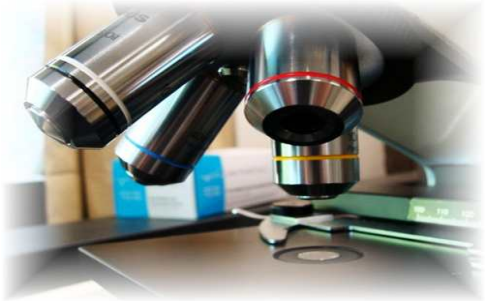


About Science Prof Online PowerPoint Resources

• Science Prof Online (SPO) is a free science education website that provides fully-developed Virtual Science Classrooms, science-related PowerPoints, articles and images. The site is designed to be a helpful resource for students, educators, and anyone interested in learning about science.

• The SPO Virtual Classrooms offer many educational resources, including practice test questions, review questions, lecture PowerPoints, video tutorials, sample assignments and course syllabi. New materials are continually being developed, so check back frequently, or follow us on Facebook (Science Prof Online) or Twitter (ScienceProfSPO) for updates.

• Many SPO PowerPoints are available in a variety of formats, such as fully editable PowerPoint files, as well as uneditable versions in smaller file sizes, such as PowerPoint Shows and Portable Document Format (.pdf), for ease of printing.

• Images used on this resource, and on the SPO website are, wherever possible, credited and linked to their source. Any words underlined and appearing in blue are links that can be clicked on for more information. PowerPoints must be viewed in *slide show mode* to use the hyperlinks directly.

• Several helpful links to fun and interactive learning tools are included throughout the PPT and on the Smart Links slide, near the end of each presentation. You must be in *slide show mode* to utilize hyperlinks and animations.

Alicia Cepaitis, MS
Chief Creative Nerd
Science Prof Online
Online Education Resources, LLC
alicia@scienceprofonline.com

Tami Port, MS
Creator of Science Prof Online
Chief Executive Nerd
Science Prof Online
Online Education Resources, LLC
info@scienceprofonline.com

Image: Compound microscope objectives, T. Port

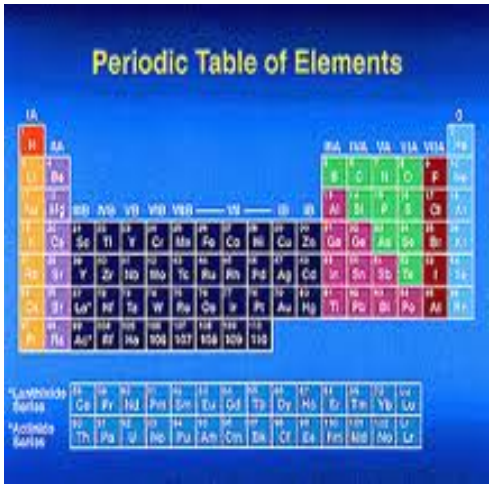
Inorganic Chemistry

For additional resources on this lecture topic, see the Inorganic Chemistry Main Page on SPO.

Image: Chemicals in Flasks, J. Sullivan, Wiki

Elements, Atoms, Molecules & Compounds

- **Elements** → Substances that can't be broken down any further.
- **Atom** → The smallest unit of an element.
- Two or more atoms joined together chemically: **Molecule**
- Molecule containing at least two different elements: **Compound**
- ***Examples of molecules:*** Carbon dioxide (CO_2) and methane (CH_4), molecular hydrogen (H_2), molecular oxygen (O_2) and molecular nitrogen (N_2).
- ***Examples of compounds***: Only molecules containing two or more elements, such as carbon dioxide (CO_2) and methane (CH_4).
- ***Q: Explain why all compounds are molecules but not all molecules are compounds.***



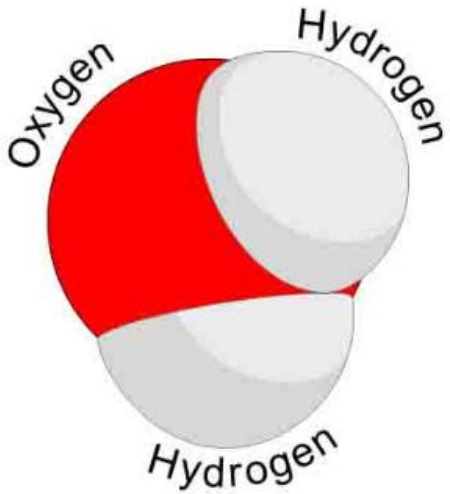
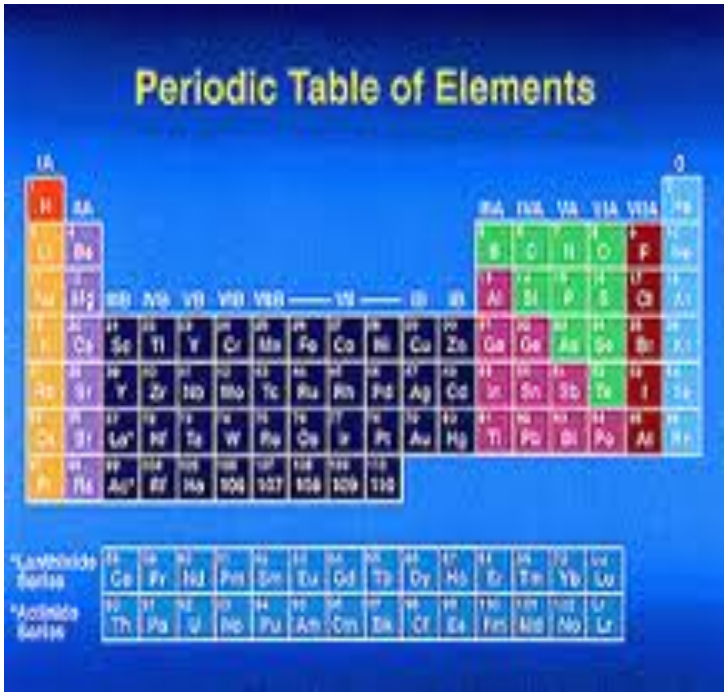


Image: Periodic Table of Elements, NASA; Water Molecule, Wiki

Chemical Shorthand



Follow this link to see Daniel Radcliff (Harry Potter) **sing "The Element Song".**

Chemical Symbol

- Begins with **one or two letters** based on elements name.
- ***Q:*** *What if there is more than one element that starts with the same letter?*
- Example: Carbon (C), Calcium (Ca), Chlorine (Cl)

Chemical Formula

- "Shorthand" for a compound.
- Contains chemical symbols of the elements that make up the molecule.
- Numerical subscripts represent number of atoms of each element in molecule.
  Example: H_2O *= water; has two hydrogen atoms and one oxygen.*
- More than one molecule of same type…the group of letters is preceded by number.
  Example $2H_2O$ *= two water molecules.*

Image: Periodic Table of Elements, NASA

The Structure of an Atom

Atoms are the basis for everything in the universe.

Q: *What are the three basic parts of an atom?*

- ? = "-" negative charge
- ? = "+" positive charge
- ? = neutral (a charge of zero)

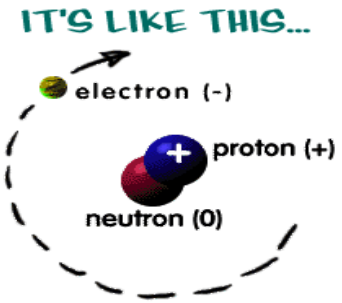
The thing that makes each element unique is the number of protons, since the number of neutrons and electrons can vary.

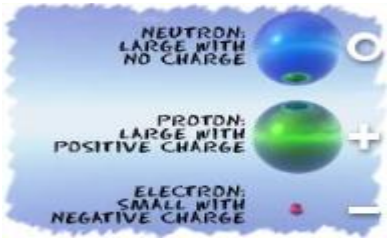
Protons and **neutrons** always in the center of atom (the nucleus).

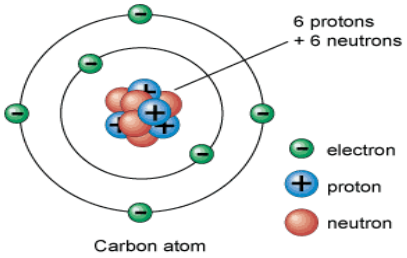
Electrons are found whizzing around nucleus in areas called electron shells.

Q: *If there is an equal number of electrons and protons in an atom, what is it's charge?*

Here are some examples:







NERDY SCIENCE JOKE: A neutron walks into a bar and asks "How much for a drink?"

Q: What does the bartender tell him?

Images: Structure of Atom, Chem4Kids Website; Carbon, Universe Today Website

Chemical Bonding and Electron Valences

The electrons of an atom can be located in different shells, which are at different **energy levels**.

Electrons in the highest energy level are called **valence electrons**.

Number of valence electrons governs an atom's bonding behavior.

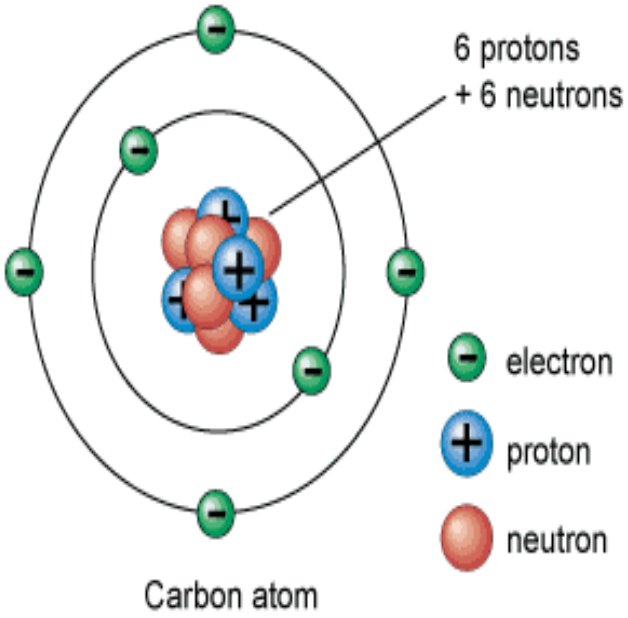
Q: What is the max number of valence electrons for a full valence shell?

Atoms are much more stable, or less reactive, with a full valence shell.

By moving electrons, the two atoms become linked. This is known as **chemical bonding**.

This stability can be achieved one of two ways:

- **Ionic** bond
- **Covalent** bond

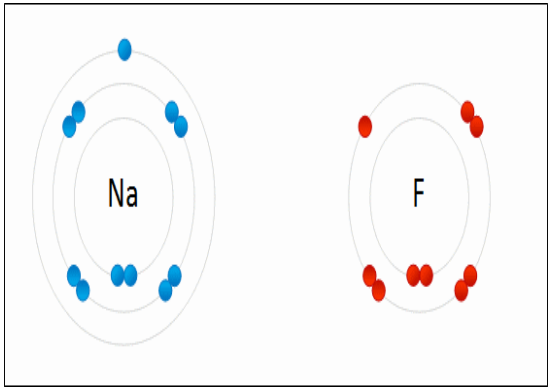


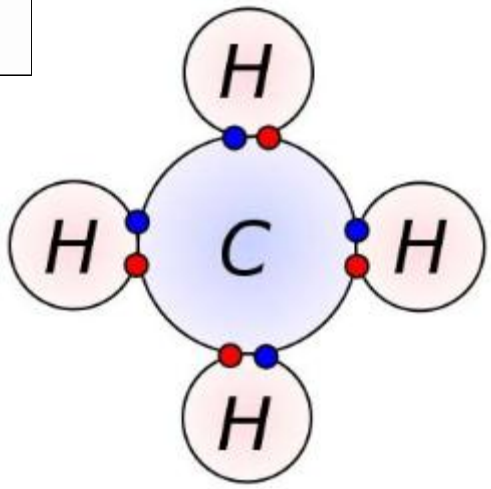
Images: Carbon, Universe Today Website

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

Three Main Types of Chemical Bonds:

1. **Ionic**
2. Covalent
3. Hydrogen





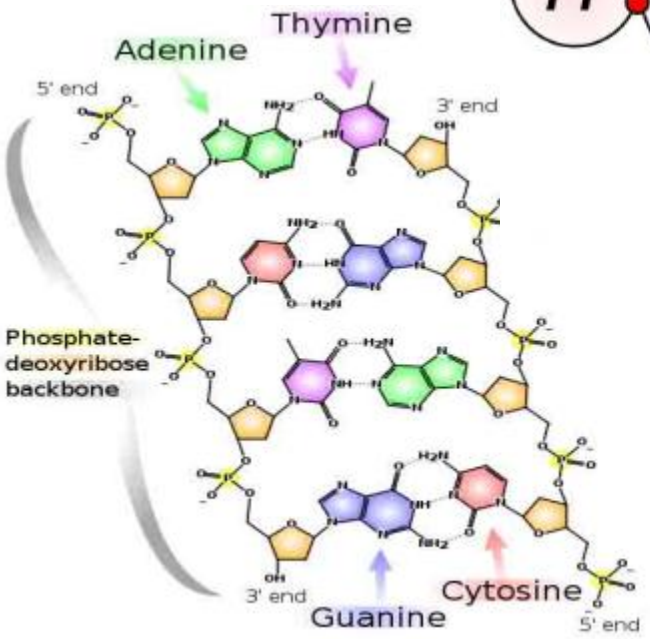


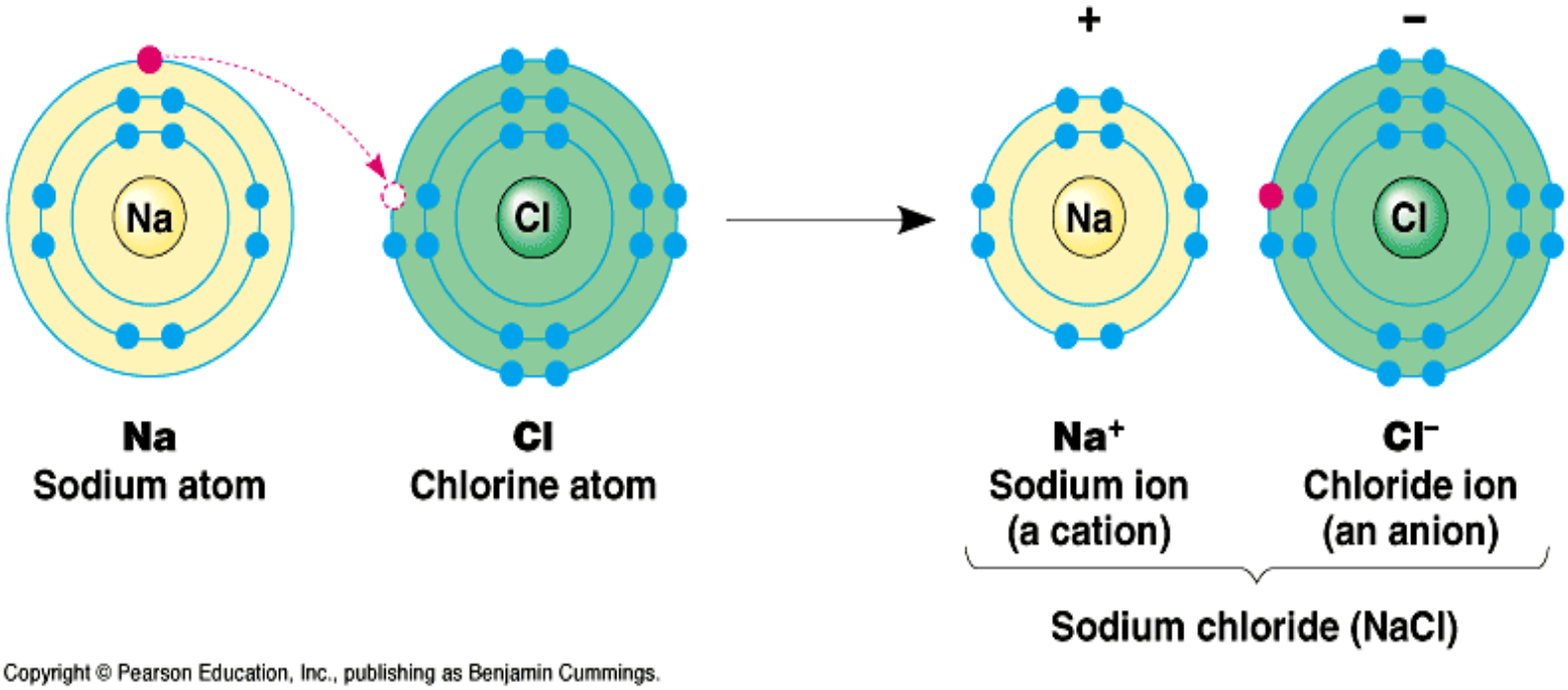
Image: Formation of ionic sodium fluoride, Wdcf; Methane Covalent Bonds, Dynablast, Wiki; DNA Chemical Structure,

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

Ionic Bonds

Involves transfer of electrons between two atoms.

Found mainly … inorganic compounds.



Ion = an atom or group of atoms which have lost or gained one or more electrons, making them negatively or positively charged.

Q: What are positively charged ions (+) called?

Q: What are negatively charged ions (-) called?

Images: Sodium Chloride, University of Winnepeg

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

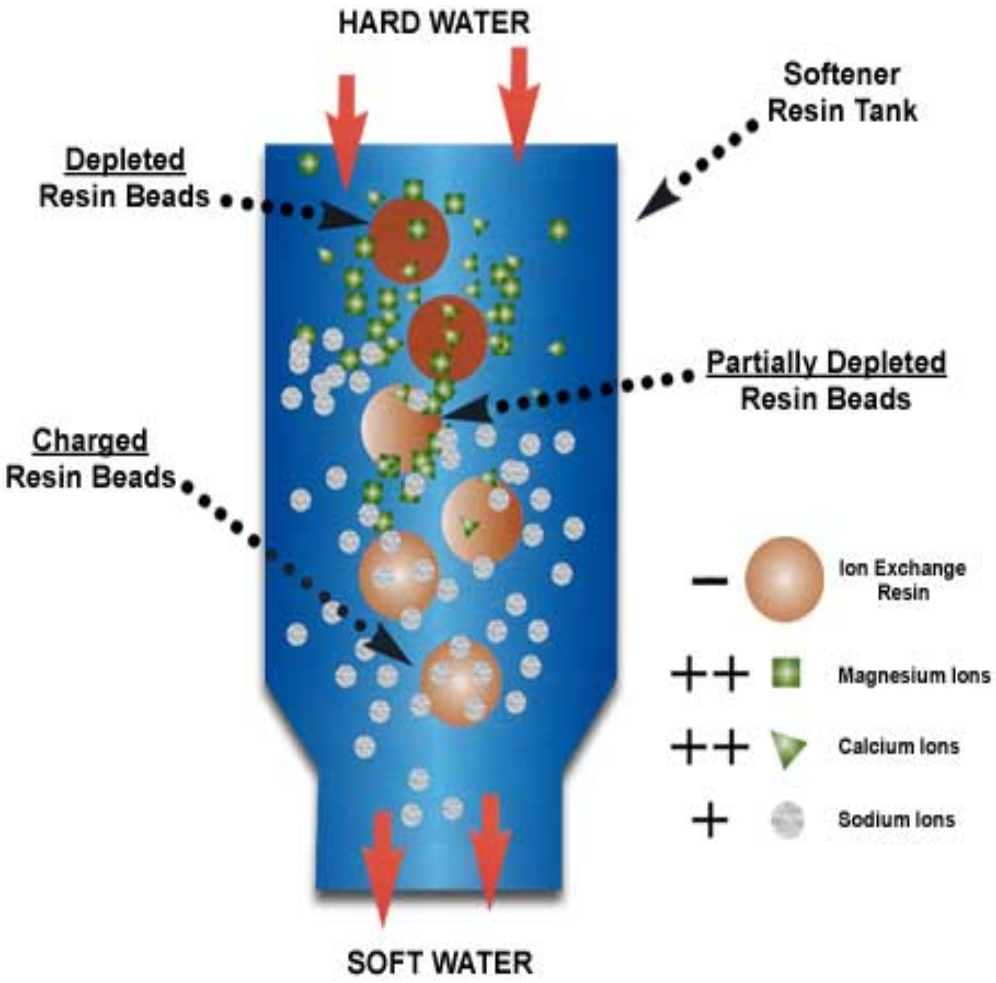
Reactions Involving Ions

Remember… **ion** = an atom which has lost or gained one or more electrons, so it's negatively or positively charged.

The Principle of

ion exchange

is a common water softening method.



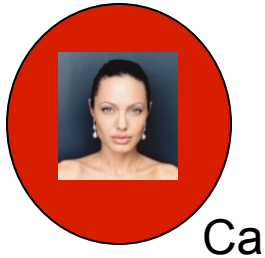
Lets use a **Branganalogy** to help us Understand the Concept of Ion Exchange…

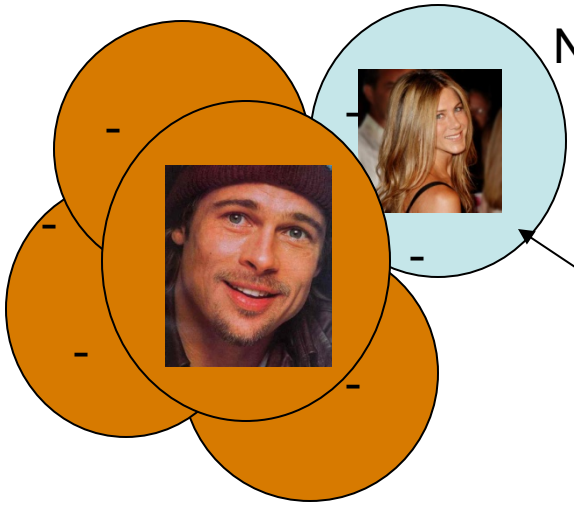
1. Brad Pitt is a negatively charged resin bead

2. Jennifer Anniston is a positively charged Sodium Ion

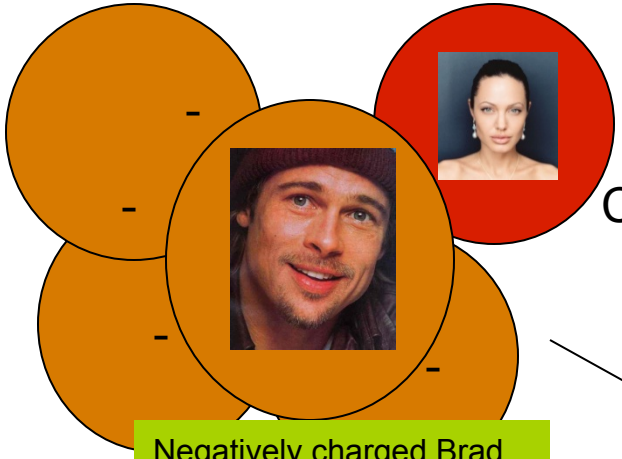
Now lets say that 'positiveness' equates with 'drop-dead gorgeousness'

3. Angelina Jolie is a positively charged Calcium Ion

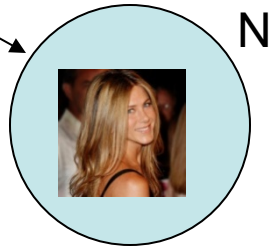




Negatively charged Brad is attracted to reasonably positive Jennifer.



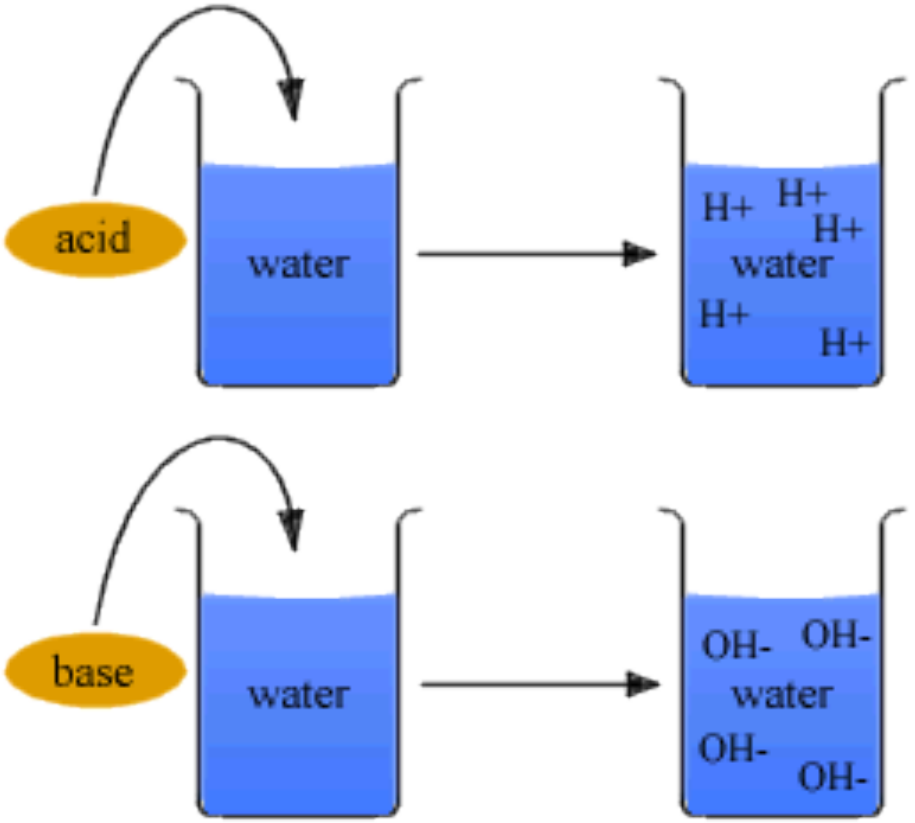
Negatively charged Brad lets go of reasonably positive Jennifer in the presence of insanely positive Angelina.



Ions: Acids & Bases

An **acid** is any ionic compound that releases **hydrogen** _____ (H^+) in solution.

A **base** is any ionic compound that releases **hydroxide** _____ (^-OH) in solution.



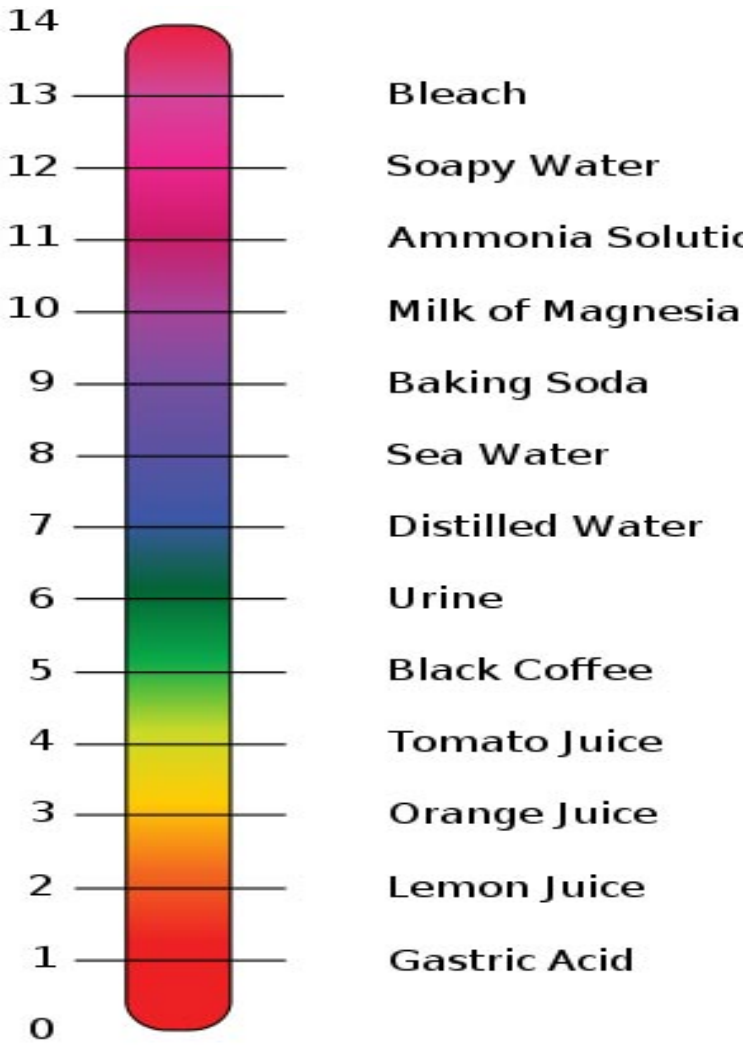
Measurements of Acidity & Alkalinity (pH)

Acidity of a solution > measured by concentration of hydrogen ions (H+).

pH ranges: 0 (very acidic) to 14 (very basic).

Change in just one unit of scale = tenfold change in H+ concentration.

If concentration of H+ = OH - … neutral.



Images: pH scale, Edward Stevens, Wiki

Ions & Acids

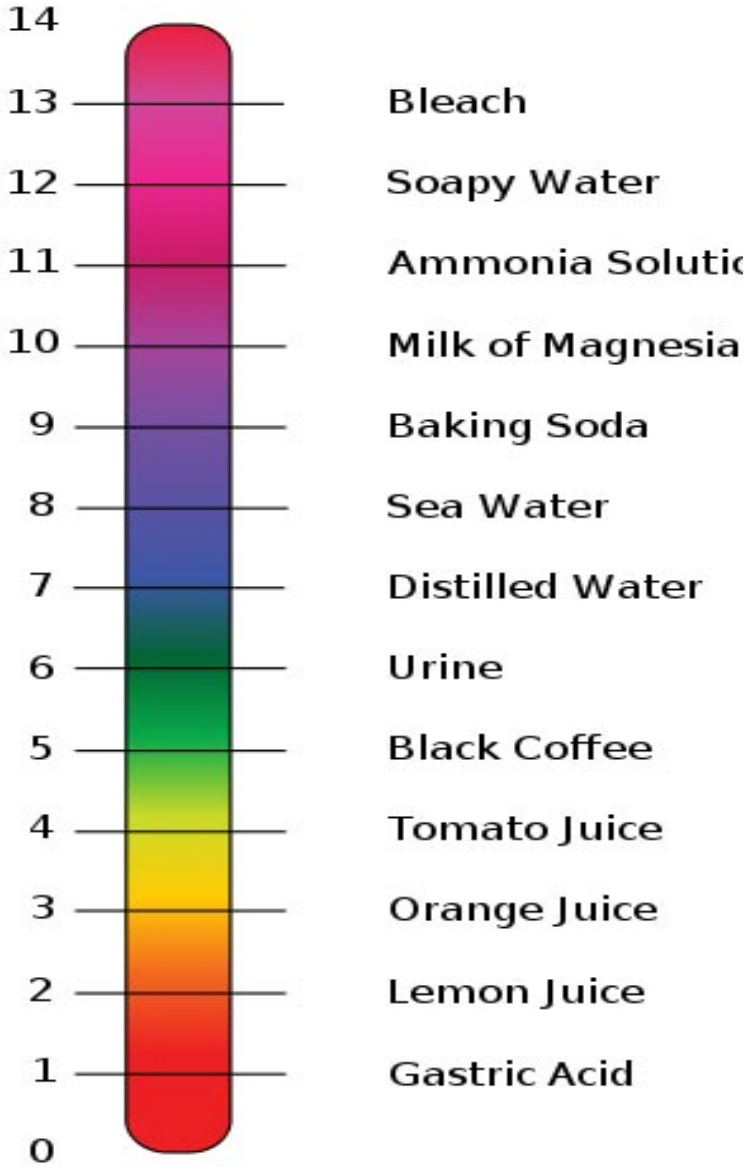
An **acid** is any ionic compound that releases hydrogen ions (H+) in solution.

Weak acids have a sour taste.

Strong acids are highly corrosive (So don't go around taste-testing acids.)

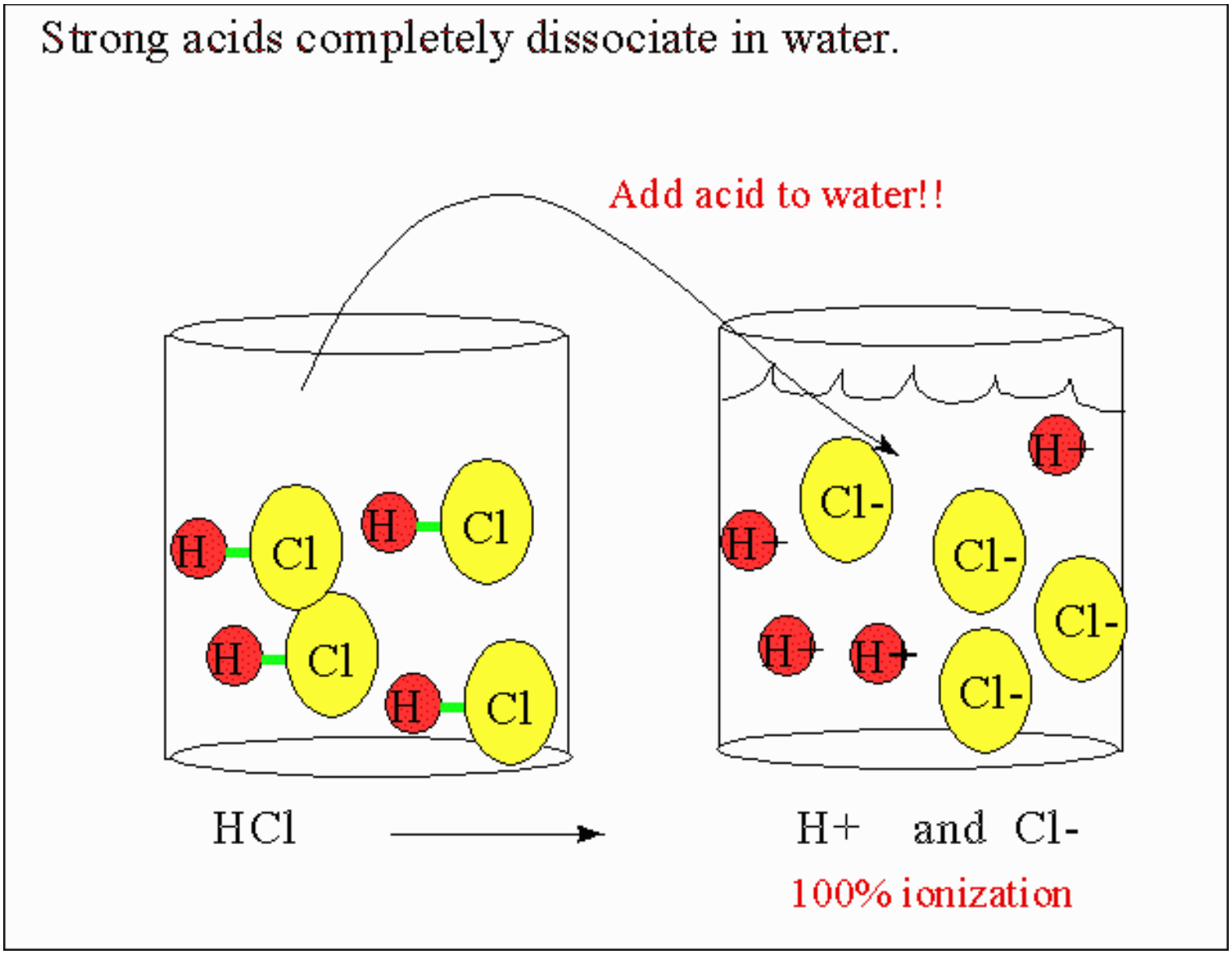
Examples:

- **Ascorbic acid** ($C_6H_8O_6$, Vitamin C)
- **Citric acid** ($C_6H_8O_7$, a weak organic acid in citrus fruits)
- **Phosphoric acid** (H_3PO_4, in pop…this stuff is also used to remove rust…hmmm)



Images: pH scale, Edward Stevens, Wiki

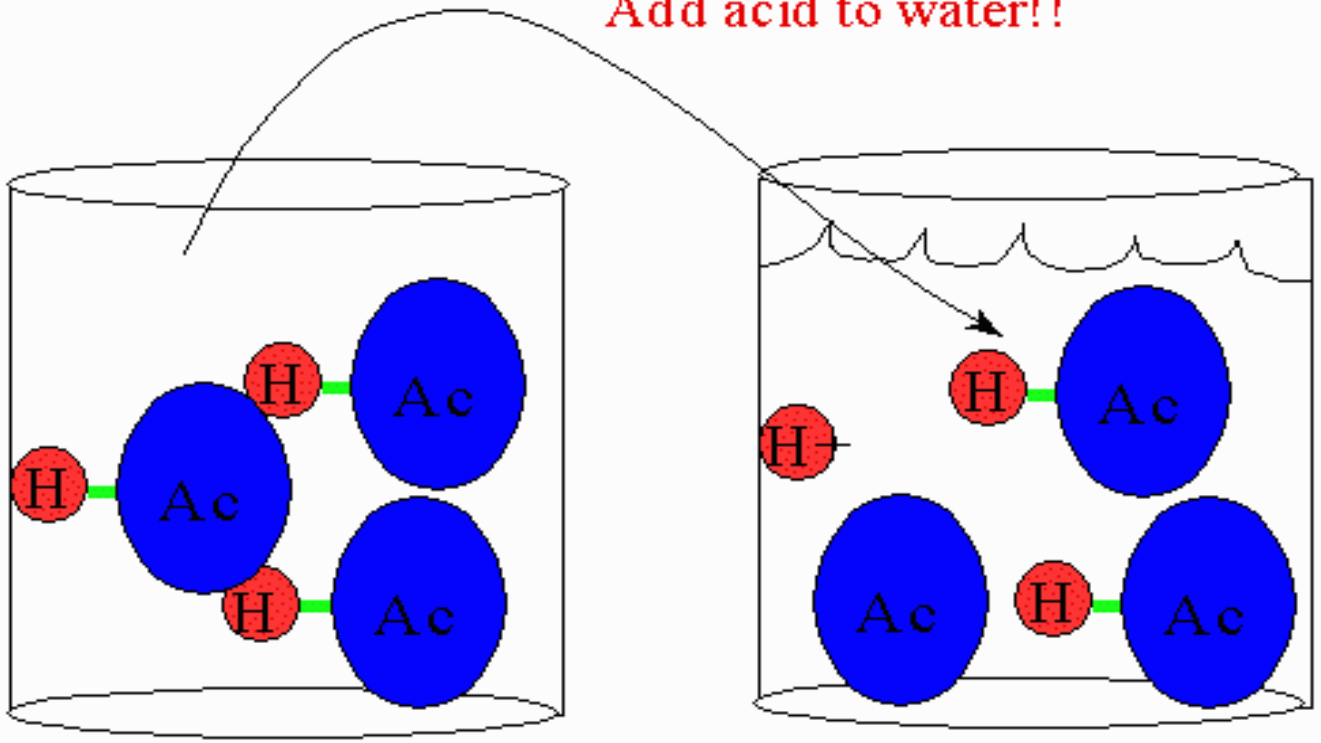
From the Virtual Cell Biology Classroom on ScienceProfOnline.com



Images: Strong Acids, Department of Chemistry, CSU

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

Weak acids DO NOT completely dissociate in water.



HAc → H+ and Ac and HAc

partial ionization

HAc = acetic acid = H-O-C(=O)-CH_3

Ions & Bases

A **base** is an ionic compound that releases hydroxyl ions (OH-) in solution.

Bases are also called **alkaline** substances.

Some general properties of bases include:

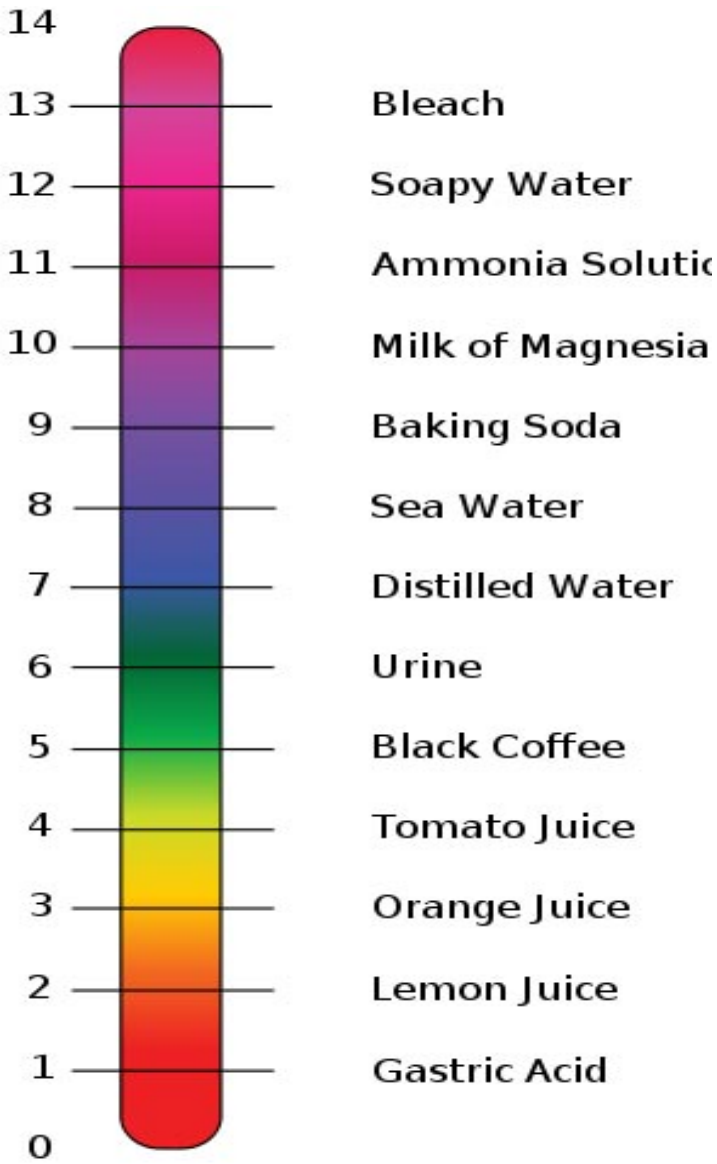
Taste: Bitter taste (opposed to sour taste of acids and sweetness of aldehydes and ketones).

Touch: Slimy or soapy feel on fingers.

Reactivity: Strong bases are caustic on organic matter, react violently with acidic substances.

Examples:

- **Sodium hydroxide**, NaOH, of lye or caustic soda used in oven cleaners.
- **Magnesium hydroxide**, $Mg(OH)^2$, also known as milk of magnesia, a weak base used in antacids and laxatives.



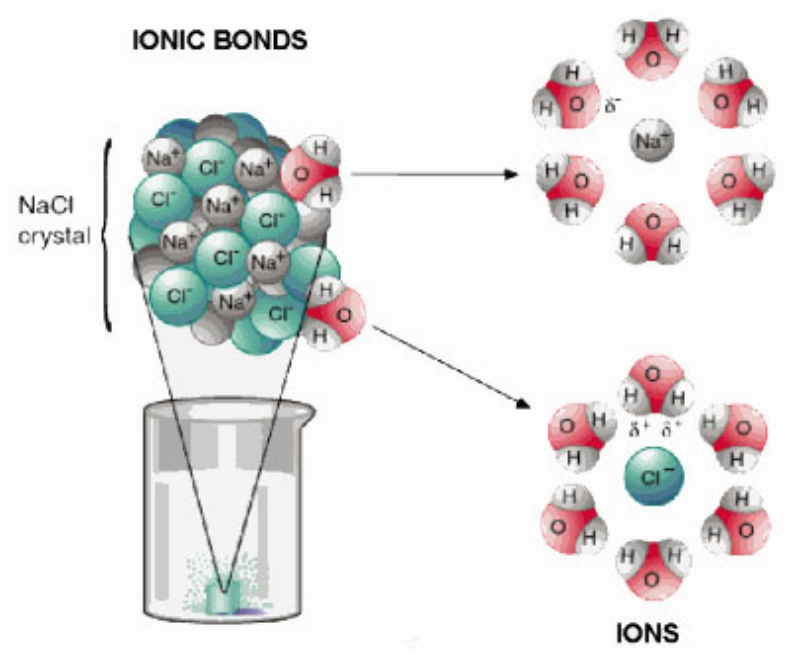
Images: pH scale, Edward Stevens, Wiki

Ions & Salts

- Compounds that dissociate in water and produce cations other than H+ and anions other than OH- are called **salts**.

- The most familiar salt is **sodium chloride**, the principal component of **common table salt**.

- **Other examples of salts:**
  - Baking soda (NaHCO3)
  - Epsom Salts (MgSO4)



Salts: The Role of Buffers

- Certain salts, called **buffers**, can combine with excess hydrogen (H+) or hydroxide (OH-) ions.

- Produce substances less acidic or alkaline.

- ***Example:***
  Antacids are buffers made of the salt calcium carbonate (CaCo3).

Images: Antacid Tablets, Wiki

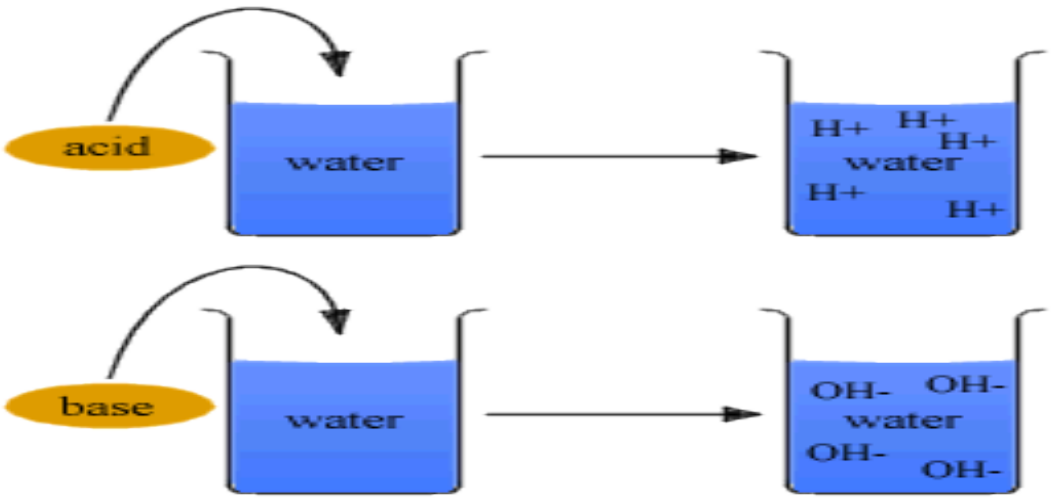
REVIEW!

Interactive animated lessons on

pH: Acids & Bases

and

Buffers

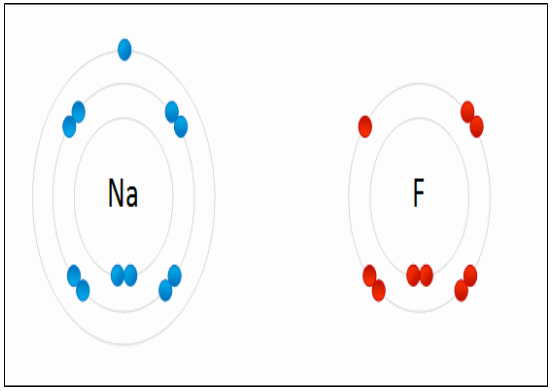


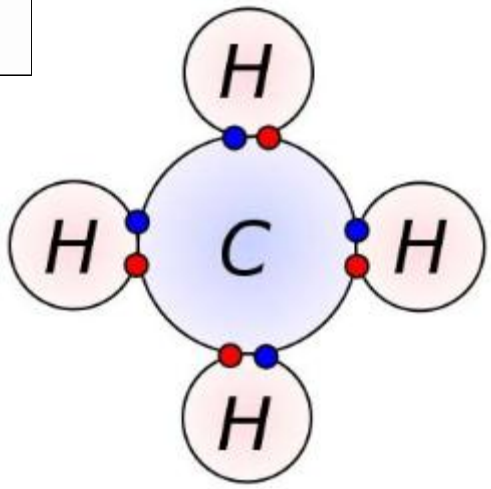
From the Virtual Cell Biology Classroom on ScienceProfOnline.com

Image: Methane Covalent Bonds, Dynablast; Formation of ionic sodium fluoride,

Three Main Types of Chemical Bonds:

1. Ionic
2. **Covalent**
3. Hydrogen





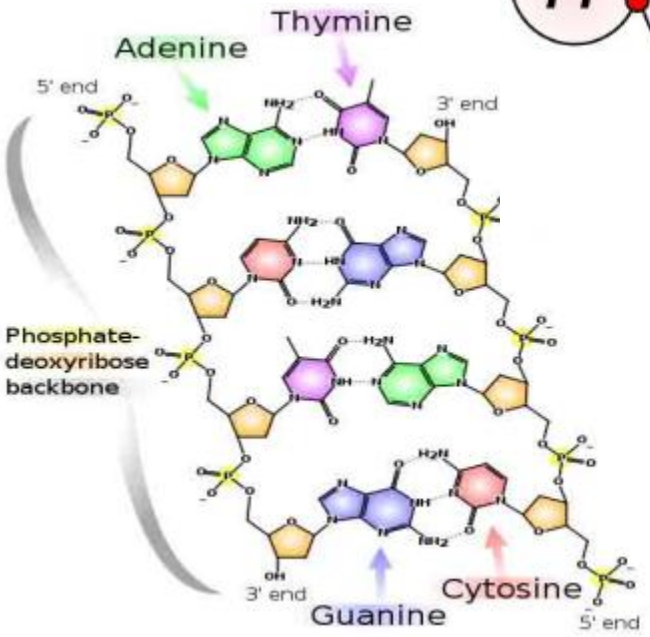


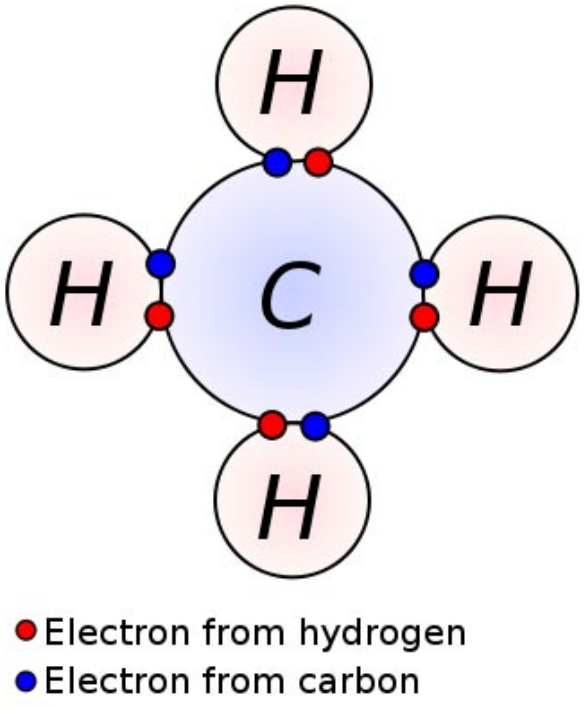
Image: Formation of ionic sodium fluoride, Wdcf; Methane Covalent Bonds, Dynablast, Wiki; DNA Chemical Structure,

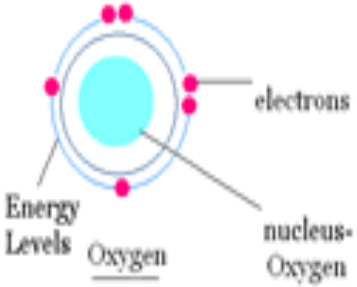
From the Virtual Cell Biology Classroom on ScienceProfOnline.com

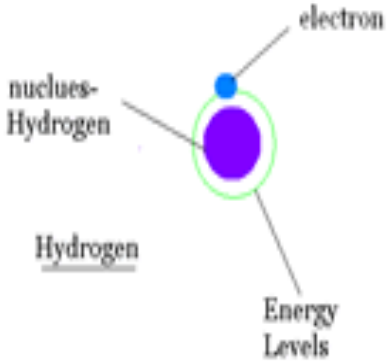
Covalent Bonds

Involves the sharing of a pair of electrons between atoms.
One covalent bond = 1 pair of shared electrons
Covalent Compounds can make single (2 electrons), double (4 electrons) or even triple bonds (6 electrons) depending on the number of electrons they share.

Found mainly … organic compounds







If combined you get...

H_2O

Because the Oxygen and Hydrogen are sharing two electrons. It has two have two Hydrogen Atoms , because Hydrogen only has one electron.

Image: Methane Covalent Bonds, Dynablast, Wiki

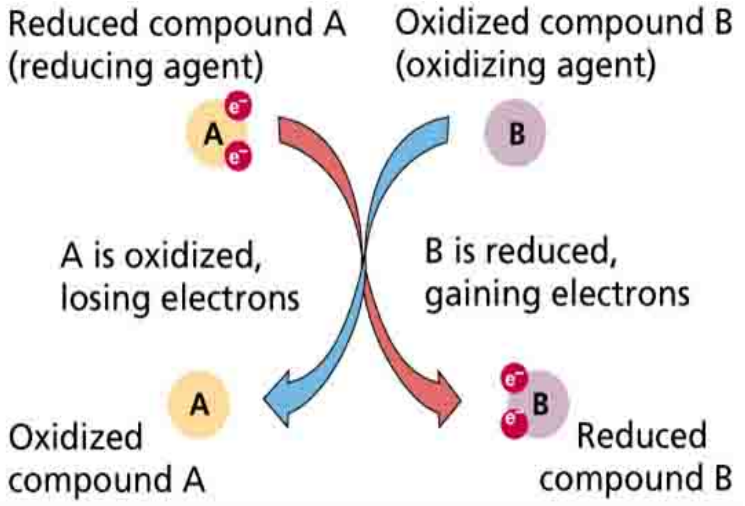
From the Virtual Cell Biology Classroom on ScienceProfOnline.com

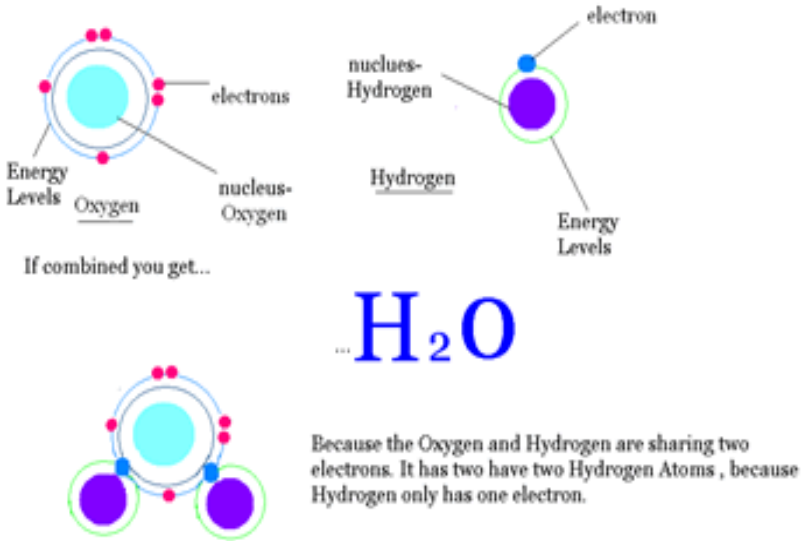
Oxidation - Reduction Reaction

- Or **Redox** reaction = chemical reactions in which electrons are ***gained***, ***lost*** (*Q: What kind of bond?*) or ***shared*** (*Q: What kind of bond?*) in a chemical reaction.

- **oxidation**: ***loss*** of electrons by a molecule, atom or ion.

- **reduction**: ***gain*** of electrons by a molecule, atom or ion.





Oil Rig

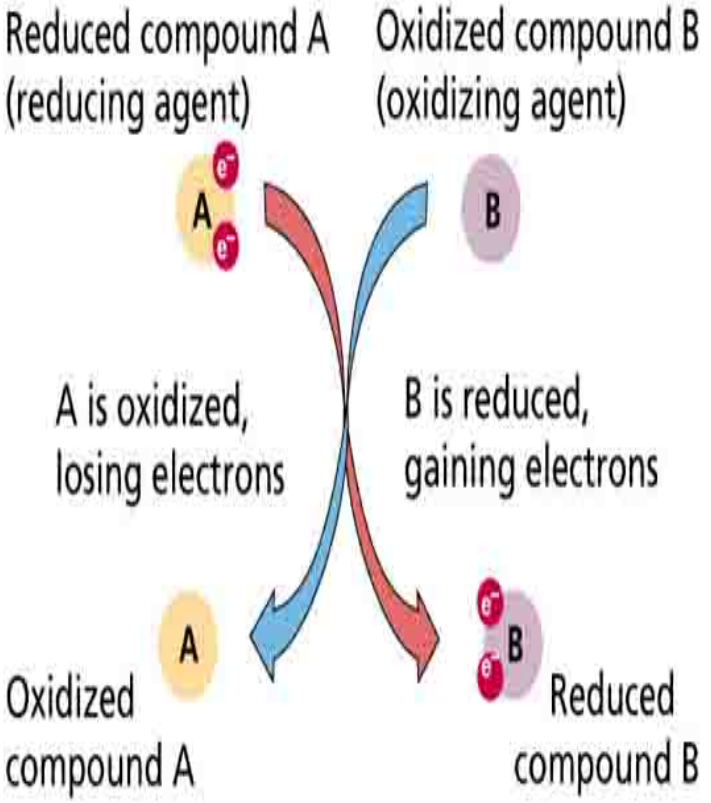
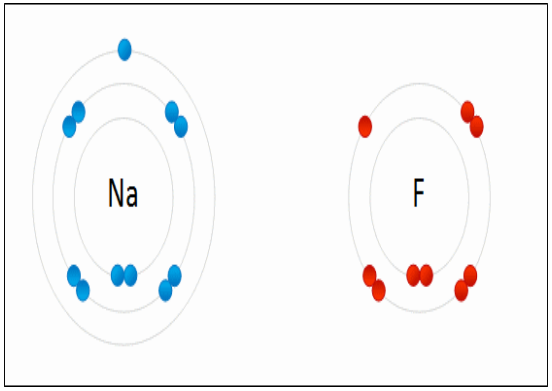


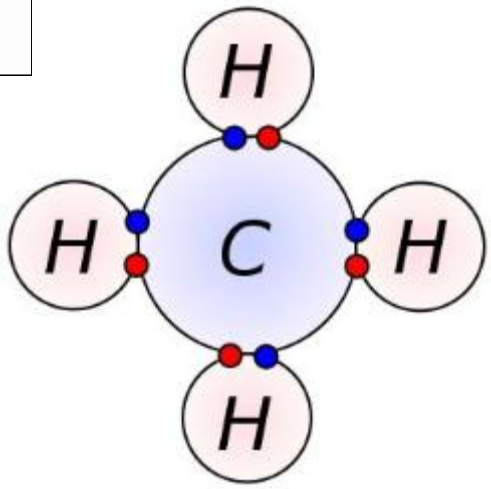
Image: Oil Rig Platform, Nasa

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

Three Main Types of Chemical Bonds:

1. Ionic
2. Covalent
3. **Hydrogen**





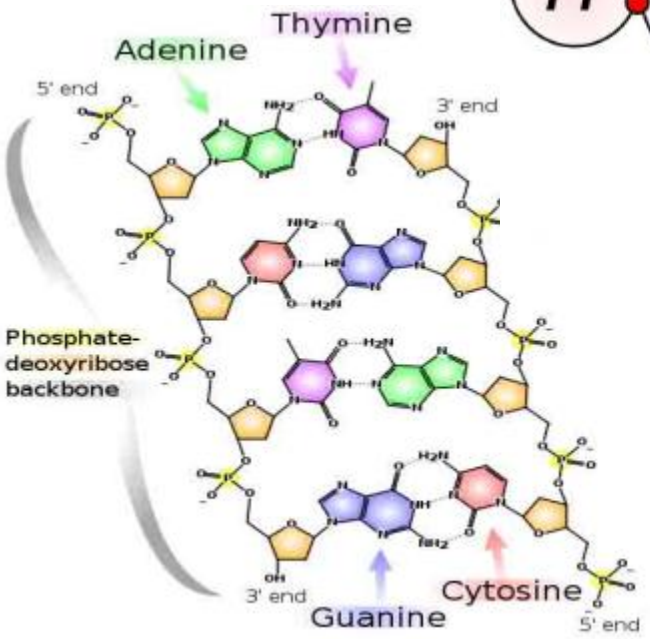


Image: Formation of ionic sodium fluoride, Wdcf; Methane Covalent Bonds, Dynablast, Wiki; DNA Chemical Structure,

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

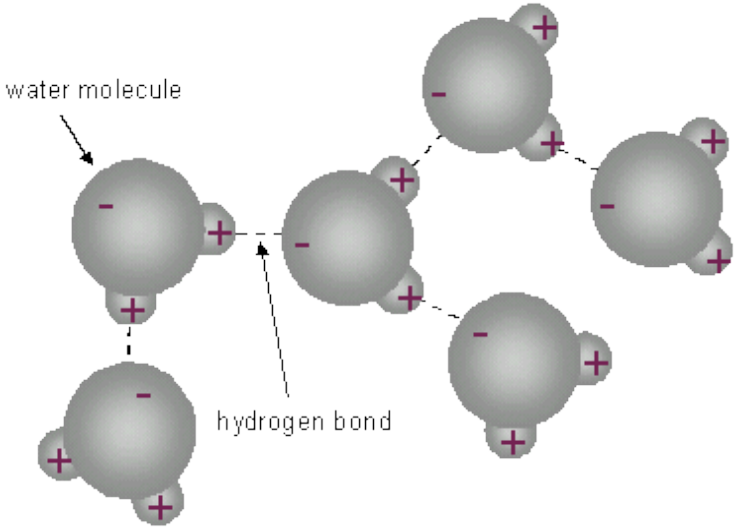
Hydrogen Bonds

Hydrogen Bonds: When an atom of hydrogen is attracted to another electronegative atom in addition to the one it is covalently bonded to.

In some covalent bonds electrons are shared *unequally* by the hydrogen and the atom that the hydrogen is bound to. When the electrons in a covalent bond are not equally shared, the molecule is **polar**.

See the **polar, covalent bonds** of *each individual water molecule* below.

See the **hydrogen bond attractions** *between the hydrogens and the oxygens of nearby, but separate water molecule below.*



Found in water, proteins & DNA

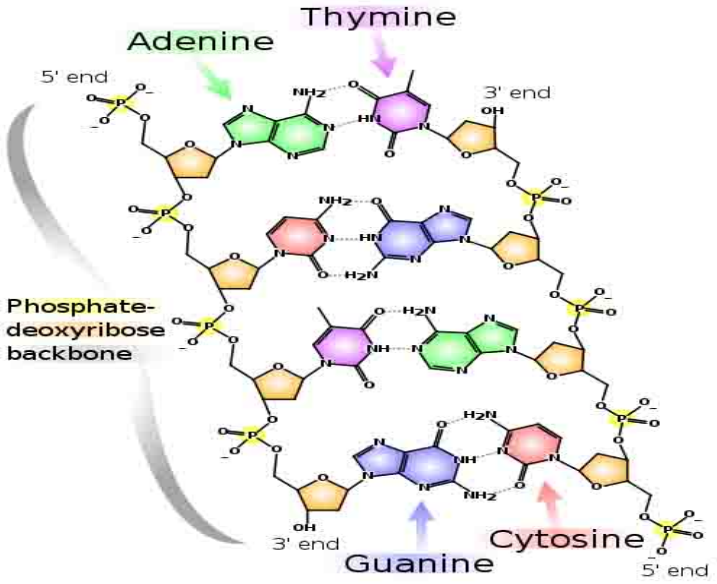
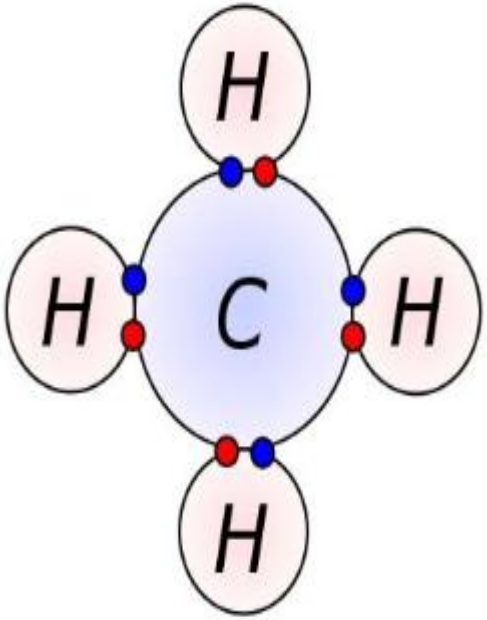
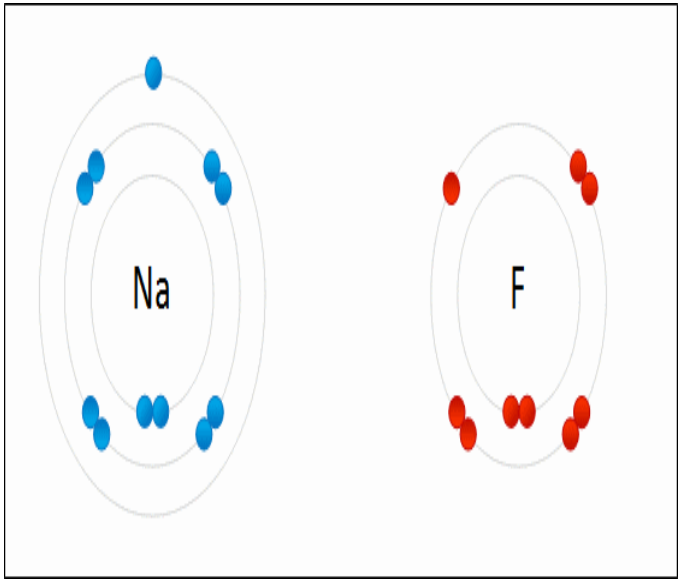


Image: DNA Chemical Structure, Madprime, Wiki; Water Striders, Markus Gayda, Wiki

REVIEW!

Animated lessons on
Chemical Bonding





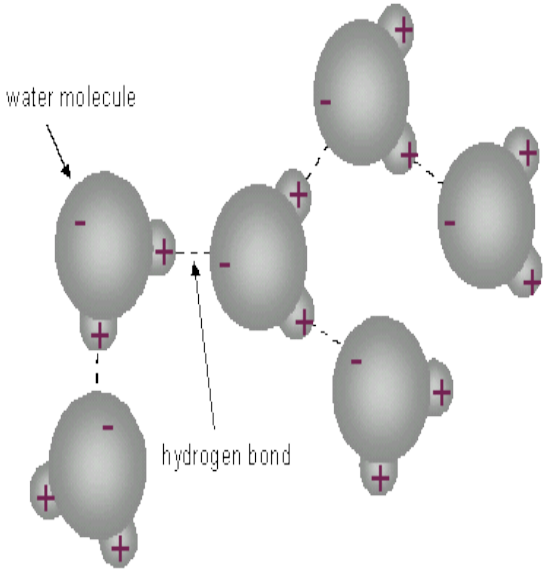
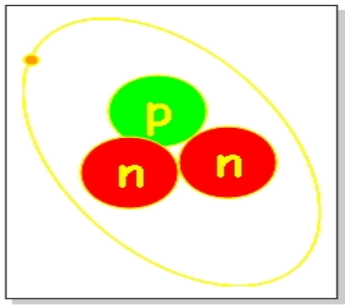


Image: Methane Covalent Bonds, Dynablast; Formation of ionic sodium fluoride,



What Is an Isotope?

Normal Atoms

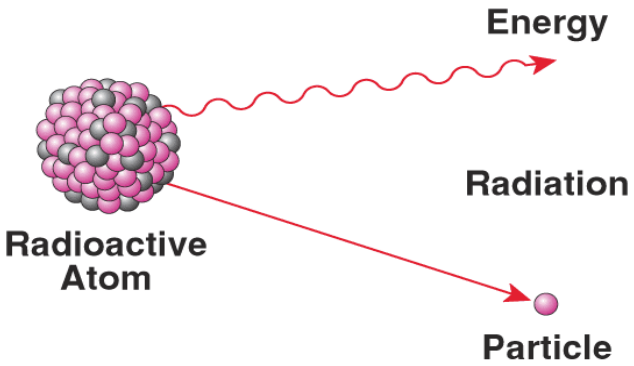
- Except for hydrogen *(1 proton / no neutrons),* every atomic nucleus in normal matter is made of both protons and neutrons.
- Typically, the number of protons and neutrons is the same.
- Protons in the nucleus are positively charged, and repel each other.
- Neutrons are neutral. They separate the protons slightly, making the atom stable.

Isotopes

- An isotope is a variant of an element, with a different # of **neutrons** than is typical.
- This makes a nucleus unstable.

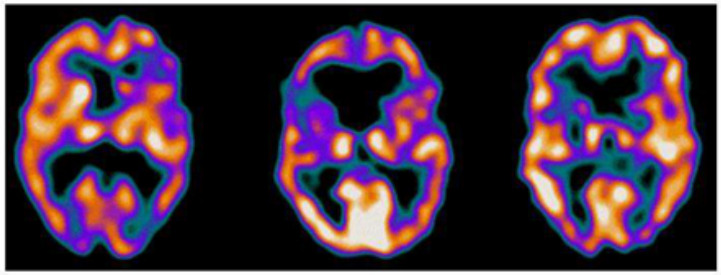
Image: Isotope, GRAC

Isotopes & Radioactivity



- Isotope is **radioactive** if nucleus is unstable.
- Most isotopes disintegrate spontaneously with the release of energy by processes of **nuclear** or **radioactive decay**.
- When the nucleus changes in structure, energy and/or subatomic particles are given off.
- Other than radioactivity, isotopes behaves similarly to the natural variant.
- When controlled, radioactive isotopes can be valuable medical tools. (Ex. Gamma camera can produce images of soft tissue when radiopharmaceuticals are injected into or ingested by patient.)

1. Schizophrenic female
2. Female with depression
3. Healthy female



Synthesis, Decomposition & Exchange Reactions

Synthesis **Reaction** (a.k.a. Combination or Anabolic Reaction)

When two or more substances combine to form a single compound.

Requires energy in order to take place

The general form of a direct combination reaction is:

A + B → AB where A and B are elements or compounds, and AB is a compound consisting of A and B.

Examples of combination reactions include:

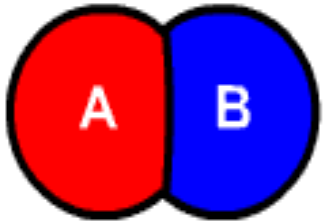
$2Na + Cl_2 \rightarrow 2\ NaCl$ (formation of table salt)

$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$ (iron rusting)

Decomposition **Reaction** (a.k.a. Catabolic Reaction)

The opposite of a composition reaction. A compound is broken down.

The generalized reaction formula for chemical decomposition is:
AB → A + B



Exchange **Reaction** (a.k.a. Transfer or Replacement Reaction)

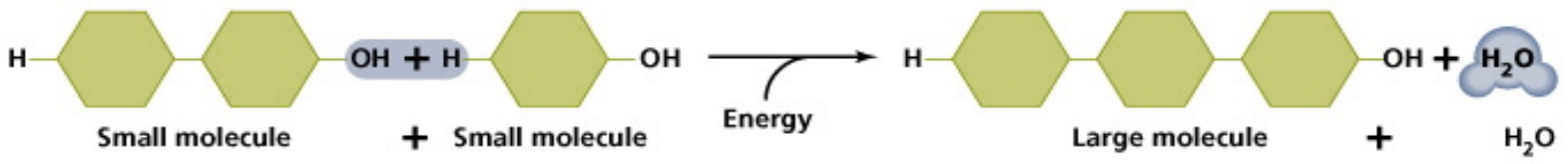
Atoms are moved from one molecule to another.

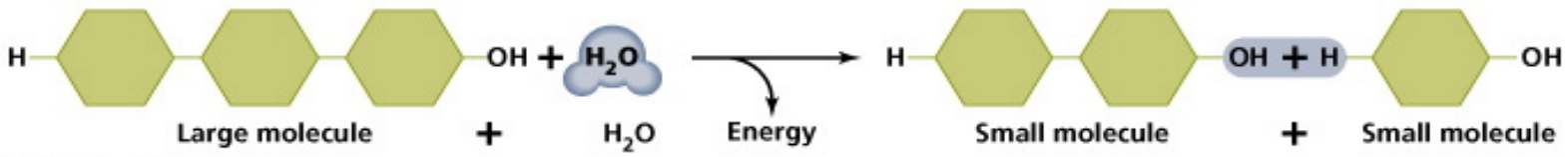
A + BC → AB + C

Images: Animation decomposition reaction, Armando-Martin; Rust, Later Keiwos From the Virtual Cell Biology Classroom on ScienceProfOnline.com

Q: Based on the reaction types we just discussed, how would you categorize the reactions below?

What type is the top reaction?

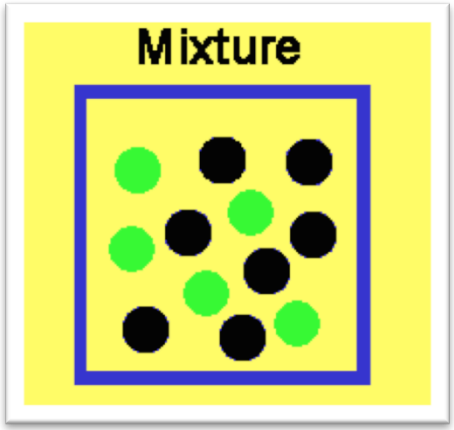




What type is the bottom reaction?

Mixtures, Compounds & Solutions

Mixtures & Compounds



mixture = **Physical** combination of two or more pure substances.

compound = **Chemical** combination of two or more pure substances in a fixed, definite proportion.

Example:

Mixture - Iron & Sulfur

Iron filings may be mixed with powdered sulfur in any proportion.
The two components are easily separated by means of a magnet,
The magnet will draw out the iron from the mixture.

The components of a mixture usually can be separated by physical means such as distillation, evaporation, etc.

Compound – Iron sulfide (Pyrite or Fools Gold)

However, if:

a. seven parts iron filings or powder are mixed with four parts powdered sulfur
b. mixture is heated to a red glow
c. iron and sulfur form a compound - iron sulfide; chemically combined, not readily separated.

Watch Video: Mixture vs Compound

Solutions

Solutions are mixtures in which one substance is dissolved in another.

Solutions have two parts: **solute** and **solvent**

Q: Which is the substance that is dissolved?

So the substance that does the dissolving is called the **?**.

(Remember water, the 'universal solvent'?)

Solubility: A measure of how much of a given substance will dissolve in a liquid.

A substance that does not dissolve in water is **insoluble**.

Example: *Oil is insoluble in water.*

A substance that does dissolve in water is called **soluble**.

Example: *Sugar is soluble in water.*

Confused?

Here are some links to fun resources that further explain Chemistry:

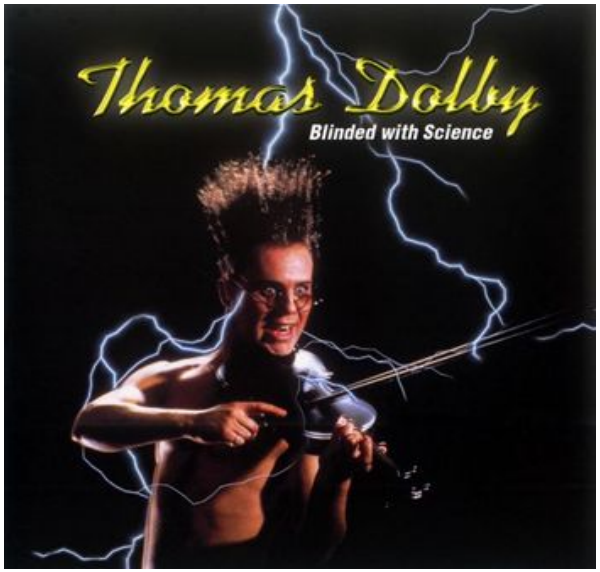
Smart Links

- Inorganic Chemistry Main Page on the Virtual Cell Biology Classroom of Science Prof Online.
- "What Kind of Bonds Are These?" song and slide show by Mark Rosengarten.
- Chemical Bond Formation animated science tutorial.
- "Meet the Elements" music video by They Might Be Giants.
- Redox Reactions video lecture by Kahnacademy.
- Chem4Kids website by Rader.
- Neutron Dance …a so-bad-its-good '80s music video by The Pointer Sisters
- Acids & Bases Are Everywhere from Chem4Kids website by Rader.
- Acid & Bases, an Introduction by Vision Learning
- Acids, Bases & You, and in-depth YouTube video.
- Buffer System YouTube video.
- Bicarbonate Buffer System & pH imbalances YouTube video.

(You must be in PPT slideshow view to click on links.)

Want to see me sing the Element Song?

Image: Daniel Radcliff by Joella Marano

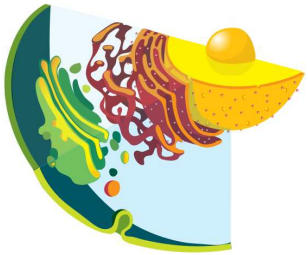


Are you feeling blinded by science?

Do yourself a favor. Use the…

Virtual Cell Biology Classroom *(VCBC)* !

The VCBC is full of resources to help you succeed, including:



- practice test questions
- review questions
- study guides and learning objectives
- PowerPoints on other topics

You can access the VCBC by going to the Science Prof Online website
www.ScienceProfOnline.com

Images: Blinded With Science album, Thomas Dolby; Endomembrane system, Mariana Ruiz, Wiki