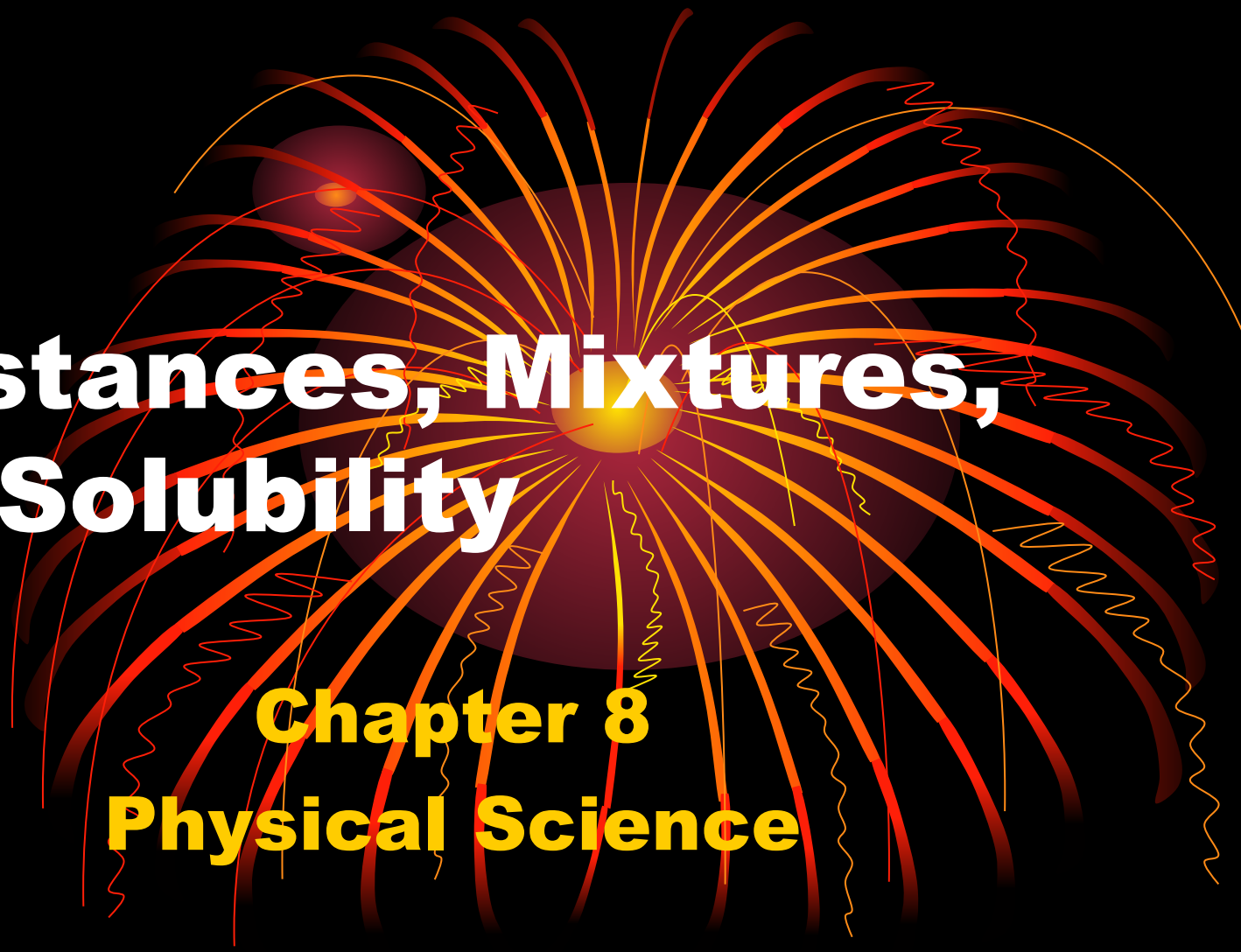


Substances, Mixtures, and Solubility

Chapter 8

Physical Science

8.1 – What is a Solution?

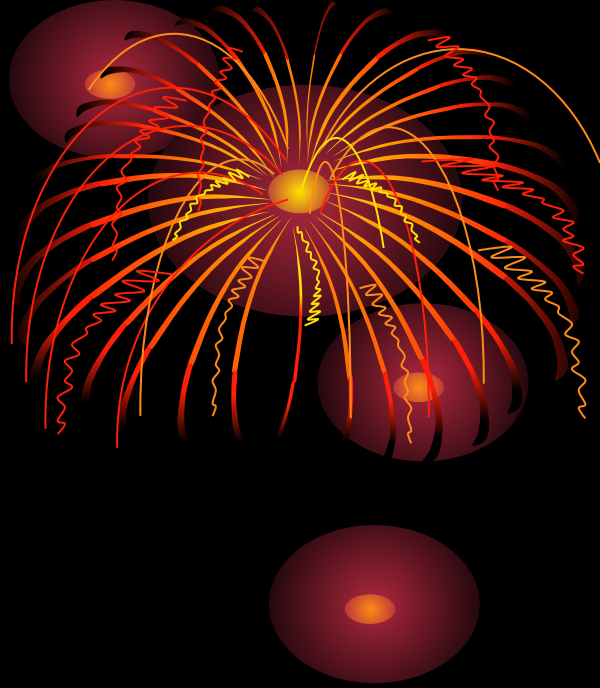
Objectives:

1. Distinguish between substances and mixtures.
2. Describe two different types of mixtures.
3. Explain how solutions form.
4. Describe different types of solutions.

Why it's important to you!

- **The air you breathe, the water you drink, and even parts of your body are all solutions.**

Substances



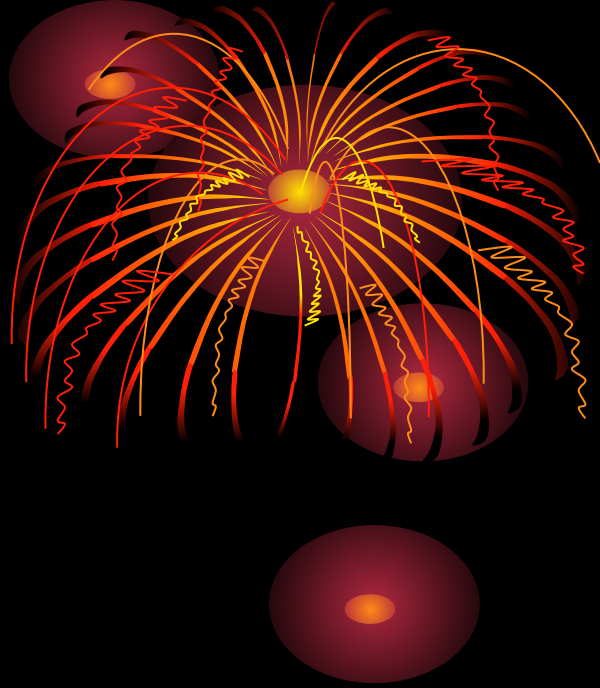
- We see differences in everything around us
  - Water
  - Orange juice
  - Salt water

Chemistry explains how these are different and how they are connected.

Atoms & Elements

- **Atoms – basic building block of ALL matter**
- **Atoms of one kind make up the elements**
- **Atoms chemically combine to make substances like compounds**

Pure Substances



- **Element is pure**
  - **One type of atom only**
- **Compound is pure**
  - **Two or more elements chemically combined to form a new matter that is pure**
  - **Has the same ratio of elements always**
  - **Has new set of properties unlike those of the elements that make it up**

Mixture

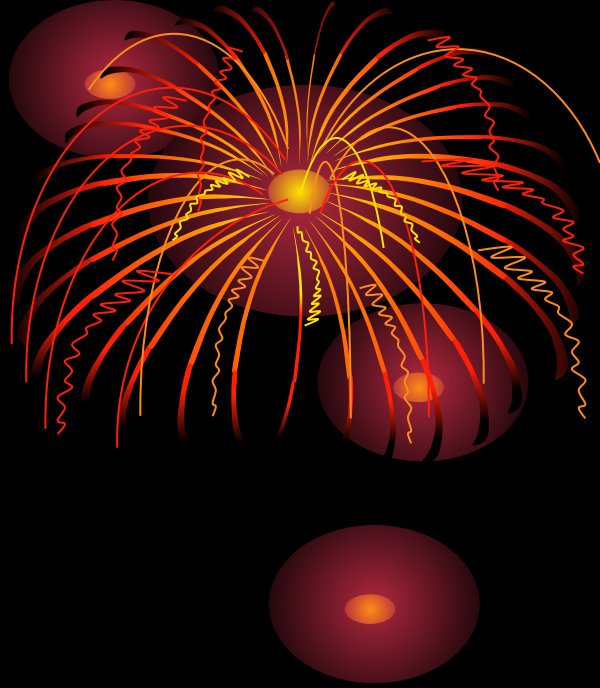
- Combination of substances that are not bonded together
- How do you know?
- Each substance retains its own properties

So you will taste the salt in a salt water mixture.

- **Unlike compounds, mixtures do not keep the same proportions of substances that make them up**

- **A mixture may taste really sweet or not so sweet depending on the amount of sugar added to the mixture**

Kinds of Mixtures



- **Homogeneous**

- **Heterogeneous**

Homogeneous Mixture

- Contains two or more substances
- Evenly mixed on a molecular level
- NOT bonded together
- Examples – pop, kool-aid, popsicle
- Another name is a solution

Heterogeneous Mixture

- Two or more substances unevenly mixed
- One particle typically larger than the other
- Examples – seeds in a watermelon, bowl of cold cereal in milk, jello

How Solutions Form

- **Solute – substance dissolving (smaller amount)**
- **Solvent – substance does dissolving (larger amount)**

Solutions of many kinds

- Solutes can fall out of a solution
- Process of crystallization

- In a chemical reaction, a solid can form between two solutions this solid is a precipitate – Example - minerals (soap scum) in your sink when soap and water combine

Formed from solutions

- Stalactites (cave roof)
- Stalagmites (cave floors)

- Formed when a solution of minerals drips in the cave and the liquid evaporates leaving the mineral behind

Types of Solutions

- Solutions come in many forms
  - Gas/ gas solutions (air)
  - Gas/ Liquid solutions (pop)
  - Solid/ solid solutions (solder)
  - Liquid/ solid solutions (apple juice)

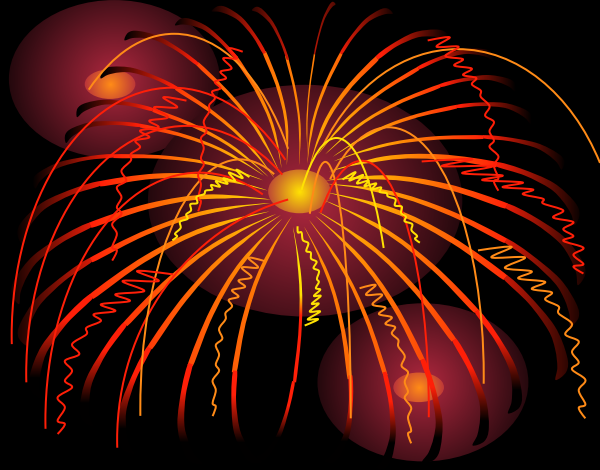
- **Solid / Solid solutions can make solder for welding or statues**

- **Remember that the two solids would need to be heated and mixed before allowing them to cool into the solid solution they will form**

Test YourSelf

- How are substances and mixtures different?
- What are the two types of mixtures?
- How do you form a solution?
- Describe different types of solutions.

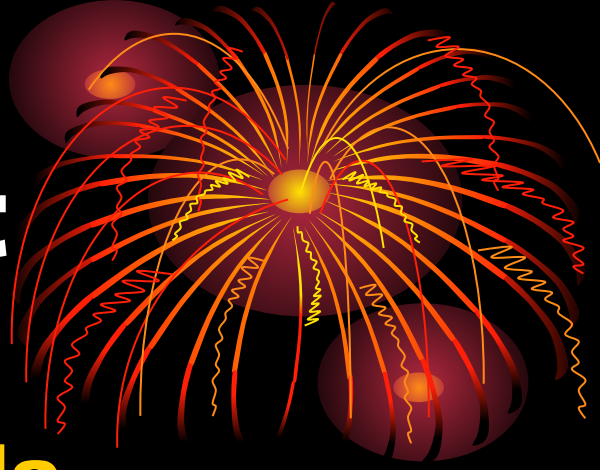
8.2 Solubility



Objectives

1. Explain why water is a good general solvent.
2. Describe how the structure of a compound affects which solvents it dissolves in.
3. Describe how temperature affects the reaction rate.
4. Explain how solute particles affect physical properties of water.

Why it's important



How you wash your hands, clothes, and dishes depends on which substances can dissolve in other substances. It is important to understand why this happens.

Water – the Universal Solvent

- Since many substances dissolve in water, it is called the universal solvent
- All chemical reactions in your cells take place in a water environment so this is an important fact

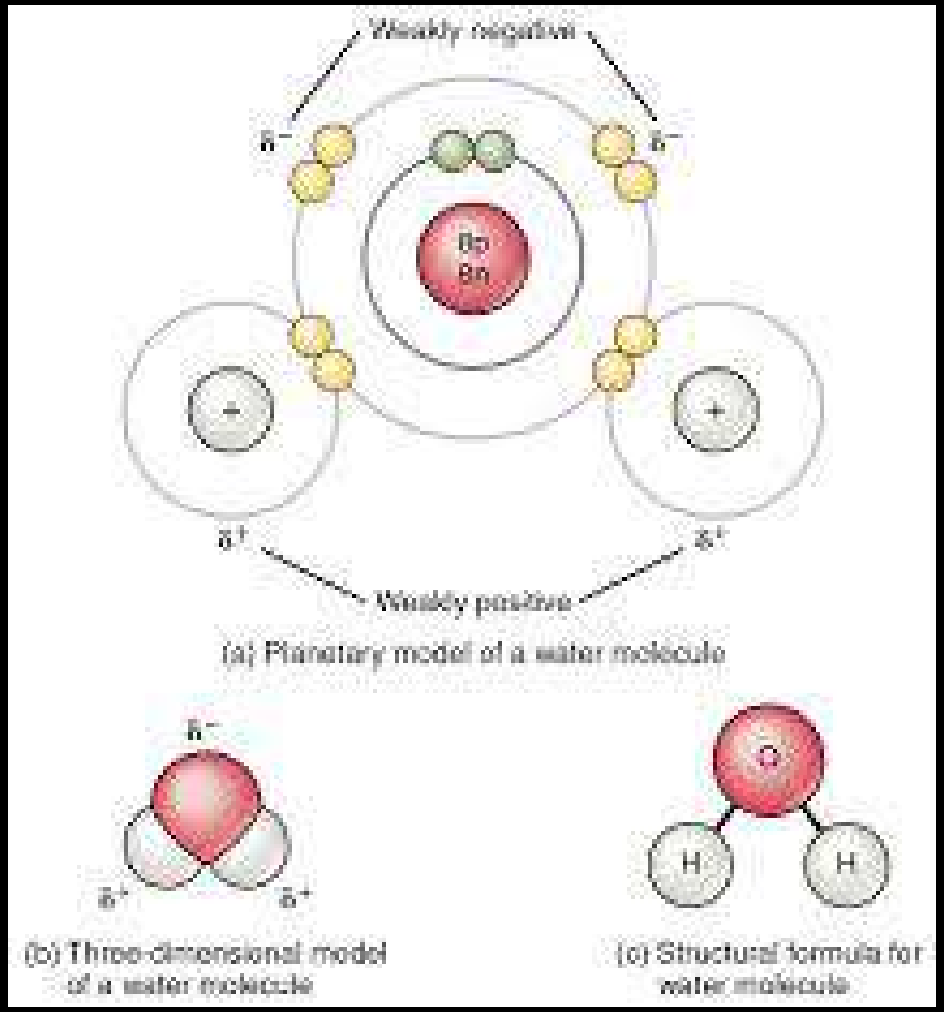
Molecular Compounds

- Happen when atoms share electrons
- This forms a covalent bond
- Sometimes the electron sharing is not equal

Molecular Compound Bonds

- **Polar – the electrons are unevenly shared so one element keeps them closer to its nucleus than the other**
  - **Water is an example**
- **Nonpolar – electrons are evenly shared between the atoms**

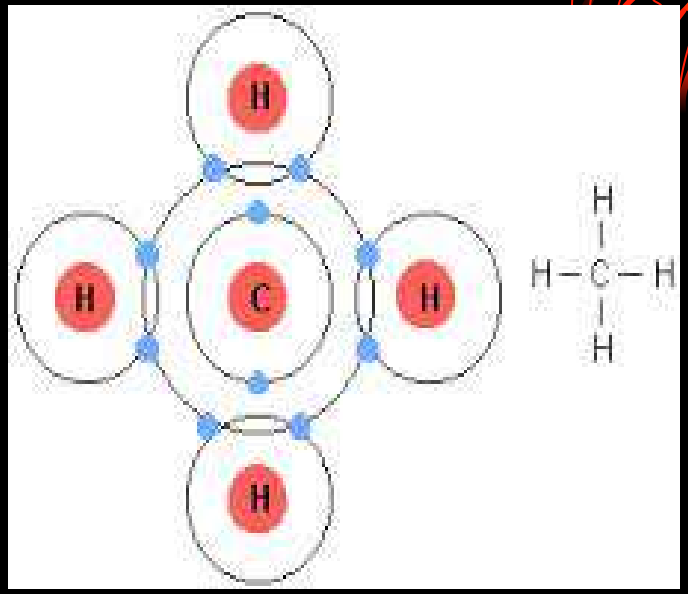
Polar Bond



- **Notice the electrons are closer to the oxygen than the hydrogen.**
- **This gives a positive end (Hydrogen) and a negative end (Oxygen)**

Nonpolar Bond

- Sugar
- Methane



- Since the electrons move evenly between both atoms

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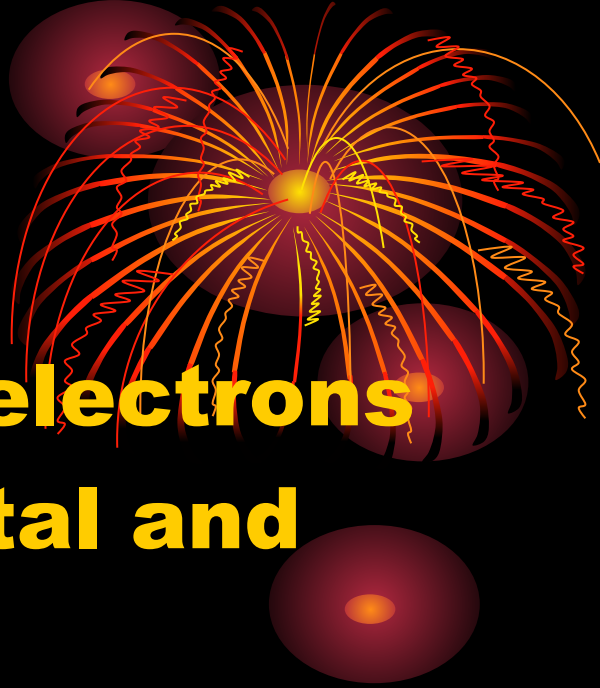
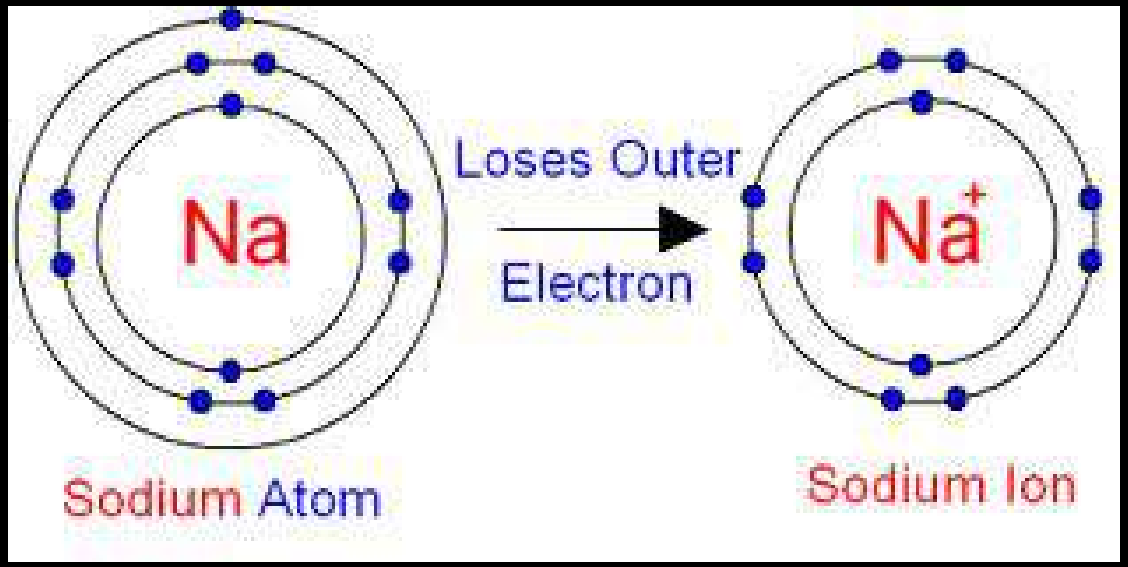
Ionic Bonds



- Some atoms exchange electrons
- Happens between a metal and nonmetal

- This electron exchange causes an atom to have an uneven number of protons and electrons creating ions

Ions

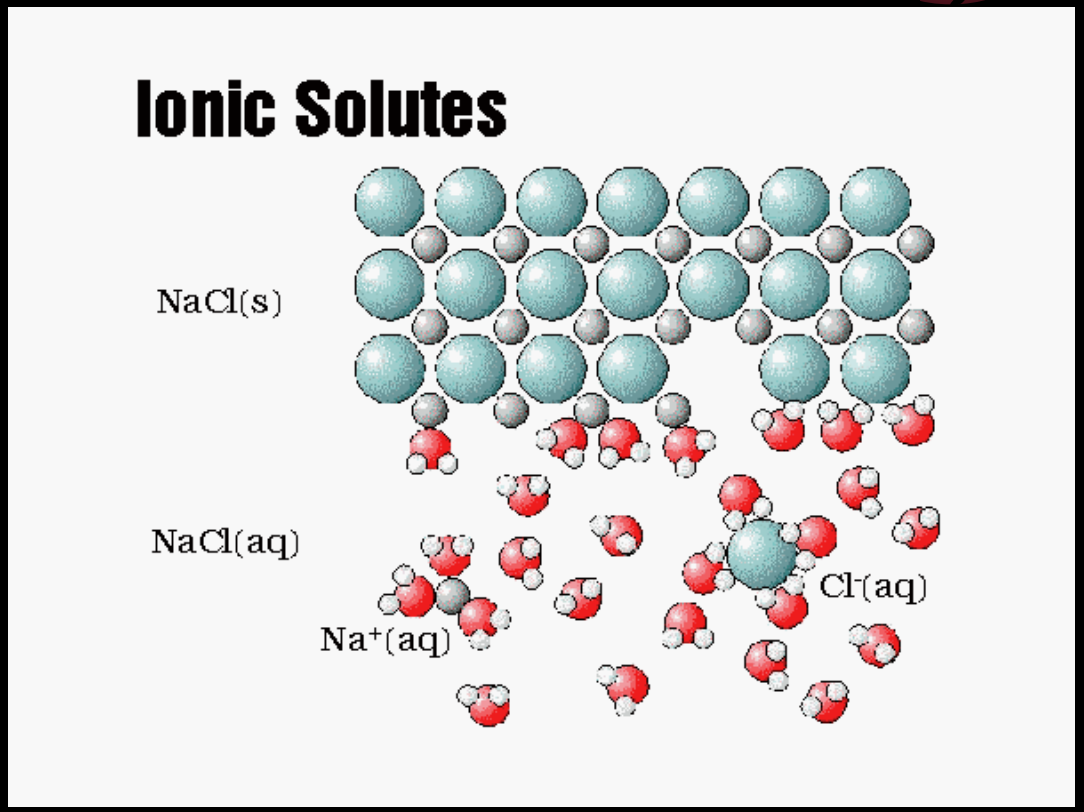


- **Notice the loss of one electron creates a 1+ ion**

https://www.google.com/search?q=nonpolar+bond+methane+image&tbm=isch&source=iu&imgil=O3WkTPLzPPNQOM%253A%253Bhttps%253A%252F%252Fencrypted-tbn0.gstatic.com%252Fimages%253Fq%253Dtbn%253AANd9GcQ7GXcBK0PUJGzMGhHjanvRPiDX49lpVJwqvXBt8diVTh_co37IeQ%253B284%253B211%253BX7tXIgoMhCqHvM%253Bhttp%25253A%25252F%252252Ffaculty.clintoncc.suny.edu%25252Ffaculty%25252Fmichael.gregory%25252Ffiles%25252Fbio%2525252520101%25252Fbio%2525252520101%2525252520lectures%25252Fbiochemistry%25252Fbiochemi.htm&sa=X&ei=NM7OUseXHo7foASW9YCwDA&ved=0CDYQ9QEwBQ&biw=1024&bih=569#q=ion+image&tbm=isch&facrc=_&imgdii=_&imgrc=guBRd1a4VDXQGM%253A%3B4zv1jbRwGg25yM%3Bhttp%253A%252F%252Fwww.gcsescience.com%252FSodium-Atom-Sodium-Ion.gif%3Bhttp%253A%252F%252Fwww.gcsescience.com%252Fa4-sodium-ion.htm%3B396%3B198

Dissolving Ionic Compounds

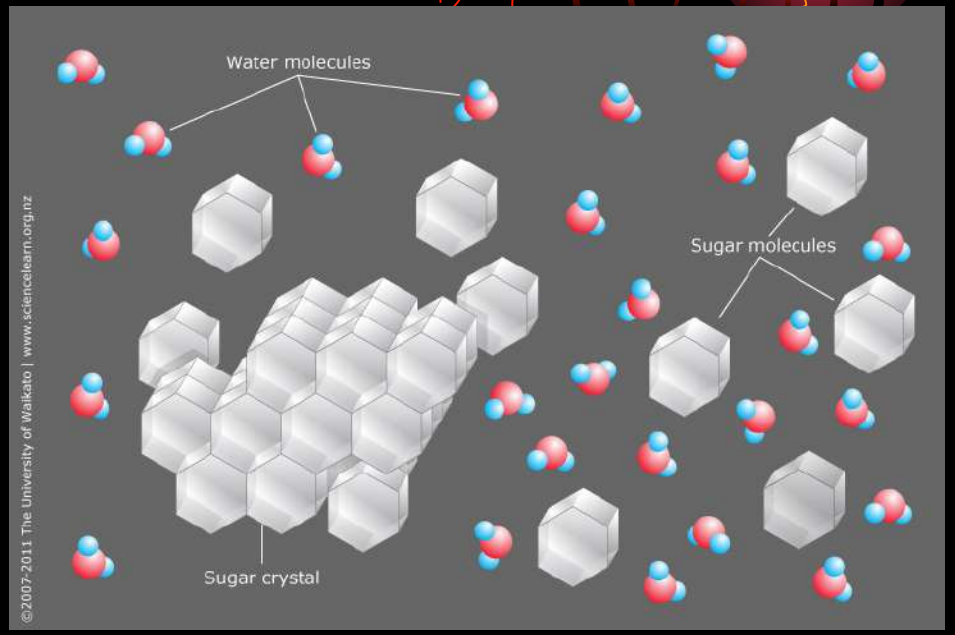
- Each ion is surrounded by the water molecules
Notice the positive Hydrogen end surrounds The negative Chlorine ion And the positive Oxygen End surrounds the Na+



http://www.shs.d211.org/science/faculty/S2B/Old%20Stuff/water_dissolving_an_ionic_compou.htm

Dissolving Covalent Compounds

Notice the
Entire sugar
Molecule gets
Surrounded
Instead of parts
Of the sugar
molecule



What Will Dissolve?

- Like Dissolves Like
- Molecules of similar chemistry will dissolve others like themselves
- This is why oil and water will not dissolve in one another

Solubility

- Describes how much solute will dissolve in a solvent

- This is described as 60 g of sugar will dissolve in 100 g of water.
- 100 g of water = 100 mL

Solubility

- Some solutes are highly soluble
- Some are not
- Usually increasing the heat increases solubility
- Remember our rate of reaction lab?

Insoluble

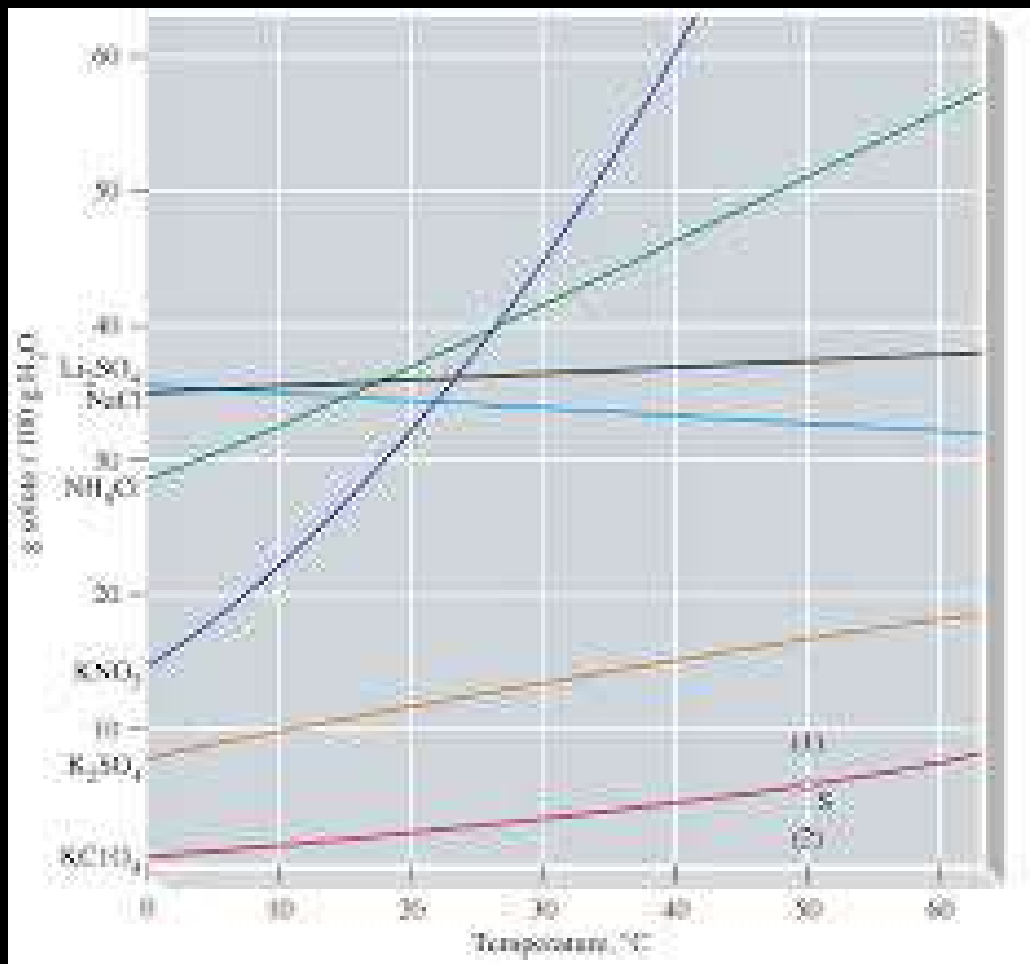
- When a substance like barium sulfate has an extremely low solubility, we refer to it as being insoluble
- This image

Illustrates oil

And water

Solubility Curves

- **The steeper the line, the More soluble The substance**



Liquid-Solid Solutions

- Temperature makes a difference
- Increased temperature increases the solubility
- Sodium chloride and calcium carbonate do not become more soluble with higher temperatures– they remain constant

Liquid-Gas Solutions

- An increase in temperature decreases the solubility of a gas in a liquid- gas solution
- Carbon dioxide is less soluble at lower temperatures

Saturated Solutions

- This indicates all the spaces available in a solvent are filled by molecules of solute

- No more solute can be held by the solvent unless we add heat

Unsaturated Solution

- More Solute can be added to the solvent without adding any energy

Rate of Dissolving

- If the molecules move faster the dissolving rate will increase
- Ways to move the molecules faster include:
  - Heat
  - Stirring
  - Lower concentration
  - Greater surface area

Concentration

- The amount of solute in a solvent
- Concentrated = full of solute
- Dilute = room is available for the solute to fill spaces in the solvent

Measuring Concentration

- 2 g of glucose in 100 mL of water

$$\frac{2\text{g}}{100\text{mL}} = .02 \text{ or } 2\% \text{ solution}$$

Effects of Solute Particles

- **When adding a solute to a solvent if affects the melting point and boiling point of the solvent**

Effects of Solute

- Adding solute to water when freezing the water changes how the water molecule arrange while trying to form crystals
- To overcome this interference the temperature must get lower to freeze the solvent
- This is why salt is placed on icy walkways

Boiling with a Solute

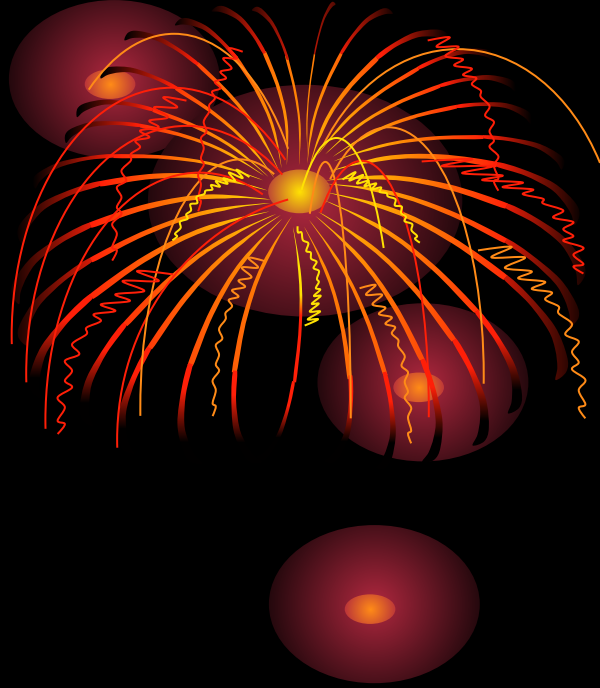
- When water boils, each molecule of solvent gains enough energy to change states
- Solutes in the water will disrupt this energy absorption so MORE energy is needed to boil the water– the boiling point will be higher

Review

- **How does adding a solute to a solution change its boiling point?**

- **The boiling point is elevated because it takes more energy to get each of the solvent molecules to energy level needed to escape the liquid phase and turn into a gas**

- A _____ changes color to identify the hydronium ion concentration and determine if there is an acid or base present.



- **Indicator**

8.3 Acidic & Basic Solutions

- What You'll Learn
- Compare acids and bases and their properties
- Describe practical uses of acids and bases
- Explain how pH is used to describe the strength of an acid or base
- Describe how acids and bases react when they are brought together

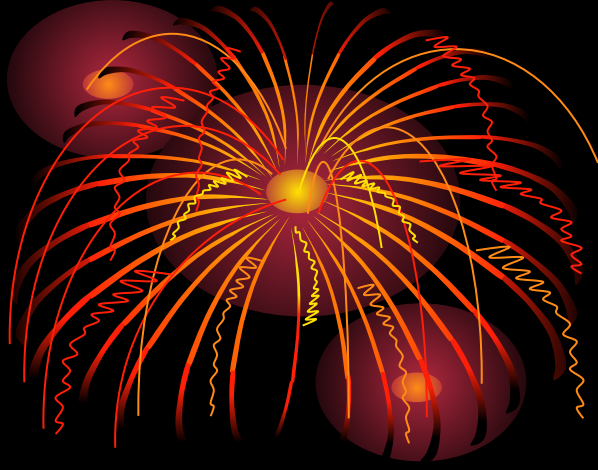
Why it's important?

- **Many common products, such as batteries and bleach, work because of acids and bases. Since we use these products daily, we need to understand them.**

Acids

- **Are substances that release positively charged hydrogen ions in the water**
- **Hydrogen ions are represented as H^+**

Hydronium Ion

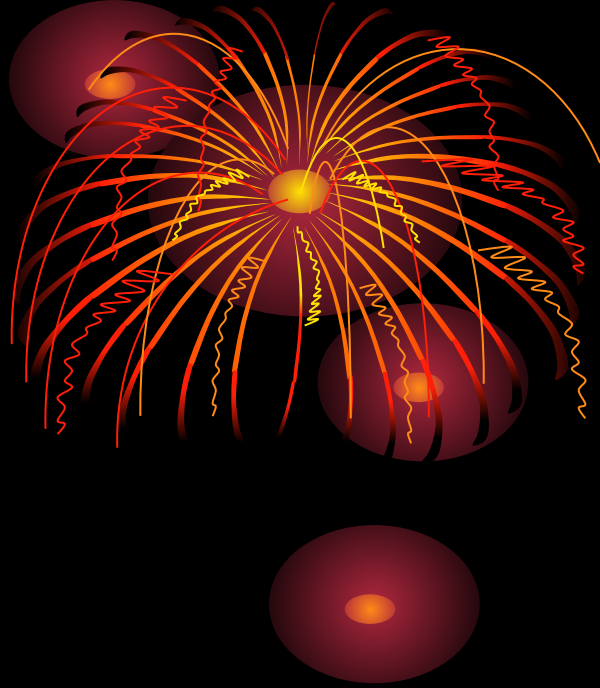


- H_3O^+
- Is created when a water molecule bonds with a hydrogen ion
- This is what acids typically are made up of

Properties of Acidic Solutions

- Sour taste
  - Think about the foods that are sour
- Conduct electricity
- Corrosive- meaning they can break down certain substances
- Some acids react strongly with metals releasing hydrogen gas

Acids

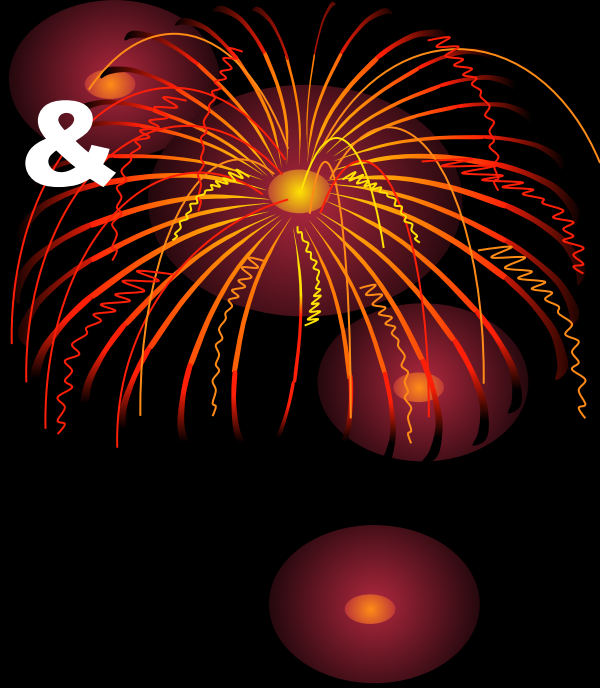


- Can corrode
  - Fabric
  - Skin
  - paper

Uses of Acids

- Vinegar – acetic acid
- Lemons, limes, oranges
  - Ascorbic acid = Vitamin C
- Ant stings
  - Formic acid

Products of Acids & Uses



- Sulfuric Acid
  - Fertilizers, steel, paints
  - Batteries
- Hydrochloric acid
  - Pickling metals
  - Clean mortar from brick walls
- Nitric acid
  - Fertilizers, dyes and plastics

Acid in the Environment

- Cave formation
  - Carbonic acid formed from carbon dioxide in the soil dissolving in ground water
  - This carbonic acid then dissolves large basic rocks like limestone which is Calcium Carbonate
  - When the rock is dissolved, a cave forms

Lewis & Clark Caverns

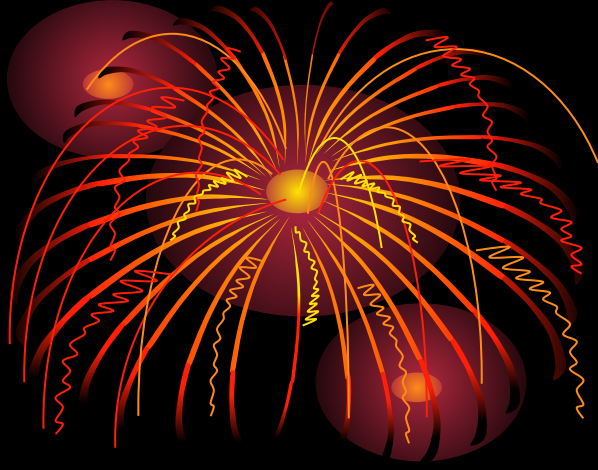
Lewis & Clark Caverns

Lewis & Clark Caverns

Cave Formations

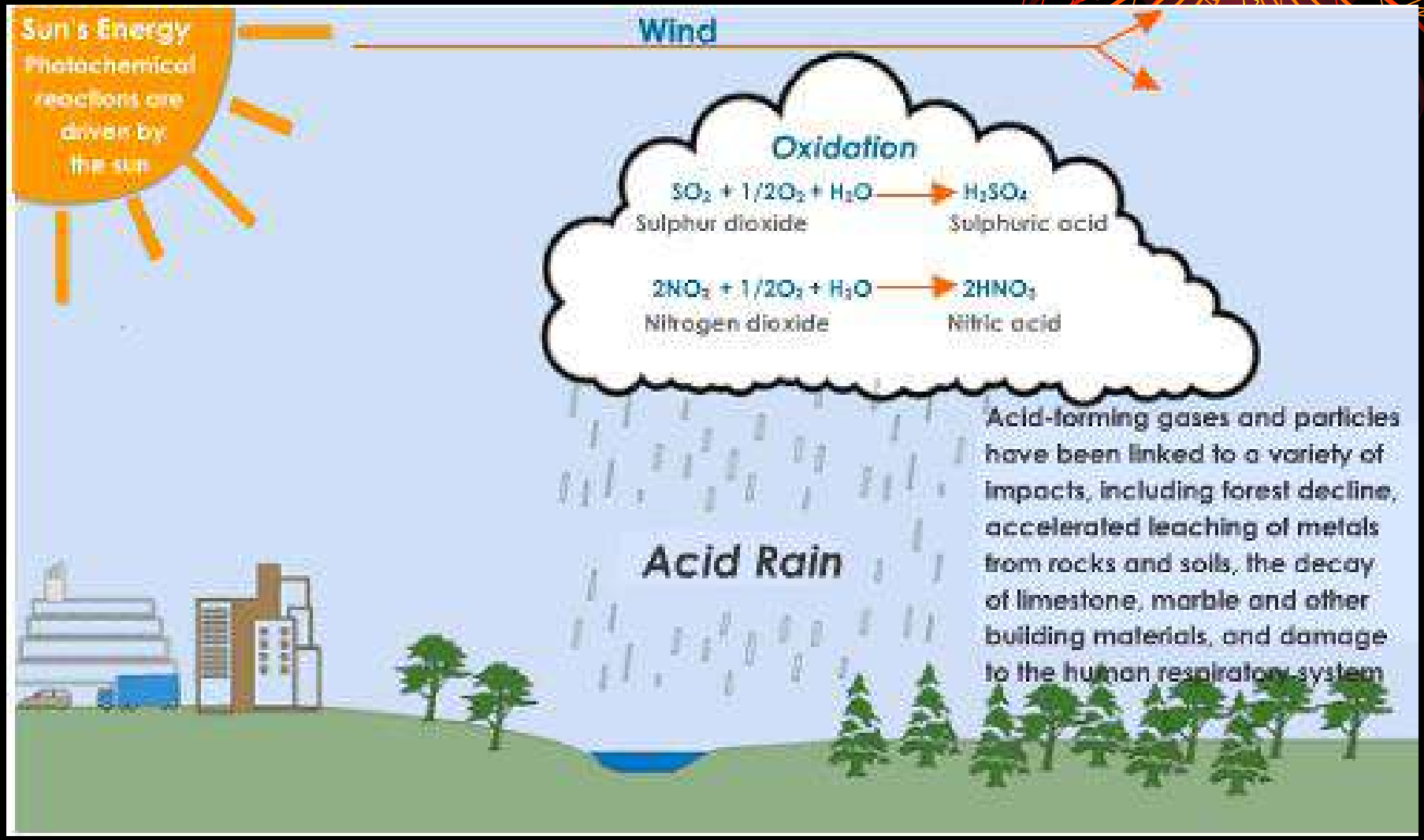
- **Stalactites – form when the acidic solution drips from the ceiling and the water evaporates off leaving a hanging formation**
- **Remember they hold “tight” to the ceiling**

Cave Formation



- **Stalagmites**
  - **Form as the acidic solution drips onto the floor building a column**
  - **Remember they “might” reach the top**

Acid Rain


Sun's Energy
Photochemical reactions are driven by the sun
Wind
Oxidation
$SO_2 + 1/2O_2 + H_2O \rightarrow H_2SO_4$
Sulphur dioxide
Sulphuric acid
$2NO_2 + 1/2O_2 + H_2O \rightarrow 2HNO_3$
Nitrogen dioxide
Nitric acid
Acid Rain
Acid-forming gases and particles have been linked to a variety of impacts, including forest decline, accelerated leaching of metals from rocks and soils, the decay of limestone, marble and other building materials, and damage to the human respiratory system

Bases

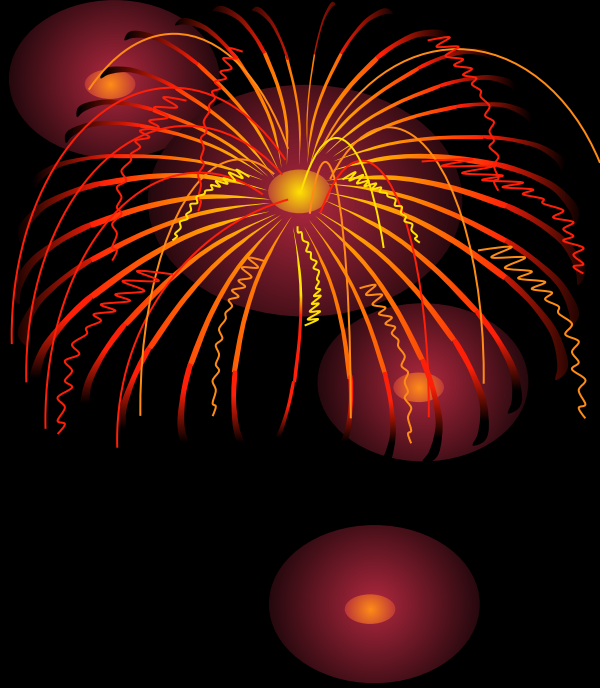
- **Substances that accept hydrogen ions**

- **Causes the formation of a hydroxide ion (OH^-) which is an indication of a base**

Properties of Basic Solutions

- Most soaps
- Slippery
- Taste bitter
- Corrosive
- Conduct electricity
- Not as reactive with metals as acids are

Uses of Bases

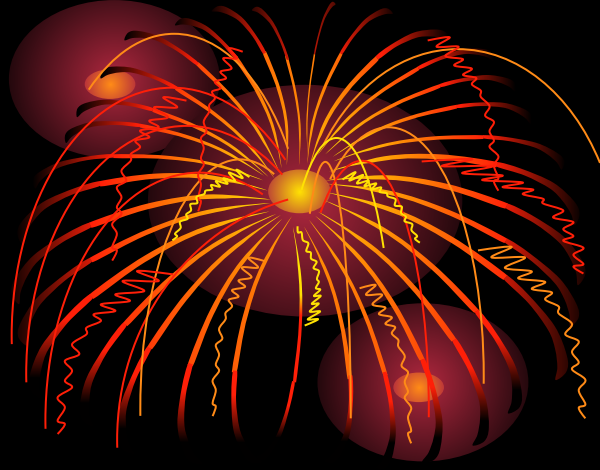


- Ammonia – cleaner
- Chalk
- Calcium Hydroxide
  - Athletic field lines (chalk)
  - Garden and soil treatment
- Sodium Hydroxide
  - Also called Lye
  - Oven cleaners and unclog drains

What is pH?

- A measurement of how acidic or basic a solution is
- Each time the pH increases there is a power of 10 difference in the level of ions
- This means a pH of 2 is 10 times stronger than a pH of 3!

Comparing pH



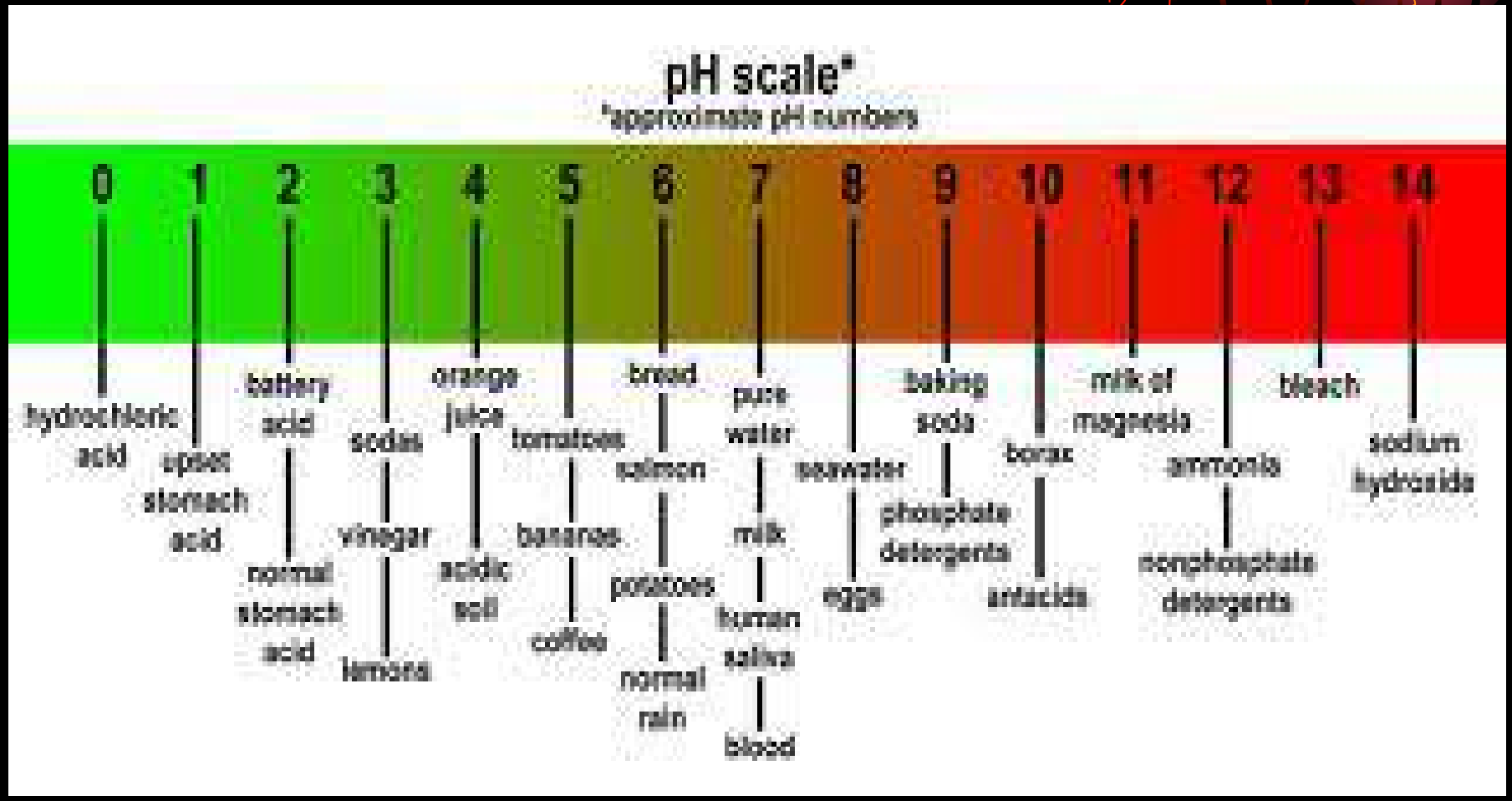
- A pH of 9 vs a pH of 11
  - Since there is a difference of 2 between 9 and 11 there is 10 X10 difference in the concentration of ions
  - 10 X 10 = 100 X stronger
  - 11 is 100 X stronger than 9 because a bigger number is more basic

pH Solution

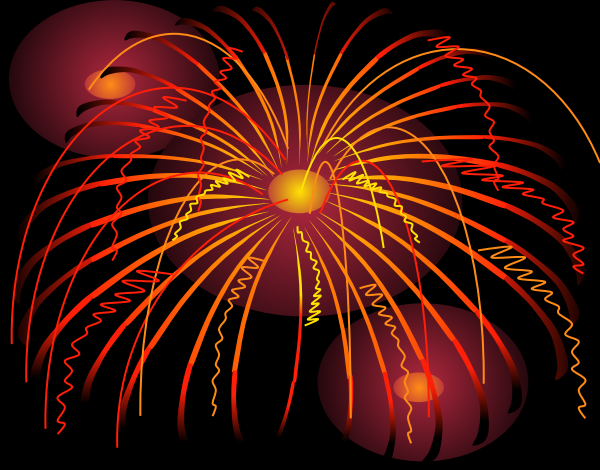
- pH measures the concentration of Hydronium ions

- The more hydronium ions in a solution the fewer hydroxide ions (acidic)
- The fewer hydronium ions, the more hydroxide (basic)

pH Scale


pH scale*
*approximate pH numbers
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
hydrochloric acid
upset stomach acid
battery acid
normal stomach acid
sodas
vinegar
lemons
orange juice
acidic soil
tomatoes
bananas
coffee
bread
salmon
potatoes
normal rain
pure water
milk
human saliva
blood
seawater
eggs
baking soda
phosphate detergents
borax
antacids
milk of magnesia
ammonia
nonphosphate detergents
bleach
sodium hydroxide

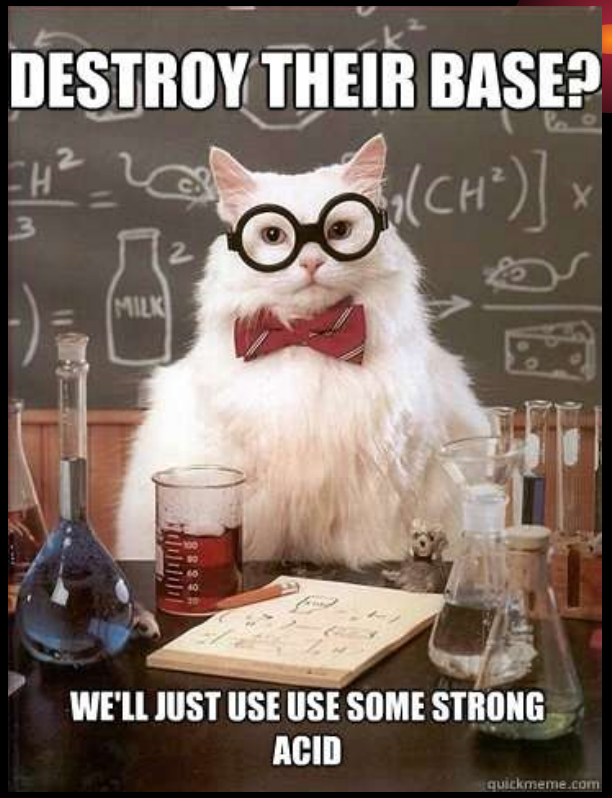
pH Scale



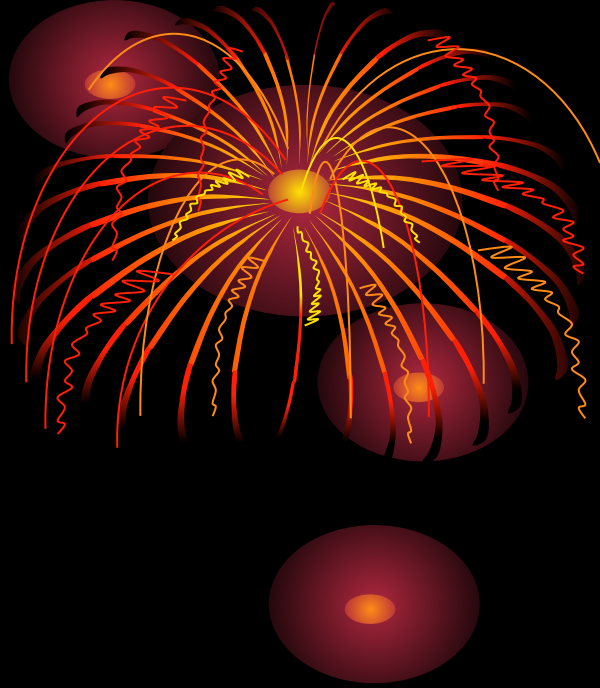
- 0 – 7 Acidic
  - Closer to 0 the stronger the acid
- 7 – Neutral
  - Even concentrations of hydroxide and hydronium ion concentrations
- 7-14 Basic
  - Closer to 14 the stronger the base

Strong Acids

- **Hydrochloric – HCl**
- **Sulfuric – H_2SO_4**
- **Nitric – HNO_3**



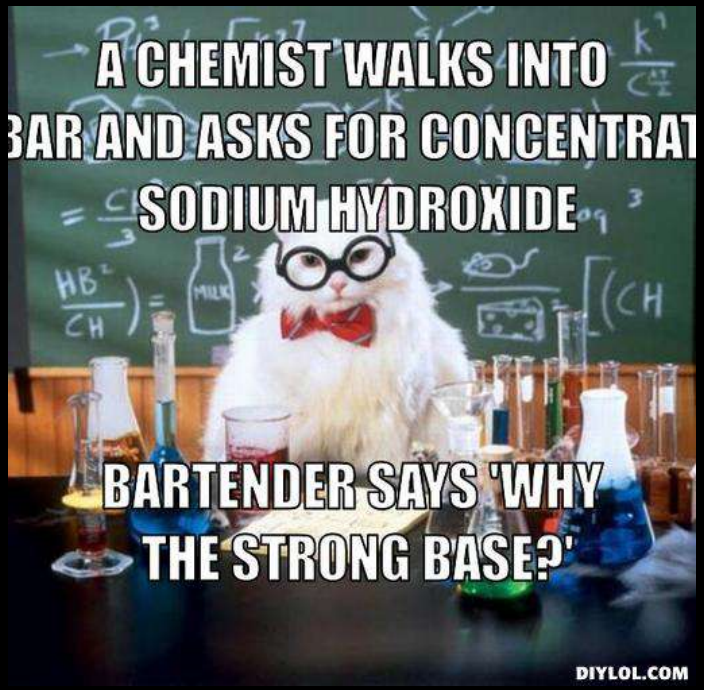
Weak Acid



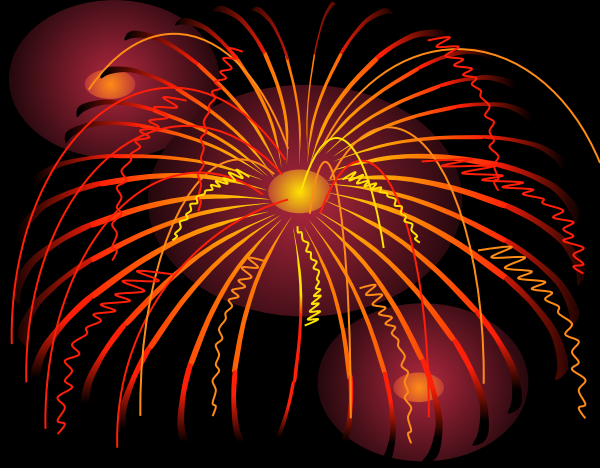
- Acetic – CH_3COOH
  - Vinegar
- Carbonic – H_2CO_3
  - Pop or first aid
- Ascorbic – $H_2C_6H_6O_6$
  - Vitamin C

Strong Base

- **Sodium hydroxide (NaOH)**
- **Potassium hydroxide (KOH)**



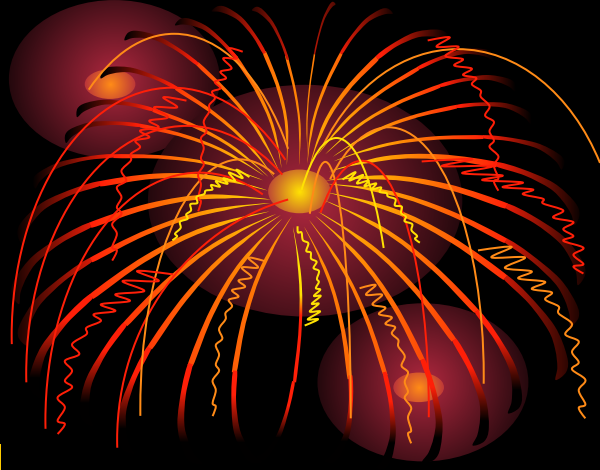
Weak Base



- **Ammonia – NH_3**
- **Aluminum hydroxide $Al(OH)_3$**
- **Iron(III) hydroxide $Fe(OH)_3$**

Indicators

- Substances that change color to indicate the strength of an acid or base
- They are triggered by the hydronium ion concentration in the solution
- The indicator however does not change

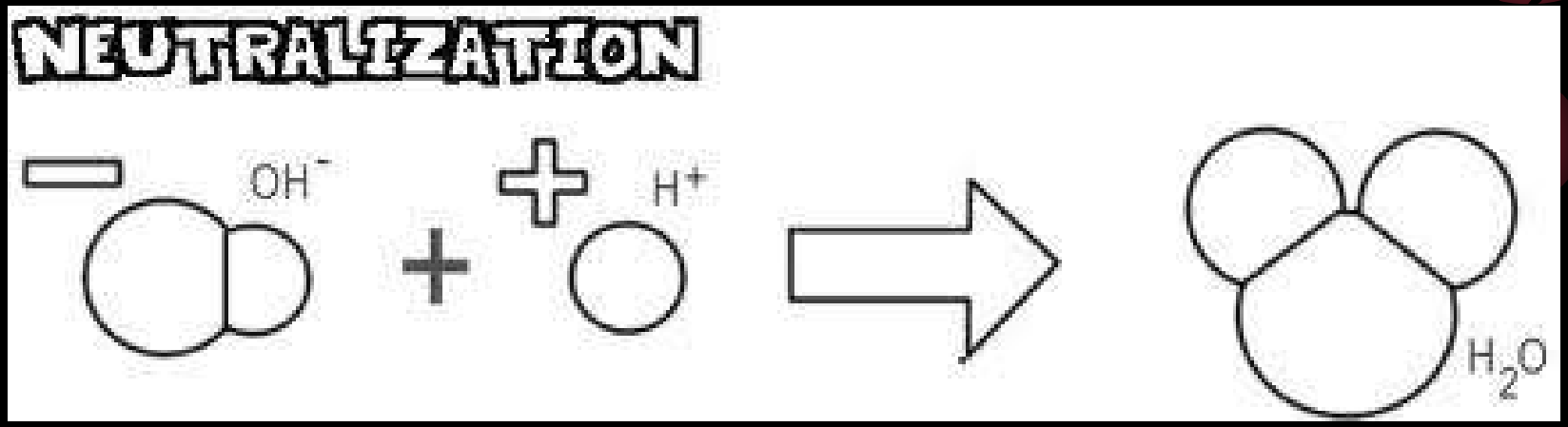


- There are many natural indicators like red cabbage
- We will test with red cabbage
- There are also man made indicators like pH paper
- Electronic pH meters too

Neutralization

- The reaction between an acid and a base
- The ions of the base – OH^-
- Combine with the ions of the acid H^+
- To produce water and an ionic compound called a salt

Neutralization



Review 8.3

- **How much more acidic is a pH of 2 than a pH of 4?**

Answer

- Since there is a difference of 2 pH values and each one equals a power of 10 difference
- 10 X 10 = 100 x
- 2 is the stronger acid
- 2 is 100 times stronger than 4

- **Be able to list industrial uses for acids.**
- **Be able to list household uses for bases.**