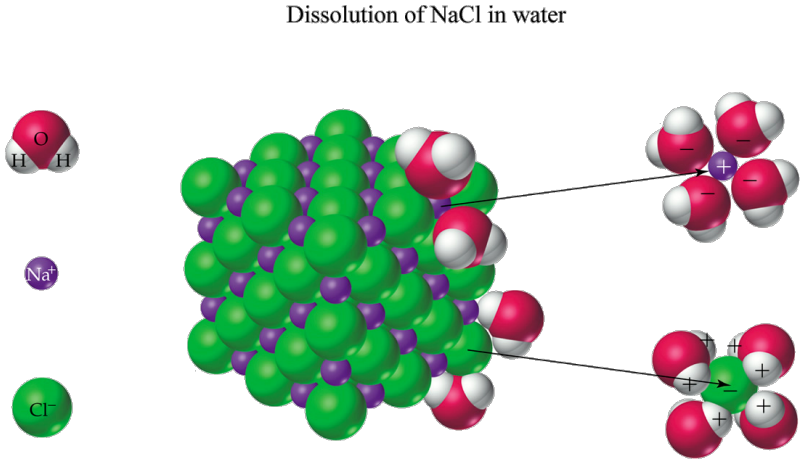
Ch. 4.1-4.2: Aqueous Solutions; Solubility Rules

Input & Modeling

- General Properties of Aqueous Solutions
  - Recall: Homogeneous mixture of 2 or more pure substances
  - **Aqueous Solutions** of interest because water is polar, can dissolve many polar and ionic substances
    - **Hydration** is process in which H_2O molecules surround an ion or molecule to dissolve it.
      - Ions surrounded by H_2O molecules, which are oriented with their opposite charge directed at the ion:



  - **Electrolytes**
    - Soluble ionic compounds, **dissociate** when dissolved: $A_xB_y\ (s) \xrightarrow{H_2O} x\ A^{n+}\ (aq) + y\ B^{m-}\ (aq)$, where $x(n^+) + y(m^-) = 0$ [Often x=m and y=n, but not always]
      - e.g. $Na_3PO_4\ (s) \xrightarrow{H_2O} 3\ Na^+\ (aq) + PO_4^{3-}\ (aq)$
    - Ions in solution provide mobile charges to conduct electricity (Demo!)
      - Stronger solutions, higher solubility give higher conductivity
      - Ionic compounds also conduct when molten (mobile charges)
    - Strong Acids & Bases dissociate/ionize completely, so are strong electrolytes
      - e.g. $HCl\ (g) \xrightarrow{H_2O} H^+\ (aq) + Cl^-\ (aq)$
      - Strong acids on handout
    - Weak Acids & Bases partially ionize, so are weak electrolytes
    - Molecular substances (e.g. sugar) do not ionize, no conductivity—**Nonelectrolytes**

Rules to determine electrolytes and non-electrolytes:
• All soluble ionics are strong electrolytes (including ionic bases)
• All molecular substances (covalents) are non-electrolytes except for acids and NH_3
• All strong acids are strong electrolytes HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$ **MEMORIZE! Dissociate completely in water
• All other acids are weak electrolytes -Some common weak acids are the following: HF, HNO_2, H_3PO_4, CH_3COOH (acetic acid) Dissociate only slightly in water
• Ammonia (NH_3) is a weak electrolyte (weak base) **MEMORIZE

- Solubility Rules
  - When two solutions are brought together, an **insoluble** combination of cation-anion may form (remember double replacement!):
    - Insoluble compound precipitates from solution.
    - Predict product based on solubility rules (must know how to use!)

Solubility Rules

Always soluble:
alkali metal ions (Li^+, Na^+, K^+, Rb^+, Cs^+),
NH_4^+, NO_3^-, ClO_3^-, ClO_4^-, CH_3COO^- ($C_2H_3O_2^-$)

Generally soluble:

Cl^-, Br^-, I^-	Soluble except Ag^+, Pb^{2+}, Hg_2^{2+} *(CuI_2 is insoluble)*
F^-	Soluble except Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, Mg^{2+}
SO_4^{2-}	Soluble except Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, Hg_2^{2+}

Generally insoluble:

O^{2-}, OH^-	Insoluble except alkali metals, and NH_4^+ Somewhat soluble Ca^{2+}, Sr^{2+}, Ba^{2+}
CO_3^{2-}, PO_4^{3-}, S^{2-}, SO_3^{2-}, $C_2O_4^{2-}$, CrO_4^{2-}	Insoluble except alkali metals and NH_4

- Exceptions have common trends:
  - Ca Ba Sr often exceptions (i.e. SO_4^{2-}, OH^-)
  - Ag^+, Pb^{2+}, Hg_2^{2+} always insoluble unless with always soluble anion
  - Most anions always insoluble unless with always soluble cation
- Examples: Are the following compounds soluble or insoluble? K_2SO_4; $AgNO_3$; AgCl, K_2S, $BaSO_4$, $CaCO_3$
- For AP exam, need to know Na^+, K^+, NO_3^-
  - In double-replacement reactions, the there will always be one product containing at least one of these ions—the other will be insoluble

- **Homework #4-1:** Problems pg. 151 #4.1, 4.2, 4.3, 4.6, 4.8, 4.9 - 4.12, 4.20