

## Step by Step: Molecular Reactions, Complete Ionic Reactions and Net Ionic Reactions

### Solubility Rules

**\*\* soluble = aqueous      marginally/slightly soluble = solid**

#### Solubility Table

1. Nitrate ( $\text{NO}_3^{-1}$ ) salts are soluble.
2. Ammonium ( $\text{NH}_4^{+1}$ ) and Group I Alkali metal ( $\text{Li}^{+1}$ ,  $\text{Na}^{+1}$ ,  $\text{K}^{+1}$ ,  $\text{Cs}^{+1}$ ,  $\text{Rb}^{+1}$ ) salts are soluble.
3. Chloride, Bromide, Iodide ( $\text{Cl}^{-1}$ ,  $\text{Br}^{-1}$ ,  $\text{I}^{-1}$ ) salts are soluble, except for salts with  $\text{Ag}^{+1}$ ,  $\text{Pb}^{2+}$  and  $\text{Hg}_2^{2+}$ .
4. Sulfate ( $\text{SO}_4^{2-}$ ) salts are soluble, except  $\text{Ba}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Pb}^{2+}$ , and  $\text{Hg}_2^{2+}$ .
5. Soluble Hydroxides are  $\text{LiOH}$ ,  $\text{NaOH}$  and  $\text{KOH}$ . Marginally soluble:  $\text{Ba}(\text{OH})_2$ ,  $\text{Sr}(\text{OH})_2$  and  $\text{Ca}(\text{OH})_2$ . The rest are slightly soluble.
6. Carbonates ( $\text{CO}_3^{2-}$ ), Sulfides ( $\text{S}^{2-}$ ), Chromates ( $\text{CrO}_4^{2-}$ ) and Phosphates ( $\text{PO}_4^{3-}$ ) are slightly soluble. (All with ammonium or Group 1 Alkali metals are soluble.)

Ex. 1) Write the **molecular** equation:



Steps: 1) Break compounds apart to their Single ions:  $\text{Ba}^{2+}$   $\text{Cl}^{-1}$  &  $\text{Na}^{+1}$   $\text{SO}_4^{2-}$

Ba is in the 2<sup>nd</sup> column, so +2. Cl is in the 17<sup>th</sup> column, so -1.

Na is in the 1<sup>st</sup> column, so +1. Sulfate you have memorized is -2.

\*Do not worry about the 2 for chlorine; you want only the single ions. Just one Cl. You will fix the amount in step number 4.

\*Do not worry about the 2 for sodium; you want only the single ions. Just one Na.

2) Mix ions to make new neutral compounds:

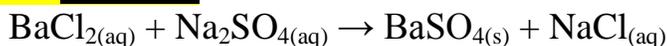


Now you need to mix and match to make the new compounds. **Opposites Attract!** So put positive with negative. (Do not reform the compounds you started with; they have already broken up and do not want to go back together.) If necessary, you will need to multiply the ions to make new neutral compounds. But in this case Ba is +2 and  $\text{SO}_4$  is -2, a perfect match. Na is +1 and Cl is -1, a perfect match.

For step 3: Look at the solubility rules to see if it is soluble (aq) or not (s).

-Rule 4 says that sulfates are soluble, except for  $\text{BaSO}_4$ . If it is not soluble, then **solid**.

-Rule 2 says that sodium will be soluble (aq) and Rule 2 says that chloride will be soluble (aq), so NaCl is **aqueous**.



3) Solubility Rules from Table:    Rule #4    Rule #2,3    \*\*If no rule, then soluble (aq).

For step 4: Balance the equation. This will fix the amounts of elements we ignored in the first step.



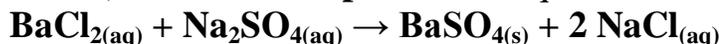




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**Only for Chem Honors:**

Ex. 1b) Write the **complete ionic** equation:

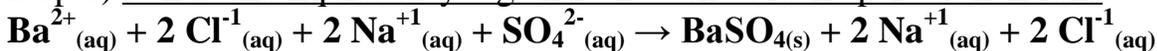


Break all compounds apart to their elements, except for solids and liquids.

Reactant side:  $\text{Cl}_2$ , so 2 chloride ions.  $\text{Na}_2$ , so 2 sodium ions.

Product side: 2  $\text{NaCl}$ , so 2 sodium ions and 2 chlorine ions.

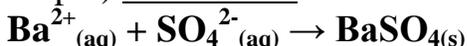
Step 5) Solids and liquids stay together and don't break apart to their ions.



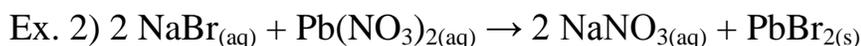
Ex. 1c) Write the **net ionic** equation:

Cancel all ions. The 2  $\text{Cl}^{-1}$  and 2  $\text{Na}^{+1}$  cancel from both sides. When these cancel, they should cancel completely. The amounts should be the same on the reactant and product sides. If not, something is wrong!

Step 6) Cancel ions.



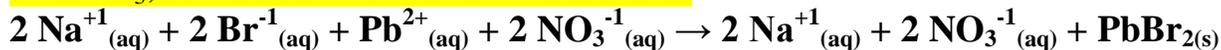
**\*\*\*Make sure you are writing all ions with their charges and all ions/compounds with their (aq) or (s)!!!**



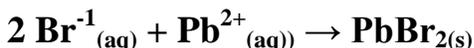
Break the compounds apart, except for solids and liquids:

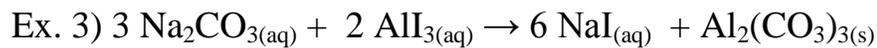
2  $\text{NaBr}$ , so 2 sodium ions and 2 bromide ions.  $(\text{NO}_3)_2$  so 2 nitrates!

2  $\text{NaNO}_3$ , so 2 sodium ions and 2 nitrate ions.



Cancel the 2 sodium ions and the 2 nitrate ions.

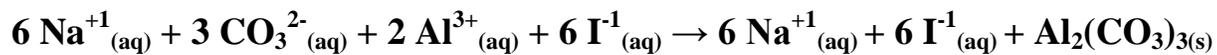




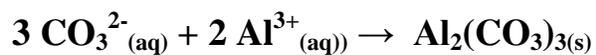
3 Na<sub>2</sub>CO<sub>3</sub>, so 6 sodium ions. 3 Na<sub>2</sub>CO<sub>3</sub>, so 3 carbonates.

2 AlI<sub>3</sub>, so 2 aluminum ions. 2 AlI<sub>3</sub>, so 6 iodide ions.

6 NaI, so 6 sodiums and 6 iodides.



Cancel the sodiums and iodides.



**\*End of Notes\***