

Solubility Rules

When salt solutions are mixed, two things can happen: 1) no reaction (all ions remain soluble), or 2) a solid forms (called precipitation). You will examine which salts (positive + negative ions) are soluble and which are insoluble.

- Gather together: 1 paper grid, 1 overhead (acetate) sheet, two pieces of masking tape.
- Place your grid on the lab bench. Cover the grid with the acetate and secure it to the bench with tape.
- Using the dropper bottle at your lab station, carefully add one drop (from a height of 1-2 cm) to each box for that ion. E.g. for Br^- a drop goes in each box under Br^- ; for Ag^+ a drop goes in each box left of Ag^+ .
- Pass the bottle left. Add drops from the next bottle that comes to you from your right (be careful to note the label on each bottle). **It is critical to add drops from a height of 1-2 cm. If you touch the tip of the dropper bottle to another solution, the contents of that bottle can become contaminated, ruining the results of other students.** Continue this procedure until all ions have been added together. At the end of this step you should have, in each box, a mixture of two drops (1 positive ion + 1 negative ion).
- Look in the boxes: some will contain a precipitate (i.e. solid), others will be clear (indicating the salt is soluble). If you are uncertain if a precipitate has formed, **carefully** remove the tape and slide the acetate onto a dark surface, without disturbing any drops. This will allow you to see white precipitates clearly.
- On the grid below, place an "X" in every box where a precipitate has formed.
- Carefully remove the tape from the acetate. Rinse off the acetate in the sink. Rinse out the sink. Wipe the acetate clean using a damp paper towel. Dry the acetate. Return all equipment. Wipe off your lab bench.

	Br^-	Cl^-	CO_3^{2-}	NO_3^-	OH^-	PO_4^{3-}	SO_3^{2-}	SO_4^{2-}
Ag^+								
Al^{3+}								
Ba^{2+}								
Ca^{2+}								
Co^{2+}								
Cu^{2+}								
Fe^{3+}								
K^+								
Na^+								
Ni^{2+}								
NH_4^+								

Questions (answer on a separate sheet of paper)

- Elements from which group on the periodic table form ions that always remain soluble?
- Salts containing which other +ve ion were always soluble?
- Salts containing which negative ion were always soluble?
- Which negative ions were almost always soluble?
- All solutions must be electrically neutral. I.e. they contain both +ve and -ve ions. However, bottles were identified with only one ion. Based on your results, which -ve ion is most likely also present in bottles labeled as +ve?
- Which +ve ion(s) are likely in bottles labeled as -ve ions?
- Write the formula of the precipitate, if one forms, for each box in the PO_4^{3-} column (don't forget valences).
- The results of solubility tests can be summarized as a list of solubility rules. Look at the list of solubility rules below. Based on these rules which are soluble: $\text{Ca}(\text{NO}_3)_2$, FeCl_3 , $\text{Ni}(\text{OH})_2$, AgNO_3 , BaSO_4 , CuCO_3 ? For each state a) if it is soluble, b) which rule applies, and c) if this agrees with your experimental results.
- A test-tube contains Ba^{2+} , Pb^{2+} , Cu^{2+} and Na^+ . Describe how these ions can be separated from one another, one at a time, by "selectively" precipitating each (i.e. by adding an appropriate negative ion and then filtering the solution). Which positive ion will remain soluble in the solution at the end? Why?
- Write balanced molecular, ionic, and net ionic equations for each reaction. If no solid forms simply write NR (No Reaction) as the product for the molecular equation and do not give ionic or net ionic equations.
 - ammonium sulfide + lead (II) nitrate,
 - cobalt (II) nitrate + sodium sulfate,
 - silver nitrate + sodium iodide,
 - aluminum nitrate + potassium hydroxide,
 - $\text{Zn}(\text{NO}_3)_2(\text{aq}) + \text{K}_2\text{CO}_3(\text{aq})$,
 - $\text{KCl}(\text{aq}) + \text{NaNO}_3(\text{aq})$

Soluble Compounds

- All compounds of the alkali metals (Group IA) are soluble.
- All salts containing NH_4^+ , NO_3^- , ClO_4^- , ClO_3^- , and $\text{C}_2\text{H}_3\text{O}_2^-$ are soluble.
- All chlorides (Cl^-), bromides (Br^-), and iodides (I^-) are soluble, except those of Ag^+ , Pb^{2+} , and Hg_2^{2+} .
- All sulfates (SO_4^{2-}) are soluble, except those of Pb^{2+} , Ca^{2+} , Sr^{2+} , Hg_2^{2+} , and Ba^{2+} .

Insoluble Compounds

- All hydroxides (OH^-) are insoluble except those of Group IA and Ca^{2+} , Sr^{2+} , and Ba^{2+} .
- All salts containing PO_4^{3-} , CO_3^{2-} , SO_3^{2-} , and S^{2-} are insoluble, except those of Group IA and NH_4^+ .