

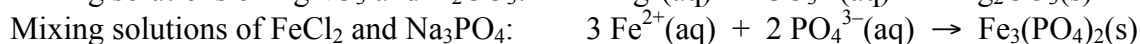
AQUEOUS REACTIVITY for CHEM 101A TOPIC B

1) Solubility rules and precipitation reactions

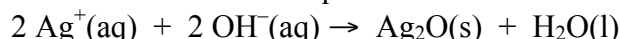
All compounds that contain the cations Na^+ , K^+ or NH_4^+ , or the anions NO_3^- or $\text{C}_2\text{H}_3\text{O}_2^-$ are soluble in water. It is best to memorize these. Beyond this, solubilities are normally classified using the anion in the compound. Here are the rules that you will use in Chem 101A:

Anion	Cations that produce soluble compounds	Cations that produce insoluble compounds
NO_3^- , $\text{C}_2\text{H}_3\text{O}_2^-$	All	None
Cl^- , Br^- , I^-	Most	Ag^+ Pb^{2+} Hg_2^{2+}
SO_4^{2-}	Most	Ag^+ Pb^{2+} Hg_2^{2+} Ca^{2+} Sr^{2+} Ba^{2+} (the heavier IIA elements)
OH^-	Na^+ K^+ (NH_4^+ reacts with OH^- : see the acid-base section below) Ba^{2+}	All others (see note below on Ag^+)
CO_3^{2-} , PO_4^{3-}	Na^+ K^+ NH_4^+	All others
S^{2-}	Na^+ K^+ NH_4^+ Mg^{2+} Ca^{2+} Sr^{2+} Ba^{2+} (group IIA)	All others (the reactions of sulfide with 3+ ions are not simple precipitations: you do not need to know these)

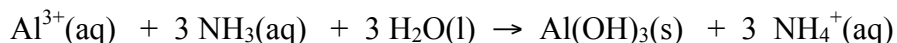
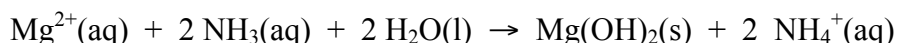
An insoluble salt will be produced whenever its constituent ions are mixed. Here are two examples:



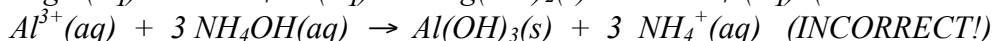
Note that the reaction of Ag^+ with OH^- produces Ag_2O (and water), not AgOH . This is a “quirk” of the chemistry of silver ions. The net ionic equation for this reaction is:



Note that ammonia dissolves in water to produce a small concentration of hydroxide ions, which can participate in precipitation reactions. The combination $\text{NH}_3 + \text{H}_2\text{O}$ is equivalent to $\text{NH}_4^+ + \text{OH}^-$ when you are considering reactivity for precipitation reactions. However, $\text{NH}_4^+ + \text{OH}^-$ are not the major species in solution and should not be written in net ionic equations. Instead, you must include the major species $\text{NH}_3 + \text{H}_2\text{O}$ as the reactants. Remember, “the majority rules” when writing net ionic equations. (Note that $\text{NH}_4\text{OH}(\text{aq})$ does not exist.) Here are two examples, using Mg^{2+} and Al^{3+} :

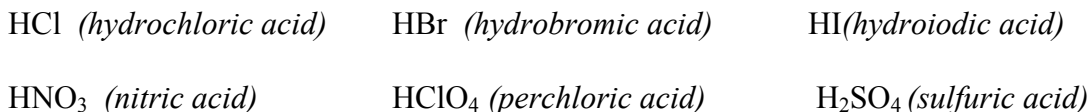


The reactions below would be INCORRECT:

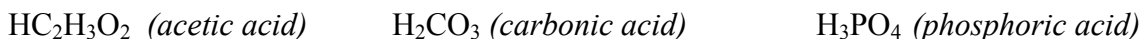


2) Acid-base reactivity

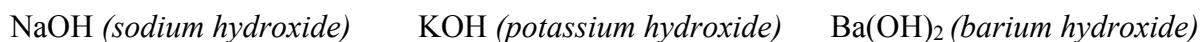
Any compound that contains hydrogen and can lose it (in the form of H^+) is an **acid**. The following acids are strong (100% ionized in aqueous solution):



You may assume that any other acid you encounter in Chem 101A is weak. Here are three common weak acids whose formulas you should know:



A compound that binds to H^+ is a **base**. Hydroxide ions (OH^-) bind to H^+ and so any ionic compound that contains OH^- ion is a **base**. Most of these compounds are insoluble in water. The following are soluble in water and 100% ionized. These are strong bases:



You may assume that any other base you encounter in Chem 101A is a weak base. Here is the most common weak base that you will encounter in Chem 101A whose formula you should know:



Ammonia (NH₃) binds to H^+ and is therefore a base. It will react with any acid "HX":

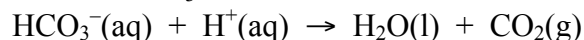


Note that ammonia can also participate in precipitation reactions! See section 1.

3) Special reactions of carbonate and bicarbonate ions

Carbonate ion and bicarbonate ion react with H^+ to form H₂CO₃ (carbonic acid). However, carbonic acid can only exist at very low concentrations. Under normal circumstances, carbonic acid decomposes into CO₂ and H₂O. Therefore, carbon dioxide and water are the normal products whenever carbonate or bicarbonate react with acids. Here are some examples:

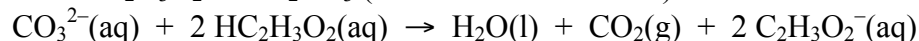
Mixing solutions of NaHCO₃ and HCl:



Adding a solution of HCl to solid CaCO₃:



Mixing solutions of HC₂H₃O₂ and K₂CO₃ (with the acid in excess):



You can see an example of this kind of reaction for yourself by mixing baking soda (NaHCO₃) and vinegar (a solution of acetic acid) in your kitchen. The mixture will bubble vigorously as gaseous carbon dioxide forms.