

Chemistry 11  
Solution Chemistry II

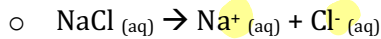
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- 1. Ions in Solutions
- 2. Solubility Table
- 3. Separating Ions

Ions in Solutions

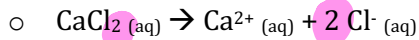
Ionization Equation

- Represents the salt breaking apart into ions.

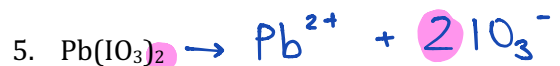


*\*keep polyatomic ions together!*

- If the salt were  $\text{CaCl}_2$ .

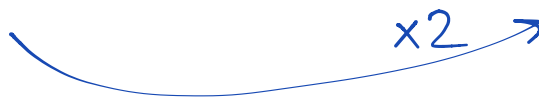
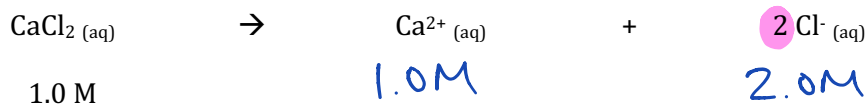
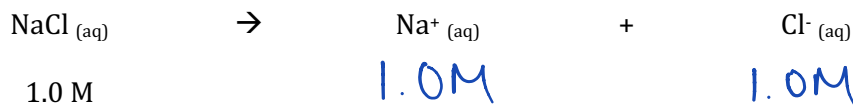


Practice:

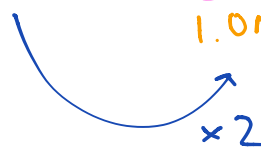
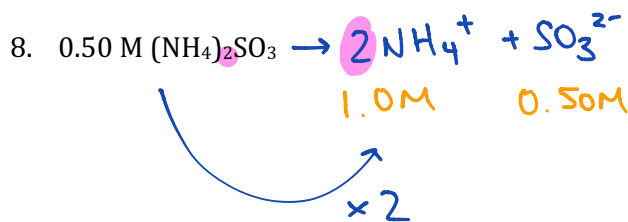
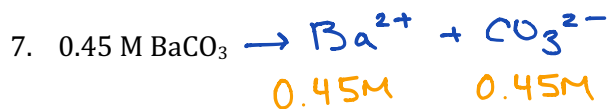
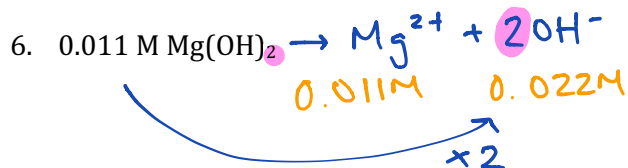
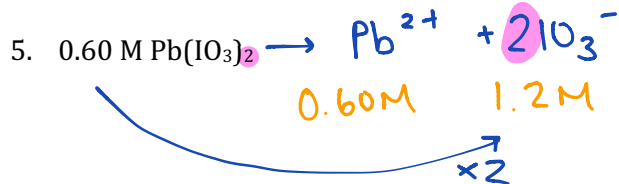
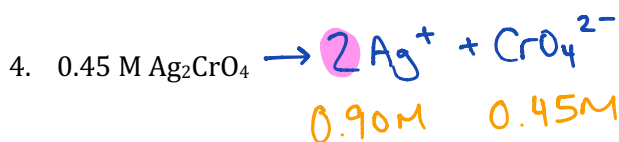
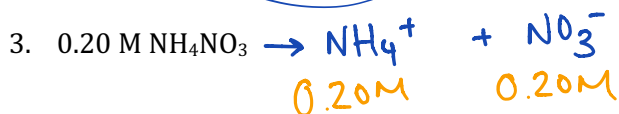
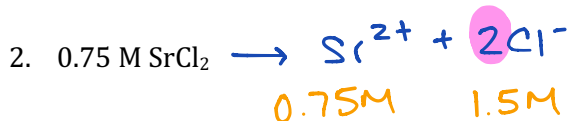
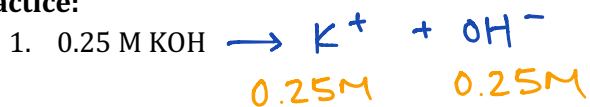


Calculating Concentration

- Mole ratios represent the relative amounts of ions in solution.



**Practice:**



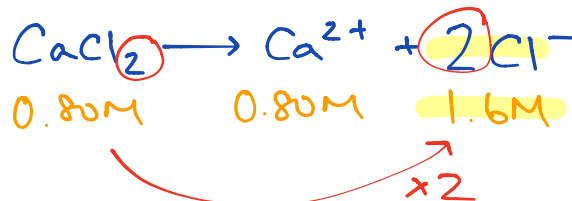
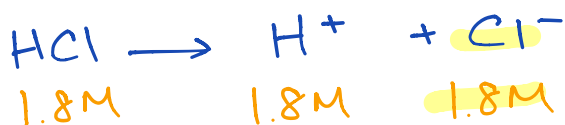
**Ionization + Dilution**

$V_2 = 25.0 \text{ mL}$

✓ A 15.0 mL sample of 3.0 M HCl was added to 10.0 mL of 2.0 M CaCl<sub>2</sub>. Calculate the concentration of each ion in the solution. Assume no reaction occurs ( $[\text{H}^+] = 1.8 \text{ M}$   $[\text{Cl}^-] = 3.4 \text{ M}$   $[\text{Ca}^{2+}] = 0.80 \text{ M}$ )

$[\text{HCl}]$   
 $C_1 V_1 = C_2 V_2$   
 $(3.0 \text{ M})(15.0 \text{ mL}) = (C_2)(25.0 \text{ mL})$   
 $C_2 = \frac{(3)(15)}{(25)}$   
 $= 1.8 \text{ M} = [\text{HCl}]$

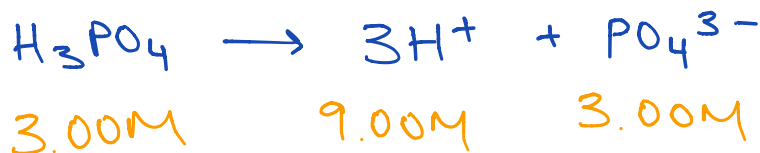
$[\text{CaCl}_2]$   
 $C_1 V_1 = C_2 V_2$   
 $(2.0 \text{ M})(10.0 \text{ mL}) = (C_2)(25.0 \text{ mL})$   
 $C_2 = \frac{(2)(10)}{(25)}$   
 $= 0.80 \text{ M} = [\text{CaCl}_2]$



$[\text{H}^+] = 1.8 \text{ M}$   
 $[\text{Ca}^{2+}] = 0.80 \text{ M}$   
 $[\text{Cl}^-] = 1.8 \text{ M} + 1.6 \text{ M} = 3.4 \text{ M}$

### Practice 1.

What are the concentrations of both ions in a 3.00 M solution of  $\text{H}_3\text{PO}_4$ ? ( $[\text{H}^+] = 9.00\text{M}$   $[\text{PO}_4^{3-}] = 3.00\text{M}$ )

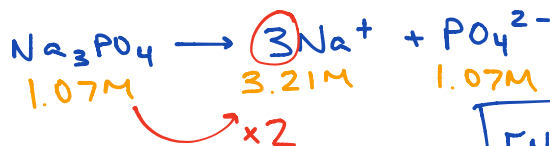


### Practice 2.

What is the sodium ion concentration when 250.0 mL of water is added to 125.5 mL of a 3.21 M solution of sodium phosphate? ( $[\text{Na}^+] = 3.21\text{M}$ )

$$C_1 = 3.21\text{M}$$
$$V_1 = 125.5\text{mL}$$
$$C_2 = ?$$
$$V_2 = 375.5\text{mL}$$

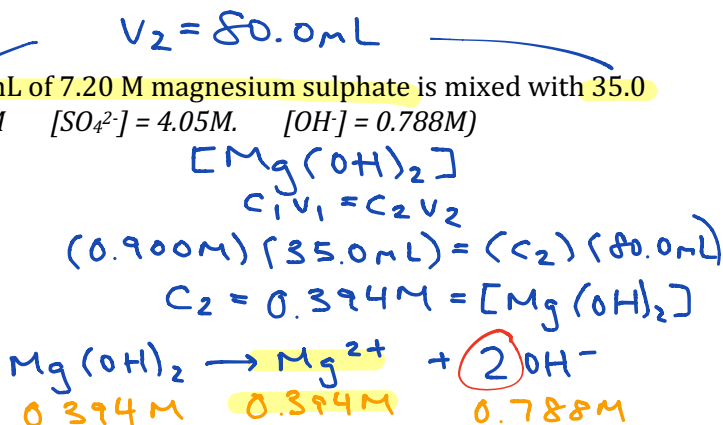
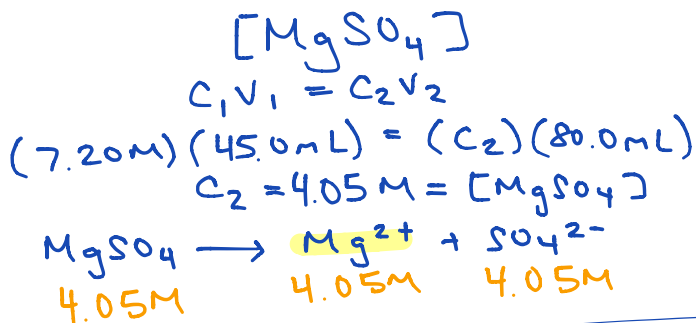
$$C_1V_1 = C_2V_2$$
$$(3.21\text{M})(125.5\text{mL}) = (C_2)(375.5\text{mL})$$
$$C_2 = 1.07\text{M}$$



$[\text{Na}^+] = 3.21\text{M}$

### Practice 3.

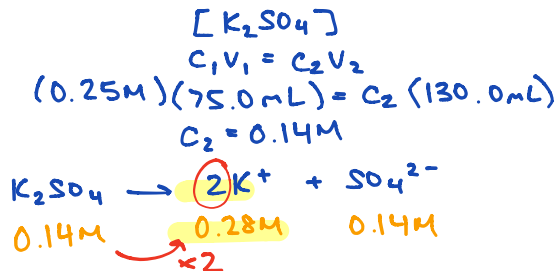
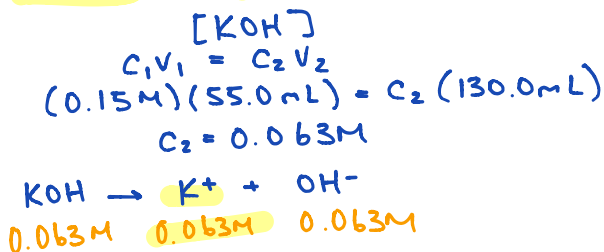
Determine the concentration of each ion when 45.0 mL of 7.20 M magnesium sulphate is mixed with 35.0 mL of 0.900 M magnesium hydroxide. ( $[\text{Mg}^{2+}] = 4.44\text{M}$   $[\text{SO}_4^{2-}] = 4.05\text{M}$   $[\text{OH}^-] = 0.788\text{M}$ )



$[\text{Mg}^{2+}] = 4.44 \quad [\text{SO}_4^{2-}] = 4.05\text{M} \quad [\text{OH}^-] = 0.788\text{M}$

### Practice 4.

What is the molar concentration of each ion in solution resulting from mixing 55.0 mL of 0.15 M potassium hydroxide with 75.0 mL of 0.25 M potassium sulphate? ( $[\text{K}^+] = 0.34\text{M}$   $[\text{OH}^-] = 0.063\text{M}$   $[\text{SO}_4^{2-}] = 0.14\text{M}$ )



$[\text{K}^+] = 0.34\text{M} \quad [\text{OH}^-] = 0.063\text{M} \quad [\text{SO}_4^{2-}] = 0.14\text{M}$

## Solubility Table

When some ions are combined, they create a solid →

they are NOT soluble (will form a precipitate)

**SOLUBLE** → Dissolves in water; aqueous

**LOW SOLUBILITY** → Does not dissolve in water; solid (ppt)

### SOLUBILITY OF COMMON COMPOUNDS IN WATER

The term soluble here means > 0.1 mol/L at 25°C.

Negative Ions (Anions)	Positive Ions (Cations)	Solubility of Compounds
All	Alkali ions: Li <sup>+</sup> , Na <sup>+</sup> , K <sup>+</sup> , Rb <sup>+</sup> , Cs <sup>+</sup> , Fr <sup>+</sup>	Soluble
All	Hydrogen ion: H <sup>+</sup>	Soluble
All	Ammonium ion: NH <sub>4</sub> <sup>+</sup>	Soluble
Nitrate, NO <sub>3</sub> <sup>-</sup>	All	Soluble
Chloride, Cl <sup>-</sup> or Bromide, Br <sup>-</sup> or Iodide, I <sup>-</sup>	All others	Soluble
	Ag <sup>+</sup> , Pb <sup>2+</sup> , Cu <sup>+</sup>	Low Solubility
Sulphate, SO <sub>4</sub> <sup>2-</sup>	All others	Soluble
	Ag <sup>+</sup> , Ca <sup>2+</sup> , Sr <sup>2+</sup> , Ba <sup>2+</sup> , Pb <sup>2+</sup>	Low Solubility
Sulphide, S <sup>2-</sup>	Alkali ions, H <sup>+</sup> , NH <sub>4</sub> <sup>+</sup> , Be <sup>2+</sup> , Mg <sup>2+</sup> , Ca <sup>2+</sup> , Sr <sup>2+</sup> , Ba <sup>2+</sup>	Soluble
	All others	Low Solubility
Hydroxide, OH <sup>-</sup>	Alkali ions, H <sup>+</sup> , NH <sub>4</sub> <sup>+</sup> , Sr <sup>2+</sup>	Soluble
	All others	Low Solubility
Phosphate, PO <sub>4</sub> <sup>3-</sup> or Carbonate, CO <sub>3</sub> <sup>2-</sup> or Sulphite, SO <sub>3</sub> <sup>2-</sup>	Alkali ions, H <sup>+</sup> , NH <sub>4</sub> <sup>+</sup>	Soluble
	All others	Low Solubility

### Practice:

1. Classify the following salts as being soluble or having low solubility in water:

a. Sodium phosphate

Soluble

b. Aluminum hydroxide

low solubility

c. \* Copper (II) chloride

Soluble

d. Calcium sulphate

low solubility

e. Iron (II) sulphide

low solubility

f. Strontium hydroxide

Soluble

g. Zinc bromide

Soluble

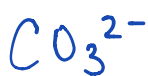
h. Cesium sulphite

Soluble

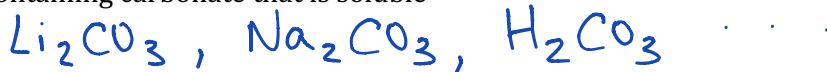
i. Potassium chromate

Soluble

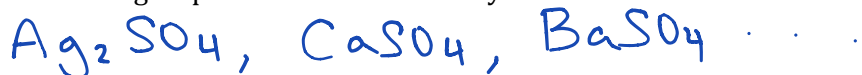
2. Write the formula for the following:



a. A salt containing carbonate that is soluble



b. A salt containing sulphate with low solubility



c. A cation that forms a salt with low solubility with both chloride and sulphate ions



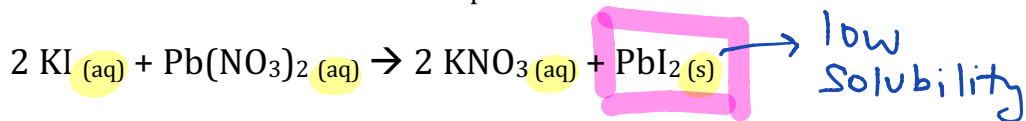
d. An anion that forms soluble salts with all cations



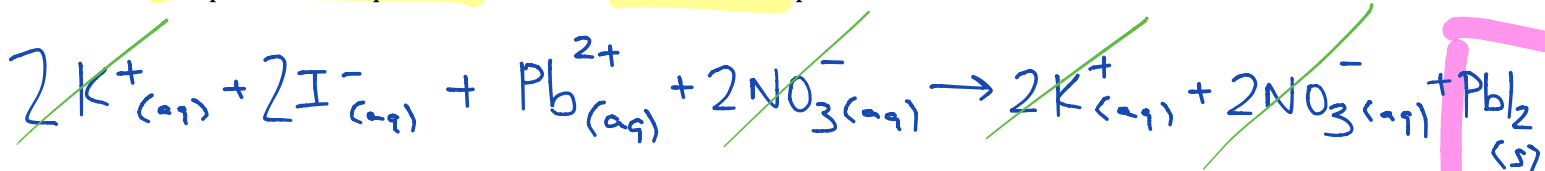
ionic compound

## Types of chemical equations:

Formula Equation: shows the chemical formulas of the compounds and their states.



Complete Ionic Equation: shows the soluble salts represented in their dissociated form.



Net Ionic Equation: shows only the ions that take part in the reaction. Ions that are the same on both sides of the equation are called **spectator ions**.

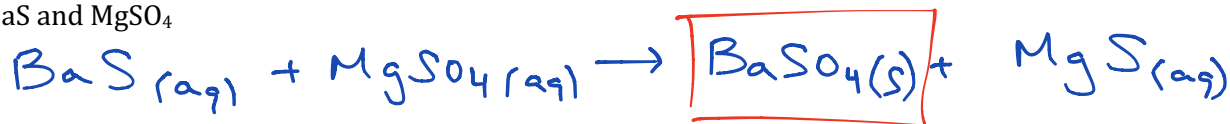


### Practice:

(Formula Equation)

1. Write the formula for the precipitate that forms when the following solutions are mixed:

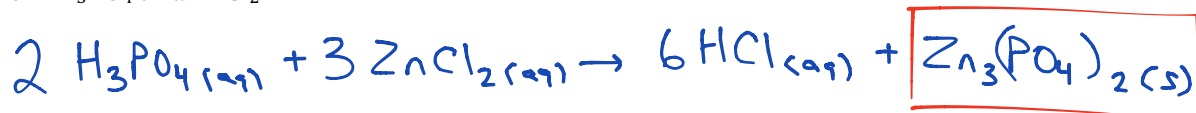
a. BaS and MgSO<sub>4</sub>



b. NH<sub>4</sub>OH and FeBr<sub>2</sub>



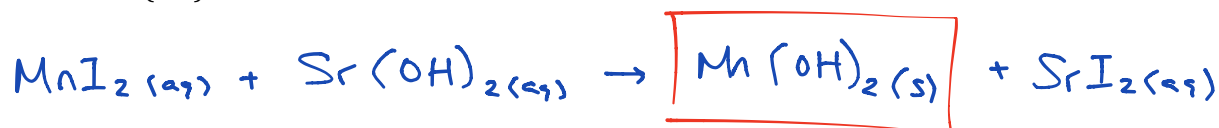
c. H<sub>3</sub>PO<sub>4</sub> and ZnCl<sub>2</sub>



d. K<sub>2</sub>CO<sub>3</sub> and CrSO<sub>4</sub>

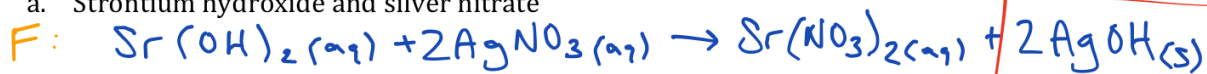


e. MnI<sub>2</sub> and Sr(OH)<sub>2</sub>

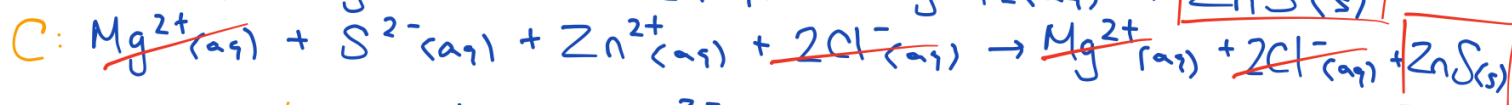
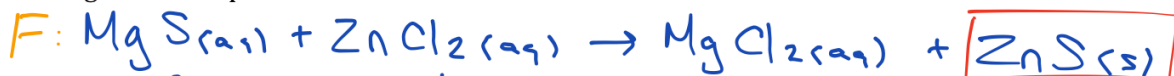


2. Write a **formula equation**, **complete ionic equation** and **net ionic equation** for the following reactions:

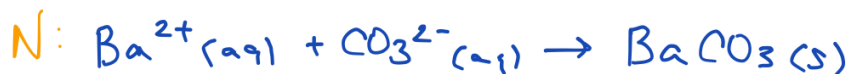
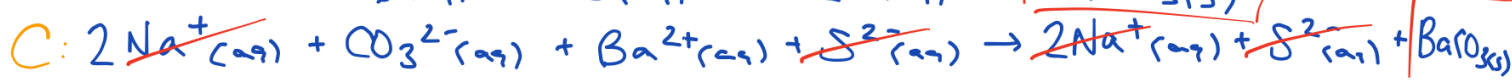
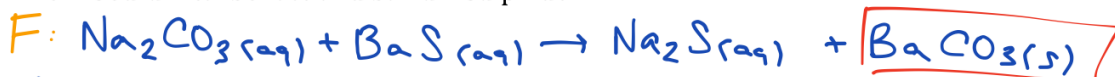
a. Strontium hydroxide and silver nitrate



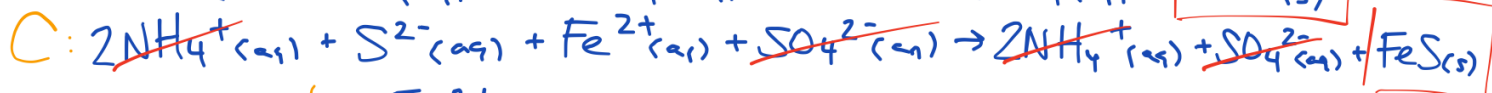
b. Magnesium sulphide and zinc chloride



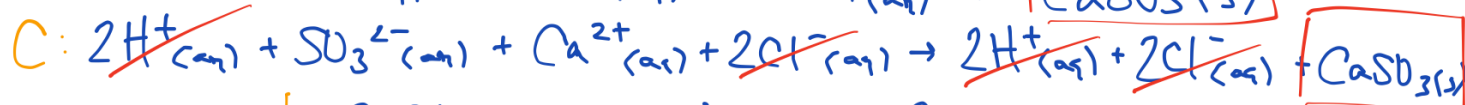
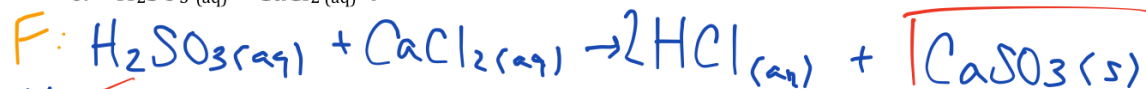
c. Sodium carbonate and barium sulphide



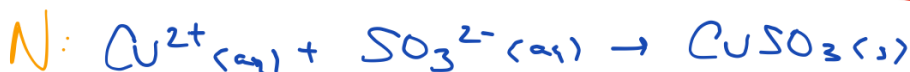
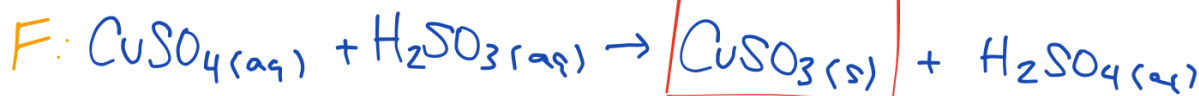
d.  $(\text{NH}_4)_2\text{S}(\text{aq}) + \text{FeSO}_4(\text{aq}) \rightarrow$



e.  $\text{H}_2\text{SO}_3(\text{aq}) + \text{CaCl}_2(\text{aq}) \rightarrow$



f. Copper (II) sulphate +  $\text{H}_2\text{SO}_3$



## Separating Ions

### Example:

A solution may contain the ions  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$  and  $\text{Zn}^{2+}$ . How would you precipitate the ions out of solution individually? Describe your answer using a flow chart.

- All are cations - therefore an addition of an anion will precipitate out these cations.
- "Low solubility" - means will precipitate out.

1. Which anion will precipitate just one of the ions out first?



a. Which ions are left?



2. Which anion will precipitate just one of the two ions left?

$\text{OH}^-$  will create a ppt with  $\text{Ca}^{2+}$

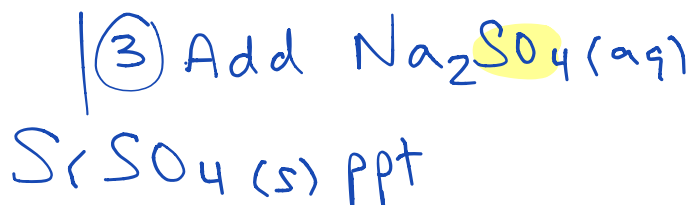
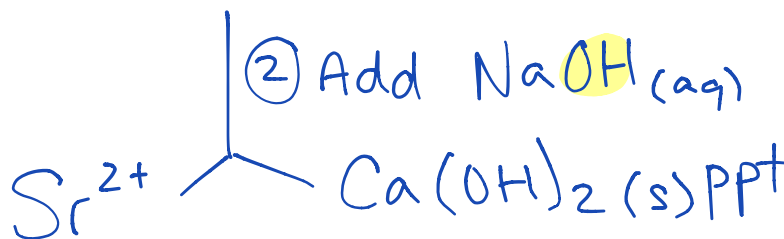
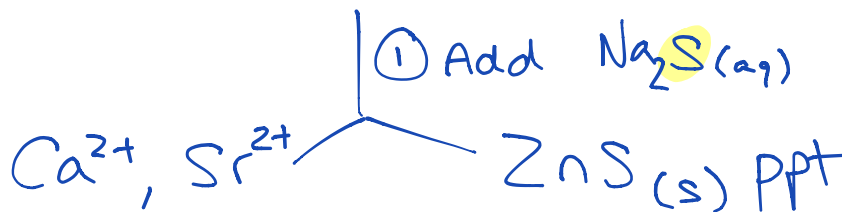
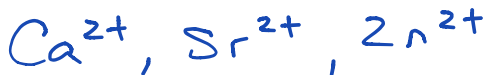
3. Which anion will precipitate out the last ion left?



$\text{SO}_4^{2-}$  will create a ppt with  $\text{Sr}^{2+}$

SOLUBILITY OF COMMON COMPOUNDS IN WATER  
The term soluble here means > 0.1 mol/L at 25°C.

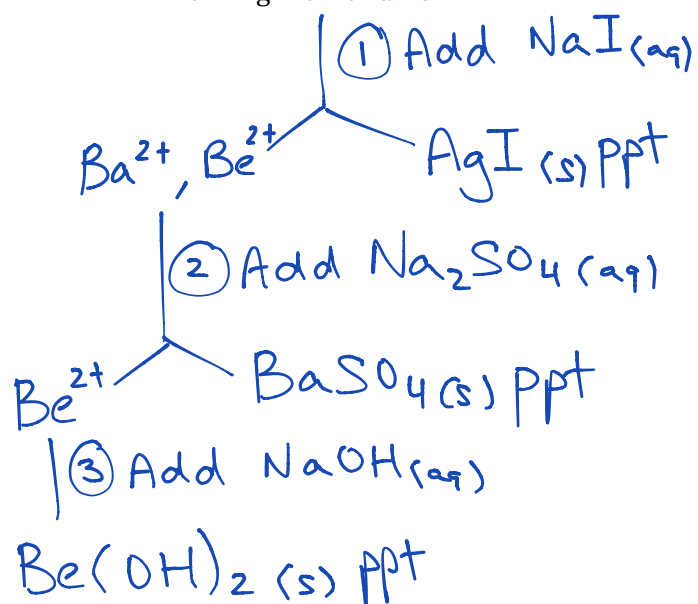
Negative Ions (Anions)	Positive Ions (Cations)	Solubility of Compounds
All	Alkali ions: $\text{Li}^+$ , $\text{Na}^+$ , $\text{K}^+$ , $\text{Rb}^+$ , $\text{Cs}^+$ , $\text{Fr}^+$	Soluble
All	Hydrogen ion: $\text{H}^+$	Soluble
All	Ammonium ion: $\text{NH}_4^+$	Soluble
Nitrate, $\text{NO}_3^-$	All	Soluble
Chloride, $\text{Cl}^-$ or Bromide, $\text{Br}^-$ or Iodide, $\text{I}^-$	All others	Soluble
	$\text{Ag}^+$ , $\text{Pb}^{2+}$ , $\text{Cu}^+$	Low Solubility
Sulphate, $\text{SO}_4^{2-}$	All others	Soluble
	$\text{Ag}^+$ , $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$ , $\text{Pb}^{2+}$	Low Solubility
Sulphide, $\text{S}^{2-}$	Alkali ions, $\text{H}^+$ , $\text{NH}_4^+$ , $\text{Be}^{2+}$ , $\text{Mg}^{2+}$ , $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$	Soluble
	All others	Low Solubility
Hydroxide, $\text{OH}^-$	Alkali ions, $\text{H}^+$ , $\text{NH}_4^+$ , $\text{Sr}^{2+}$	Soluble
	All others	Low Solubility
Phosphate, $\text{PO}_4^{3-}$ or Carbonate, $\text{CO}_3^{2-}$ or Sulphite, $\text{SO}_3^{2-}$	Alkali ions, $\text{H}^+$ , $\text{NH}_4^+$	Soluble
	All others	Low Solubility



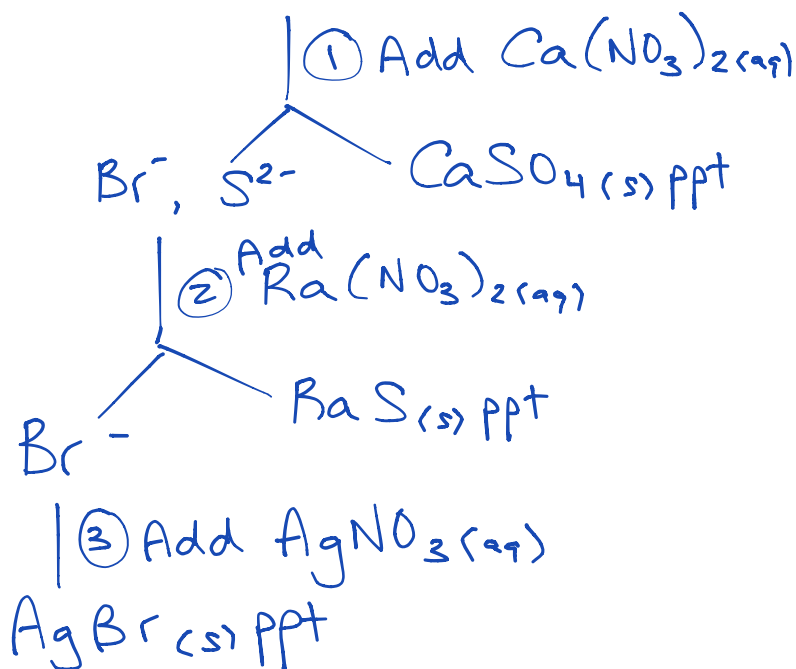
**Practice:**

1. For each of the following solutions, describe a process to individually remove each ion. Be sure to list the compounds that you add in order, and the method of removing the precipitate. You may wish to use a flow chart.

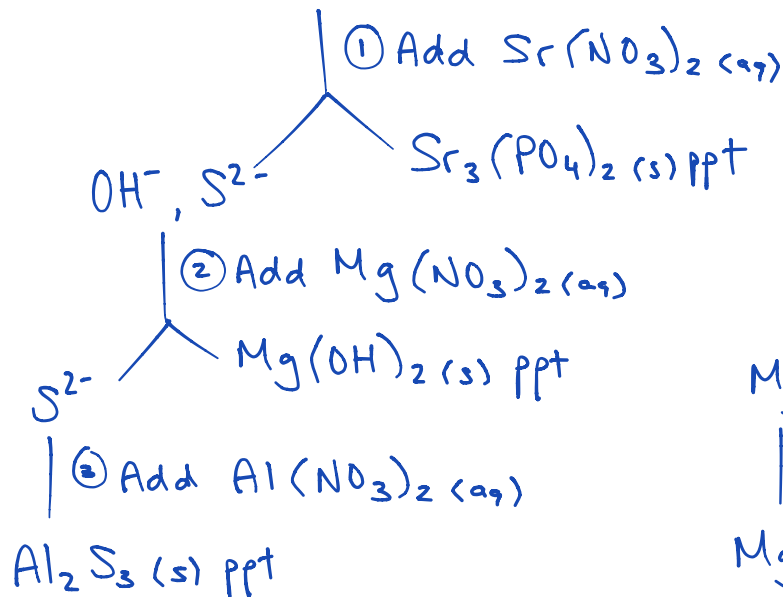
a.  $\text{Ag}^+$ ,  $\text{Ba}^{2+}$  and  $\text{Be}^{2+}$



b.  $\text{Br}^-$ ,  $\text{SO}_4^{2-}$  and  $\text{S}^{2-}$



c.  $\text{OH}^-$ ,  $\text{PO}_4^{3-}$  and  $\text{S}^{2-}$



d.  $\text{Cr}^{3+}$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$

