

Net Ionic Equations Roadmap

- Being able to classify the reaction type is the key to writing the net ionic equation.
- Reaction Types (Watch for this):
 - Precipitation (ions and solubility)
 - Acid-Base (ions and water[#] forms)
 - Gas Forming (gas forms)
 - Redox (oxidation numbers change)
- Net ionic equations show key chemistry

Soluble Salts Form Ions when they dissolve in water



Ions Conduct Electricity

Solutions with ions are called **ELECTROLYTES**
 HCl, NaOH, CuCl_2 , and NaCl

are **strong electrolytes**. They dissociate completely (or nearly so) into ions.

* ions form in solution

Strong Electrolytes Are:

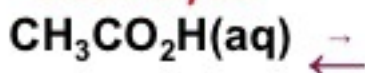
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- 1) **Ionic compounds, strong acids or strong bases** (not molecular compounds, weak acids or weak bases)
- 2) **Soluble in water** (not insoluble or slightly soluble)

Weak Electrolytes Form Few Ions

5

Acetic acid is a **weak electrolyte**.



* Mostly molecules in solution, not ions

Nonelectrolytes Form No Ions

6

Some compounds dissolve in water

Examples include:

sugar
ethanol
ethylene glycol

Some compounds don't dissolve much in water

Examples include:

CaCO_3
 AgCl
 Hg_2SO_4

Determine Water Solubility of Ionic Compounds ⁷

Soluble Ionic Compounds

1. All compounds of the alkali metals (Group IA) are soluble.
2. All salts containing NH_4^+ , NO_3^- , ClO_4^- , and $\text{C}_2\text{H}_3\text{O}_2^-$ are soluble.
3. All chlorides (Cl^-), bromides (Br^-), and iodides (I^-) are soluble, except those of Ag^+ , Pb^{2+} , and Hg_2^{2+} (note the subscript "2").
4. All sulfates are soluble, except those of Pb^{2+} , Ca^{2+} , Sr^{2+} , Hg_2^{2+} , and Ba^{2+} .

Insoluble Ionic Compounds

5. All hydroxides (OH^-) and metal oxides (containing O^{2-}) are insoluble, except those of Group IA and Ca^{2+} , Sr^{2+} , and Ba^{2+} . When metal oxides do dissolve, they give hydroxides (their solutions do not contain O^{2-} ions). For example,



6. All compounds that contain PO_4^{3-} , CO_3^{2-} , SO_3^{2-} , and S^{2-} are insoluble, except those of Group IA and NH_4^+ .

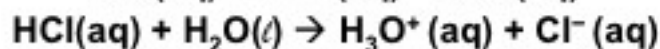
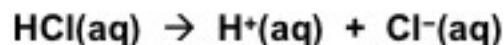
-Soluble ionic compounds form ions in solution and are electrolytes

-Insoluble ionic compounds form no ions in solution and are nonelectrolytes

Solubility rules are given

Practice: $\text{Mg}(\text{OH})_2$

Acids Form H_3O^+ in Water ⁸



HCl is a strong acid

Write formulas of acids with H at the beginning or at the end

Memorize the 6 Strong Acids ⁹

HCl	hydrochloric acid
HBr	hydrobromic acid
HI	hydroiodic acid
H_2SO_4	sulfuric acid
HClO_4	perchloric acid
HNO_3	nitric acid

All Other Acids Are Weak

$\text{CH}_3\text{CO}_2\text{H}$ acetic acid, vinegar
(CH_3COOH , HOAc , $\text{HC}_2\text{H}_3\text{O}_2$)

H_2CO_3 carbonic acid

H_3PO_4 phosphoric acid

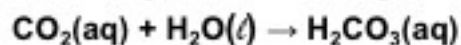
HF hydrofluoric acid

And many more...

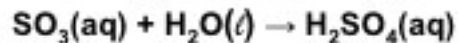
* Weak acids form primarily molecules (not ions) in solution so they are weak electrolytes or nonelectrolytes

Nonmetal Oxides Can Be Acids

• Burning fuel containing C



• Burning fuel containing S



Are these acids strong or weak?

Bases form OH^- in Water



NaOH is a strong base

Write formulas of bases that contain OH with the OH at the end

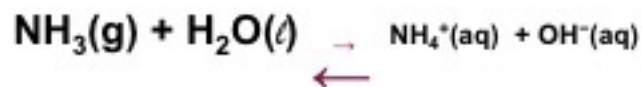
Memorize the 4 Strong Bases

LiOH	Lithium hydroxide
NaOH	Sodium hydroxide
KOH	Potassium hydroxide
Ba(OH) ₂	Barium hydroxide

Other bases are:

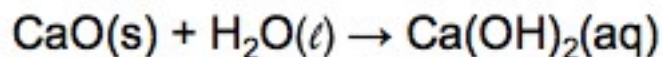
- Weak — NH₃
- Not very soluble — Ca(OH)₂
- Not common — CsOH

Ammonia, NH₃, A Weak Base



* NH₃ exists as mostly molecules in solution

Most Metal Oxides are Bases

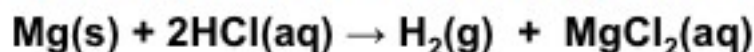


Because they produce hydroxides

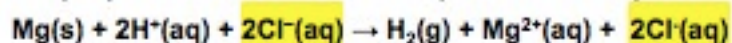
Writing Net Ionic Equations

- Write the **total ionic equation** by dissociating species that form ions (Keep solids, gases, weak acids, and weak bases together as molecules)
- Cancel ions (**spectator ions**) if they are the same on both sides of a reaction to give the **net ionic equation**.

Example Net Ionic Equation



Step 1) Dissociate into ions (total ionic equation)



Step 2) Cancel spectator ions (net ionic equation)

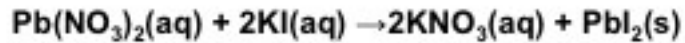


Cl⁻ ions are **SPECTATOR IONS**
 Could have used another anion, NO₃⁻.

Net Ionic Equations Roadmap

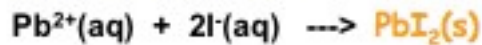
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Recognizing **Precipitation** Reactions

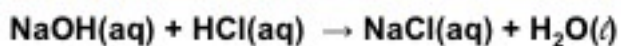


- Driving force is forming a precipitate

Net ionic equation

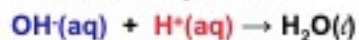


Recognizing **Acid-Base** Reactions



Driving force is forming water

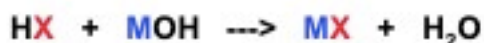
Net ionic equation



This net ionic equation applies to **STRONG** acids and **STRONG** bases because weak acids and weak bases stay as molecules.

Recognizing **Acid-Base** Reactions

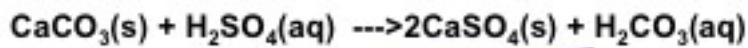
- Also called **Neutralizations**
- Other product of **Acid-Base** reaction is a **Salt, MX**.



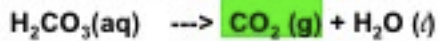
M^{n+} comes from **base** & X^{n-} comes from **acid**

This is one way to make compounds!

Recognizing Gas-Forming Reactions



Carbonic acid is unstable and forms $\text{CO}_2(\text{g})$ & $\text{H}_2\text{O}(\text{l})$



Terminology for Solutions

- **SOLVENT** - component whose physical state is preserved when solution forms.
- **SOLUTE** - the other solution component.

Molarity Is A Unit of Concentration

$$\text{Molarity (M)} = \frac{\text{moles solute}}{1 \text{ liter of solution}}$$

The solution
includes the solute
and the solvent

Units of Molarity Are

$$2.0 \text{ M HCl} = \frac{2.0 \text{ moles HCl}}{1 \text{ L HCl solution}}$$

$$[\text{HCl}] = 2.0\text{M}$$

$$6.0 \text{ M HCl} = \frac{6.0 \text{ moles HCl}}{1 \text{ L HCl solution}}$$

$$[\text{HCl}] = 6.0\text{M}$$

PROBLEM: Dissolve 5.00 g of $\text{NiCl}_2 \cdot 6 \text{ H}_2\text{O}$ in enough water to make 250 mL of solution.

Step 1: Calculate moles of $\text{NiCl}_2 \cdot 6 \text{ H}_2\text{O}$

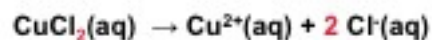
$$5.00 \text{ g} \cdot \frac{1 \text{ mol}}{237.7 \text{ g}} = 0.0210 \text{ mol}$$

Step 2: Calculate molarity

$$\frac{0.0210 \text{ mol}}{0.250 \text{ L}} = 0.0841 \text{ M}$$

$$[\text{NiCl}_2 \cdot 6 \text{ H}_2\text{O}] = 0.0841 \text{ M}$$

Determine Concentrations of Ions in a 0.30M CuCl_2 Solution



If $[\text{CuCl}_2] = 0.30 \text{ M}$, then

$$[\text{Cu}^{2+}] = 0.30 \text{ M}$$

$$[\text{Cl}^{-}] = 2 \times 0.30 \text{ M}$$

Problem: What mass of oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$, is required to make 250. mL of a 0.0500 M solution?

$M = \text{moles}/V$

So moles = $M \cdot V$

Problem: What mass of oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$, is required to make 250. mL of a 0.0500 M solution?

Step 1: Calculate moles of acid.

$$(0.0500 \text{ mol/L})(0.250 \text{ L}) = 0.0125 \text{ mol}$$

Step 2: Calculate mass of acid.

$$(0.0125 \text{ mol})(90.00 \text{ g/mol}) = \mathbf{1.13 \text{ g}}$$

Preparing a Solution by

Use this equation:

$$M_{\text{conc}} V_{\text{conc}} = M_{\text{dilute}} V_{\text{dilute}}$$

PROBLEM: You have 50.0 mL of 3.0 M NaOH and you want 0.50 M NaOH. What do you do?

Add water to the 3.0 M solution to lower its concentration to 0.50 M

Dilute the solution!

PROBLEM: You have 50.0 mL of 3.0 M NaOH and you want 0.50 M NaOH. What do you do?

$$M_{\text{conc}} = 3.0\text{M} \qquad M_{\text{dilute}} = 0.50\text{M}$$

$$V_{\text{conc}} = 0.0500\text{L} \qquad V_{\text{dilute}} = ?$$

$$M_{\text{conc}} \cdot V_{\text{conc}} = C_{\text{dilute}} \cdot V_{\text{dilute}}$$

$$3.0\text{M} \cdot 0.0500\text{L} = 0.50\text{M} \cdot V_{\text{dilute}}$$

$$V_{\text{dilute}} = 0.3 \text{ L,}$$

To the 0.050L NaOH, add 0.250L of water