical reaction. Two of these combinations are the meeting of ions of like charge; that is, A++C+ and B++D. But since like charges repel, no reaction will occur with these combinations. Two other possible combinations are those of the original two compounds; that is, $A^+ + B^-$ and $C^+ + D^-$. Since we originally had a solution containing each of these pairs of ions, they can mutually exist in the same solution; therefore they do not recombine. Thus the two possibilities for chemical reaction are the combination of each of the positive ions with the negative ion of the other compound; that is, A++ D and C++ B.

In summary, when the solutions are mixed, these ions can all come into contact with each other, and new products could be formed. If new products are to be formed, there is only one possible combination of products: since like charges repel each other, we cannot have new compounds containing two negative ions or two positive ions. The only other possible new combination comes from the positive and negative ions of the two compounds switching places.

There are three types of equations that can be written for reactions that involve ions in solution. The first type is just the regular, overall (often called "molecular") equation. An example of an overall equation for a double displacement reaction is:

$$Na_2CO_3$$
 (aq) + 2 $AgNO_3$ (aq) \rightarrow 2 $NaNO_3$ (aq) + Ag_2CO_3 (s)

In this type of equation, the complete formulas are shown along with the appropriate state symbols. The formulas of the products are obtained as follows:

- 1. Determine what ions are present in the reactants, without worrying about how many of each there are. Include their charges: Na⁺_(aq), CO₃²⁻_(aq), Ag⁺_(aq), and NO₃
- Switch the ions so that the cation of the first compound is paired with the anion of 2. the second compound, and vice versa. In this case, the Na (aq is paired with the $NO_{3(aq)}$, and the $Ag^{+}_{(aq)}$ is paired with the $CO_{3(aq)}$.
- Determine the correct formulas of the products, keeping in mind the charges on 3. each of the ions and remembering that the overall formula of an ionic compound must have no net charge. In this case, since sodium ion has a charge of +1 and nitrate ion has a charge of -1, the correct formula of the compound sodium nitrate contains one of each ion: NaNO₃. For the other compound, silver ion has a charge of +1 and carbonate ion has a charge of -2. Therefore, two silver ions are needed to balance out the charge on one carbonate ion, and the formula of the compound is Ag₂CO₃.