Reactions in Which a Solid Forms
Double Replacement Reactions (Precipitation-type)

Name_____________________Per___

In a double replacement reaction, two soluble compounds react and form an insoluble precipitate as demonstrated in class.

Written using generic symbols, it can be shown as:

AX + BY → AY + BX (A and B represent cations – usually metals)
(X and Y represent anions – nonmetal elements or polyatomic ions)

Specific steps for writing and balancing equations for double replacement reactions:

1. Determine the solubility of the two reactant salts (salt is a chemist's term for any ionic compound).
   a. If one or both of the reactant salts are insoluble − STOP − no reaction can occur because the insoluble salt can not dissociate (break apart) and therefore can not make the double replacement "switcheroo", therefore, if either salt is insoluble write; "No reaction can occur because a reactant is insoluble."
   b. Both salts must be soluble to proceed.
2. Determine the identity of the product salts by making the "switcheroo".
   a. If given the names of the reactant salts, make the double replacement switch to predict the names of the products.
   b. If given the formulas for the reactant salts, make the double replacement switch to predict the products, being careful to carry just the ions not any subscripts that are there to equalize the charge in the compound.
3. Look up the solubility of the products.
   a. If both products are soluble − STOP − no reaction occurs because there is no chemical change to the products, all ions are still just dissolved in the water. Write; "No reaction occurs because both products are soluble."
   b. If one of the products is insoluble, that substance should be labeled $_{(ppt)}$ precipitate.
4. Make a skeleton equation by writing out the correct chemical formulas of both the reactants and the products, setting the subscripts as a result of the charges of the individual ions using the criss-cross method. (Do not set the subscripts of the products the same as the subscripts in the reactants – you must consider the charges of the ions that are attaching to each other.)
5. Balance the skeleton equation changing only the coefficients out in front of the formulas.
6. Label the appropriate product $_{(s)}$ or $_{(ppt)}$ Some chemists will label the soluble salts as $_{(aq)}$, but we will consider $_{(aq)}$ to be understood if there is no other $_{(s)}$ or $_{(ppt)}$ label.
7. Convert the overall equation (sometimes called a molecular equation) into a "net" ionic equation by dropping out the spectator ions.
   a. Any ion that is aqueous on both sides "drops out" of the equation. There is no need for $_{(s)}$ or $_{(ppt)}$ in the net ionic equation because representation of ions with their respective charges tell us that those ions must be in solution, and any compounds written together will assumed to be solids (or possibly liquids or gases, as appropriate.)
   b. Only the ions that are part of the precipitate are included in the equation. The spectator ions drop out.

Practice: Consider using the carefully outlined steps above to avoid making mistakes.

1. sodium chloride is combined with silver sulfide.

2. zinc hydroxide is combined with potassium chromate.

3. sodium sulfate is combined with tin(II) nitrate.

4. ammonium sulfide is combined with sodium chloride.

5. calcium nitrate is combined with potassium sulfite.

6. sodium carbonate is combined with aluminum nitrate.

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ANSWERS

The steps suggested on the first page are referenced in the answers.

1 sodium chloride is soluble, silver sulfide is insoluble thus no reaction can occur. (step 1a)

2 zinc hydroxide is insoluble thus no reaction can occur. (step 1a) (potassium chromate is soluble)

3 step 1 sodium sulfate is soluble, tin(II) nitrate is soluble
step 2 products: sodium nitrate + tin(II) sulfate
step 3 both products are soluble thus no reaction occurs since no precipitate is formed.

4 step 1 ammonium sulfide is soluble, sodium chloride is soluble
step 2 products: ammonium chloride and sodium sulfide
step 3 both products are soluble thus no reaction occurs since no precipitate is formed.

5 step 1 calcium nitrate is soluble, potassium sulfite is soluble
step 2 products: calcium sulfite + potassium nitrate
step 3 calcium sulfite is insoluble $_{(ppt)}$ thus a reaction occurs (potassium nitrate is soluble)
step 4 $Ca^{2+}\ NO_3^{-} + K^{+}\ SO_3^{2-} \rightarrow Ca^{2+}\ SO_3^{2-} + K^{+}\ NO_3^{-}$
$Ca(NO_3)_2 + K_2SO_3 \rightarrow CaSO_3 + KNO_3$
steps 5+6 $Ca(NO_3)_2 + K_2SO_3 \rightarrow CaSO_{3\,(ppt)} + 2\ KNO_3$
step 7 $Ca^{+2} + SO_3^{2-} \rightarrow CaSO_3$

6 step 1 sodium carbonate is soluble, aluminum nitrate is soluble
step 2 products: sodium nitrate + aluminum carbonate
step 3 aluminum carbonate is insoluble $_{(ppt)}$ thus a reaction occurs, (sodium nitrate is soluble)
step 4 $Na^{+}\ CO_3^{2-} + Al^{3+}\ NO_3^{-} \rightarrow Al^{3+}\ CO_3^{2-} + Na^{+}\ NO_3^{-}$
$Na_2CO_3 + Al(NO_3)_3 \rightarrow Al_2(CO_3)_3 + NaNO_3$
steps 5+6 $3\ Na_2CO_3 + 2\ Al(NO_3)_3 \rightarrow Al_2(CO_3)_{3\,(ppt)} + 6\ NaNO_3$
step 7 $3\ CO_3^{2-} + 2\ Al^{3+} \rightarrow Al_2(CO_3)_3$
Please note that the aluminum ions are written as $2\ Al^{3+}$ not Al_2^{3+}. It is important to represent the aluminum ions as separated, not stuck together.