WRITING NET IONIC EQUATIONS
FOR CHEM 101A

Chemical reactions that occur in solution are most concisely described by writing net ionic equations. A net ionic equation is the most accurate representation of the actual chemical process that occurs. Writing these equations requires a familiarity with solubility rules, acid-base reactivity, weak electrolytes and special reactions of carbonates and bicarbonates. See the "properties and reactivity of inorganic compounds" handout for help with these topics. The following is the strategy we suggest following for writing net ionic equations in Chem 101A.

Writing net ionic equations:

Step 1: Identify the species that are actually present, accounting for the dissociation of any strong electrolytes. (Insoluble ionic compounds do not ionize, but you must consider the possibility that the ions in an insoluble compound might still be involved in the reaction.)

Step 2: Identify the products that will be formed when the reactants are combined. The most common products are insoluble ionic compounds and water. See the "reactivity of inorganic compounds" handout for more information.

Step 3: Write the balanced equation for the reaction you identified in step 2, being certain to show the major species in your equation. This is the net ionic equation for the reaction.

Example problems: For each of the following combinations, write a net ionic equation to describe any reaction that occurs.

1) 0.100 M K_3PO_4 solution is mixed with 0.100 M $Ca(NO_3)_2$ solution

Step 1: The species that are actually present are:

From the K_3PO_4	From the $Ca(NO_3)_2$
K^+	Ca^{2+}
PO_4^{3-}	NO_3^-

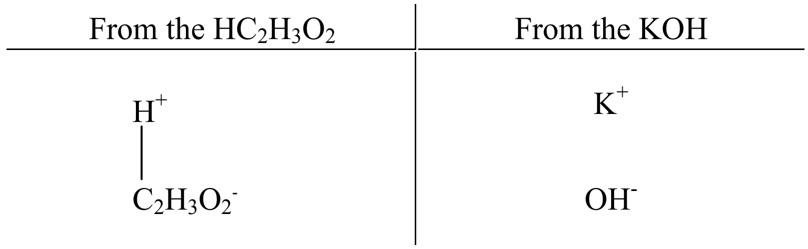
Step 2: There are two possible combinations of ions here: $K^+ + NO_3^-$ (forming KNO_3) and $Ca^{2+} + PO_4^{3-}$ (forming $Ca_3(PO_4)_2$). We know from the general solubility rules that $Ca_3(PO_4)_2$ is an insoluble compound, so it will be formed. KNO_3 is water-soluble, so it will not form.

Step 3: The reaction is the combination of calcium and phosphate ions to form calcium phosphate. The balanced equation for this reaction is:

$$3\,Ca^{2+}(aq) + 2\,PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s)$$

2) 0.1 M $HC_2H_3O_2$ solution is mixed with 0.1 M KOH solution

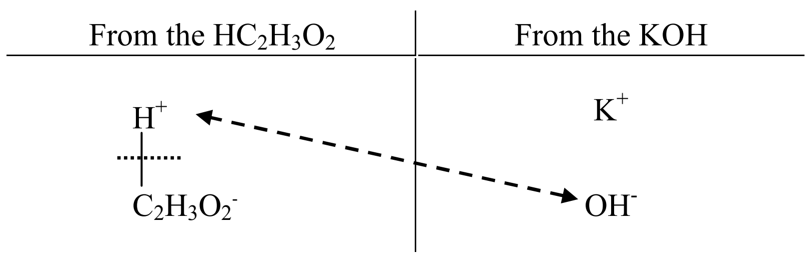
Step 1: The species that are actually present are:



Acetic acid, $HC_2H_3O_2$, is a weak acid. Think of the acid molecules as "potential" H^+ and $C_2H_3O_2^-$ ions, however, these "potential" ions are held together by a covalent bond. A small percentage of the acid molecules do actually ionize (break apart into ions) when they dissolve in water, but most of the weak acid molecules do not ionize.

Step 2: Reaction of an acid (source of H^+) and a base (source of OH^-) will form water. The H^+ from the $HC_2H_3O_2$ can combine with the OH^- to form H_2O. Note that $KC_2H_3O_2$ is a water-soluble compound, so it will not form.

Step 3: In order to form water as a product, the covalent bond between the H^+ and the $C_2H_3O_2^-$ ions must break. The H^+ and OH^- will form water. The acetate ion is released when the covalent bond breaks.

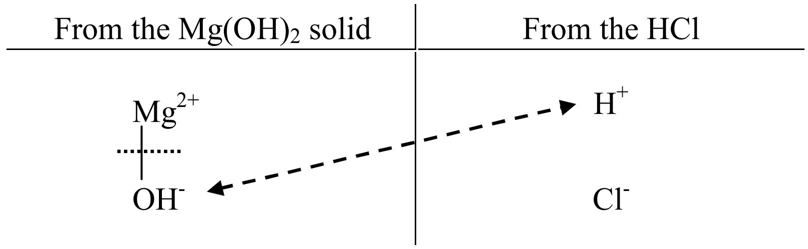


Remember to show the major species that exist in solution when you write your equation. Most of the acid molecules are not ionized, so you must write out the complete formula of the acid in your equation. The balanced equation for this reaction is:

$$HC_2H_3O_2\,(aq) + OH^-(aq) \rightarrow H_2O(l) + C_2H_3O_2^-(aq)$$

3) solid $Mg(OH)_2$ and excess 0.1 M HCl solution

Step 1: The species that are actually present are:



Notice that the magnesium hydroxide is a solid; it is not water soluble. The magnesium ions and the hydroxide ions will remain held together by ionic bonds even if they are in the presence of polar water molecules. However, these individual ions must be considered as possible reactants. Think of the solid ionic compound as a possible source of Mg^{2+} and OH^- ions. If a chemical reaction is possible, the ionic bonds between Mg^{2+} and OH^- will break.

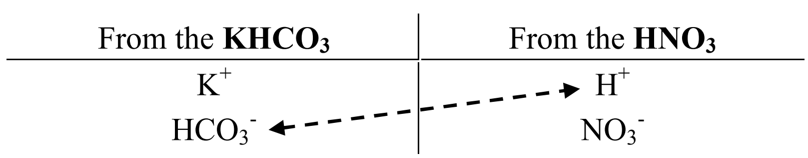
Step 2: Reaction of an acid (source of H^+) and a base (source of OH^-) will form water. The H^+ from the HCl can combine with the OH^- from the solid $Mg(OH)_2$ to form H_2O. Note that $MgCl_2$ is a water-soluble compound, so it will not form.

Step 3: In order to form water as a product, the ionic bond between the magnesium and hydroxide ions must break. The OH^- and H^+ will form water. The magnesium ion is released into solution when the ionic bond breaks. Remember to show the major species that exist in solution when you write your equation. The magnesium hydroxide is a solid reactant, so you must write out the complete formula in your equation. The balanced equation for this reaction is:

$$Mg(OH)_2(s) \; + \; 2\,H^+(aq) \;\rightarrow\; 2\,H_2O(l) \; + \; Mg^{2+}(aq)$$

4) 0.1 M $KHCO_3$ solution is mixed with excess 0.1 M HNO_3 solution

Step 1: The species that are actually present are:



Step 2: From the "reactivity of inorganic compounds" handout, we know that when carbonate or bicarbonate ions react with acids, carbon dioxide and water are the normal products. Be sure to refer to the handout for details of this process.

Step 3: The reaction is the combination of bicarbonate ions and hydrogen ions that will first form carbonic acid (H_2CO_3). However, carbonic acid can only exist at very low concentrations. Under normal circumstances, carbonic acid decomposes into CO_2 and H_2O. The balanced equation for this reaction is:

$$HCO_3^-(aq) \; + \; H^+(aq) \;\rightarrow\; H_2O(l) \; + \; CO_2(g)$$

PRACTICE PROBLEMS ON NET IONIC EQUATIONS

For each of the following, write the net ionic equation for the reaction that will occur when the two substances are mixed. If no reaction occurs, write "no reaction." *Note: the reactions are grouped according to the difficulty that typical students have with them—our groupings may not match your own experience and ability.* (Answers are available as a supplemental handout on the class website.)

Easy reactions:

1) 0.1 M $AgNO_3$ and 0.1 M KBr
2) 0.1 M $CaCl_2$ and 0.1 M $NaNO_3$
3) 0.1 M $Fe(NO_3)_3$ and 0.1 M Na_2CO_3
4) 0.1 M KOH and 0.1 M $CoBr_2$
5) 0.1 M HNO_3 and 0.1 M $Ba(OH)_2$
6) 0.1 M $Pb(NO_3)_2$ and 0.1 M $MgSO_4$
7) 0.1 M Na_2S and 0.1 M MnI_2
8) 0.1 M K_3PO_4 and 0.1 M $CuCl_2$
9) 0.1 M HCl and 0.1 M $NaC_2H_3O_2$
10) 0.1 M $NiSO_4$ and 0.1 M $FeCl_3$

Harder reactions:

1) 0.1 M $HC_2H_3O_2$ and 0.1 M KOH
2) 0.1 M NH_3 and 0.1 M HBr
3) 1 M HCl and solid $Mn(OH)_2$
4) excess 1 M HNO_3 and solid $AlPO_4$
5) 0.1 M $AgNO_3$ and 0.1 M NaOH
6) 0.1 M HClO and 0.1 M $Ba(OH)_2$ (no precipitate forms)

Still harder reactions:

1) 0.1 M Na_2HPO_4 and 0.1 M HI (equal volumes)
2) 0.1 M NH_3 and 0.1 M $Fe(NO_3)_2$
3) 0.1 M $NaHCO_3$ and 0.1 M HCl
4) 0.1 M K_2CO_3 and 0.1 M HNO_3 (equal volumes)
5) 0.1 M H_3PO_4 and 0.1 M NH_3 (equal volumes)

Very tricky reactions:

1) 0.1 M $AgNO_3$ and 0.1 M NH_3
2) solid $BaCO_3$ and excess 2 M $HC_2H_3O_2$
3) solid $Cu(OH)_2$ and 1 M H_2SO_4 (equal numbers of moles)
4) solid Ag_2O and excess 2 M HCl
5) 0.1 M H_3PO_4 and excess 1 M KOH