Chapter 4 Part 2

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Acids and Bases

Acids

- An acid is a type of compound usually written with H at the beginning of its formula.
- Acids are species that produce H^+ when dissolved in water

Bases

- A base is a type of compound often written with OH at the end of its formula because many bases are hydroxide compounds.
- Bases are species that produce OH^- when dissolved in water

Acid-Base Reactions

$$HI(aq) + KOH(aq) \rightarrow KI(aq) + H_2O(l)$$

Acid

Base

Salt

Water

Strong and Weak Acids

Strong Acid

- Strong acids have all H^+ ions separate from the acid

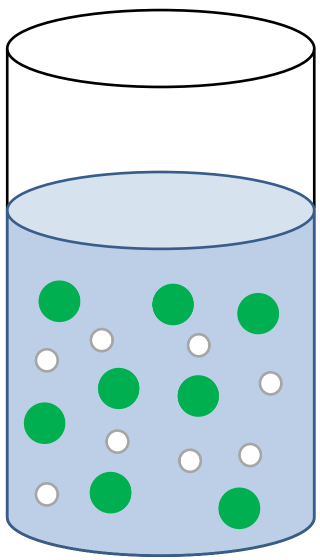
Weak Acid

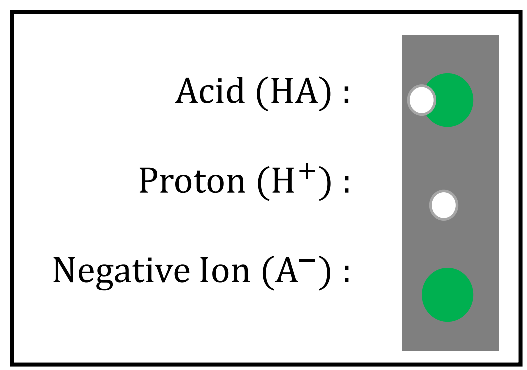
- The weak acids are the ones that aren't strong
- Weak acids have only some H^+ ions separate from the acid

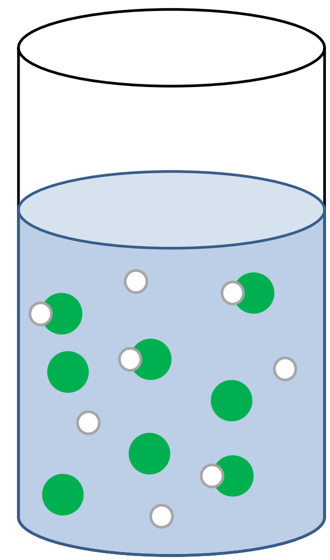
Strong vs. Weak Acids

Strong Acid

Weak Acid







Since strong acids fully dissociate in water, we see all the H^+ ions separated from the A^- ions

Since weak acids only partially dissociate in water, we see some H^+ ions separated from the A^- ions and some undissociated HA molecules

Memorize These Strong Acids

Name	Formula	Ions
Hydrochloric acid	HCl	$H^+(aq) + Cl^-(aq)$
Hydrobromic acid	HBr	$H^+(aq) + Br^-(aq)$
Hydroiodic acid	HI	$H^+(aq) + I^-(aq)$
Nitric acid	HNO_3	$H^+(aq) + NO_3^-(aq)$
Perchloric acid	$HClO_4$	$H^+(aq) + ClO_4^-(aq)$
Chloric Acid	$HClO_3$	$H^+(aq) + ClO_3^-(aq)$
Sulfuric acid	H_2SO_4	$H^+(aq) + HSO_4^-(aq)$

Strong and Weak Bases

Strong Base

- Strong bases have all OH^- ions separate from the base
- Strong bases are strong electrolytes

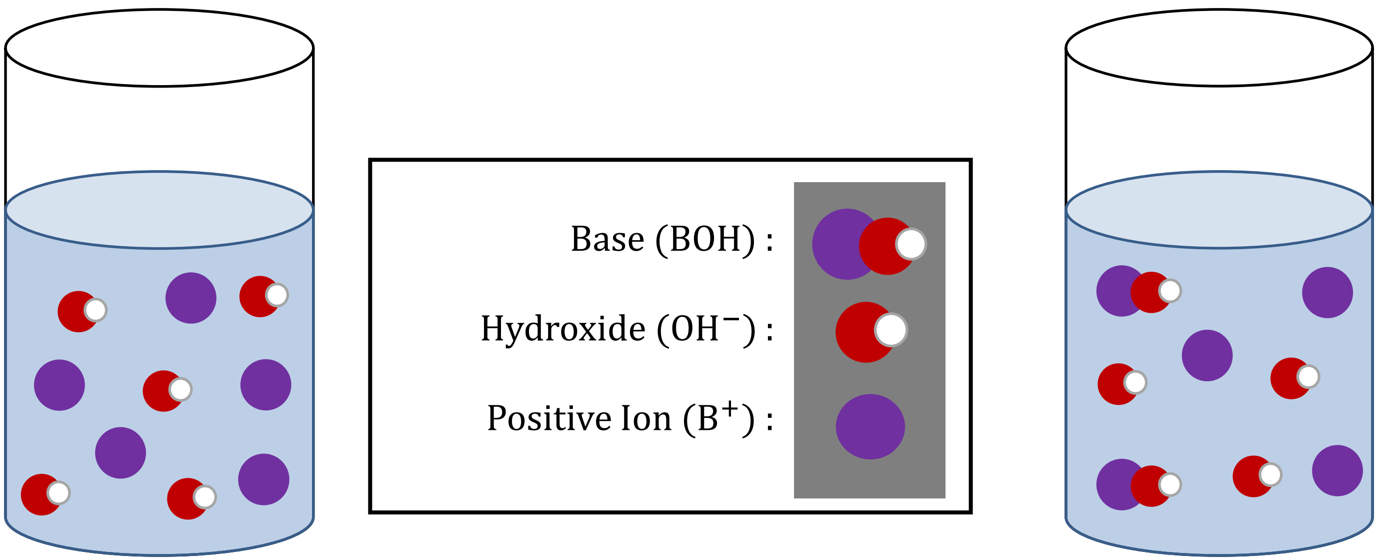
Weak Base

- The weak bases are the ones that aren't strong
- Weak acids have only some OH^- ions separate from the bases
- Weak bases are weak electrolytes

Strong vs. Weak Bases

Strong Base

Weak Base



Since strong bases fully dissociate in water, we see all the OH^- ions separated from the B^+ ions

Since weak bases only partially dissociate in water, we see some the OH^- ions separated from the B^+ ions and some undissociated BOH molecules

Memorize These Strong Bases

Name	Formula	Ions
Lithium hydroxide	$LiOH$	$Li^{+}(aq) + OH^{-}(aq)$
Sodium hydroxide	$NaOH$	$Na^{+}(aq) + OH^{-}(aq)$
Potassium hydroxide	KOH	$K^{+}(aq) + OH^{-}(aq)$
Rubidium hydroxide	$RbOH$	$Rb^{+}(aq) + OH^{-}(aq)$
Cesium hydroxide	$CsOH$	$Cs^{+}(aq) + OH^{-}(aq)$
Calcium hydroxide	$Ca(OH)_2$	$Ca^{2+}(aq) + 2\ OH^{-}(aq)$
Strontium hydroxide	$Sr(OH)_2$	$Sr^{2+}(aq) + 2\ OH^{-}(aq)$
Barium hydroxide	$Ba(OH)_2$	$Ba^{2+}(aq) + 2\ OH^{-}(aq)$

Acid base reactions

The products of an acid–base reaction in aqueous solution are always

A. two water molecules.
B. a salt and water.
C. a solid precipitate and water.
D. spectator ions.

Acid-base reactions

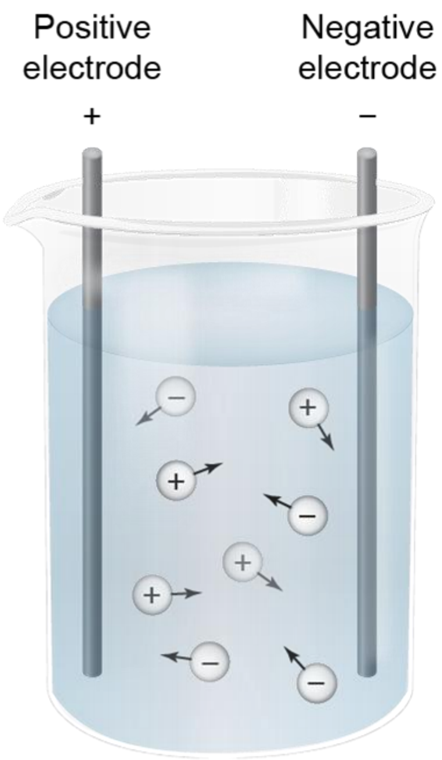
Provide the net ionic equation for the following reaction

$$NaOH + HI \rightarrow$$

Electrolytes

- Aqueous solutions of ionic compounds can conduct electricity due to the mobile hydrated ions.
- Electrolytes are substances that, when dissolved in water, conduct electricity.
- Ionic compounds are known as strong electrolytes because they dissociate 100% to produce solutions that conduct electricity readily.

Electrolyte



Can conduct electricity because charged particles can move to the oppositely charged electrode

Nonelectrolytes

- Most molecular (covalent) compounds that dissolve in water form solutions that do not conduct electricity and, thus, are nonelectrolytes.
- Nonelectrolytes dissolve as molecules.
- Can't conduct electric current because there are no mobilized, charged particles

Strong, Weak, and Nonelectrolytes

- When essentially 100% of the solute particles yield ions (dissolve) in solution, the solute is a strong electrolyte
  - These are soluble compounds, strong acids, and strong bases
  - Ex. HCl, NaOH, and NaCl
- When only a relatively small fraction of the dissolved substance undergoes the ion producing process, the solute is a weak electrolyte
  - These weak acids and weak bases
  - Ex. H_2CO_3 and NH_3
- When the substance dissolves as a molecule and produces no ions, the solute is a nonelectrolyte
  - These are molecular (covalent compounds)
  - Ex. CO_2, CH_4, $C_6H_{12}O_6$

Electrolytic Properties of Various Types of Compounds

Solution Type	Compound Type	Examples
Strong electrolyte	Ionic (salts)	$NaCl(aq)$, $K_2SO_4(aq)$
	Ionic (strong bases)	$NaOH(aq)$, $KOH(aq)$
	Strong acid	$HCl(aq)$, $HNO_3(aq)$
Weak electrolyte	Weak acid	$HNO_2(aq)$, $H_3PO_4(aq)$
	Weak base	$NH_3(aq)$, $CH_3NH_2(aq)$
Nonelectrolyte	Molecular (most)	$C_6H_{12}O_6(aq)$ and other sugars

Electrolytic Properties

Classify the following water-soluble substances as strong electrolytes, weak electrolytes, or nonelectrolytes in aqueous solution.

A. $CaCl_2$
B. $C_6H_{12}O_6$
C. HNO_2
D. NH_3
E. KOH
F. HBr

Electrolytic Properties

Which choice contains only weak electrolytes?

A. NaCl, $C_6H_{12}O_6$
B. HF, NH_3
C. HCl, NaOH
D. HCl, HF
E. NaCl, NaOH

Oxidation Numbers

- The oxidation number of an atom is the charge that an atom would have if the compounds was composed of ions.

Rules for assigning oxidation numbers

1. The sum of oxidation state for all atoms in a molecule or polyatomic ion equals the charge of the molecule or ion (indicated as a superscript)
2. The oxidation state of an atom in an elemental substance is zero
3. The oxidation state of a monatomic ion is equal to the ion's charge
4. Group 1 metals and silver have +1 oxidation states. Group 2 atoms and zinc have +2 oxidation states. Aluminum has a +3 oxidation state.
5. Hydrogen is +1 when combined with nonmetals and −1 when combined with metals
6. Oxygen is −2 is most compounds but is occasionally -1 in peroxides, O_2^{2-}.
7. Other atoms follow the previously discussed common charges

Oxidation Numbers

What is the oxidation state of bromine in $BrO_4{}^-$

Oxidation Numbers

Give the oxidation number of all of the atoms in the following compounds

A. N_2O_3

B. NO_3^-

C. $Mg(NO_3)_2$

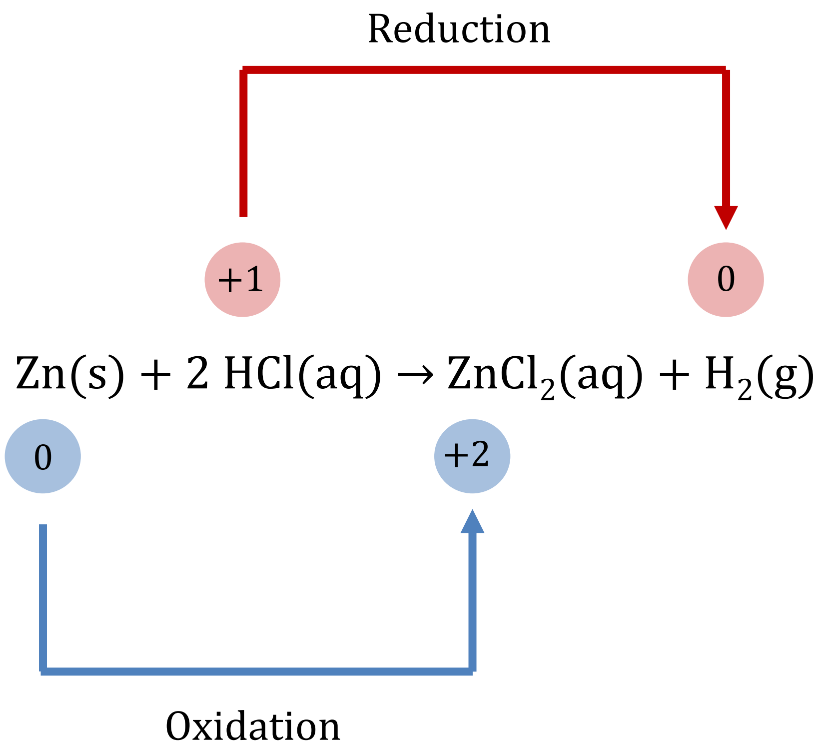
D. H_2SO_4

E. $MnCl_2$

Redox Reactions

- Redox reactions involve the transfer of electrons.
- One reactant loses electrons (oxidation), while another gains electrons (reduction).
- Oxidation occurs when the oxidation state of an element increases.
- Reduction occurs when the oxidation state decreases.
- This can be remembered with “LEO” says “GER”
  - Loosing electrons, oxidized. Gaining electrons, reduced

Redox Reactions



- Zinc
  - Oxidation state increases from 0 to +2
  - Zinc is oxidized
  - Zn(s) is reducing agent
- Hydrogen
  - Oxidation state decreases from +1 to 0
  - Hydrogen is reduced
  - HCl(aq) is oxidizing agent

Summary of Redox Terminology

Oxidation	Reduction
Increase in oxidation state	Decrease (reduction) in oxidation state
Loss of electrons	Gain of electrons
Reducing agent (whole substance)	Oxidizing agent (whole substance)

Redox Reactions

Identify whether the reaction is an oxidation reduction reaction. If so, identify what is oxidized, reduced, the oxidizing agent, and the reducing agent.

A. $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

B. $MgI_2(aq) + 2\ AgNO_3(aq) \rightarrow 2\ AgI(s) + Mg(NO_3)_2(aq)$

C. $2\ C_8H_{18}(g) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(l)$

Redox Reactions

Identify the oxidizing agent in the reaction below

$$Zn(s) + CuCl_2(aq) \rightarrow ZnCl_2(aq) + Cu(s)$$

A. Zn
B. $CuCl_2$
C. Cu
D. Cl
E. This is not a redox reaction

Activity Series and Single Replacement

- Active metals are good reducing agents (oxidize readily)
- More active cations will replace less active cations
- Single replacement reactions will only proceed if the incoming cation is more active than the cation currently bound to the anion

Most active Li > K > Ba > Ca > Na > Mg > Al > Mn > Zn > Cr

Cr > Fe > Ni > Sn > Pb > H_2 > Cu > Ag > Au Least Active

Activity Series

Will the two reactants below produce a product by single replacement?

$$Ni(NO_3)_2(aq) + Pb(s) \rightarrow$$

Most active $Li > K > Ba > Ca > Na > Mg > Al > Mn > Zn > Cr$

$Cr > Fe > Ni > Sn > Pb > H_2 > Cu > Ag > Au$ Least Active

Predicting Single Replacement Reactions

Identify the single-replacement reaction that will occur as written.

A. $Cu(s) + FeCl_3(aq) \rightarrow$
B. $Cu(s) + HCl(aq) \rightarrow$
C. $Zn(s) + KNO_3(aq) \rightarrow$
D. $Zn(s) + HCl(aq) \rightarrow$

Reducing Agent	Activity as Element
Group 1–2 metals Li, K, Ba, Ca, Na, Mg	Most active (best reducing agent)
Al	
Mn	
Zn	
Cr	Ease of oxidation
Fe	
Ni	
Sn	
Pb	
H	
Cu	
Ag	
Au	Least active (worst reducing agent)