Acids

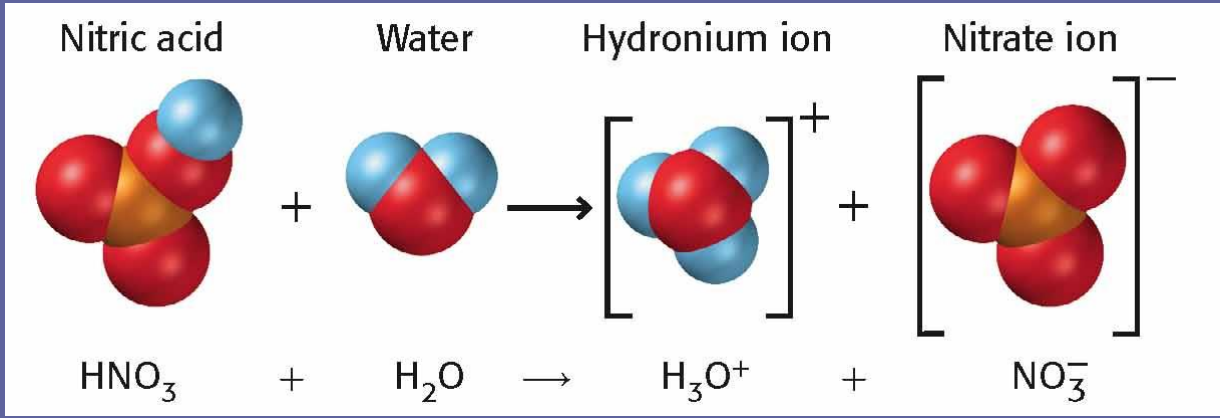
〉 What are the properties of acids?

〉 Acids taste sour, cause indicators to change color, and conduct electric current. They are also corrosive and can damage materials, including your skin.

- **acid:** any compound that increases the number of hydronium ions, H_3O^+, when dissolved in water
- **indicator:** a compound that can reversibly change color depending on conditions such as pH

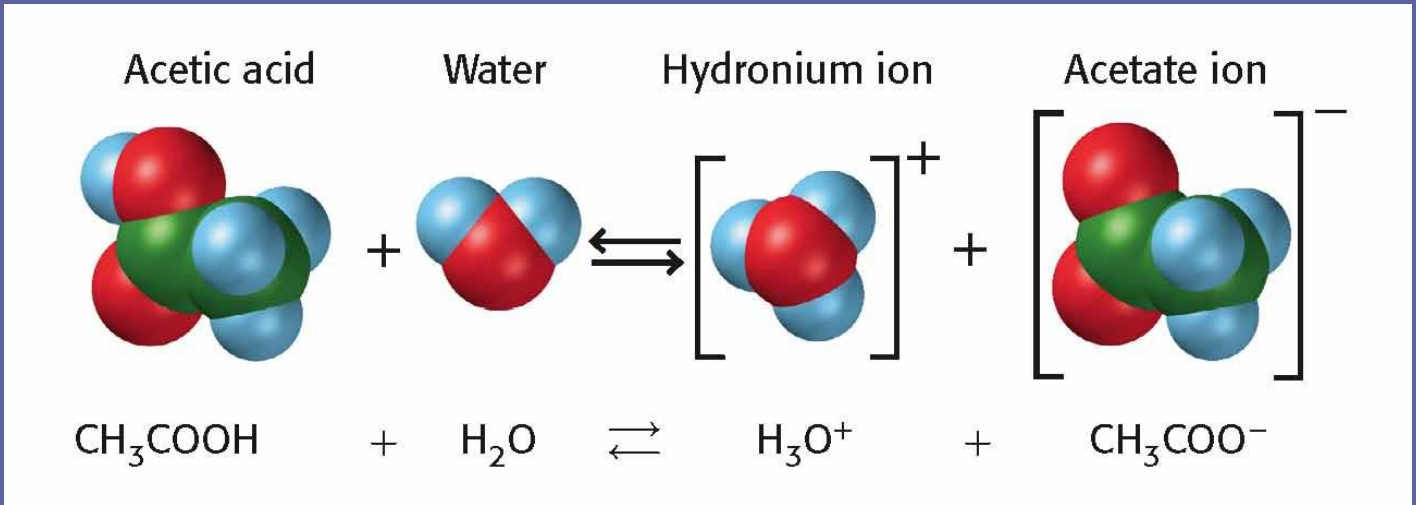
Acids, *continued*

- Strong acids ionize completely.
  - Strong acids are strong electrolytes.
  - **electrolyte:** a substance that dissolves in water to give a solution that conducts an electric current



Acids, *continued*

- Weak acids do not ionize completely.
  - Weak acids are weak electrolytes.



Acids, *continued*

Some common acids

Acid	Formula	Strength	Uses
Hydrochloric acid	HCl	strong	cleaning masonry; treating metal before plating or painting; adjusting the pH of swimming pools
Sulfuric acid	H_2SO_4	strong	manufacturing fertilizer and chemicals; most-used industrial chemical; the electrolyte in car batteries
Nitric acid	HNO_3	strong	manufacturing fertilizers and explosives
Acetic acid	CH_3COOH	weak	manufacturing chemicals, plastics, and pharmaceuticals; the acid in vinegar
Formic acid	HCOOH	weak	dyeing textiles; the acid in stinging ants
Citric acid	$H_3C_6H_5O_7$	weak	manufacturing flavorings and soft drinks; the acid in citrus fruits (oranges, lemons, and limes)

Acids, *continued*

- Concentrated acids can be dangerous.
- Weak acids are not always safe to handle.
- Always wear safety goggles, gloves, and a laboratory apron when working with acids.

Bases

〉 What are the properties of bases?

〉 Bases have a bitter taste, and solutions of bases feel slippery. Solutions of bases also conduct electric current, cause indicators to change color, and can damage the skin.

- **base:** any compound that increases the number of hydroxide ions, OH^-, when dissolved in water

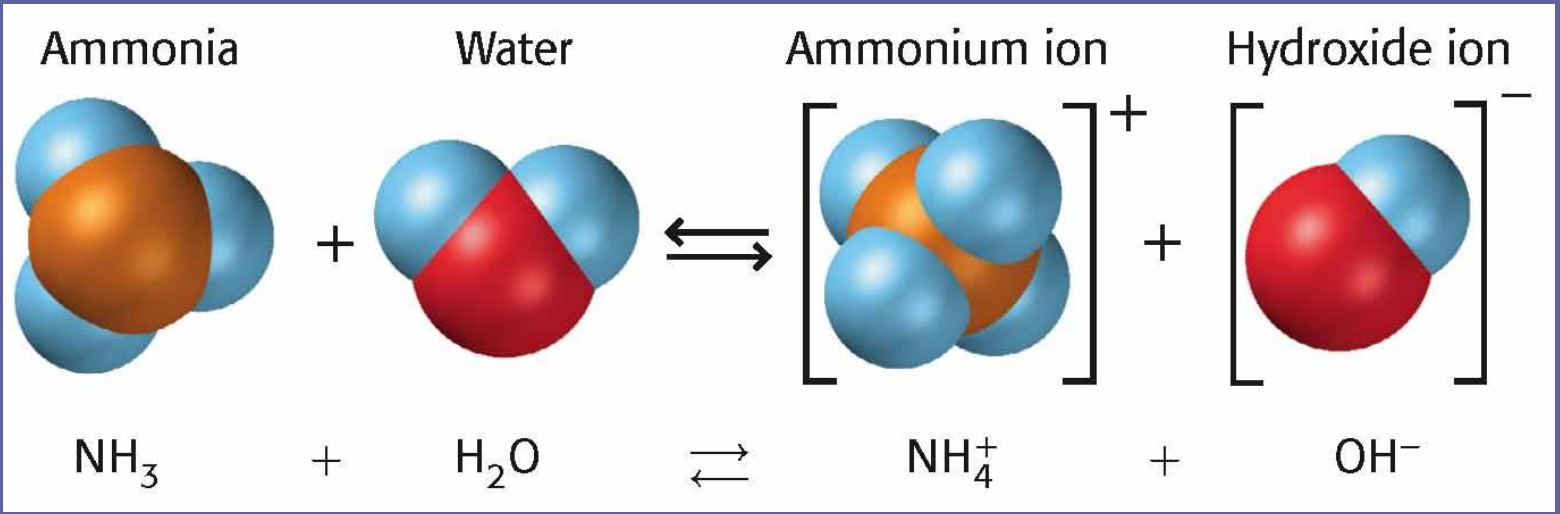
Bases, *continued*

- Many common bases contain hydroxide ions.
- Strong bases are ionic compounds that contain a metal ion and a hydroxide ion.
  - example: NaOH, sodium hydroxide

$$NaOH \longrightarrow Na^+ + OH^-$$

Bases, *continued*

- Some bases ionize in water to form hydroxide ions.
  - example: ammonia, NH_3



  - Only some of the ammonia molecules actually become ammonium ions when ammonia dissolves.

- Weak bases are weak electrolytes.

Bases, *continued*

Some common bases

Base	Formula	Strength	Uses
Potassium hydroxide (potash)	KOH	strong	manufacturing soap; absorbing carbon dioxide from flue gases; dyeing products
Sodium hydroxide (lye)	NaOH	strong	manufacturing soap; refining petroleum; cleaning drains; manufacturing synthetic fibers
Calcium hydroxide	$Ca(OH)_2$	strong	treating acidic soil; treating lakes polluted by acid precipitation; making mortar, plaster, and cement
Ammonia	NH_3	weak	fertilizing soil; manufacturing other fertilizers; manufacturing nitric acid; making cleaning solutions
Methylamine	CH_3NH_2	weak	manufacturing dyes and medicines; tanning leather
Aniline	$C_6H_5NH_2$	weak	manufacturing dyes and varnishes; used as a solvent

pH

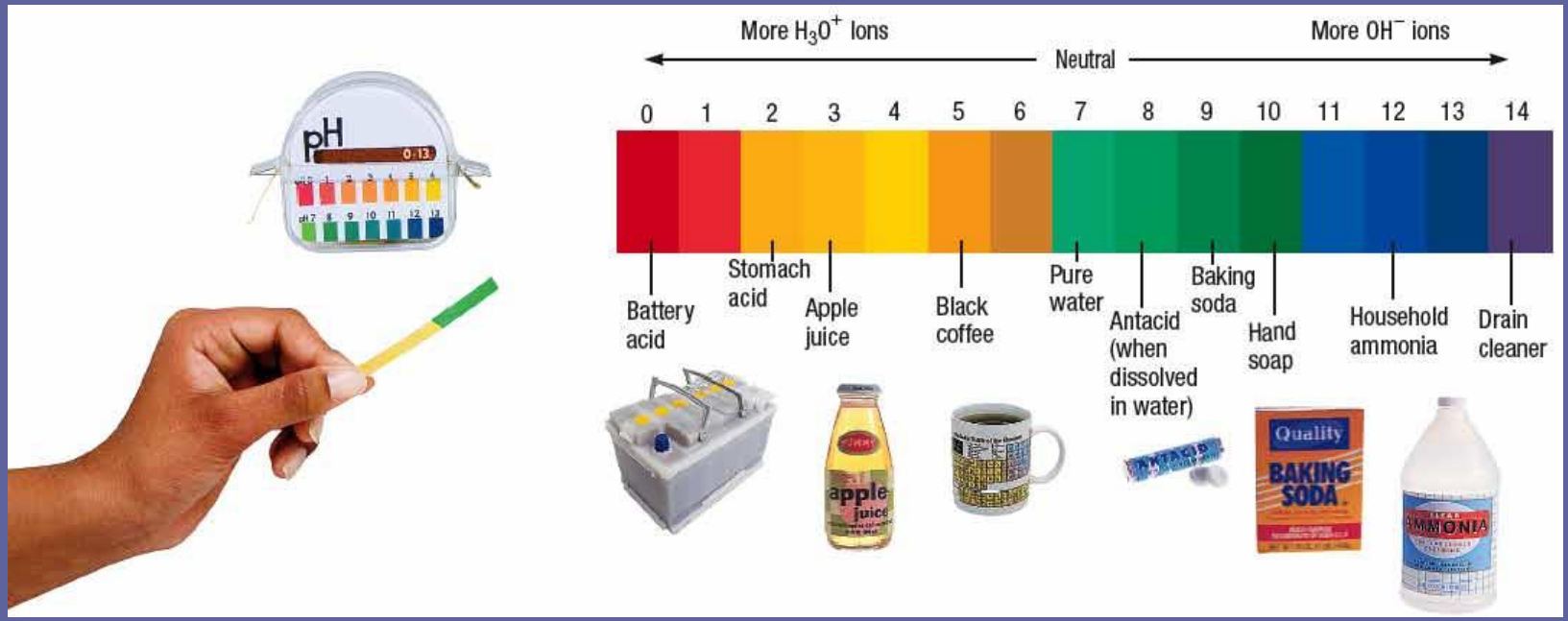
- How is pH related to the concentration of hydronium ions and hydroxide ions in solution?
- The pH of a solution indicates its concentration of H_3O^+ ions.
- In solutions, the concentration of hydronium ions is related to the concentration of hydroxide ions, OH^-.
- The pH of a solution also indicates the concentration of OH^- ions. pH is a value used to express the acidity or basicity of a solution.

pH, *continued*

- **pH:** a value that is used to express the acidity or basicity of a system
- A pH value corresponds to the concentration of hydronium ions.
  - Each whole number on the scale indicates a tenfold change in acidity.
- A neutral solution, such as pure water, has a pH of 7.
- An acidic solution has a pH of less than 7.
- A basic solution has a pH of greater than 7.

pH, *continued*

The pH Scale



pH, *continued*

- You can find pH from the concentration of a strong acid.
- The pH is the negative of the power of 10 that is used to describe the concentration of H_3O^+ ions.
  - example: The concentration of H_3O^+ of pure water is 1×10^{-7} M.
    - The pH of pure water is 7.
- The concentration of hydronium ions in a solution of strong acid is the same as the concentration of the acid.

Math Skills

Determining pH

Determine the pH of a 0.0001 M solution of the strong acid HCl.

1. List the given and unknown values.

Given: *concentration of HCl in solution* = 0.0001 M

Unknown: pH

Math Skills, *continued*

2. Write the molar concentration of hydroxide ions in scientific notation.
   HCl is completely ionized into H_3O^+ and Cl^- ions.

   concentration of H_3O^+ = concentration of HCl

   $= 0.0001\ M = 1 \times 10^{-4}\ M$
3. The pH is the negative of the power of 10 in the H_3O^+ concentration.
   concentration of H_3O^+ ions $= 1 \times 10^{-4}\ M$

$pH = -(-4) = 4$

pH, *continued*

- Small differences in pH mean large differences in acidity.
  - example: pH of apple juice = 3
    pH of coffee = 5
    so apple juice is 10^2, or 100, times more acidic than coffee.
- pH can be measured in more than one way.
  - electronic pH meters can measure pH more precisely than indicators can.

Acid-Base Reactions

〉 What is a neutralization reaction?

〉 A neutralization reaction is the reaction between an acid and a base.

- **neutralization reaction:** the reaction of the ions that characterize acids and the ions that characterize bases to form water molecules and a salt

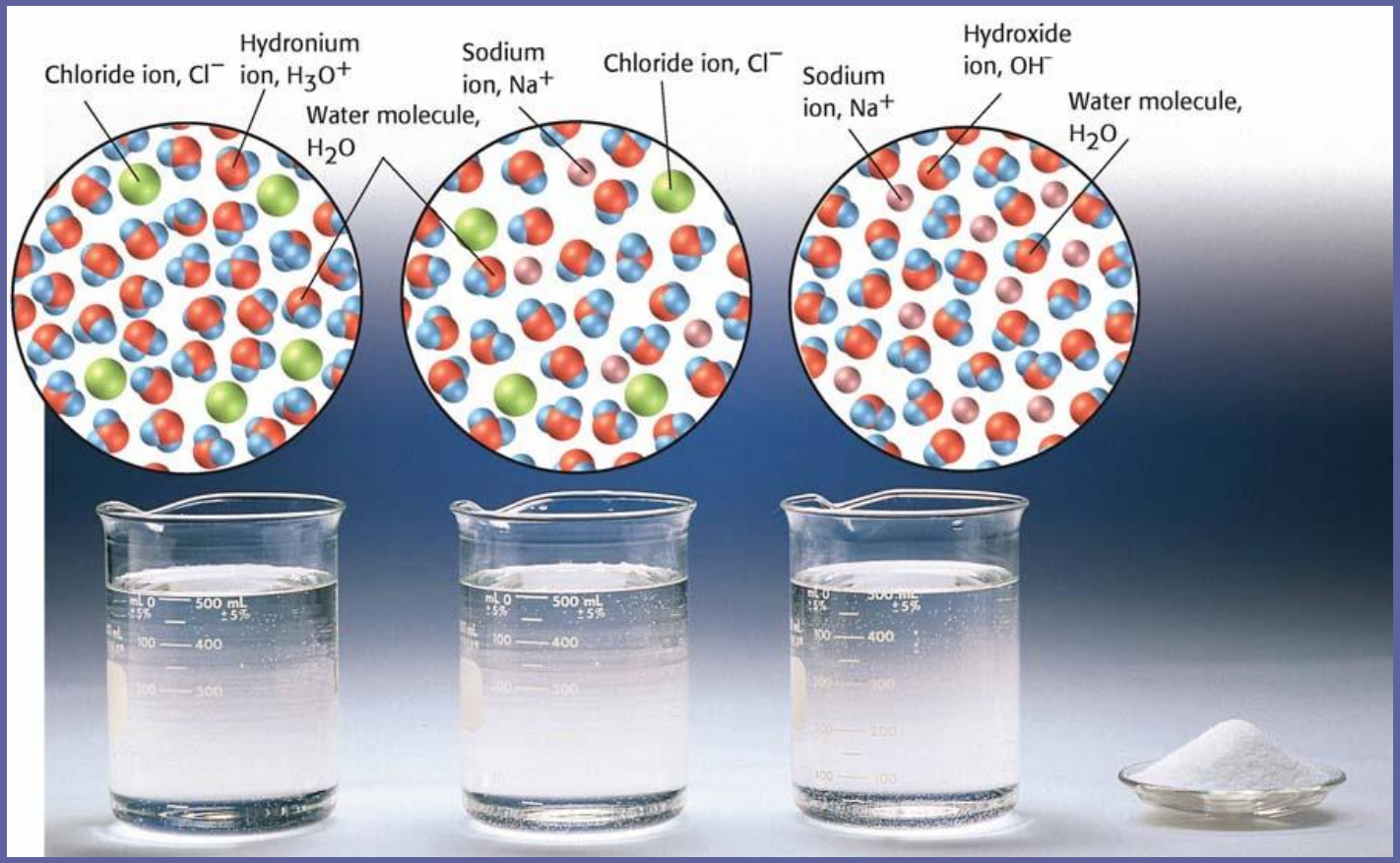
Acid-Base Reactions, *continued*

- Neutralization is reaction between ions.
  - Example:
    - A strong acid ionizes completely in solution.
      $HCl + H_2O \rightarrow Cl^- + H_3O^+$
    - A strong base ionizes completely in solution.
      $NaOH \rightarrow Na^+ + OH^-$
    - The total neutralization reaction is the following:
      $Cl^- + H_3O^+ + Na^+ + OH^- \rightarrow Na^+ + Cl^- + 2H_2O$

Acid-Base Reactions, *continued*

- Neutralization reactions form water and a salt.
- **salt:** an ionic compound that forms when a metal atom or a positive radical replaces the hydrogen of an acid
- Neutral solutions are not always formed.
  - The final pH of the solution depends on:
    - the amounts of acid and base that are combined
    - the strength of the acid and base

Neutralization Reaction



Acid-Base Reactions, *continued*

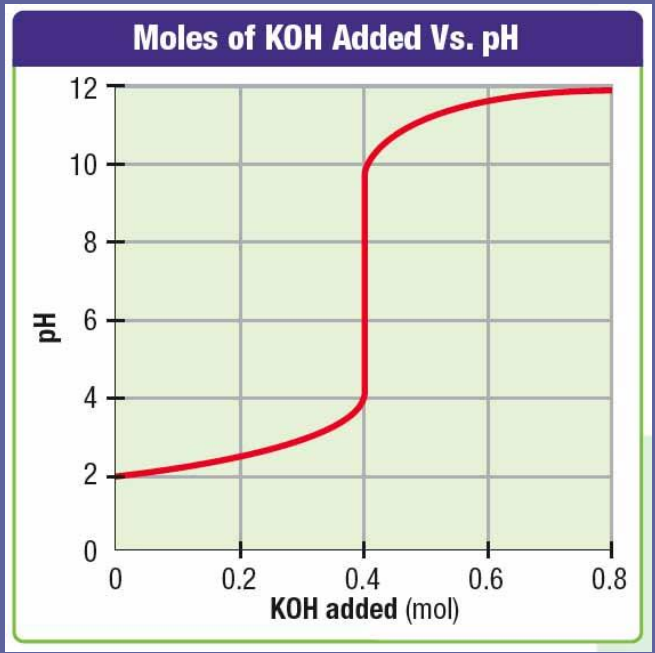
- Titrations are used to determine concentration.
- *titration:* the process of adding carefully measured amounts of one solution to another solution
- *equivalence point:* the point when the original amount of acid equals the original amount of base added
  - strong acid with a strong base, equivalence point = pH 7
  - strong acid with a weak base, equivalence point < pH 7
  - strong base with a weak acid, equivalence point > pH 7

Titration

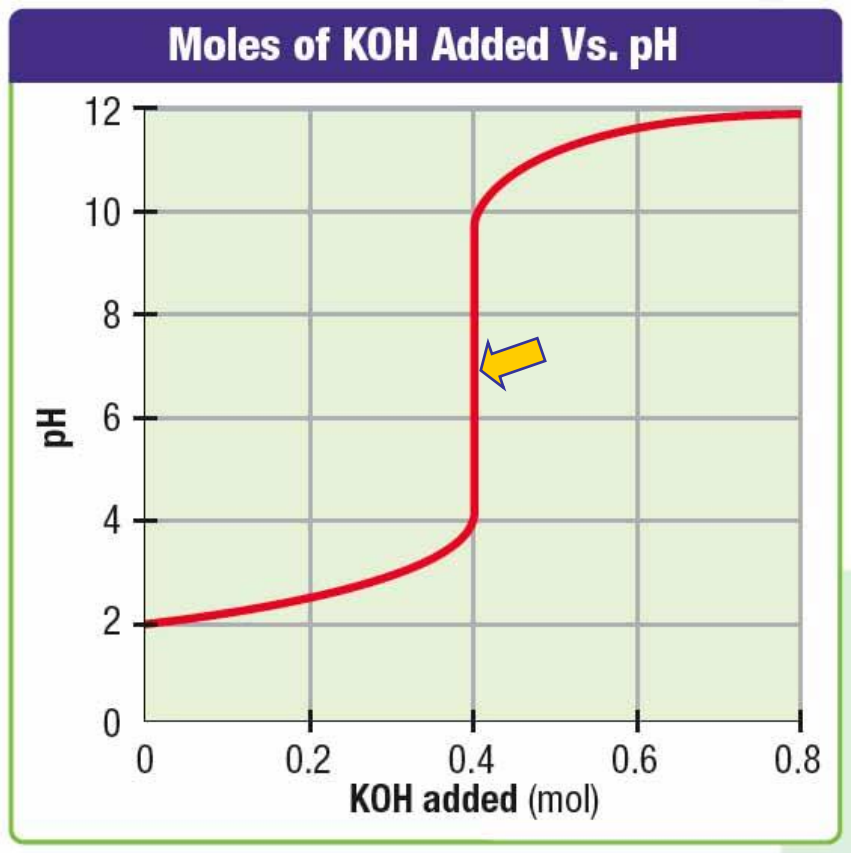
Graphing Skills

Interpreting Titration Curves

Hydrochloric acid, HCl, was titrated with potassium hydroxide, KOH. How many moles of KOH were added to reach the equivalence point?



Graphing Skills, *continued*



1. Locate the equivalence point on the graph.

A strong acid was titrated with a strong base. The *y*-axis indicates the pH, so the equivalence point on the titration curve has a *y*-value of 7.

2. Read the moles of KOH from the graph.

The *x*-axis indicates how many moles of KOH were added. At pH = 7, 0.4 mol of KOH was added.

Salts

〉 To a chemist, what exactly is a salt?

〉 To a chemist, a salt can be almost any combination of cations and anions, except hydroxides and oxides, which are bases.

- Salts have many uses.
- Salts are important in the body.

Salts, *continued*

Some Common Salts

Salt	Formula	Uses
Aluminum sulfate	$Al_2(SO_4)_3$	purifying water; used in antiperspirants
Ammonium sulfate	$(NH_4)_2SO_4$	flameproofing fabric; used as fertilizer
Calcium chloride	$CaCl_2$	de-icing streets and highways; used in some kinds of concrete
Potassium chloride	KCl	treating potassium deficiency; used as table-salt substitute
Sodium carbonate	Na_2CO_3	manufacturing glass; added to wash to soften water
Sodium hydrogen carbonate	$NaHCO_3$	treating upset stomach; ingredient in baking powder; used in fire extinguishers
Sodium stearate	$NaO_2C_{18}H_{35}$	typical example of a soap; used in deodorant
Sodium lauryl sulfonate	$NaSO_3C_{12}H_{25}$	typical example of a detergent

Cleaning Products

〉 Why are cleaning products added to water?

〉 Water does not mix with grease or oil. Cleaning products improve water's ability to clean because they help water mix with oily substances.

- Soaps allow oil and water to mix.
- **Soap:** a substance that is used as a cleaner and that dissolves in water
  - It can dissolve in both oil and in water.
  - Soap allows oil and water to form an emulsion that can be washed away by rinsing.

Cleaning Products, *continued*

- Detergents have replaced soap in many uses.
- **Detergent:** a water-soluble cleaner that can emulsify dirt and oil
- Soap forms soap scum when it combines with Mg^{2+}, Ca^{2+}, and Fe^{3+}.
  - *Soap scum* is an insoluble salt.
  - Detergents do not form scum.
- The hydrocarbon chains in detergents come from petroleum products.
- The hydrocarbon chains in soap come from animal fats or plant oils.

Cleaning Products, *continued*

- Many household cleaners contain ammonia.
  - Solutions of ammonia can clean away light grease smears.

- Bleach can eliminate stains.
- **Bleach:** a chemical compound used to whiten or make lighter
  - Household bleach is a solution of a strong base, sodium hypochlorite (NaOCl).
  - Bleach changes substances to colorless forms.

- Bleach is also a strong disinfectant.
- **disinfectant:** a chemical substance that kills harmful bacteria or viruses

Personal-Care and Food Products

- What are some household products that contain acids, bases, and salts?

- Many healthcare, beauty, and food products in your home, in addition to cleaners, contain acids, bases, or salts.

Personal-Care and Food Products, *continued*

- Many healthcare products are acids or bases.
  - Vitamin C is ascorbic acid.
  - Sodium hydrogen carbonate and magnesium hydroxide (milk of magnesia) are antacids.
  - **antacid:** a weak base that neutralizes stomach acid
- Shampoos are adjusted for an ideal pH.
  - The pH of most shampoos is between 5 and 8.
  - A shampoo that is too basic can cause strands of hair to swell.
    - Your hair will look dull and lifeless.

Personal-Care and Food Products, *continued*

- Acids can be used as antioxidants.
  - *Antioxidants* prevent oxygen from reacting with molecules.
  - Vitamin C and citric acid are antioxidants.
- Acids, bases, and salts are used in the kitchen.
  - Vinegar or citrus juices make acidic marinades that can tenderize meats.
  - Bacteria convert lactose, a sugar in milk, into lactic acid. The lactic acid changes the shape of the protein casein, which thickens the milk.
  - Many drain cleaners contain sodium hydroxide.