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CLASSROOM AND LABORATORY ACTIVITIES

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Metathesis reactions, Full Ionic Equation, Net Ionic Equation, Spectator Ions Using Kemblox™

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Objective Illustration of the following terms and concepts: metathesis reactions, spectator ions, full ionic equation, net ionic equations.

Introduction

Metathesis reactions, or double exchange reactions, are reactions between two ionic compounds in which the anion of one substance is exchanged for the anion of the other substance. An important class of metathesis reactions is the class of reactions in which an insoluble precipitate is formed. A schematic representation of these reactions is:

AB(aq) + CD(aq) →AD(s) +CB(aq)

In this laboratory session one will use Kemblox™ to model this type of reactions, and several important terms associated with them.

Safety – No special safety measures need to be taken.

Materials

Two KembloX™ kits. For convenience, we'll call them "reactant kit" and "product kit", respectively. Two kits ensure enough blocks to allow for comparison of the reactants with the products.

Solubility chart (https://kemblox.org/solubility-and-dissolution/, or a traditional one from the textbook).

Rubber bands (optional).

Erasable pen and erasing pad (alternatively one can use preprinted stickers with element symbols, or dry erase stickers to affix to the blocks) or any other means to temporarily assign chemical identity to the blocks.

Procedure

Write the balanced metathesis equation, as assigned by instructor:

AB(aq) + CD(aq) →AD(s) +CB(aq)

i.e.

Soluble salt 1 + Soluble salt 2 → Insoluble salt 3 + soluble salt 4

e.g.

Na_2SO_4(aq) + $CaCl_2$(aq) →$CaSO_4$(s) + 2 NaCl(aq)

Divide the workspace into the "reactant side" on the left, a "solution region" in the middle, and a "product side" on the right. Using the reactant kit, mark the ions (with the marker) with their chemical identity (marking two of the ions, an anion and a cation, would generally suffice).

1) With blocks from the first kit, on the reactant side, build the reactants, Na_2SO_4 and $CaCl_2$, respectively. Draw a schematic representation of the formula units involved. Make sure to mark (with the marker) at least the cation from one species and the anion from the other.
2) Separate the ions in the solution region. Make sure that the **all** ions are completely separated. Upon dissolution, the ions separate completely. In the given example:

$Na_2SO_4 + CaCl_2 \rightarrow 2\ Na^+ + SO_4^{2-} + Ca^{2+} + 2\ Cl^-$

Thus, in the solution region, one has the six ions: 2 Na^+, SO_4^{2-}, Ca^{2+}, and 2 Cl^-

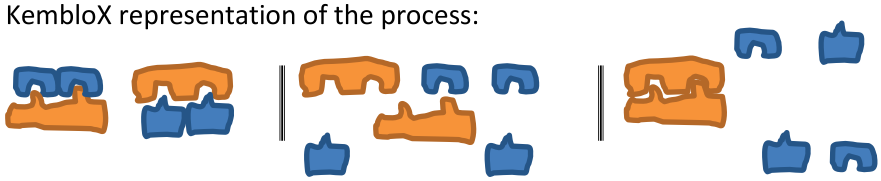
3) Select, from the products side, blocks representing the ions present in the "solution region" (the six ions), and build the insoluble product (to emphasize the lack of solubility, one can use a rubber band to hold the ions together). The other ions will remain separated, as being dissolved.

$2\ Na^+\ (aq) + SO_4^{2-}\ (aq) + Ca^{2+}\ (aq) + 2\ Cl^-(aq) \rightarrow CaSO_4\ (s) + 2\ Na^+\ (aq) + 2\ Cl^-\ (aq)$

One has modeled the metathesis reaction, and illustrated *all* the ions involved. We call the equation that involves **all** the ions the **Full Ionic Equation**:

$2\ Na^+\ (aq) + SO_4^{2-}\ (aq) + Ca^{2+}\ (aq) + 2\ Cl^-\ (aq) \rightarrow CaSO_4\ (s) + 2\ Na^+\ (aq) + 2\ Cl^-\ (aq)$

KembloX representation of the process:



Na_2SO_4 $CaCl_2$ $CaSO_4$

By comparing the reactant side with the product side, we'll notice that there are ions that stay the same. They are called **Spectator Ions.** They are the ions left separated on the product side. In our example, they are Na^+ and Cl^-.

If the spectator ions are removed from both the reactant side and the product side, then we are left with the **net ionic equation:**

$SO_4^{2-}\ (aq) + Ca^{2+}(aq) \rightarrow CaSO_4\ (s)$

The instructor will assign tasks by selectively filling some of the columns in the following table and ask the students to fill in the blank spaces.

Soluble 1	Soluble 2	Insol. 3	Soluble4	Full Ionic	Spect.	Net ionic
Na_2SO_4	$CaCl_2$	$CaSO_4$	NaCl	$2\ Na^+\ (aq) + SO_4^{2-}\ (aq) + Ca^{2+}\ (aq) + 2\ Cl^-\ (aq) \rightarrow CaSO_4\ (s) + 2\ Na^+\ (aq) + 2\ Cl^-\ (aq)$	Na^+, Cl^-	$SO_4^{2-}\ (aq) + Ca^{2+}(aq) \rightarrow CaSO_4\ (s)$

For example, the information provided by the instructor might be

Soluble 1	Soluble 2	Insol. 3	Soluble4	Full Ionic	Spect.	Net ionic
NaCl	$AgNO_3$					