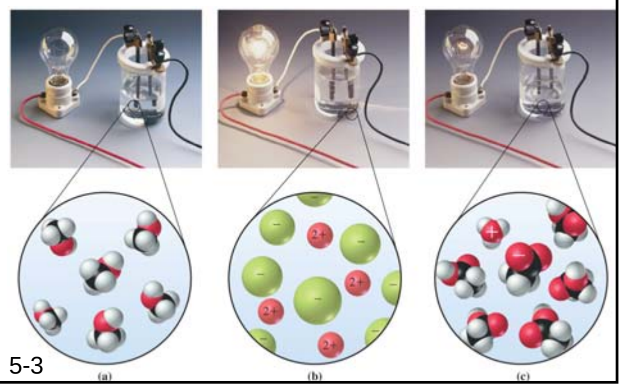
Reactions in Aqueous Solution

Solutions:

- Homogeneous mixtures
- Solvent - medium in which something is dissolved.
- Solute - material that is dissolved.

Electrolytes - Compounds whose solutions conduct electricity.

- Electrolytic Solution
- Strong vs weak electrolytes
- Water as a solvent: How does water dissolve something like NaCl?



Solubility and Precipitation Rxns

Degrees of solubility

– Table 5.1 – Know this!

TABLE 5.1 Solubility Guidelines for Common Ionic Solids

Follow the lower-numbered guideline when two guidelines are in conflict. This leads to the correct prediction in most cases.

1. Salts of group 1 cations (with some exceptions for Li^{+}) and the NH_4^{+} cation are soluble.
2. Nitrates, acetates, and perchlorates are soluble.
3. Salts of silver, lead, and mercury(I) are insoluble.
4. Chlorides, bromides, and iodides are soluble.
5. Carbonates, phosphates, sulfides, oxides, and hydroxides are insoluble (sulfides of group 2 cations and hydroxides of Ca^{2+}, Sr^{2+}, and Ba^{2+} are slightly soluble).
6. Sulfates are soluble except for those of calcium, strontium, and barium.

Spectator ions and net ionic equations

Example: Predict the products and write the net ionic equation for the following reaction: $BaS(aq) + CuSO_4(aq) \rightarrow$??

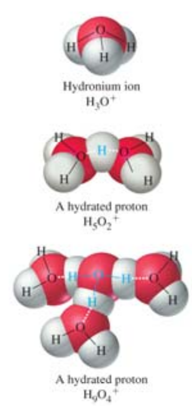
Some Simplified Solubility Rules

These are worth committing to memory!

Anion	Guideline
NO_3^-	All nitrates are soluble.
Cl^-	All chlorides are soluble except AgCl, Hg_2Cl_2, and $PbCl_2$.
SO_4^{2-}	Most sulfates are soluble. Exceptions include $BaSO_4$, $PbSO_4$, and $SrSO_4$.
CO_3^{2-}	All carbonates are insoluble except NH_4^+ and those of the Group 1 elements.
OH^-	All hydroxides are insoluble except those of the Group 1 elements, $Ba(OH)_2$, and $Sr(OH)_2$. $Ca(OH)_2$ is slightly soluble.
S^{2-}	All sulfides are insoluble except those of the Group 1 and Group 2 elements and NH_4^+

Acids and Bases

- **Acid**
- **Base**
- **Strong versus Weak**
  - Know that HCl, HBr, HI, HNO_3, $HClO_4$, H_2SO_4, LiOH, NaOH, KOH are strong!
- **Neutralization reactions**



Redox Reactions

- Based around changes in **oxidation state**

Guidelines for assigning oxidation states (section 3-4):

1. Atoms of pure elements have an oxidation number of **zero.**
2. The sum of the oxidation numbers in a compound or ion ***MUST*** be equal to the charge on the compound or ion.
   - For monatomic ions, the oxidation number is the charge on the atom.
3. In compounds, group 1 metals are +1 and group 2 metals are +2
4. In compounds fluorine is always -1.
5. In compounds hydrogen is always +1.
   - *Except in binary metal hydrides (MHx), where it is -1.*
6. Oxygen is always -2.
   - *Except in peroxides (O_2^{2-}), which are relatively rare.*
7. In binary compounds with metals, group 7 (17) elements are -1, group 6 (16) are -2, and group 5 (15) are -3.
   - *Except when combined with oxygen and fluorine.*

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Redox Reactions

Using oxidation numbers to identify redox reactions

- Oxidation
- Reduction

Example 5-4. Are each of these redox reactions?

$$MnO_2 + 4H^+ + 2Cl^- \rightarrow Mn^{2+} + 2H_2O + Cl_2$$

$$H_2PO_4^- + OH^- \rightarrow HPO_4^- + H_2O$$

- Half reactions
- Oxidizing and Reducing agents

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Balancing Redox Reactions: Half-Reaction Method

Br^{-} (aq) + MnO_4^{-} (aq) → Br_2 (l) + Mn^{2+} (aq)

1. Write oxidation and reduction half reactions.
2. Balance all elements in each half reaction except oxygen and hydrogen.
3. Balance oxygen using H_2O.
4. Balance hydrogen using H^+
5. Balance charge using electrons.
6. Multiply one or both balanced half reaction to equalize the number of electrons transferred in each.
7. Add the half reactions and cancel redundant species.
8. Check to be sure that mass and charge balance.

- Modification for basic solutions

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Solution Stoichiometry and Titrations

Key premise:

- If you know the quantity of one reagent that is just enough to react with all of the other reagent and,
- If you know the reaction stoichiometry,
- You can determine the quantity of the "other" reagent in a reaction.

A + 2B → 2C + D

- In virtually every calculation, you convert between ***moles*** of reagents in the reaction. As long as you can convert from grams or concentration to moles (and back) you are well on your way to the correct answer!

Titrations aid in this determination, as long as you can "see" the **equivalence point**.

Indicator:

Standardization:

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Titration Example

Example: You are given a 4.554 g sample that is a mixture of oxalic acid ($H_2C_2O_4$) and another solid that does not react with sodium hydroxide. If 29.58 mL of 0.550 M NaOH is required to titrate the sample, what is the weight percent of oxalic acid in the mixture?

$$H_2C_2O_4 + 2\ NaOH \rightarrow Na_2C_2O_4 + 2\ H_2O$$