

You have mastered this topic when you can:

- 1) define or describe these terms: aqueous solution, solvent, solute, solubility, soluble, low solubility, precipitation.
- 2) use the **Solubility of Ionic Compounds Chart** to determine if an ionic compound is soluble or has low solubility.
- 3) classify, predict products, and write balanced equations for these types of chemical reactions:
 - a) double replacement
 - c) neutralization

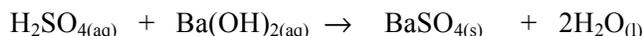
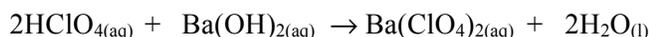
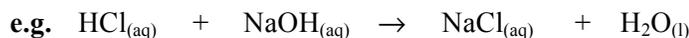
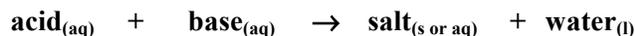
CHEMICAL REACTIONS THAT ALWAYS INVOLVE AQUEOUS IONIC REACTANTS

I) NEUTRALIZATION REACTIONS

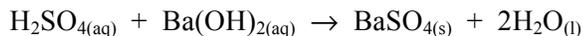
An **acid** is an **aqueous** molecular compound beginning with **hydrogen** and a **base** is any **aqueous** compound ending with **polyatomic ion hydroxide**, $(\text{OH})^-$.

e.g. **ACIDS:** $\text{HCl}_{(\text{aq})}$, $\text{HClO}_{4(\text{aq})}$, $\text{H}_2\text{SO}_{4(\text{aq})}$; **BASES:** $\text{NaOH}_{(\text{aq})}$, $\text{Ba}(\text{OH})_{2(\text{aq})}$, $\text{KOH}_{(\text{aq})}$

A) MEMORIZE THE PATTERN FOR A NEUTRALIZATION REACTION IN ORDER TO USE THEM TO PREDICT THE FORMULAE OF PRODUCTS FORMED. The **solubility table** is used to determine if the product salt is **soluble** or has **low solubility**.

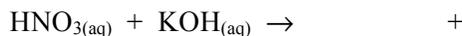
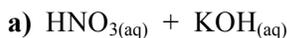


- 1) NOTICE that **liquid water** is a product of a **neutralization reaction**. The formation of a liquid is evidence that a chemical reaction has occurred.

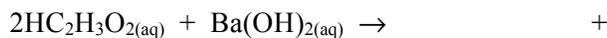
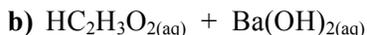


- 2) **Sample Problems 1:** Write a balanced equation for the possible reaction between these compounds then state whether or not a reaction will occur. Justify your answer.

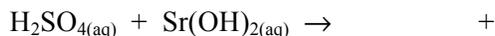
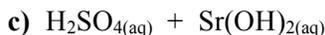
NOTE: To answer these problems you must write the formula of the possible products. The formula of the possible salt is created by criss-crossing the valence of the cation from the base with valence of the anion from the acid while the water is formed by combining the hydrogen from the acid and the hydroxide from the base to make $\text{H}_2\text{O}_{(\text{l})}$.



A reaction has occurred because a new compound, water, was produced.

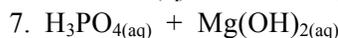
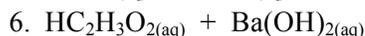
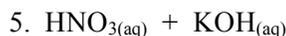
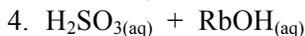
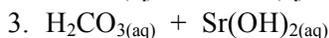
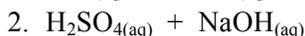
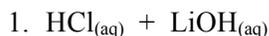


A reaction has occurred because a new compound, water, was produced.



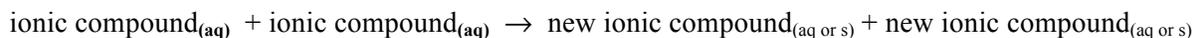
A reaction has occurred because two new compound, solid salt and water, were produced.

3) **Required Practice 1:** Write a balanced equation for the reaction between these compounds then state whether or not a reaction will occur. Justify your answer. **{Ans. on pg. 4}**

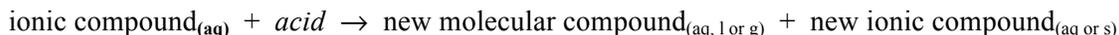


II) DOUBLE REPLACEMENT REACTION

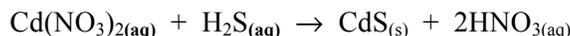
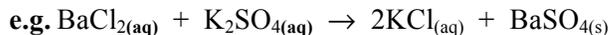
replacement reaction. **FIRST:** two *aqueous ionic compounds* react together to produce *two new ionic compounds one of which must be a solid*. **SECOND:** an *aqueous ionic compound* reacts with an *acid* producing an *aqueous or solid ionic compound* and an *aqueous, solid or gaseous molecular compound*. **MEMORIZE THE PATTERNS FOR THE TWO TYPES OF DOUBLE REPLACEMENT REACTIONS IN ORDER TO USE THEM TO PREDICT THE FORMULAE OF PRODUCTS FORMED.**



OR



A) The first product compound is formed by combining the cation from the first reactant compound with the anion from the second reactant compound. The second product compound is formed by combining the cation from the second reactant compound with the anion from the first reactant compound. The ions in the reactant compounds “change partners” to form the product compounds.

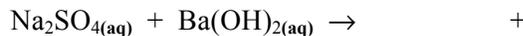
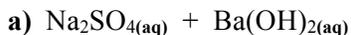


1) **NOTICE:** *THE REACTANT COMPOUNDS ARE SOLUBLE IONIC COMPOUNDS OR ACIDS AND AT LEAST ONE OF THE PRODUCTS IS A SOLID OR A GAS.*

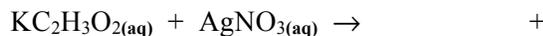
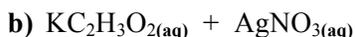
a) Use the ***Solubility of Ionic Compounds Chart*** to determine the state (solid or aqueous) of the products.

2) **Sample Problems 2:** State whether or not a reaction will occur between these combinations of substances. Write a balanced equation if a reaction occurs. If not indicate why a reaction does not occur.

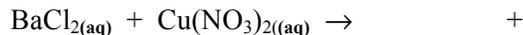
NOTE: To answer these problems you must predict the formula of the possible products by combining the cation from the first reactant compound with the anion from the second reactant compound then combining the cation from the second reactant compound with the anion from the first reactant compound. Then use the ***Solubility of Ionic Compounds Chart*** to determine solubility (aqueous or solid) of the possible ionic compound products. If one or both of the products is a solid or a gas, a reaction has occurred. If all of products are aqueous, no reaction has occurred.



A reaction has occurred because a solid product, $\text{BaSO}_{4(\text{s})}$, forms.

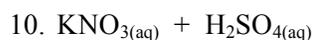
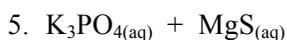
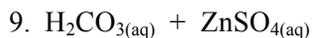
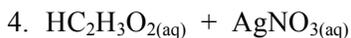
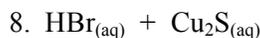
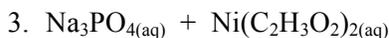
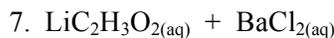
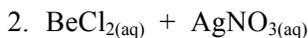
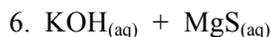
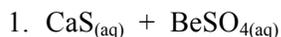


A reaction has occurred because a solid product, $\text{AgC}_2\text{H}_3\text{O}_{2(\text{s})}$, forms.



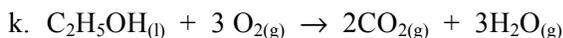
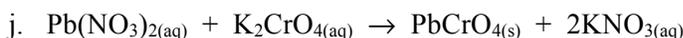
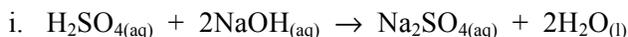
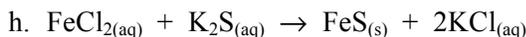
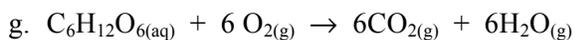
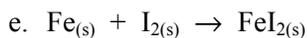
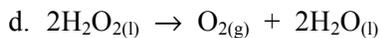
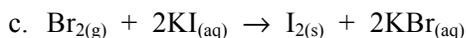
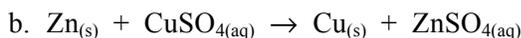
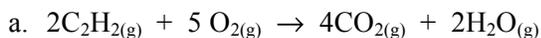
A reaction has not occurred because a neither product is a solid.

3) **Required Practice 2:** Write a balanced equation for the reaction between these compounds then state whether or not a reaction will occur. Justify your answer. **{Ans. on pg. 4}**

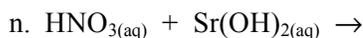
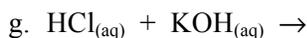
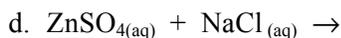
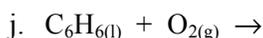
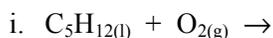
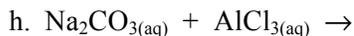


III) **Required Practice 3.** **{Ans. on pg. 4}**

1. Classify these chemical reactions as a *synthesis*, *decomposition*, *combustion*, *single replacement*, *double replacement* or *neutralization reaction*.



2. Predict the possible products when these combinations of reactants are mixed together. If no reaction occurs, state so. You are not required to balance them.



ANSWERS TO THE REQUIRED PRACTICE**Required Practice 1 from page 2**

- $\text{HCl}_{(\text{aq})} + \text{LiOH}_{(\text{aq})} \rightarrow \text{LiCl}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$ A reaction occurs because water is produced.
- $\text{H}_2\text{SO}_{4(\text{aq})} + 2\text{NaOH}_{(\text{aq})} \rightarrow \text{Na}_2\text{SO}_{4(\text{aq})} + 2\text{H}_2\text{O}_{(\text{l})}$ A reaction occurs because water is produced.
- $\text{H}_2\text{CO}_{3(\text{aq})} + \text{Sr}(\text{OH})_{2(\text{aq})} \rightarrow \text{SrCO}_{3(\text{s})} + 2\text{H}_2\text{O}_{(\text{l})}$ A reaction occurs because a solid salt and water are produced.
- $\text{H}_2\text{SO}_{3(\text{aq})} + 2\text{RbOH}_{(\text{aq})} \rightarrow \text{Rb}_2\text{SO}_{3(\text{aq})} + 2\text{H}_2\text{O}_{(\text{l})}$ A reaction occurs because water is produced.
- $\text{HNO}_{3(\text{aq})} + \text{KOH}_{(\text{aq})} \rightarrow \text{KNO}_{3(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$ A reaction occurs because water is produced.
- $2\text{HC}_2\text{H}_3\text{O}_{2(\text{aq})} + \text{Ba}(\text{OH})_{2(\text{aq})} \rightarrow \text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_{2(\text{aq})} + 2\text{H}_2\text{O}_{(\text{l})}$ A reaction occurs because water is produced.
- $2\text{H}_3\text{PO}_{4(\text{aq})} + 3\text{Mg}(\text{OH})_{2(\text{aq})} \rightarrow \text{Mg}_3(\text{PO}_4)_{2(\text{s})} + 6\text{H}_2\text{O}_{(\text{l})}$ A reaction occurs because a solid salt and water are produced.
- $\text{H}_2\text{S}_{(\text{aq})} + 2\text{NH}_4\text{OH}_{(\text{aq})} \rightarrow (\text{NH}_4)_2\text{S}_{(\text{aq})} + 2\text{H}_2\text{O}_{(\text{l})}$ A reaction occurs because water is produced.

Required Practice 2 from page 3

- $\text{CaS}_{(\text{aq})} + \text{BeSO}_{4(\text{aq})} \rightarrow \text{BeS}_{(\text{aq})} + \text{CaSO}_{4(\text{s})}$ A reaction occurs because a precipitate forms.
- $\text{BeCl}_{2(\text{aq})} + 2\text{AgNO}_{3(\text{aq})} \rightarrow 2\text{AgCl}_{(\text{s})} + \text{Be}(\text{NO}_3)_{2(\text{aq})}$ A reaction occurs because a precipitate forms.
- $2\text{Na}_3\text{PO}_{4(\text{aq})} + 3\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_{2(\text{aq})} \rightarrow 6\text{NaC}_2\text{H}_3\text{O}_{2(\text{aq})} + \text{Ni}_3(\text{PO}_4)_{2(\text{s})}$ A reaction occurs because a precipitate forms.
- $\text{HC}_2\text{H}_3\text{O}_{2(\text{aq})} + \text{AgNO}_{3(\text{aq})} \rightarrow \text{AgC}_2\text{H}_3\text{O}_{2(\text{s})} + \text{HNO}_{3(\text{aq})}$ A reaction occurs because a precipitate forms.
- $2\text{K}_3\text{PO}_{4(\text{aq})} + 3\text{MgS}_{(\text{aq})} \rightarrow \text{Mg}_3(\text{PO}_4)_{2(\text{s})} + 3\text{K}_2\text{S}_{(\text{aq})}$ A reaction occurs because a precipitate forms.
- $2\text{KOH}_{(\text{aq})} + \text{MgS}_{(\text{aq})} \rightarrow \text{K}_2\text{S}_{(\text{aq})} + \text{Mg}(\text{OH})_{2(\text{s})}$ A reaction occurs because a precipitate forms.
- $2\text{LiC}_2\text{H}_3\text{O}_{2(\text{aq})} + \text{BaCl}_{2(\text{aq})} \rightarrow 2\text{LiCl}_{(\text{aq})} + \text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_{2(\text{aq})}$ A reaction does not occur because a precipitate does not form.
- $2\text{HBr}_{(\text{aq})} + \text{Cu}_2\text{S}_{(\text{aq})} \rightarrow \text{H}_2\text{S}_{(\text{g})} + 2\text{CuBr}_{(\text{s})}$ A reaction occurs because a precipitate and a gas product form.
- $\text{H}_2\text{CO}_{3(\text{aq})} + \text{ZnSO}_{4(\text{aq})} \rightarrow \text{H}_2\text{SO}_{4(\text{aq})} + \text{ZnCO}_{3(\text{s})}$ A reaction occurs because a precipitate forms.
- $2\text{KNO}_{3(\text{aq})} + \text{H}_2\text{SO}_{4(\text{aq})} \rightarrow 2\text{HNO}_{3(\text{aq})} + \text{K}_2\text{SO}_{4(\text{aq})}$ A reaction does not occur because a precipitate does not form.

Required Practice 3 from page 3

1a. Combustion 1b. Single replacement 1c. Single replacement 1d. Decomposition 1e. Synthesis
 1f. Synthesis 1g. Combustion 1h. Double replacement 1i. Neutralization 1j. Double replacement
 1k. Combustion

- | | |
|---|---|
| 2a. $\text{Zn}_{(\text{s})} + \text{Ni}(\text{NO}_3)_{2(\text{aq})} \rightarrow \text{Ni}_{(\text{s})} + \text{Zn}(\text{NO}_3)_{2(\text{aq})}$ | 2h. $\text{Na}_2\text{CO}_{3(\text{aq})} + \text{AlCl}_3(\text{aq}) \rightarrow \text{Al}_2(\text{CO}_3)_3(\text{s}) + \text{NaCl}_{(\text{aq})}$ |
| 2b. $\text{Zn}_{(\text{s})} + \text{MgSO}_{4(\text{aq})} \rightarrow \text{No Reaction}$ | 2i. $\text{C}_5\text{H}_{12(\text{l})} + 8 \text{O}_{2(\text{g})} \rightarrow 5\text{CO}_{2(\text{g})} + 6\text{H}_2\text{O}_{(\text{g})}$ |
| 2c. $2\text{Cd}_{(\text{s})} + \text{O}_{2(\text{g})} \rightarrow 2\text{CdO}_{(\text{s})}$ | 2j. $2\text{C}_6\text{H}_6(\text{l}) + 15 \text{O}_{2(\text{g})} \rightarrow 12\text{CO}_{2(\text{g})} + 6\text{H}_2\text{O}_{(\text{g})}$ |
| 2d. $\text{ZnSO}_{4(\text{aq})} + \text{NaCl}_{(\text{aq})} \rightarrow \text{No Reaction}$ | 2k. $2\text{Sr}_{(\text{s})} + \text{O}_{2(\text{g})} \rightarrow 2\text{SrO}_{(\text{s})}$ |
| 2e. $2\text{HgO}_{(\text{s})} \rightarrow 2\text{Hg}_{(\text{l})} + \text{O}_{2(\text{g})}$ | 2l. $\text{Pb}_{(\text{s})} + \text{KNO}_{3(\text{aq})} \rightarrow \text{No Reaction}$ |
| 2f. $16\text{Fe}_{(\text{s})} + 3\text{S}_{8(\text{l})} \rightarrow 8\text{Fe}_2\text{S}_3(\text{s})$ | 2m. $\text{Br}_{2(\text{s})} + \text{CaCl}_{2(\text{aq})} \rightarrow \text{No Reaction}$ |
| 2g. $\text{HCl}_{(\text{aq})} + \text{KOH}_{(\text{aq})} \rightarrow \text{KCl}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$ | 2n. $2\text{HNO}_{3(\text{aq})} + \text{Sr}(\text{OH})_{2(\text{aq})} \rightarrow \text{Sr}(\text{NO}_3)_{2(\text{aq})} + 2\text{H}_2\text{O}_{(\text{l})}$ |

BRING A CALCULATOR WITH YOU TO THE NEXT CLASS