Acids, Bases and Ionic Equations

Arrhenius Theory of Acids and Bases

- Definitions
  - Acids – substances that produce H^+ in solution
  - Bases – Substances that produce OH^- in solution
- Properties
  - Acids have a sour taste and turn litmus red. They react with most metals, dissolving the metal and producing Hydrogen gas
  - Bases taste bitter and turn litmus blue. They dissolve fats and feel slippery to the touch.

Polyprotic acids

- Acid can have 1 or more protons (hydrogen ions) attached to them.
  - 1 proton ⇒ monoprotic acid
  - 2 proton ⇒ diprotic acid
  - 3 proton ⇒ triprotic acid (or polyprotic for 3 or more)

Acidic vs. non-acidic protons

- Not all hydrogen atoms in an acid are necessarily acidic (dissociate from the acid).
- Only the acidic protons can take part in acid/base reactions.
- Examples:

$HC_2H_3O_2$ — acidic, non-acidic

$H_3C_6H_5O_7$ — acidic, non-acidic

Strong vs. Weak acids

- Strong – dissociates completely in solution
- Weak – Does not dissociate completely

Strong acids

•HNO_3	HCl
•$HClO_3$	HBr
•$HClO_4$	HI
•H_2SO_4 (first proton)	

Strong vs. Weak bases

- Same definitions as for acids.
- The strong bases are the group IA and IIA metal hydroxides.
- The only weak base we'll see is NH_3.

Ionic Equations

- We, so far, have only dealt with chemical, or molecular, equations.
- We can also use ionic equations.
- An ionic equation will show what is actually happening in the reaction, if anything.
- To write an ionic equation we need to know which ionic compounds are soluble and which are not.

Solubility Rules

- Soluble compounds
  - Compounds containing Group IA metal ions, NH_4^+, $C_2H_3O_2^-$ or NO_3^- are soluble
  - Compounds containing Cl^-, Br^-, I^- are soluble except with Pb^{2+}, Ag^+, or Hg_2^{2+}.
  - Compounds containing SO_4^{2-} are soluble except with Ca^{2+}. Ba^{2+}, Sr^{2+}, Pb^{2+}, Ag^+, or Hg_2^{2+}.
- Insoluble compounds
  - Most compounds containing CO_3^{2-}, PO_4^{3-}, and S^{2-} are insoluble except with Group IA or NH_4^+.
  - Most compounds containing OH^- are insoluble except with Group IA, Ca^{2+}. Ba^{2+}, or Sr^{2+}.

Writing ionic equations

- All substances that are soluble ionic compounds or strong acids or bases are written as separated ions.
- All others are written as complete compounds.

Example

- $3\,BaCl_{2(aq)} + 2\,Na_3PO_{4(aq)} \rightarrow 6\,NaCl_{(aq)} + Ba_3(PO_4)_{2(s)}$
- Aqueous ionic compounds are written as separated ions. The solid is written as a complete compound.

$$3\,Ba^{2+}{}_{(aq)} + 6\,Cl^-{}_{(aq)} + 6\,Na^+{}_{(aq)} + 2\,PO_4^{3-}{}_{(aq)} \rightarrow 6\,Na^+{}_{(aq)} + 6\,Cl^-{}_{(aq)} + Ba_3(PO_4)_{2(s)}$$

This is the Total Ionic Equation.

Net Ionic Equations

- Looking at the previous result, we see that there are some things that are ***exactly*** the same on each side.
  - Na^+ and Cl^-
- These things can cancel out and are called spectator ion.
- This will leave us with the net ionic equation.

$$3\,Ba^{2+}{}_{(aq)} + 2\,PO_4^{3-}{}_{(aq)} \rightarrow Ba_3(PO_4)_{2(s)}$$

Reactions of Acids

- Acids with bases
  - Called neutralization reactions
  - products are a salt and sometimes water
  - $2\,HNO_3 + Ca(OH)_2 \rightarrow 2\,H_2O + Ca(NO_3)_2$
- Acids with metals
  - single replacement reactions in which the metal replaces the hydrogen in the acid
  - produces hydrogen gas.
  - $2\,HCl + Mg \rightarrow MgCl_2 + H_2$

Reactions of Acids

- Acids with carbonates and bicarbonates
  - a double replacement reaction coupled with a decomposition
  - the products will be a salt, water and carbon dioxide gas.
  - $2\ HCl + Na_2CO_3 \rightarrow 2\ NaCl + H_2O + CO_2$
  - $HNO_2 + KHCO_3 \rightarrow KNO_2 + H_2O + CO_2$

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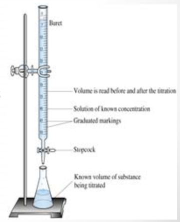
Acid-Base Calculations

- The calculations we will look at involve determining the concentration of an acid or base via titration.
- Titration is the process of adding controlled amounts of reactants to determine their concentrations.



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Example

- 25.00 mL of a nitric acid solution of unknown concentration is titrated with a calcium hydroxide solution. It requires 34.78 mL of 0.2280 M calcium hydroxide solution to completely neutralize the nitric acid. What is the molar concentration (molarity) of the nitric acid?

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Solution

- Chemical Equation:
  - $Ca(OH)_2 + 2\ HNO_3 \rightarrow 2\ H_2O + Ca(NO_3)_2$
- Calculation Setup:

$$?\frac{\text{mol } HNO_3}{L} = \frac{34.78 \text{ mL } Ca(OH)_2}{25.00 \text{ mL } HNO_3} \times \frac{0.2280 \text{ mol } Ca(OH)_2}{L\ Ca(OH)_2} \times \frac{2 \text{ mol } HNO_3}{1 \text{ mol } Ca(OH)_2}$$

$$= 0.6344\ M\ HNO_3$$

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