2 - Chemical Context of Life

{2.1 - Elements and Compounds}

- Organisms and composed of **matter**
- Matter is made up of **elements**
    - **Element** :: Cannot be broken down to other substances
    - **Compound** :: Substance consisting of two or more elements in a fixed ratio
- Elements essential for life :: 25/92 of elements
    - CHON (Carbon, Hydrogen, Oxygen, Nitrogen) made up **96%** of living matter
    - Calcium, Phosphorus, Potassium, and Sulfur make up the remaining **4%**
    - **Trace elements** :: Elements required in **very small** quantities

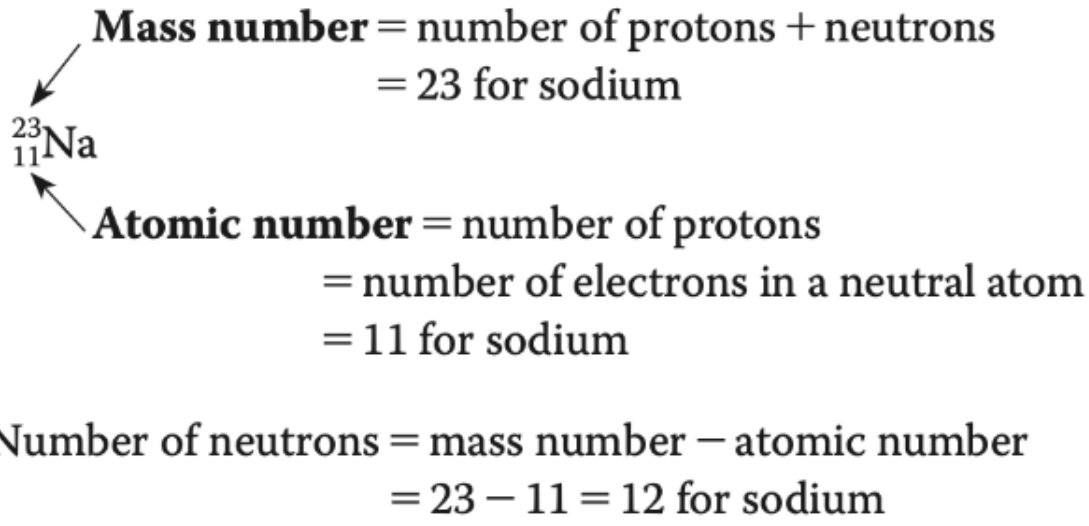
{2.2 - Atoms and Properties}

- Each element consists of unique **atoms**
- An atom is the **smallest** unit of matter that still retains the properties of an element
- Atoms are composed of **subatomic particles**
    - **Neutrons** :: No charge
    - **Protons** :: Positive Charge
    - **Electrons** :: Negative Charge
- **Nucleus** = Neutron + Proton
- **1 Neutron mass** = 1 atomic mass unit (amu) = 1 Proton mass = 1 Neutron mass

{2.2 - Atomic Notation}

- **Atomic number** :: # of **protons** = # of **electrons**
    - **Subscript** to **left**

    - Unless otherwise notated, # of protons = # of electrons
    - Atomic numbers will also tell **# of electrons in a neutral atom.**
- **Mass number** :: Total number of protons and neutrons in the nucleus
    - **Superscript** to **left**



$$\text{Number of neutrons} = \text{mass number} - \text{atomic number}$$
$$= 23 - 11 = 12 \text{ for sodium}$$

{2.2 -Isotopes}

- **Isotopes** :: Two atoms of the same elements that differ in # of neutrons
    - **# of protons cannot change for the same element**
- **Radioactive Isotopes** :: Decay spontaneously
    - Gives off particles and energy
    - When radioactive decay leads to a change in the # of protons, it transformed the atom to a **different element**
    - *EXAMPLE :: Neutron → Proton*
    - *14/6 C → 14/7 N*

{2.2 - Electron shells}

- **Energy** :: Capacity to cause change
- **PE** vs. **KE**
- The electrons in an atom can have different PE

    - Electron shells
    - **Fixed energies**
- As an electron moves **up** the shell (**further away** from nucleus), the electron needs to **gain energy**, <vice versa>
- **On periodic table**
    - Row # = # of electron shells

{2.2 - Valence Electrons}

- **Valence Electrons / Valence shell** :: Electrons in the outermost shell
- **Chemical behavior** of an atom is **determined** by the valence electrons
- **Chemically inert** :: Elements with a **full** valence shell

{2.3 - Valence Interactions}

- Atoms with **incomplete valence shell** can **share / transfer** valence electrons with **certain** other atoms
- **Chemical bonds**
    - Covalent
    - Ionic
    - WCBs (Hydrogen Bonds, Van Der Waals)

{2.3 - Covalent Bonds}

- **Covalent Bond** :: **Sharing** of a **pair** of valence electrons by two atoms
- 2 Hydrogen :: Each Hydrogen has 1 valence electron while its shell has a **capacity** of 2. So, if 2 Hydrogen are close enough, they can share their electrons
    - Now, each atom is associated with 2 electrons in what becomes a **completed** valence shell
    - Constitutes a **molecule**
    - Structural formula :: H-H
    - Molecular formula: H_2
- **Molecule** :: 2+ atoms held together by **covalent bonds**

    - **Single bond** :: Sharing **one pair** of valence electrons
    - **Double bond** :: Sharing **two pairs** of valence electrons
- **Electronegativity** :: Atom's attraction for the electrons in a covalent bond
    - The more electronegative an atom, the more **strongly** it pulls **shared electrons toward itself**
- **Nonpolar covalent bond** :: Atoms share the electron equally
- **Polar covalent bond** :: One atom is more **electronegative**, atoms **do not** share the electron equally
    - **Unequal** sharing of electrons causes a **partial positive or negative charge for each atom or molecule**

{2.3 - Ionic Bonds}

- **Ions** :: In some cases, two atoms are so unequal in their attraction for valence electrons that the **more electronegative** atom **strips an electron completely** away from its partner.
- **Cation** :: **+ charge ion**
- **Anion** :: **- charge ion**
- **Ionic bond** :: When cations and anions attract
    - Does **not** need to share an electron transfer
- Ionic compounds = **salts**
    - Found in nature as **crystals**

{2.3 - WCB- Hydrogen Bonds}

- **Hydrogen bond** :: When a **hydrogen** atom is **covalently** bonded to an **electronegative** atom, the **hydrogen atom has a particle positive charge that allows it to be attracted to a different electronegative atom nearby**
    - This attraction between hydrogen and an electronegative atom is called a **hydrogen bond**

    - In nature, the electronegative partners are usually **oxygen** or **nitrogen**

{2.3 - WCB - Van de Waals Interactions}

- Electrons are always **moving** and may not be always be distributed evenly
- Results are ever-changing regions of positive and negative charges that enable all atoms and molecules to stick to each other
- Gecko climb up wall

{2.3 - Chemical Reactions}

- **Chemical reaction (rxn)** :: Making and breaking of matter
- Reactants → rxn → Product
- **Conservation of Matter** :: Chemical rxn will change / rearrange matter, but cannot **destroy** or **create** matter
- P-Syn :: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
- All chemical rxn are **reversible**
- Products in forward rxn becomes reactants in reverse rxn
- As products accumulate, they collide to **reform** reactants
- **Chemical equilibriums** :: Products and reactants are continually being formed, but **there is no net change in the concentrations**
    - Concentrations of reactants and products are typically **not equal**, but stabilized at a **set ratio**