GENERAL CHEMISTRY STANDARD 8.4

8.4: Predict the products for each type of chemical reaction

SYNTHESIS REACTION

- First, determine whether the product will be ionic or molecular
  - If ionic, the oxidation numbers of the atoms/ions must be crossed over
  - If molecular, then common molecular compounds must be considered
  - Then balance the equation

- Example:

  $Na\ (s) + Cl_2\ (g) \rightarrow$

  This is an ionic compound, so consider Na (+1 oxidation number) and Cl (-1 oxidation number), criss-cross the oxidation numbers, resulting in NaCl:

  $Na\ (s) + Cl_2\ (g) \rightarrow NaCl\ (s)$

  Finally, balance the equation:

  $2\ Na\ (s) + Cl_2\ (g) \rightarrow 2\ NaCl\ (s)$

DECOMPOSITION

- First, determine whether the product will be ionic or molecular
  - If ionic, the cation and anion will separate from each other and exist as single atoms
  - If molecular, then common molecular compounds must be considered
  - Then balance the equation
- Example:

  $HgO\ (s) \rightarrow$

  This is an ionic compound, so the ions will separate:

  $HgO\ (s) \rightarrow Hg\ (l) + O_2\ (g)$

  Finally, balance the equation:

  $2\ HgO\ (s) \rightarrow 2\ Hg\ (l) + O_2\ (g)$

SINGLE REPLACEMENT

- **Activity Series Table:** An empirical tool used to predict the products in a single-replacement reaction by listing a series of elements arranged in order of chemical reactivity
  - If the individual element is more active than the element of the same type of ion (cation or anion) in the compound, then replacement occurs
  - If the individual element is NOT more active than the element of the same type of ion (cation or anion) in the compound, then replacement does NOT occur and no reaction takes place.
- Example:

  $Mg\ (s) + CuSO_4\ (aq) \rightarrow$

  Magnesium is more active than Copper, so the reaction occurs:

  $Mg\ (s) + CuSO_4\ (aq) \rightarrow Cu\ (s) + MgSO_4\ (aq)$ (remember to criss-cross for ionic compounds!)

  Finally, balance the equation:

  $Mg\ (s) + CuSO_4\ (aq) \rightarrow Cu\ (s) + MgSO_4\ (aq)$

DOUBLE REPLACEMENT

- First, write the skeleton equation by switching the ions and re-criss-crossing
- Then, determine the states of matter of every compound, both reactant and product
- One of the following situations must occur for the reaction to be completed:
  - A precipitate is formed. This means that one of the products is a solid. This can be determined by using a **solubility table**, which provides information about the solubility of various ionic compounds in water at room temperature.
    - If a compound is **soluble**, then it is dissolved in water at room temperature and forms an aqueous solution.
    - If the compound is **insoluble**, then the compound does not dissolve in water at room temperature and precipitates out of a solution as a solid
  - A gas is formed. That is, one of the products is in the gaseous state at room temp
  - Water is formed. That is, water is one of the products

DOUBLE REPLACEMENT EXAMPLE

Consider the following:

Na_2S (s) + HCl (aq) →

First, identify the skeleton equation:

Na_2S (s) + HCl (aq) → NaCl + H_2S

Next, balance the equation:

Na_2S (s) + 2 HCl (aq) → 2 NaCl + H_2S

Next, determine the states of matter of the products:

Na_2S (s) + 2 HCl (aq) → NaCl (aq) + H_2S (s)

You are now finished as one of the products is a solid, so the reaction does occur.

COMBUSTION

- The products will always be carbon dioxide gas (CO_2) and water vapor (H_2O)
  - Then balance the skeleton equation
- Example:

  C_3H_8 (g) + O_2 (g)→

  The only products are carbon dioxide gas and water vapor:

  C_3H_8 (g) + O_2 (g)→ CO_2 (g) + H_2O (g)

  Finally, balance the equation:

  C_3H_8 (g) + 5 O_2 (g)→ 3 CO_2 (g) + 4 H_2O (g)

EXAMPLES

- Determine the products of the following chemical equations:
  - Li (s) + CaO (s) →
  - H_2 (g) + O_2 (g) →
  - C_4H_{10} (g) + O_2 (g) →
  - Ba (s) + S (s) →
  - $Ca(OH)_2$ (aq) + H_2SO_4 (aq) →
  - Al (s) + O_2 (g) →

EXAMPLES

- Determine the products of the following chemical equations:
  - **2** Li (s) + CaO (s) → **Ca (s) + Li_2O (s)**
  - **2** H_2 (g) + O_2 (g) → **2 H_2O (g)**
  - **2** C_4H_{10} (g) + **13** O_2 (g) → **8 CO_2 (g) + 10 H_2O (g)**
  - Ba (s) + S (s) → **BaS (s)**
  - $Ca(OH)_2$ (aq) + H_2SO_4 (aq) → **$CaSO_4$ (s) + 2 H_2O (l)**
  - **4** Al (s) + **3** O_2 (g) → **2 Al_2O_3 (s)**