

## **Arrhenius Acid-Base Concept**

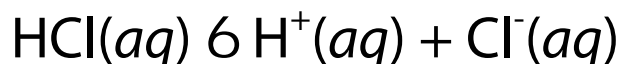
Svante Arrhenius, 1884

- O Acids and bases are electrolytes.
- O Acids are substances that produce hydrogen ion,  $\text{H}^+(aq)$ , in solution.
- O Bases are substances that produce hydroxide ion,  $\text{OH}^-(aq)$ , in solution.

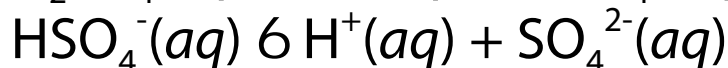
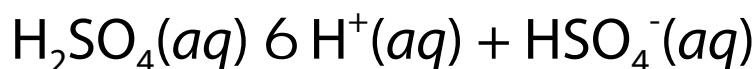
## Monoprotic vs. Polyprotic Acids

- O Monoprotic acids can produce only one  $\text{H}^+(\text{aq})$  ion per acid molecule.
- O Polyprotic acids can produce more than one  $\text{H}^+(\text{aq})$  ion per acid molecule.

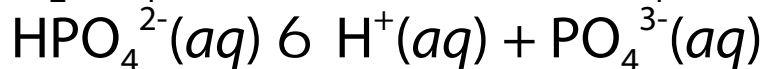
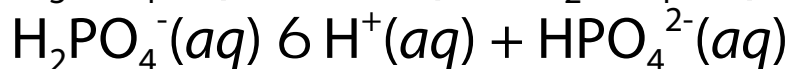
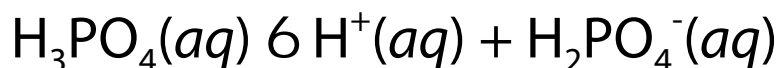
Monoprotic:



Diprotic:

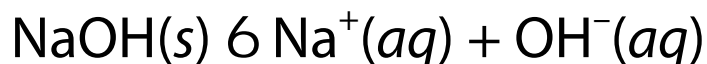


Triprotic:

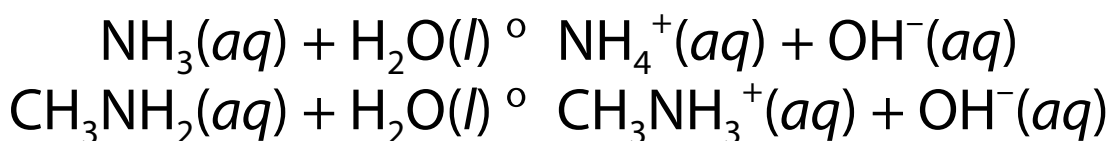


## Arrhenius Bases

- An ionic hydroxide is always a base.



- Molecular substances like ammonia and amines are bases because they produce hydroxide in solution.



- Molecular compounds that contain the OH group are usually not Arrhenius bases.

### Not Bases

CH<sub>3</sub>OH - methanol

C<sub>2</sub>H<sub>5</sub>OH - ethanol

HOCH<sub>2</sub>CH<sub>2</sub>OH - ethylene glycol

## Strong and Weak Acids and Bases

1. The following common acids are strong: HCl, HBr, HI, HNO<sub>3</sub>, HClO<sub>4</sub>, H<sub>2</sub>SO<sub>4</sub>

The following are some less common acids that are also strong: HClO<sub>3</sub>, HBrO<sub>3</sub>, HIO<sub>3</sub>, H<sub>2</sub>SeO<sub>4</sub>

- K Assume all other acids are weak unless told otherwise.

Some weak acids: HF, HNO<sub>2</sub>, HClO<sub>2</sub>, [H<sub>2</sub>SO<sub>3</sub>] = SO<sub>2</sub> + H<sub>2</sub>O, HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> = HOAc

2. All ionic hydroxides are strong bases, regardless of solubility. Bases that do not contain OH<sup>-</sup> are weak.

Some strong bases: LiOH, NaOH, KOH, RbOH, CsOH, Mg(OH)<sub>2</sub>, Ca(OH)<sub>2</sub>, Sr(OH)<sub>2</sub>, Ba(OH)<sub>2</sub>

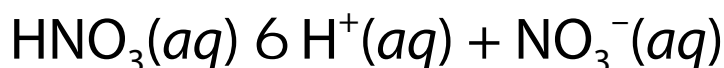
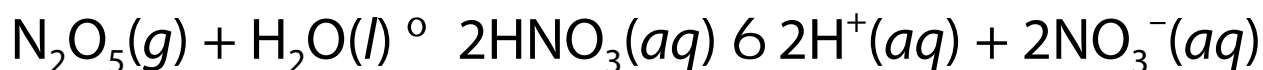
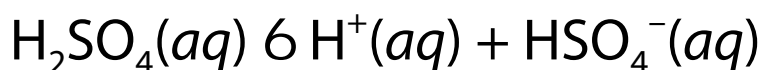
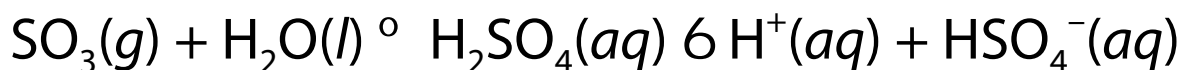
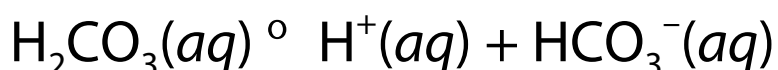
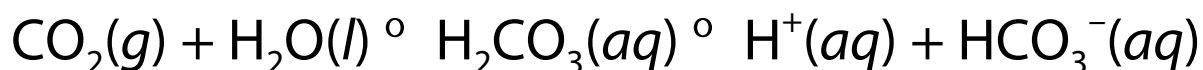
Some weak bases: NH<sub>3</sub>, CH<sub>3</sub>NH<sub>2</sub>, C<sub>2</sub>H<sub>5</sub>NH<sub>2</sub>

Not a base: CH<sub>3</sub>OH, C<sub>2</sub>H<sub>5</sub>OH

## Nonmetal Oxides as Acids

O Oxides of nonmetals, when dissolved in water, typically form acidic solutions.

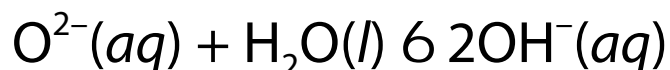
P Nonmetal oxides are sometimes called **acid oxides** or **acid anhydrides** because they dissolve in water to give solutions identical to those produced by their related oxoacids.



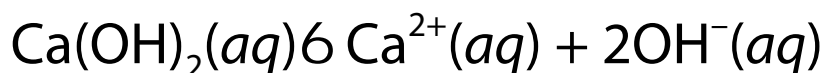
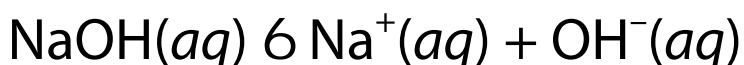
## Metal Oxides as Bases

O Metal oxides are typically ionic compounds containing the oxide ion,  $O^{2-}$ .

P In water, the oxide ion is hydrolyzed to hydroxide ion:



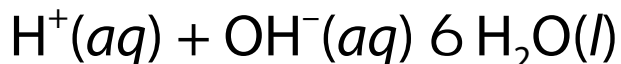
P Metal oxides are sometimes called **basic oxides** or **base anhydrides**, because they dissolve in water to give solutions identical to the metal hydroxide.



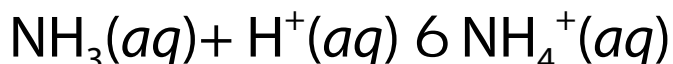
## Neutralization

○ Neutralization is the fundamental reaction between an acid and a base in which  $H^+$  from the acid is transferred either to  $OH^-$  from the base or to the base itself (if a weak base).

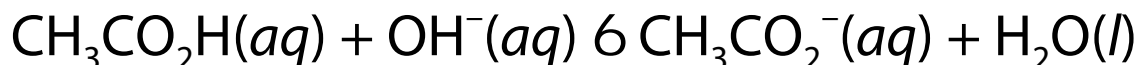
○ Water is a product when  $H^+(aq)$  and  $OH^-(aq)$  combine:



○ A cation results when  $H^+(aq)$  is transferred to a weak base:

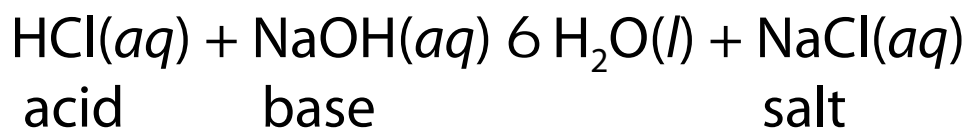


○ When a weak acid is neutralized, hydrogen ion must break away from the acid to combine with  $OH^-(aq)$ :



## Three Ways of Writing a Neutralization

Molecular equation:

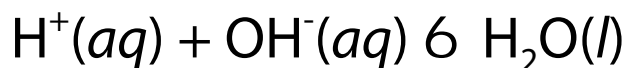


Ionic Equation:



(Spectator ions shown in blue.)

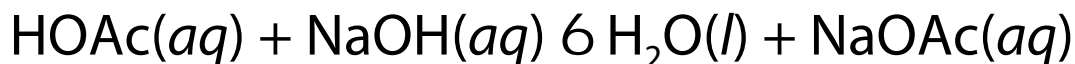
Net ionic equation:



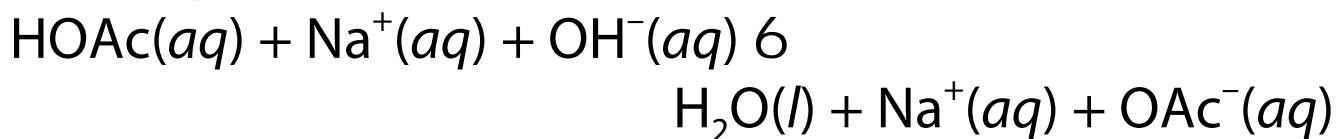
## Writing Neutralization Equations for Weak Acids or Weak Bases

- U In solutions of weak acids and weak bases, the principal species is the undissociated molecules.
- U The ions that weak acids and bases form are only minor components of the solution composition.
- K *Weak acids and all other weak electrolytes are shown in molecular form when writing ionic or net ionic equations.*

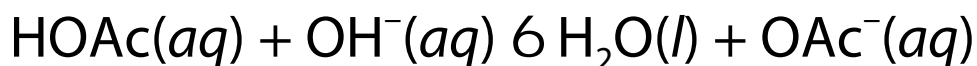
Molecular equation:



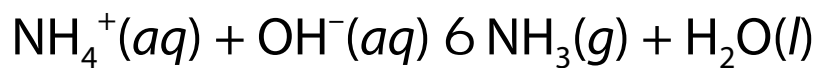
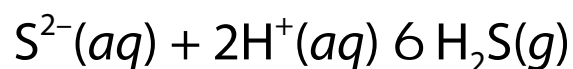
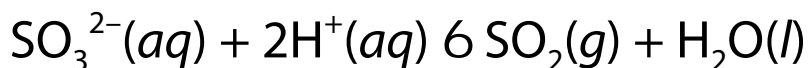
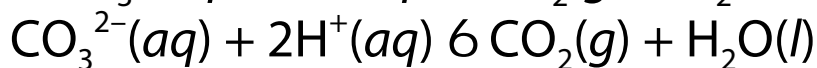
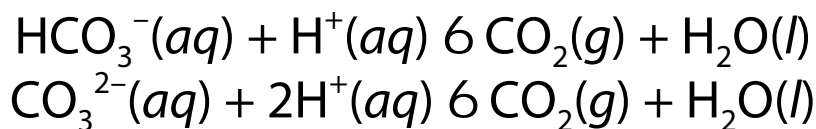
Ionic Equation:



Net Ionic Equation:



## Net Ionic Equations of Some Common Gas-Forming Reactions



## **Strong, Weak, or Non-Electrolyte?**

1. All ionic compounds are strong electrolytes, because they mostly break up into ions as they dissolve in water.

L Even insoluble ionic compounds (e.g., AgCl, PbSO<sub>4</sub>, CaCO<sub>3</sub>) are strong electrolytes, because the small amounts that do dissolve in water do so principally as ions; i.e., there is virtually no undissociated form of the compound in solution.

## Strong, Weak, or Non-Electrolyte?

2. Molecular compounds may be non-electrolytes, weak electrolytes, or strong electrolytes, depending on whether they dissolve without ion formation, a little ion formation, or mostly ion formation, respectively.

Examples:

Compound	Type	Soln Species
sucrose	nonelectrolyte	molecules
CH <sub>3</sub> COOH	weak electrolyte	molecules + ions
HCl	strong electrolyte	ions

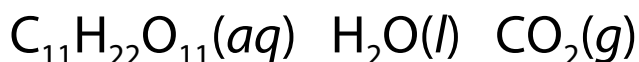
## Strong, Weak, or Non-Electrolyte?

3. Strong acids and strong bases are strong electrolytes [e.g.,  $\text{HCl}(aq)$ ,  $\text{H}_2\text{SO}_4(aq)$ ,  $\text{HClO}_4(aq)$ ;  $\text{NaOH}(aq)$ ]. There are virtually no molecules of a strong acid or base in solution, only ions.

## Rules for Writing Ionic and Net Ionic Equations

1. Write all molecular compounds in molecular form.

Examples:



2. Write all weak electrolytes in molecular form.

Examples:



3. Write soluble strong electrolytes as ions and insoluble strong electrolytes as combined solids (i.e., "molecular" form).

Examples:

