A systematic approach to solving complex equilibrium problems.

In many cases, multiple equilibria coexist in a system, making calculating concentrations difficult.

Example: How many grams of Iron (II) Sulfide can be dissolved in 100 mL of 0.1 F KCl?

$Fe^{2+} + Cl^{-} = FeCl^{+}$ $K_f = 2.51$

$FeS = Fe^{2+} + S^{2-}$ $K_{sp} = 6.0 \times 10^{-18}$

How do we tackle this problem? We can't simply set up two equilibrium constant expressions, there are too many unknowns!

Use a more systematic approach: We need to write enough equations to solve for all of our unknowns.

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Here's the Plan:

1. **Write the pertinent reactions:**

2. **Write the *charge balance* equation.**
   Charge balance requires that the total positive charge is equal to the total negative charge.

3. **Write mass balance equations.**
   Mass balance requires that the total number of moles (or atoms) of a particular element must always equal the amount of that atom delivered to the solution. (conservation of matter)

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Here's the Plan:

4. **Write equilibrium constant expressions for all equilibria.**

5. **Count equations and unknowns.**
   Four equations, four unknowns.

6. **Solve for all the unknowns.**
   Algebra, here we come!

Life becomes easier if we use computer-based tools

- Solve problem *iteratively* (repeated substitutions)
- Use numerical solution routines

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General Strategy Applies Regardless of Number of Equilibria

Now consider adding the following equilibria to the discussion:

$S^{2-} + H_2O = HS^- + OH^-$	$K_{b1} = 0.80$
$HS^- + H_2O = H_2S + OH^-$	$K_{b2} = 1.1 \times 10^{-7}$
$H_2O = H^+ + OH^-$	$K_w = 1.0 \times 10^{-14}$

Life gets even more complicated!!! Strategy still works!

1. **Write the pertinent reactions:**
2. **Write the *charge balance* equation.**
3. **Write mass balance equations.**
4. **Write equilibrium constant expressions for all equilibria.**
5. **Count equations and unknowns.**
6. **Solve for all the unknowns.**

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