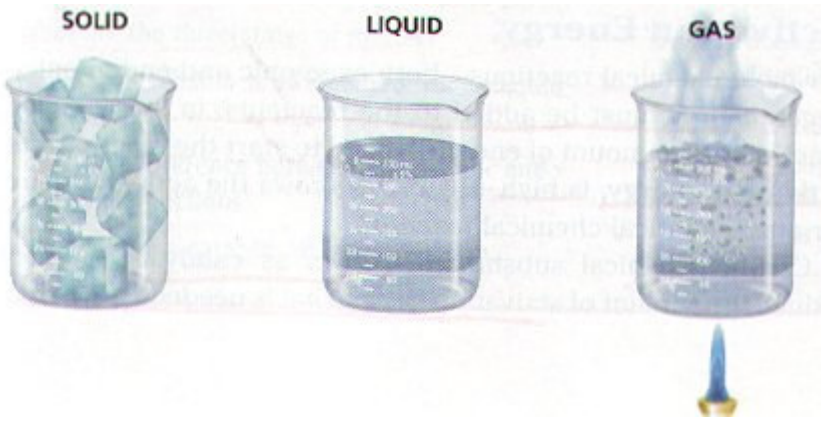
Chemistry 

Composition of Matter

- Ø Everything in the universe is made of matter
- Ø Matter takes up **space** & has **mass**
- Ø **Mass** is a measure of the amount of matter in the substance
- Ø Mass & weight are **NOT** the same
- Ø **Weight** is a measure of the pull of gravity on an object

Question: Is the mass of an object the same on the moon as it is on the Earth? Is its weight the same? (Hint: Gravitational pull on the moon is 1/6 of that on the Earth.)

- Ø Matter exists in 4 states – **solid, liquid, gas, & plasma**

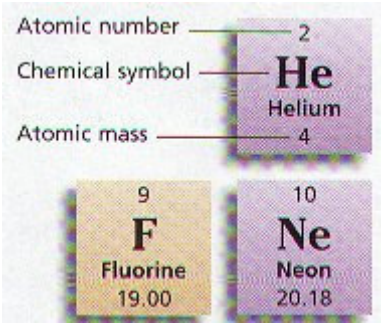


- Ø **Solids** have both a definite volume & definite shape (rock)
- Ø **Liquids** have a definite volume but no definite shape; they can be poured (water)
- Ø **Gases** do not have a definite volume or definite shape, but they take the volume & shape of their container

- **Plasmas** have no definite volume, no definite shape, and only exist at extremely high temperatures such as the sun
- **Chemical Changes** in matter are essential to all life processes
- Biologists study chemistry because all living things are made of the same kinds of matter that make up nonliving things

Elements

- **Elements** are pure substances which cannot be chemically broken down into simpler kinds of matter
- More than 100 elements have been identified, but only about 30 are important in living things
- All of the Elements are arranged on a chart known as the **Periodic Table**
- Periodic charts tell the **atomic number**, **atomic mass**, & **chemical symbol** for every element



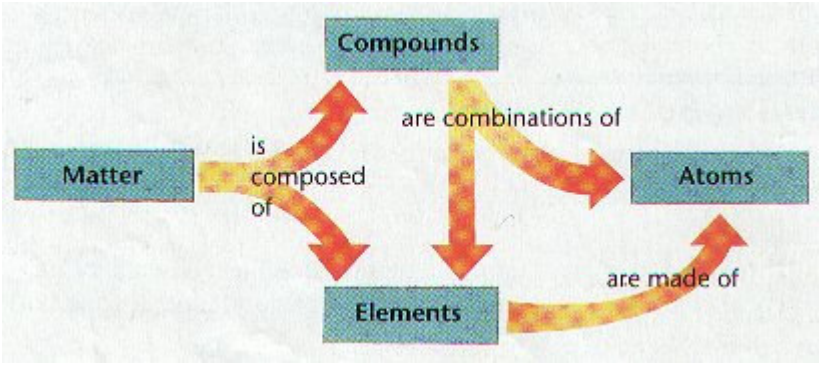
- Four elements, **Carbon – C, Hydrogen – H, Oxygen – O, and Nitrogen – N** make up almost 90% of the mass of living things
- Every element has a different **chemical symbol** composed of one to two letters
- Chemical symbols usually come from the **first letter or letters** of an element like **C** for Carbon and **Cl** for Chlorine
- Some chemical symbols come form their **Latin or Greek** name such as **Na** for Sodium (natrium) or **K** for Potassium (Kalium)

Ø Elements in the same **horizontal period** on the periodic table have the same **number of energy levels** (e.g. H & He in period 1 have only a K energy level)

	3	4	5	6	7	8	9	10
2	Lithium Li 7	Berylium Be 9	Boron B 11	Carbon C 12	Nitrogen N 14	Oxygen O 16	Fluorine F 19	Neon Ne 20

All Period 2 elements have 2 energy levels (K & L)

Ø Elements in the same **vertical Family** on the periodic table have the same **number of electrons in their outermost energy level** & react similar (e.g. Family IV, the Carbon family all have 4 electrons in their outermost energy level)



Atoms

Ø **Atoms** are the simplest part of an element that keeps all of the element's properties

Ø Atoms are **too small** to be seen so scientists have developed **models** that show their structure & properties

Ø Atoms consist of 3 kinds of **subatomic particles** – **protons** & **neutrons** in the center or nucleus, and **electrons** spinning in energy levels around the center

Ø The **nucleus** is the center of an atom where most of the mass is concentrated

Ø **Protons** are **positively** charged ($\mathbf{p^+}$), have a mass of **1 amu** (atomic

mass unit) , are found in the **nucleus**, and **determine the atomic number** of the element

Example: Carbon has 6 protons so its atomic number is 6

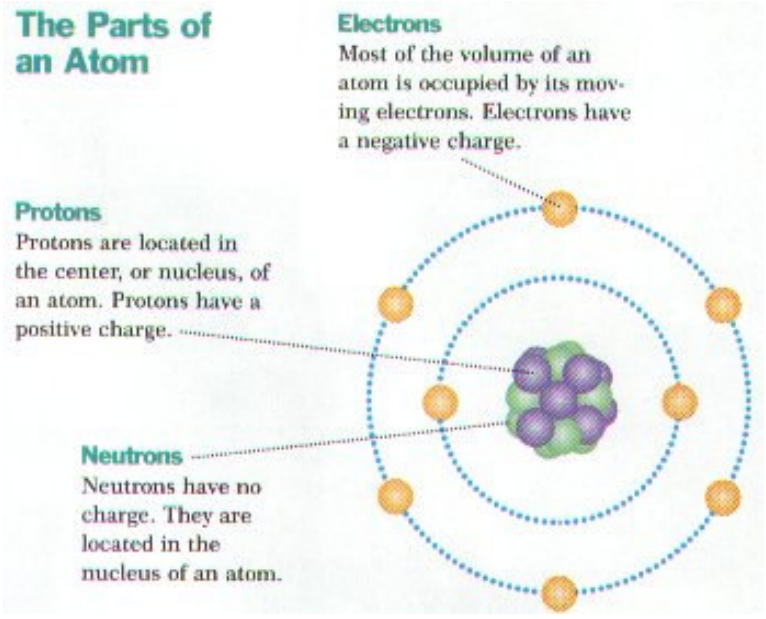
Ø **Neutrons** are **neutral** or have no electrical charge **(n)**, have a mass of **1 amu**, are found in the **nucleus**, and **when added to the number of protons, determine the atomic mass of the element**

Example: Sodium has 11 protons and 12 neutrons so its atomic mass is 11+12=23 amu

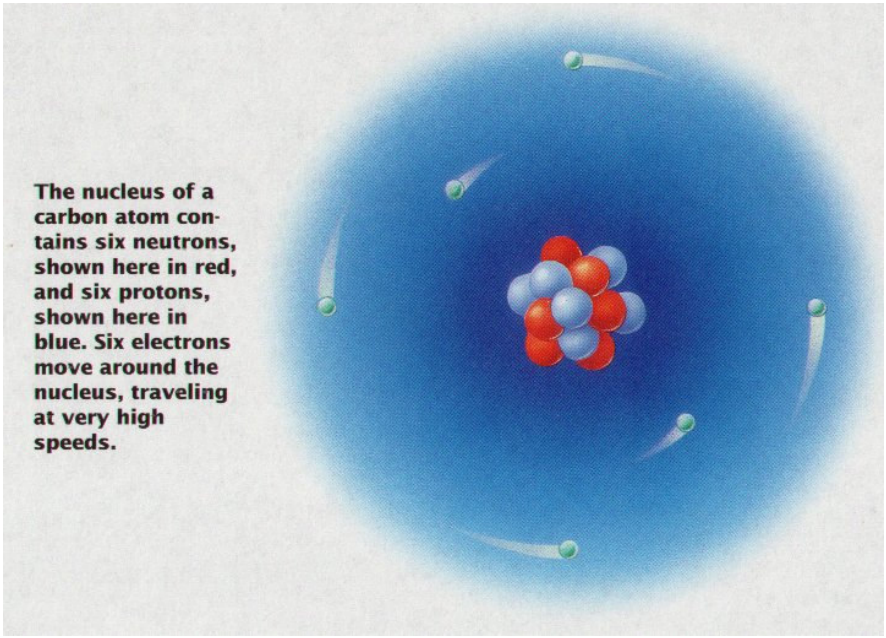
Ø **Electrons (e^-)** are **negatively** charged, high energy particles with **little mass** that **spin around the nucleus in energy levels**

Ø **Seven** energy levels **(K, L, M, N, O, P, & Q)** exist around the nucleus and each holds a certain number of electrons

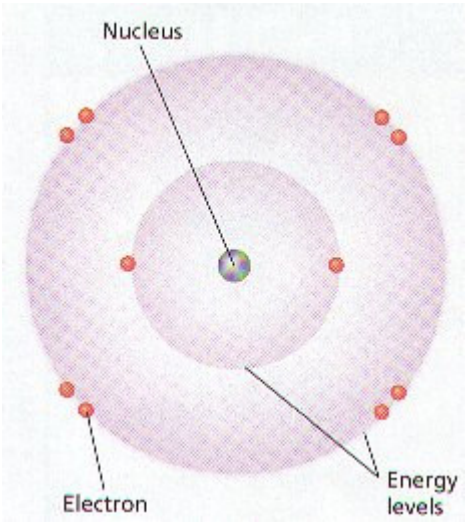
Ø The K energy level is closest to the nucleus & only holds 2 electrons, while the L – Q energy levels can hold 8 electrons



Ø Electrons in outer energy level are traveling faster & contain more energy than electrons in inner levels



- The number of **protons** (positive charges) and **electrons** (negative charges in an atom are **equal** so the net electrical charge on a atom is **zero** making it **electrically neutral**
- **Stable or non-reactive atoms** have an outer energy level that is filled with electrons



Compounds

- Most elements do not exist by themselves; Most elements combine with other elements
- **Compounds** are made of atoms of two or more elements chemically combined

- **Chemical Formulas** represent a compound & show the kind & number of atoms of each element (e.g. H_2O has 2 hydrogen & 1 oxygen)

- Compounds have **different physical & chemical properties** than the atoms that compose them (e.g. hydrogen & oxygen are gases but H_2O is a liquid)

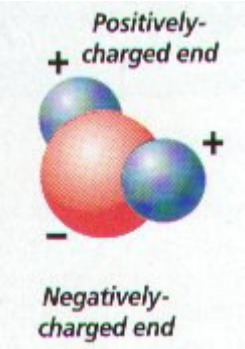
- The number & arrangement of electrons in an atom determines if it will combine to form compounds

- **Chemical reactions** occur whenever unstable atoms (outer energy level not filled) combine to form more stable compounds

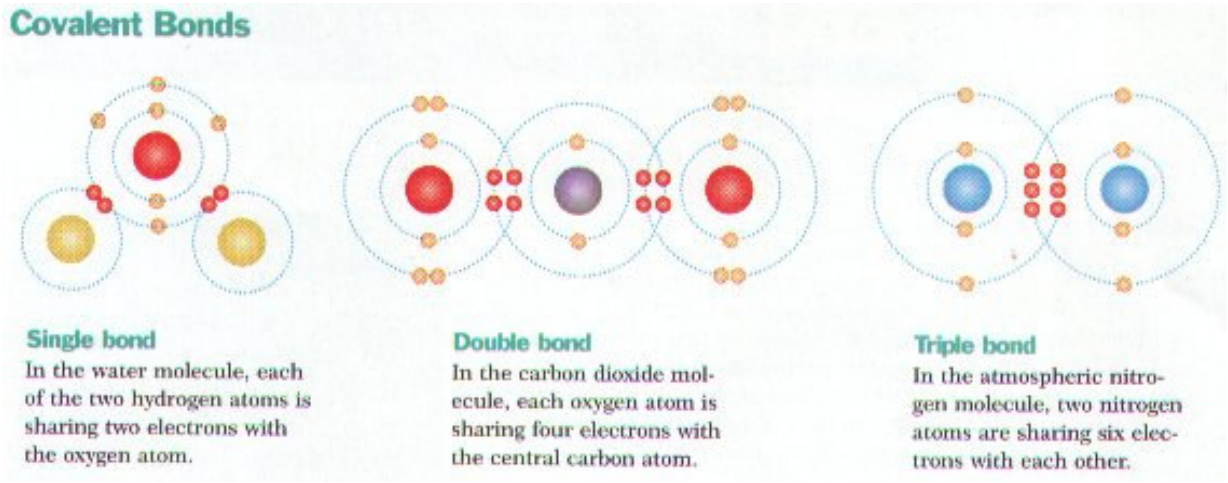
- **Chemical bonds** form between atoms during chemical reactions

Types of Chemical Bonds

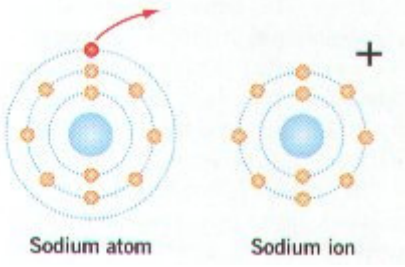
- **Covalent bonds** form between atoms whenever they share 1 or more pairs of electrons (e.g. H_2O)



- **Molecules** form from covalent bonding & are the simplest part of a compound (e.g. NaCl, H_2O, O_2)

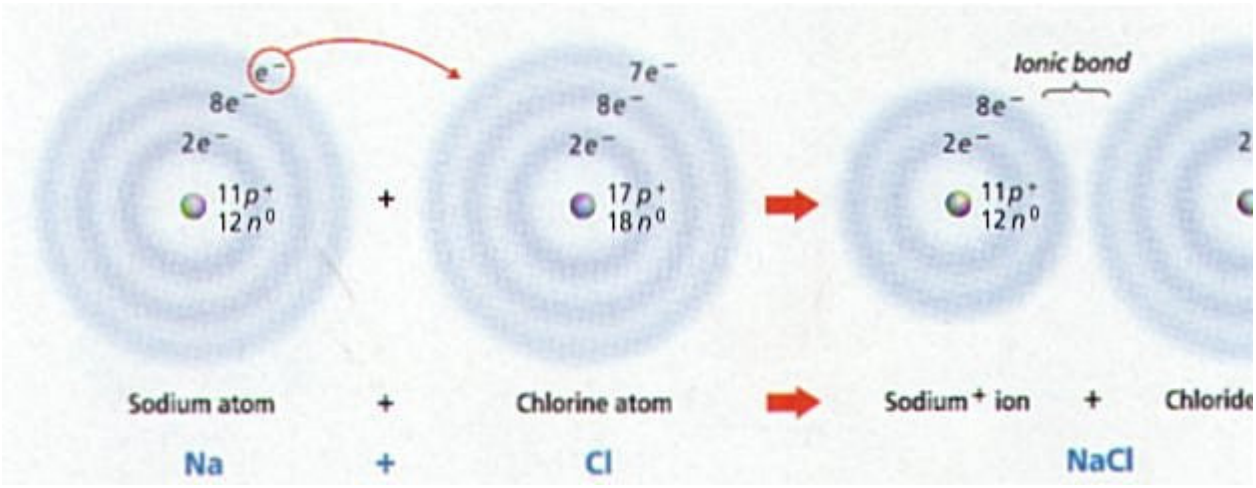


Ø **Ionic bonding** occurs between a positively & negatively charged atom or **ion**



Ø **Positively charged ions** have more electrons **(-)** than protons **(+)**; **negatively charged ions** have more protons than electrons

Ø **Table salt (NaCl)** forms when the 1 outer electron of Na is transferred to the outer energy level of chlorine that has 7 electrons **(e^-)**



Ø **Sodium (Na)** with 1 less **e^-** becomes positively charged, while **Chlorine (Cl)** with 1 more **e^-** becomes negatively charged; the **+ and**

– **charges attract** & form the ionic bond holding NaCl together

Ø Other types of chemical bonding include **hydrogen bonding**

Energy

Ø **Energy** is the ability to do work

Ø Energy occurs in several forms & **may be converted** from one form to another

Ø **Sunlight** is the ultimate energy for all life on earth

Ø **Forms of energy** include chemical, electrical, mechanical, thermal, light, & sound

Ø **Free energy** is the energy available for work (e.g. cells have energy to carry out cell processes)

Ø **Cells convert the chemical energy** stored in food into other types of energy such as thermal & mechanical

Ø Energy is used to change matter form one state into another (e.g. liquid into a gas)

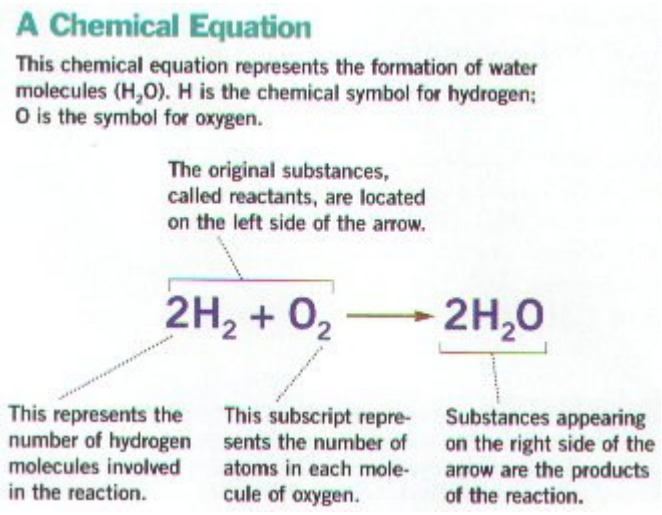
Chemical Reactions

Ø Living things undergo thousands of chemical reactions

Ø **Chemical equations** represent chemical reactions

Ø CO_2 + H_2O-----goes to-----H_2CO_3 (carbonic acid) is a sample Chemical Reaction in living things

Ø **Reactants** are on the **left** side of the equation, while **products** are on the **right** side



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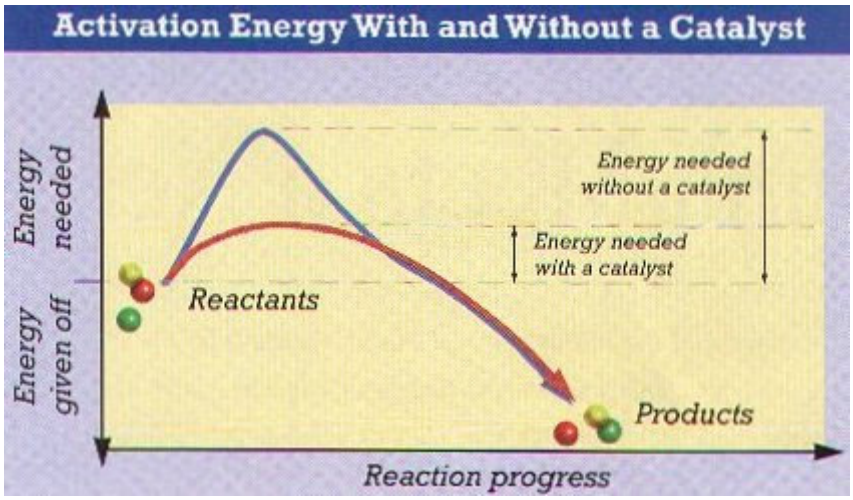


Ø Chemical bonds are broken, atoms rearranged, and new bonds form in chemical reaction

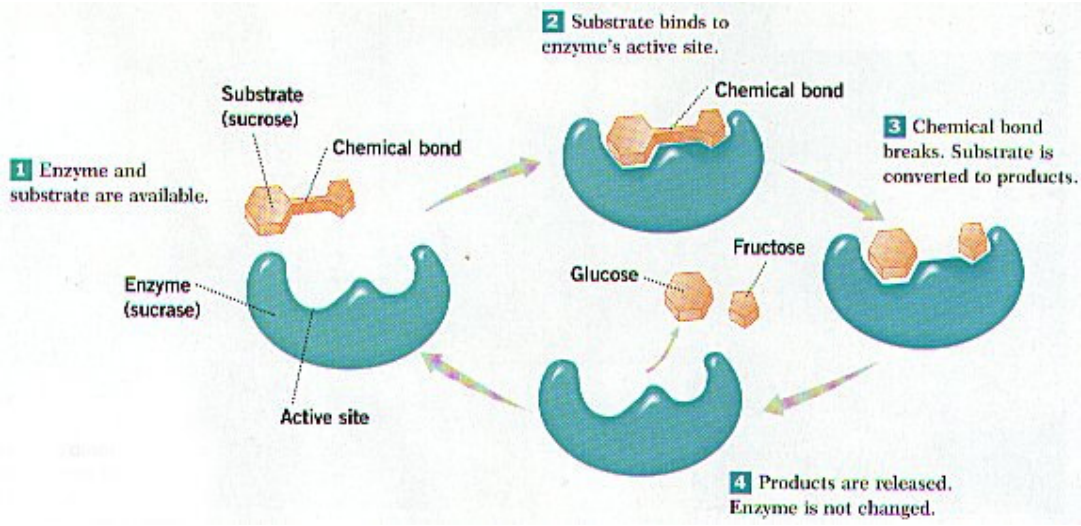
Ø **Plants** use sunlight to produce sugars such as $C_6H_{12}O_6$ **glucose;** the chemical energy from the sun is stored in the **chemical bonds of glucose**

Ø Organisms eat plants, break down the sugars, and release energy along with CO_2 & H_2O

Ø **Exergonic reactions** involve a net release of energy; while endergonic reactions involve a net absorption of energy

Ø Energy must be added to the reactants for most chemical reactions to occur; called **activation energy**

- **Enzymes** are chemical substances in living things that act as catalysts & reduce the amount of activation energy needed
- Organisms contain thousands of different enzymes
- Most enzymes end with –**ase** (e.g. **lipase** is the enzyme that acts on lipids)



Reduction-Oxidation (Redox) reactions

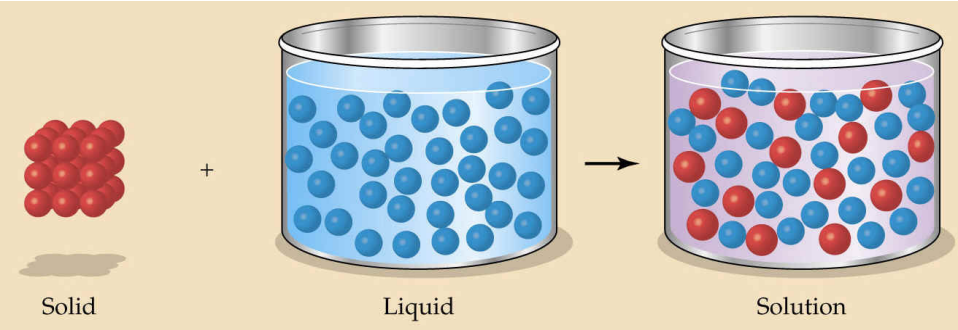
- Reactions in which e- are transferred between atoms is a **redox** or **reduction-oxidation reaction** (e.g. formation of table salt NaCl)
- In **oxidation reactions,** a reactant loses 1 or more e- & becomes positively (+) charged (e.g. **Sodium atom becomes a Na^+ ion**)
- In a reduction reaction, a reactant gains 1 or more e- and becomes negatively (-) charged (e.g. **Chlorine atom becomes a Cl^- ion**)
- **REDOX reactions always occur together;** the electron(s) from the oxidation reaction are then accepted by another substance in the reduction reaction

Solutions

- A large percentage of the mass of organisms is water & many of the chemical reactions of life occur in water

- A **solution** is a uniform mixture of one substance in anther
- Solutions may be mixtures of solids, liquids, or gases
- The **solute** is the substance uniformly dissolved in the solution & may be ions, molecules, or atoms
- The **solvent** is the substance in which the solute is dissolved
- **Water is known as the universal solvent**

- Dissolving one substance in another **does not alter** their chemical properties



- The **concentration** of a solution is a measure of the amount of solute dissolved in a given volume of solvent
- **Increasing the amount of solute** increases the solution's concentration
- **Aqueous solutions** are solutions in which **water** is the solvent; these are important in living things (e.g. blood, cytoplasm of cell...)

Acids and Bases

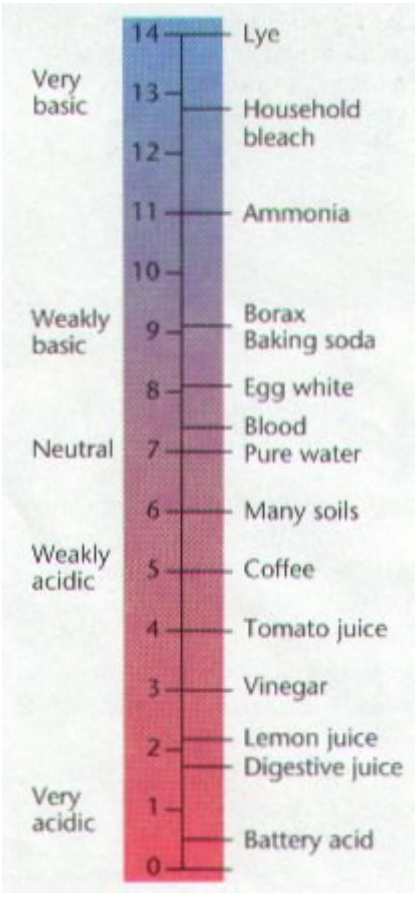
- The degree of **acidity** or **alkalinity (basic)** is important in organisms
- The force of attraction between molecules is so strong that the oxygen atom of one molecule can actually remove the hydrogen from other water molecules; called **Dissociation**

- H_2O-----GOES TO----- H^+ + OH^-
- OH^- called **hydroxide ion**; H^+ called **hydrogen ion**
- **Free H^+ ion** can react with another water molecule to form **H_3O^+ (hydronium ion)**
- **Acidity or alkalinity** is a measure of the relative amount of **H^+ and OH^- ions** dissolved in a solution
- **Neutral solutions** have an equal number of **H^+ and OH^- ions**
- **Acids** have more **H_3O^+ ions** than **OH^- ions**; taste **sour**; and can be corrosive
- **Bases** contain more **OH^- ions** than **H_3O^+ ions**; **taste bitter**; **& feel slippery**

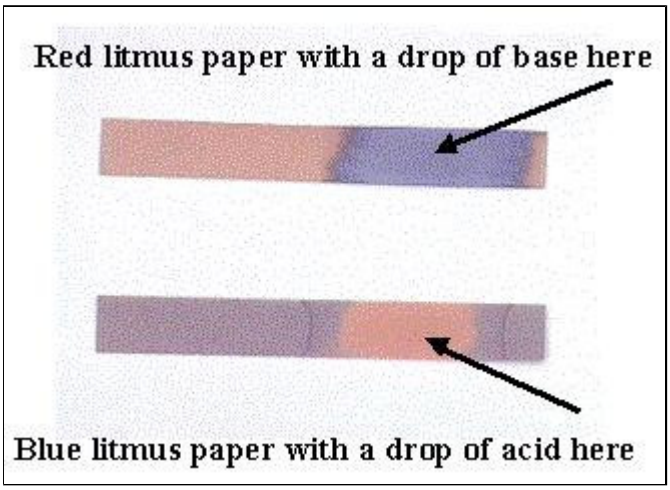
Examples of Common Acids	Examples of Common Bases
• citric acid (from certain fruits and veggies, notably citrus fruits) • ascorbic acid (vitamin C, as from certain fruits) • vinegar (5% acetic acid) • carbonic acid (for carbonation of soft drinks) • lactic acid (in buttermilk)	• detergents • soap • lye (NaOH) • household ammonia

PH Scale

- Compares the relative concentration of **H_3O^+ ions** and **OH^- ions**
- Scale ranges from **0 to 14; 0-3** is very **acidic; 7 is neutral; 11-14** is very **basic or alkaline**



- Litmus paper, phenolphthalein, pH paper, & other indicators that change color can be used to measure pH



Buffers

- Ø Control of pH is important to organisms
- Ø **Enzymes** function only within a narrow pH range; **usually neutral**
- Ø **Buffers** neutral acids or bases in organisms to help control pH

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