Lecture 3: Basic Chemistry of Life:

What are you made of?

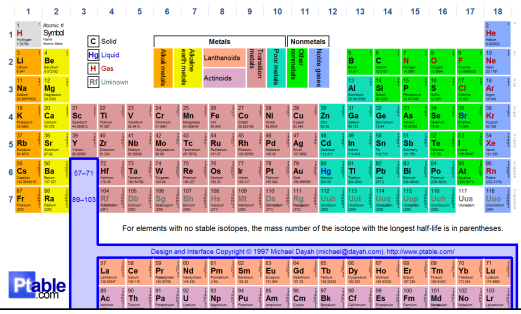
"B bec pooot commas"
Or…

Betty Boop Eats Creamy Club Panini's Outdoor on our Terrace. Cartoons offer magical moments almost secretly.

BIOSPHERE
BIOME
ECOSYSTEM
COMMUNITY
POPULATION
ORGANISM
ORGAN SYSTEM
ORGAN
TISSUE
CELL
ORGANELLE
MACROMOLECULE
MOLECULE
ATOM
SUBATOMIC PARTICLES

Which is the main element you are made of?

Periodic Table of Elements



Elements

- Basic unit of matter
- Characterized by specific properties
- **Elements** are composed of only one type of atom
  - 92 occur naturally on Earth
  - 25 essential to life
    - Recommended APP: NOVA Elements!

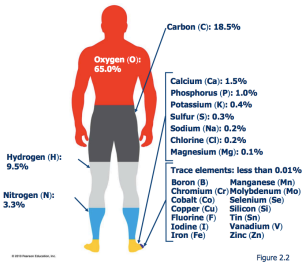
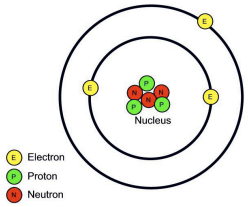


Figure 2.2

What Are Atoms?

- Smallest units of matter
- Made up of subatomic particles:
  - Protons (+)
  - Electrons (-)
  - Neutrons (no charge)



Nucleus is made of Protons and Neutrons

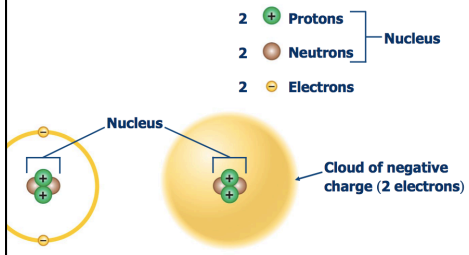


Figure 2.4

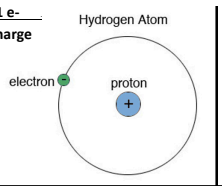
Charge in Atoms

protons (+) = # electrons (-)

therefore atoms have no net charge

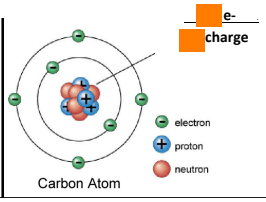
Hydrogen

1 p+
+
1 e-
0 charge



Carbon

6 p+
+
e-
charge

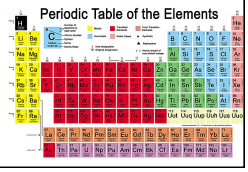


Atomic Number

- Atomic number = number of protons
- Number of protons determines the type of element
- All atoms of an element have the same number of protons

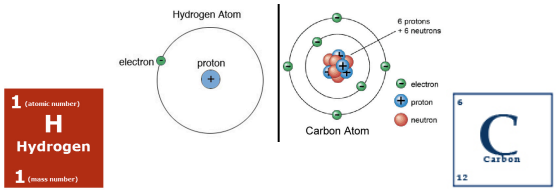
H = 1proton→atomic# = 1

C = 6proton→atomic# = 6



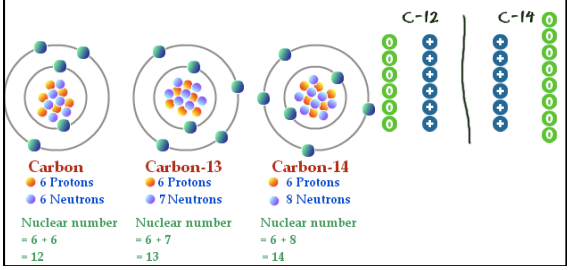
For Each Element

- The number of protons, the **atomic number**, determines which element it is.
- An atom's **mass number** is the sum of the number of protons and neutrons.



Isotopes

- Isotopes are **alternate** **mass** forms of an element.
- Isotopes have the same number of protons and electrons, but they have a *different number of neutrons*.

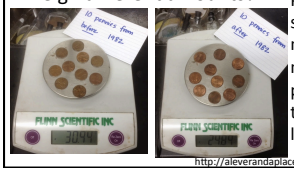


Isotopes Make Cents

- Isotopes are **alternate mass** forms of an element.
- Isotopes have the same number of protons and electrons, but they have a *different number of neutrons*.

Are these both pennies?

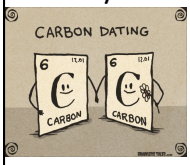
- What if I told you that they weigh different amounts?



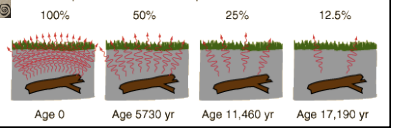
Pennies minted before 1982 were solid copper and have a heavier mass than the zinc/copper pennies minted after 1982. They are all pennies and all worth $0.01, but they have different masses. Just like isotopes.

http://aleverandaplacetostand.blogspot.com/2014/10/isotopes-make-cents.html

Radioactive isotopes are very useful in biology. We'll discuss them in more detail in our Anatomy and Physiology and/or evolution sections……stay tuned!



Measurement of the beta decay activity of a buried piece of wood provides a measurement of the time elapsed since it was living and in equilibrium with the atmosphere.



Atom Review

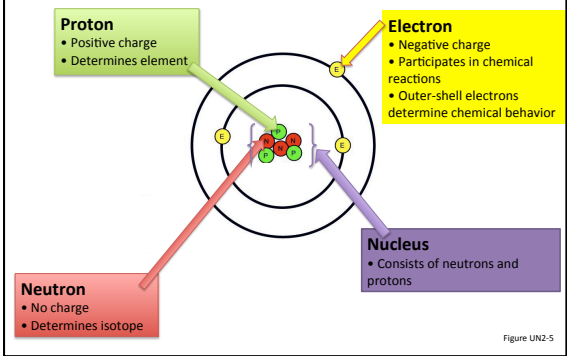
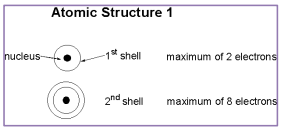
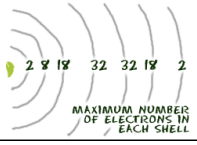


Figure UN2-5

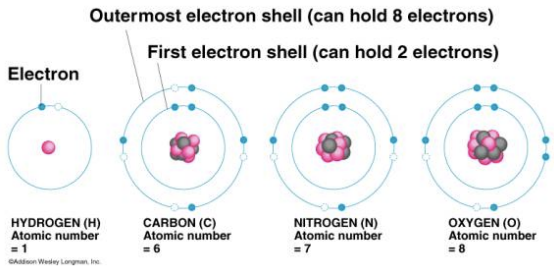
Electron Shells

- Electrons occur at certain energy levels at a fixed distance from the nucleus
- Electrons are drawn to the nucleus by the positive charge of the proton
- The number of shells differs with the number of electrons



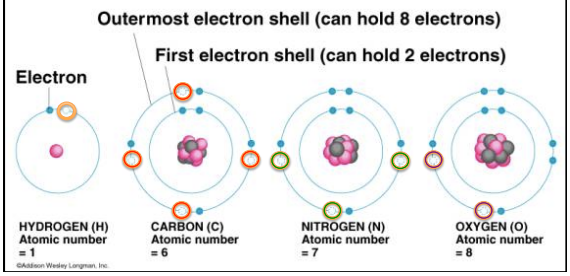


Electron Shells



Electron Vacancies

- Unfilled shells make atoms likely to **react**
- H, C, O, and N - have vacancies in their outer shells



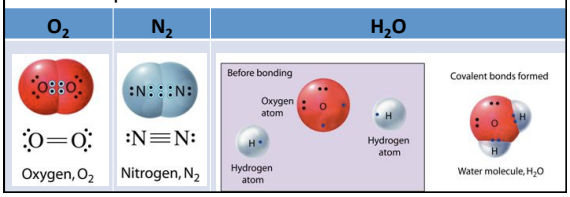
Chemical Bonding and Molecules

– Chemical reactions enable atoms to give up or acquire electrons to complete their outer shells.

– Leads to Ionic or Covalent Bonds

Chemical Bonds & Molecules

- Atoms form bonds that fill outer electron shell
- Molecules contain two or more atoms bonded together
- Examples:

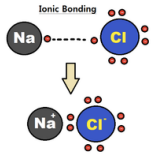


Bonds in Biological Molecules

1. Ionic Bonds – *"Theft"*
   – *Strongest*
2. Covalent Bonds – *"Sharing"*
   – *Second Strongest*
3. Hydrogen Bonds – *"Partial Charge Sharing"*
   – *Weakest*

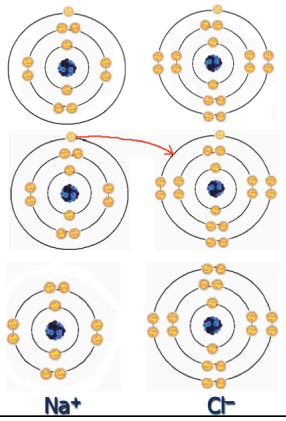
Ionic Bonds

- Atoms: #e^- =#p^+
  - no net charge H
- Ion: an atom that gains or loses e^-(s)
- Charge difference attracts the two ions to each other

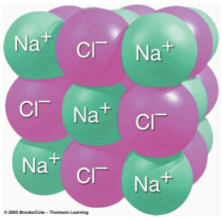


Formation of NaCl

- Sodium atom (Na)
  - Outer shell has one e^-
- Chlorine atom (Cl)
  - Outer shell has seven e
- Na transfers e^- to Cl forming Na^+ and Cl^-



- Opposite charges attract
  Na^+ Cl^-



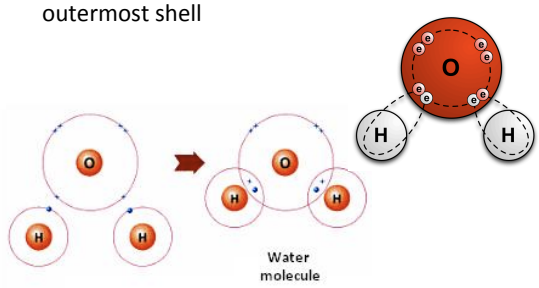
- Ions remain together as NaCl

Do not post photos to Internet

Figure 2.3a(2)

Covalent Bonding

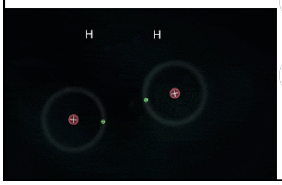
- Atoms share a pair or pairs of electrons to fill outermost shell



Types of Covalent Bonds

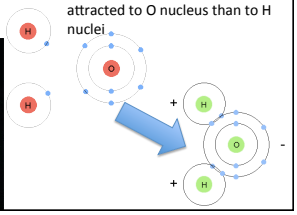
Non-Polar Covalent

- Atoms share electrons equally
- No charge difference between atoms
- Example:
  - Hydrogen gas (H–H)



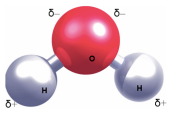
Polar Covalent

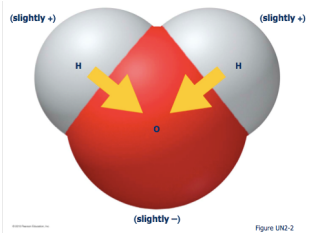
- Unequal sharing of electrons
  - One atom is stronger
  - Electrons spend more time near nucleus with the most protons
- Example:
  - Water: Electrons are more attracted to O nucleus than to H nuclei



Polar Covalent Bonding

- Polar covalent bonding creates atoms with opposite charges
- Oppositely charged atoms with polar covalent bonds are attracted to each other





Hydrogen Bonding in Water

- A hydrogen bond is the electrostatic attraction between polar molecules.
- This Happens when a Hydrogen (H) atom bound to a highly electronegative atom

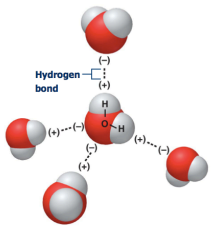
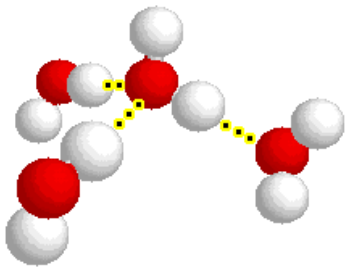


Figure UN2-8

Hydrogen Bond of H_2O



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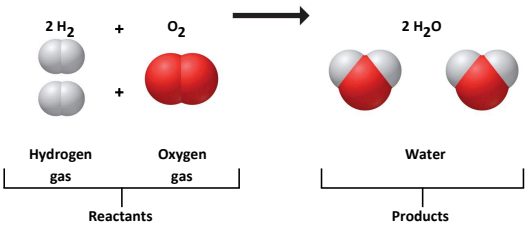
Chemical Reactions

- Cells constantly rearrange molecules by breaking existing chemical bonds and forming new ones.
  - Such changes in the chemical composition of matter are called **chemical reactions**.
- Chemical reactions include
  - **Reactants**, the starting materials
  - **Products**, the end materials



WATER AND LIFE

- Life on Earth began in water and evolved there for 3 billion years.
  - Modern life remains tied to water.
  - Your cells are composed of 70%–95% water.
- The abundance of water is a major reason Earth is habitable.

Water's Life-Supporting Properties

- The polarity of water molecules and the hydrogen bonding that results explain most of water's life-supporting properties.
  - Water molecules stick together.
  - Water has a strong resistance to change in temperature.
  - Frozen water floats.
  - Water is a common solvent for life.

The Cohesion of Water

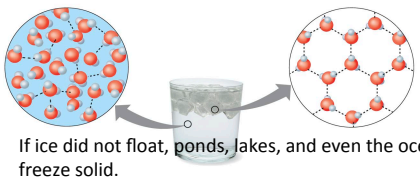
– Water molecules stick together as a result of hydrogen bonding.
  - This is called **cohesion**.
  - Cohesion is vital for water transport in plants.

PLAY Animation: Water Transport

– Surface tension is the measure of how difficult it is to stretch or break the surface of a liquid.
  - Hydrogen bonds give water an unusually high surface tension.

The Biological Significance of Ice Floating

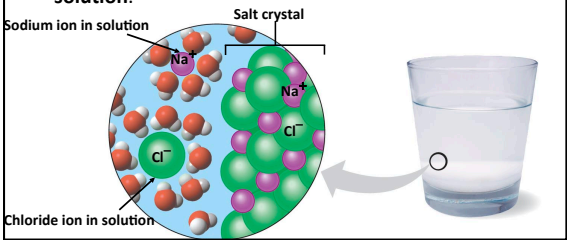
– When water molecules get cold enough, they move apart, forming ice.
– A chunk of ice has fewer molecules than an equal volume of liquid water.
– Ice floats because it is less dense than the liquid water around it.



- If ice did not float, ponds, lakes, and even the oceans would freeze solid.
- Life in water could not survive if bodies of water froze solid.

Water as the Solvent of Life

- A **solution** is a liquid consisting of a homogeneous mixture of two or more substances.
  - The dissolving agent is the **solvent**.
  - The dissolved substance is the **solute**.
- When water is the solvent, the result is an **aqueous solution**.



Acids, Bases, and pH

- A chemical compound that releases H^+ to solution is an **acid**.
- A compound that accepts H^+ and removes it from solution is a **base**.
- To describe the acidity of a solution, chemists use the **pH scale**.

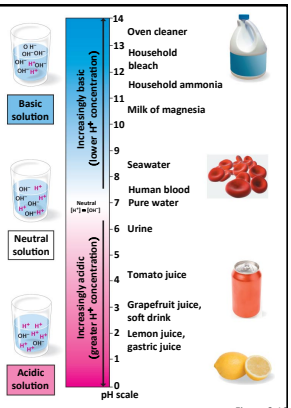


Figure 2.16

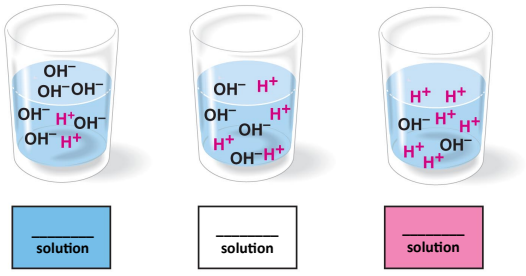


Figure 2.16a

- **Buffers** are substances that resist pH change.
- Buffers
  - Accept H^+ ions when they are in excess
  - Donate H^+ ions when they are depleted
- Increases in global CO_2 concentrations may lead to the acidification of the oceans.