PHYSICAL SCIENCES SCI 051

CHAPTER 18

TWO CLASSES OF CHEMICAL REACTIONS

SECTIONS 18.1-18.5

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THIS LECTURE WILL HELP YOU UNDERSTAND

- Acids Donate Protons, Bases Accept Them
- Relative Strengths of Acids and Bases
- Acidic, Basic, and Neutral Solutions
- Losing and Gaining Electrons

18.1 – Acids and Bases

Examples of acids:

Citrus fruits, vineger.

(a)

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Bronsted-lowery definition of acid:

Acids: A substance that donates hydrogen ion (acid donates).

Acids: has a sour taste

16.1 – Acids and Bases

Examples of bases:
Baking soda: sodium bicarbonate, $NaHCO_3$, ammonia, and soup.

(a)
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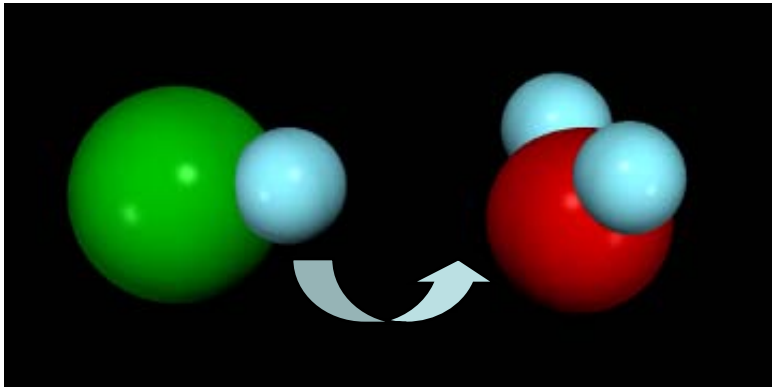
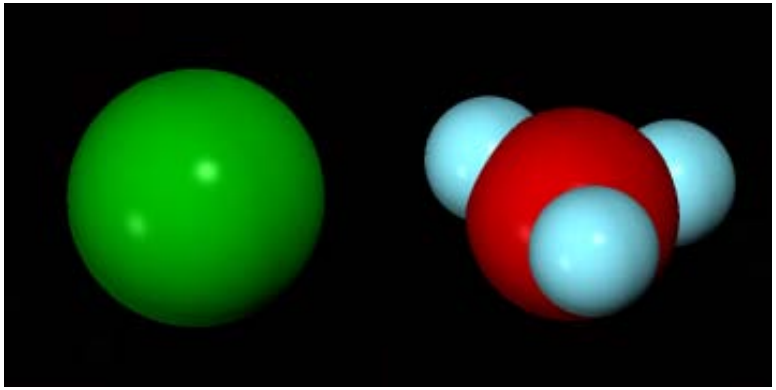
Bronsted-lowery definitions

- Base: A substance that accepts hydrogen ion

•**Bases**: has bitter taste and slippery feel

What happens when hydrogen chloride is mixed into water???!!!





$HCl + H_2O \rightarrow Cl^- + H_3O^+$

donor acceptor

(acid) (base)

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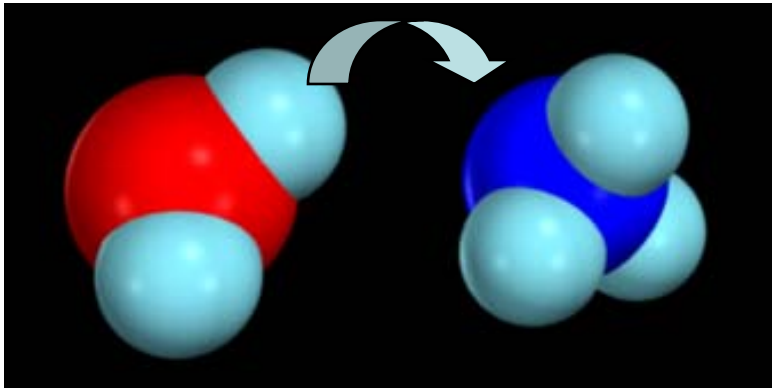
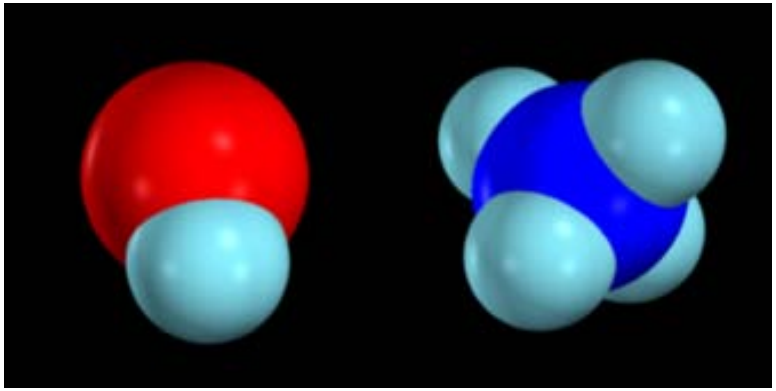
What happens when water is reacted with ammonia???!!!





$$H_2O + NH_3 \rightarrow OH^- + NH_4^+$$

donor (acid) acceptor (base)

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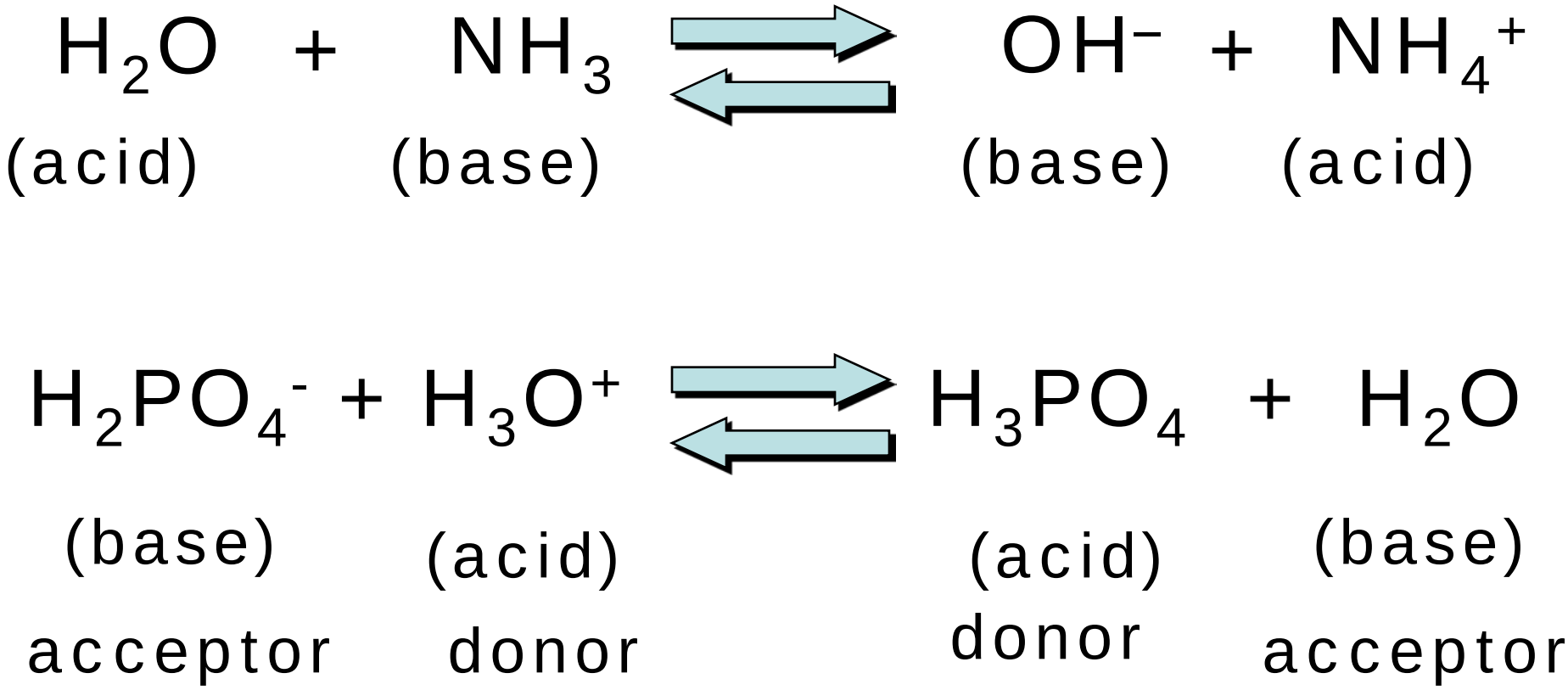

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Acids Donate Protons, Bases Accept Them
CHECK YOUR NEIGHBOR

When water behaves as an acid, what does it lose?

A. A hydrogen ion.
B. A hydrogen atom.
C. An electron.
D. Water can't behave as an acid.

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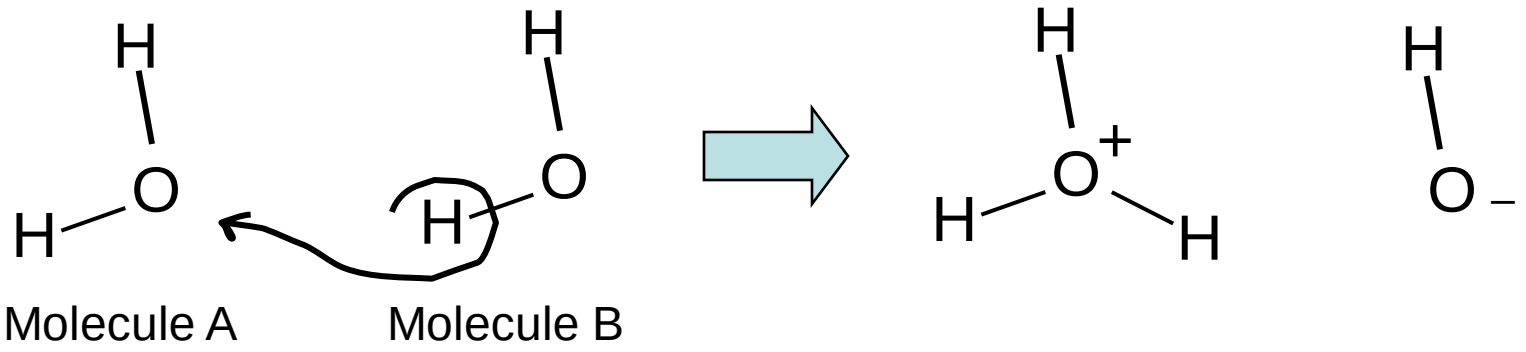
Acids Donate Protons, Bases Accept Them
CHECK YOUR NEIGHBOR

Which water molecule is behaving as an acid, and which is behaving as a base?



A. Molecule B as a base; Molecule A as an acid.
B. Molecule B as an acid; Molecule A as a base.
C. Both Molecules A and B are behaving as acids.
D. Both Molecules A and B are behaving as bases.

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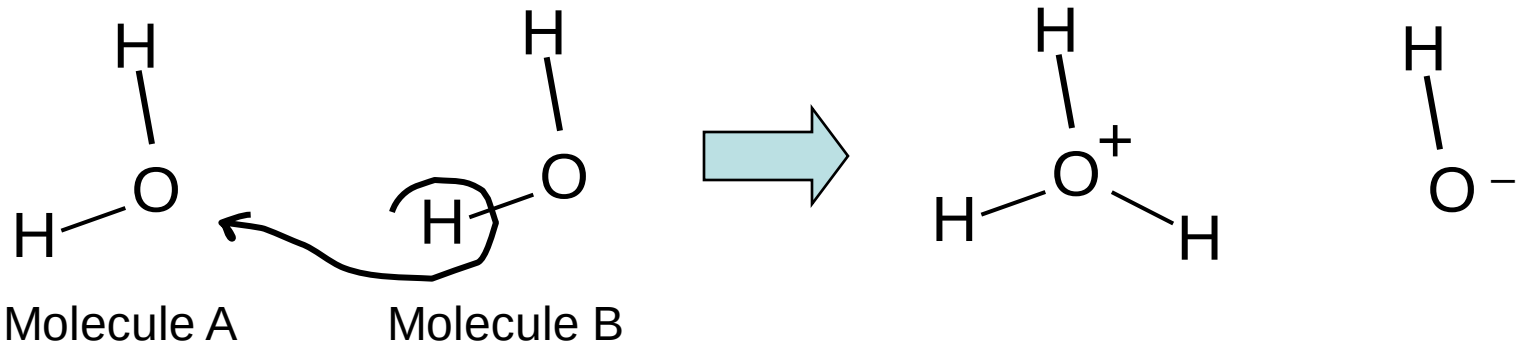
Acids Donate Protons, Bases Accept Them
CHECK YOUR ANSWER

Which water molecule is behaving as an acid, and which is behaving as a base?



A. Molecule B as a base; Molecule A as an acid.

B. Molecule B as an acid; Molecule A as a base.

C. Both Molecules A and B are behaving as acids.

D. Both Molecules A and B are behaving as bases.

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18.1 – Acids Donate Protons; Bases Accept Them

Mixing acid with base in equal portions produces an aqueous solution of salt in water

Salt: An ionic compound formed from the reaction of an acid and a base.

$$HCL + NaOH \rightarrow NaCl + H_2O$$

$$HCl + KOH \rightarrow KCl + H_2O$$

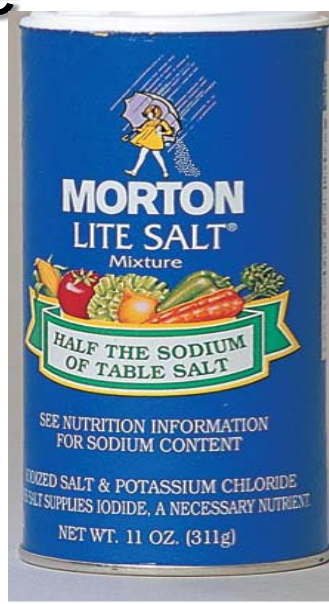

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TABLE 18.1 ACID-BASE REACTIONS AND THE SALTS FORMED

Acid		Base		Salt		Water
HCN Hydrogen cyanide	+	NaOH Sodium hydroxide	¡	NaCH Sodium cyanide	+	H_2O
HNO_3 Nitric acid	+	KOH Potassium hydroxide	¡	KNO_3 Potassium nitrate	+	H_2O
2 HCl Hydrogen chloride	+	$Ca(OH)_2$ Calcium hydroxide	¡	$CaCl_2$ Calcium chloride	+	$2H_2O$
HF Hydrogen fluoride	+	NaOH Sodium hydroxide	¡	NaF Sodium fluoride	+	H_2O

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18.1 – Acids Donate Protons; Bases Accept Them

The reaction between an acid and a base called neutralization reaction.

New chemicals are formed during a neutralization reaction, meaning the reaction is a chemical change

Acids Donate Protons, Bases Accept Them
CHECK YOUR NEIGHBOR

What salt forms from the reaction of hydrogen chloride, HCl, with potassium hydroxide, KOH?

A. KCl
B. H_3OCl
C. KOH_2
D. KOH_2Cl

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Acids Donate Protons, Bases Accept Them
CHECK YOUR ANSWER

What salt forms from the reaction of hydrogen chloride, HCl, with potassium hydroxide, KOH?

A. **KCl**
B. H_3OCl
C. KOH_2
D. KOH_2Cl

Explanation:

The K^+ from the KOH combines with the Cl^- from the HCl.

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18.2 –Relative Strengths of Acids and Bases

- Strong acids and bases ionize completely in water.

The stronger an acid, the more readily it donates hydrogen ions i.e. HCl

The stronger a base, the more readily it accepts hydrogen ions i.e. NaOH

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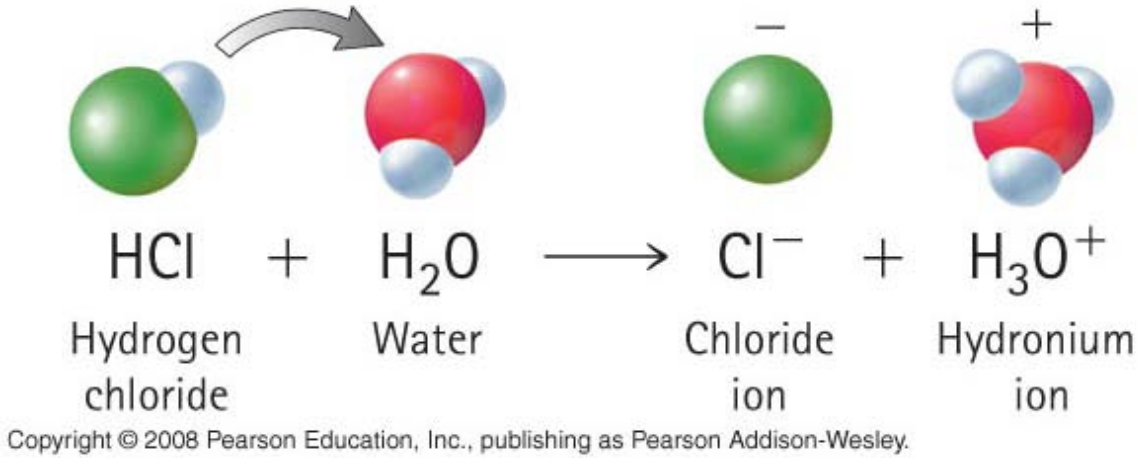
18.2 –Relative Strengths of Acids and Bases

One way to assess the strength of an acid or base is to measure how much of it remains after it has been added to water

If little remains, the acid or base is strong (example: HCl [strong acid] and NaOH[strong base])

If a lot remains, the acid or base is weak (example: vineger (week acid], ammonia [week base]).

- HCl is strong acid so nearly all of it is converted to ions



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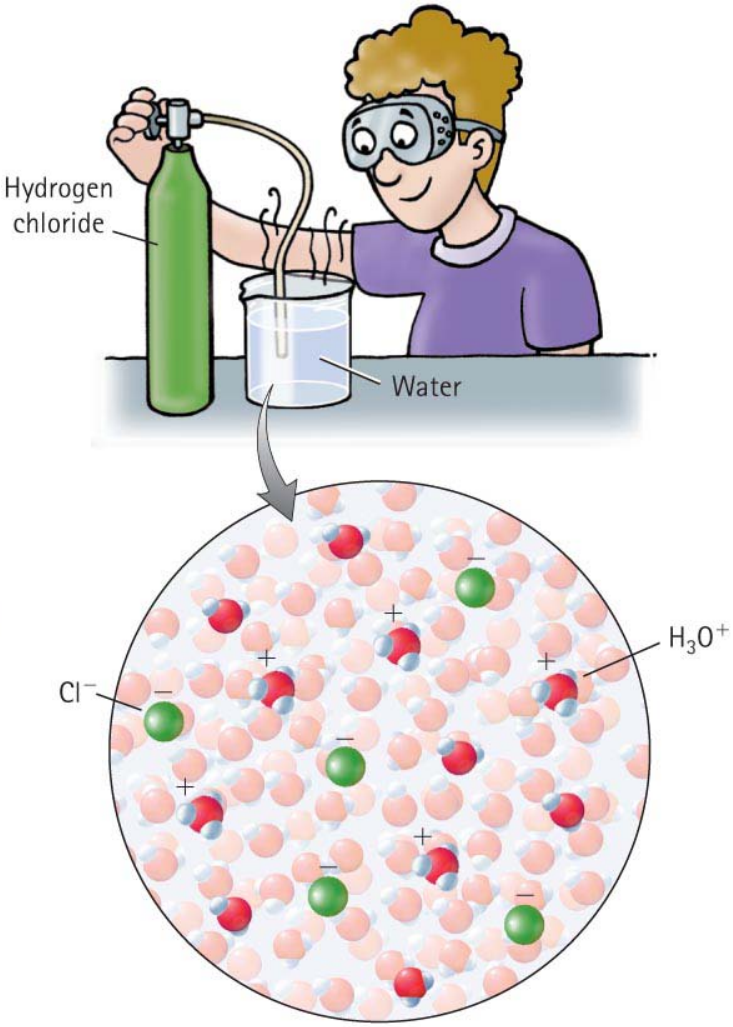

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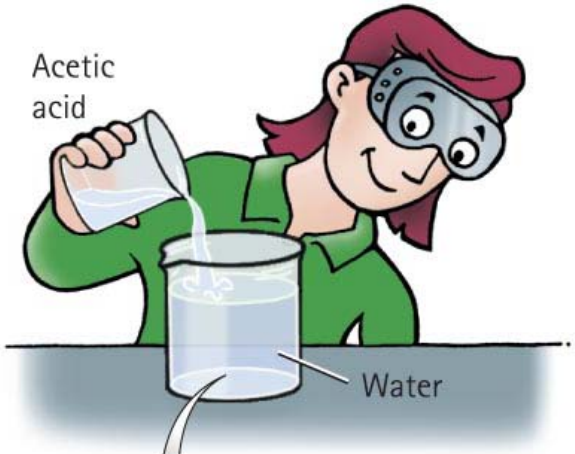
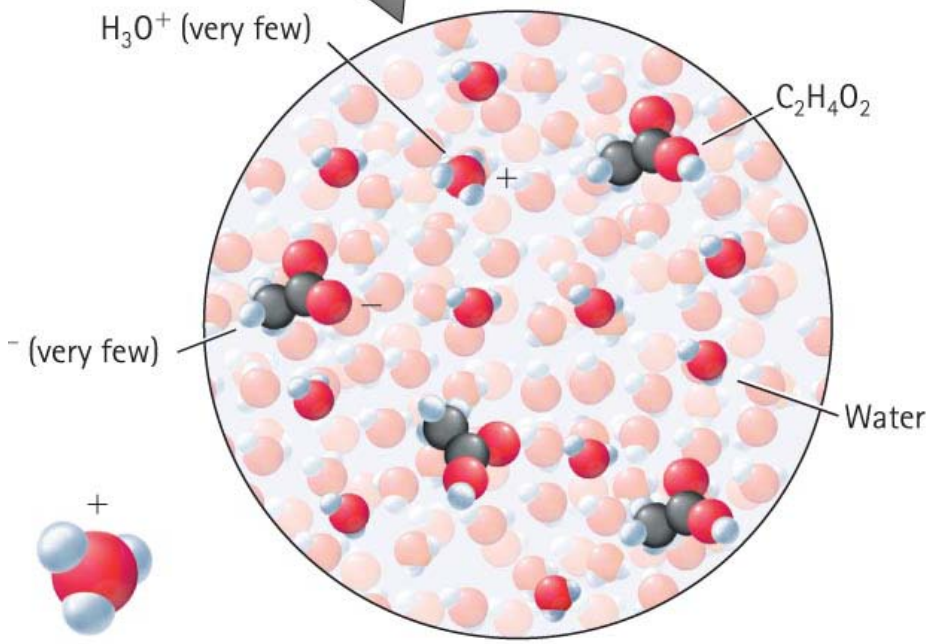
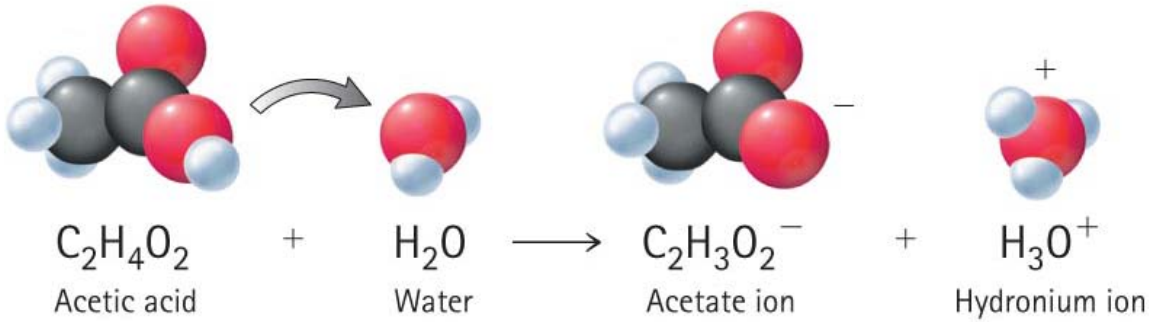
- Acetic acid is weak acid it has much less tendency to donate hydrogen ion to water







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18.2 –How does a chemist measure the strength of an acid?!

a) The pure water in this circuit cannot conduit electricity because it doesn't contain ions

(a)

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16.2 –How does a chemist measure the strength of an acid?!

b) Because HCl is strong acid, so the solution contain high concentration of ions (strong light bulb)

(b)

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16.2 –How does a chemist measure the strength of an acid?!

c) Acetic acid is weak so low concentrations of ions are existed (weak current exists and the bulb is therefore dimmer)

(c)

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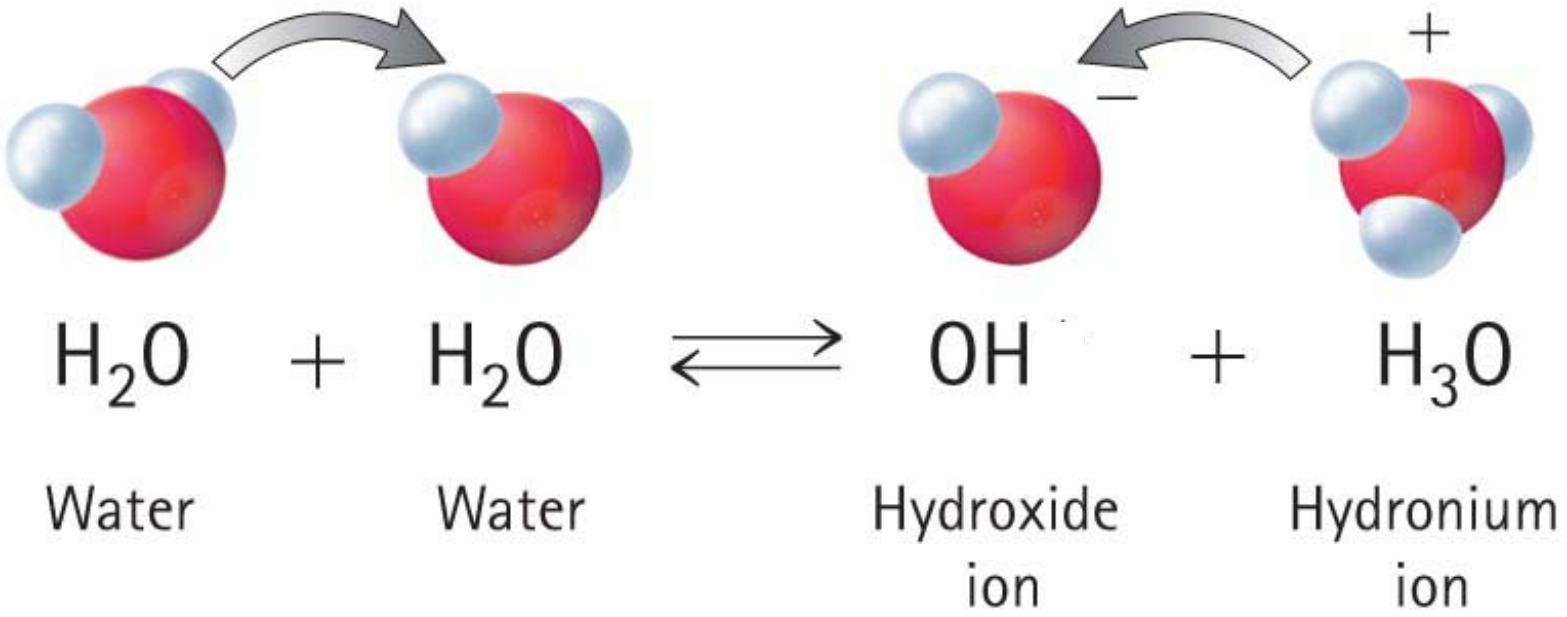
16.3 –Acidic, Basic, and Neutral Solutions

- Amphoteric substance: substance that can behave either as an acid or base
- H_2O, water can react with itself



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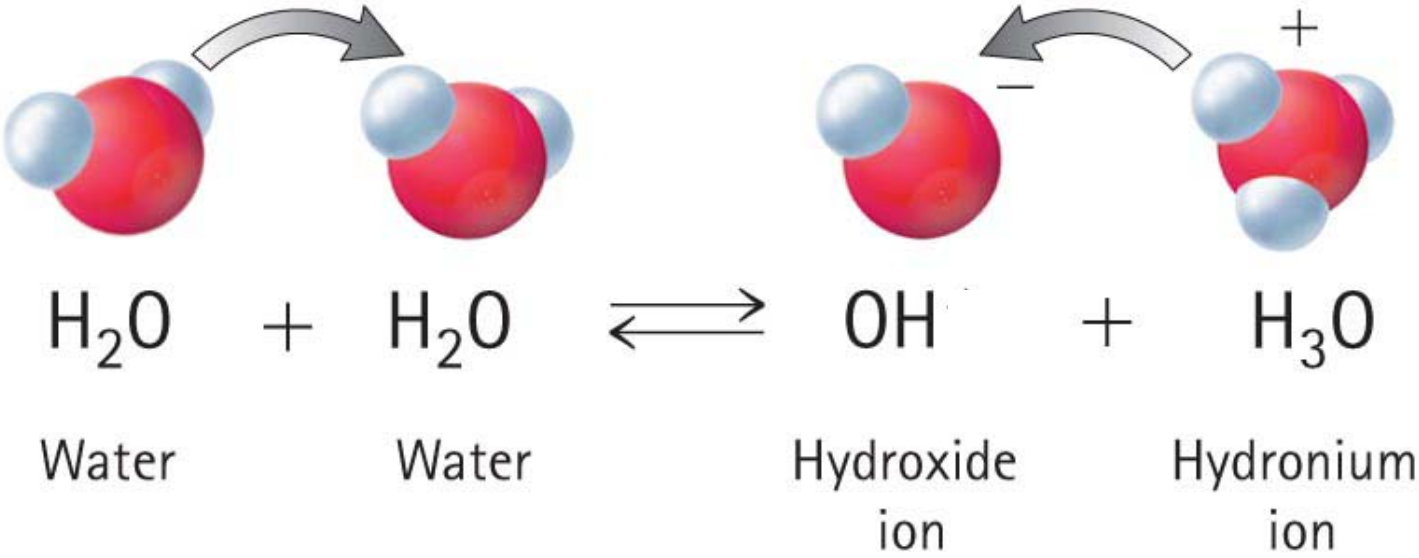
16.3 –Acidic, Basic, and Neutral Solutions

- When a water molecule gains a hydrogen ion, a second water molecule must be lose a hydrogen ion. So for every hydronium ion formed, a hydroxide ion also forms
- So in pure water, the total number of H_3O^+ ions must be equal the total number of OH^- ions,



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16.3 –Acidic, Basic, and Neutral Solutions

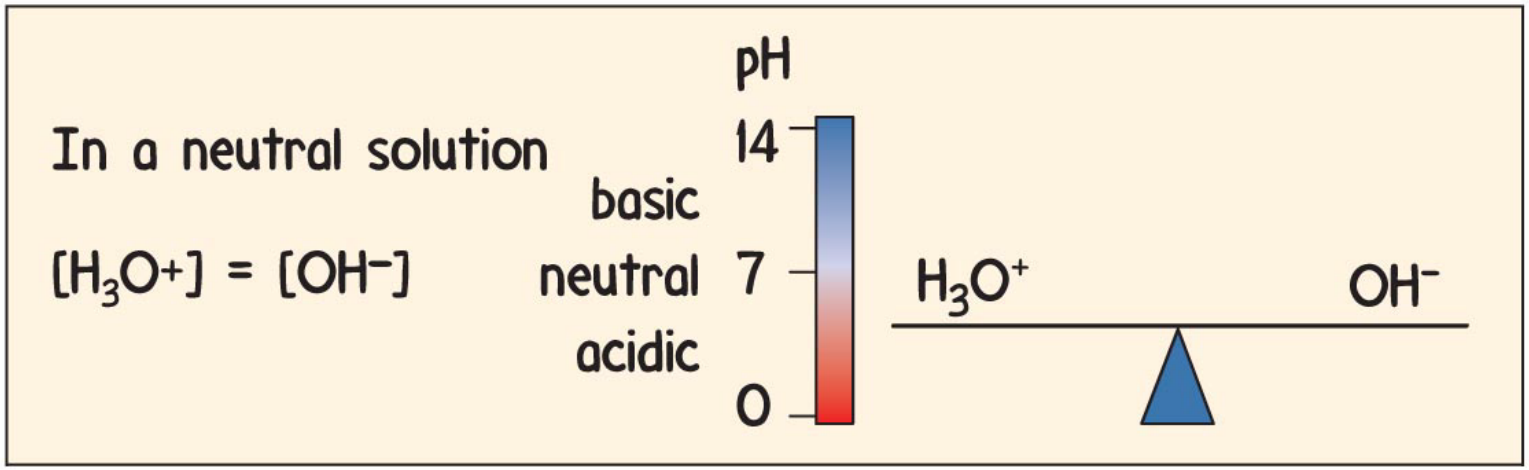
by experiment, they found that:

The concentration of $H_3O^+ = 1 \times 10^{-7}$ M

The concentration of $OH^- = 1 \times 10^{-7}$ M

Water by itself, therefore, is a very weak acid as well a very weak base.

So, in pure water, $[H_3O^+] = [OH^-] = 0.0000001\ M = 10^{-7}\ M$.



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Acidic, Basic, and Neutral Solutions
CHECK YOUR NEIGHBOR

Do water molecules react with one another

A. Yes, but not to any large extent. When they do react, they form hydronium and hydroxide ions.

B. No, at all

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Acidic, Basic, and Neutral Solutions
ANSWER

Do water molecules react with one another

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B. No, at all

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18.3 –Acidic, Basic, and Neutral Solutions

The concentration of H_3O^+ in any aqueous solution multiplied by the concentration of the hydroxide ions OH^- in the solution always equals the constant (K_w)
where $K_w = 1 \times 10^{-14}$

Equation is read $[H_3O^+] \times [OH^-] = K_w = 1 \times 10^{-14}$

The brackets [] mean, the molarity of ions (H_3O^+ and OH-)

Example:
For pure water
$[H_3O^+] \times [OH^-] = 1x10^{-7} \times 1x10^{-7} = K_w = 1x10^{-14}$

Acidic, Basic, and Neutral Solutions
CHECK YOUR NEIGHBOR

What is the concentration of H_3O^+ in a solution if the concentration of OH^- is 1×10^{-3} M

Answer:

$[H_3O^+] \times [OH^-] = 1 \times 10^{-14}$

$[H_3O^+] \times [1 \times 10^{-3}\ M] = 1 \times 10^{-14}$

$[H_3O^+] = 1 \times 10^{-11}$

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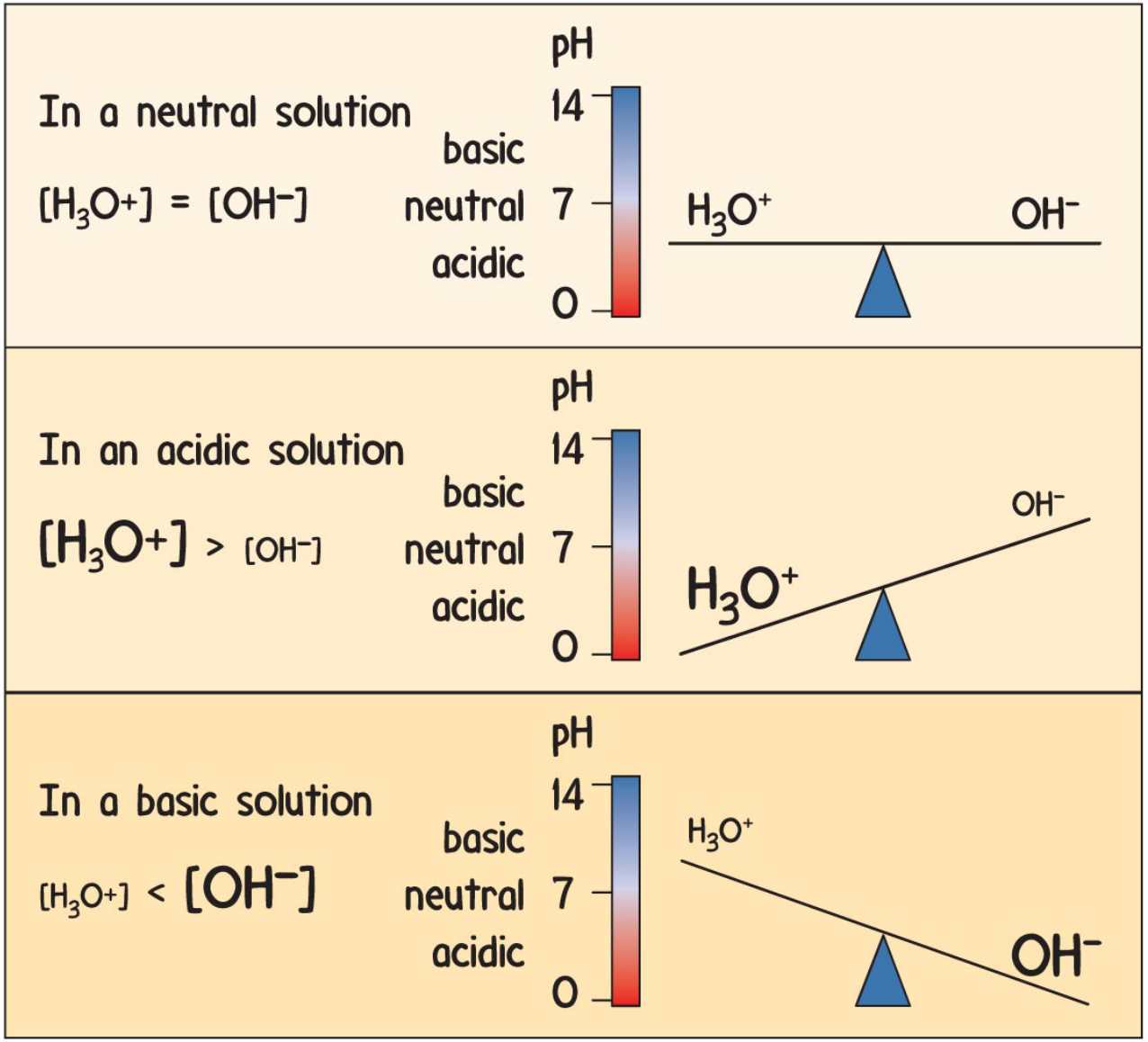
18.3 –Acidic, Basic, and Neutral Solutions



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18.3 –Acidic, Basic, and Neutral Solutions

Logarithms

The “log” of a number is simply the power to which ten is raised. The log of 10^3, for example, is 3.

$$\text{Log}_{10}\ 10^3 = 3$$

Examples

$\text{Log}_{10}\ 10^2 = \text{Log}\ 10^2 = 2$

$\text{Log}\ 1000 = \text{Log}\ 10^3 = 3$

$\text{Log}0.01 = -2$

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18.3 –Acidic, Basic, and Neutral Solutions

pH is a measure of the concentration of hydronium ions, H_3O^+ (acidity of a solution)

we can describe the acidity by pH scale

$$pH = -\log [H_3O^+]$$

the brackets [] are used to represented molar concentration

For pure water:

$$pH = -\log (10^{-7})$$

$$pH = -(-7)$$

$$pH = 7$$

18.3 –Acidic, Basic, and Neutral Solutions

- if $[H_3O^+] = 1x10^{-7}$ pH = - Log $1x10^{-7}$ = 7 neutral
- if $[H_3O^+] = 1x10^{-3}$ pH = - Log $1x10^{-3}$ = -(-3) = 3 Acidic
- if $[H_3O^+] = 1x10^{-8}$ pH = - Log $1x10^{-8}$ = -(-8) = 8 Basic

- if $[H_3O^+] = 1x10^{-7}$ pH = 7 neutral
- if $[H_3O^+] > 1x10^{-7}$ pH < 7 Acidic
- if $[H_3O^+] < 1x10^{-7}$ pH > 7 Basic

18.3 –Acidic, Basic, and Neutral Solutions

the pH of a solution can be measured electrically using pH meter

(a)

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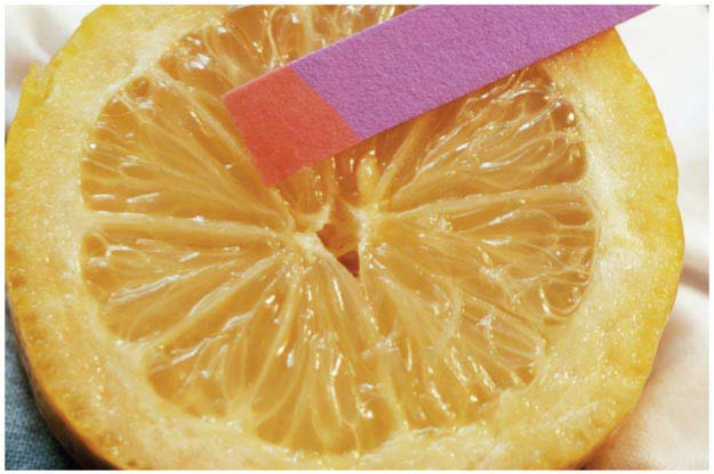
A rough estimate of the pH of a solution can be obtained with litmus paper, which coated with a dye that changes color with pH



(b)

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Acidic, Basic, and Neutral Solutions
CHECK YOUR ANSWER

What is the pH of a solution that has [H3O+] = 0.001 M

$pH = - Log[H3O+] = - Log\ 0.001 = - Log\ 10^{-3} = - (-3) = 3$

What is the pH of a solution that has [H3O+] = 10^{-9} M? is this solution basic or neutral

$pH = - Log[H3O+] = - Log\ 10^{-9} = - (-9) = 9$ basic

What is the [H_3O+] in a solution that has pH= 2.3?

$[H3O+] = 1X\ 10^{-pH} = 1X\ 10^{-2.3} = 0.005$ M

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18.5 –Losing and Gaining Electrons

Acid–Base reactions: transfer of proton

Oxidation-Reduction reactions: transfer of electron

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18.5 –Losing and Gaining Electrons

Oxidation: the process whereby a reactant loses one or more electrons

$$2\ Na \Rightarrow 2\ Na^{+} + 2\ e^{-}$$

Reducing agent: is any reactant oxidized and causes another reactant to be reduced i.e Na

Reduction: the process whereby a reactant gains one or more electrons

$$Cl_2 + 2\ e^{-} \Rightarrow 2\ Cl^{-}$$

Oxidizing agent: is any reactant reduced and causes another reactant to be oxidized i.e. Cl_2

18.5 –Losing and Gaining Electrons

Oxidation and reduction occur at the same time

So the electrons lost by one chemical in an oxidation reaction don't disappear, they are gained by another chemical in a reduction reaction

i.e.

$Na\ (s) \quad + \quad Cl_2 \quad \rightarrow \quad 2NaCl\ (s)$

18.5 –Losing and Gaining Electrons

Half reaction $2Na\ (s) \rightarrow 2\ Na^{+} + 2e^{-}$ oxidation

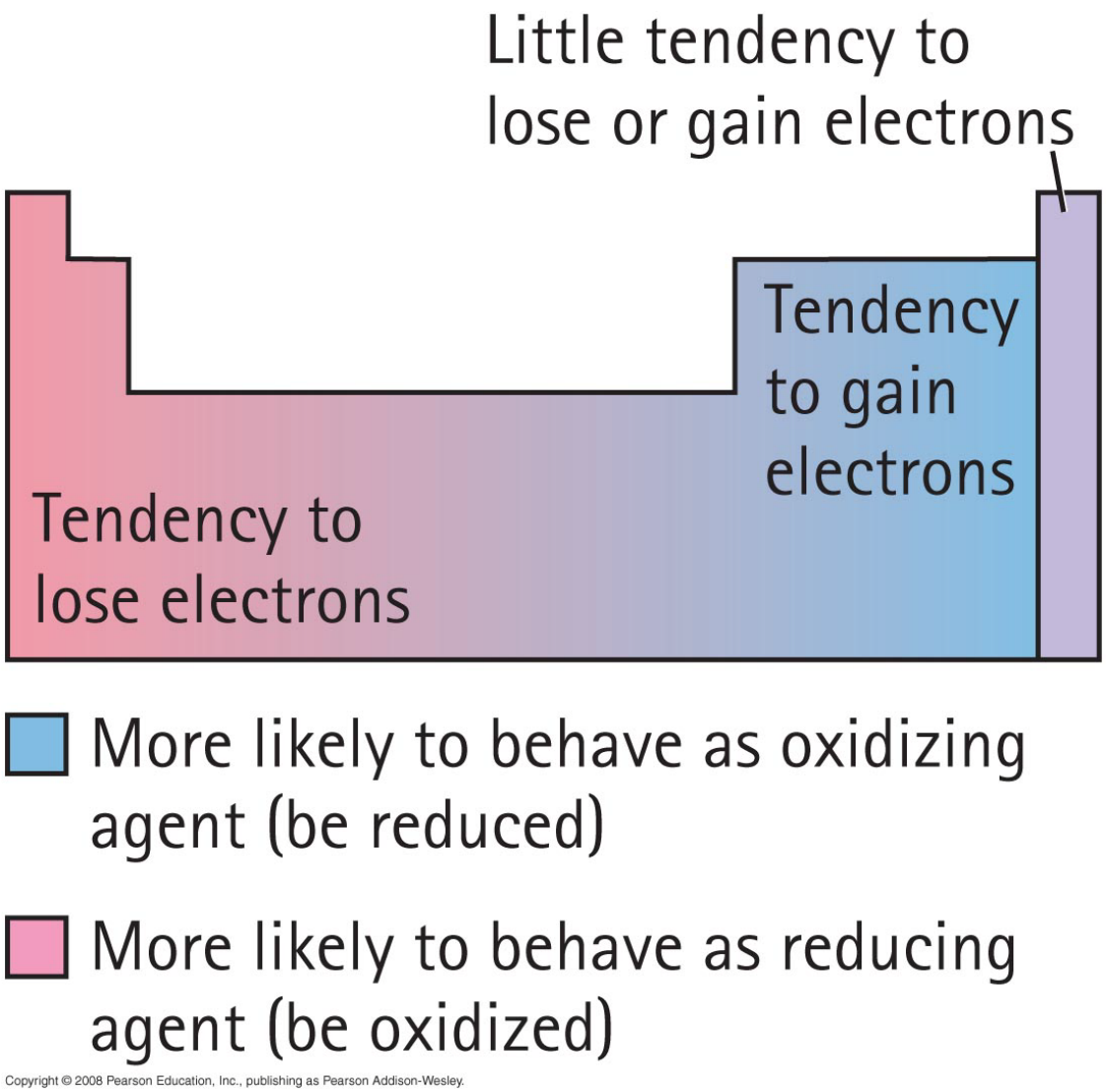
Half reaction $Cl_2 + 2e^{-} \rightarrow 2Cl^{-}$ reduction

$$2\ Na + Cl_2 \qquad 2\ Na^{+} + 2\ Cl^{-}$$

18.5 –Losing and Gaining Electrons

The ability of an atom to gain or lose electrons is indicated by it's position in the periodic table.

Those at the upper right tend to gain electrons, and those at the lower left tend to lose them



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Losing and Gaining Electrons
CHECK YOUR NEIGHBOR

True and False

1. Reducing agents are oxidized in oxidation-reduction reactions

2. oxidizing agents are reduced in oxidation-reduction reactions

Both statements are true

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Losing and Gaining Electrons
CHECK YOUR NEIGHBOR

What element within the reactants is oxidized in the following equation, and what element is reduced?

$$I_2 + 2\,Br^- \rightarrow 2\,I^- + Br_2$$

A. Iodine, I, is oxidized, while the bromine ion, Br^-, is reduced.
B. Iodine, I, is reduced, while the bromine ion, Br^-, is oxidized.
C. Both the iodine, I, and the bromine ion, Br^-, are reduced.
D. Both the iodine, I, and the bromine ion, Br^-, are oxidized.

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Losing and Gaining Electrons
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C. Both the iodine, I, and the bromine ion, Br^-, are reduced.
D. Both the iodine, I, and the bromine ion, Br^-, are oxidized.

Explanation:

Note how the iodine gains a negative charge, while the bromine loses the negative charge.

Applications of Oxidation-Reduction Reactions

1. Battery

2. Corrosion–when a metal reacts with atmospheric O_2

$4\ Fe_{(s)} + 3\ O_{2(g)} \longrightarrow Fe_2O_3$

$Al_{(s)} + O_{2(g)} \longrightarrow Al_2O_3(s)$

3. Combustion–an oxidation-reduction reaction between a nonmetal and O_2 that produces energy

$CH_4(g) + 2\ O_{2(g)} \longrightarrow CO2(g) + 2\ H2O(l) + energy$