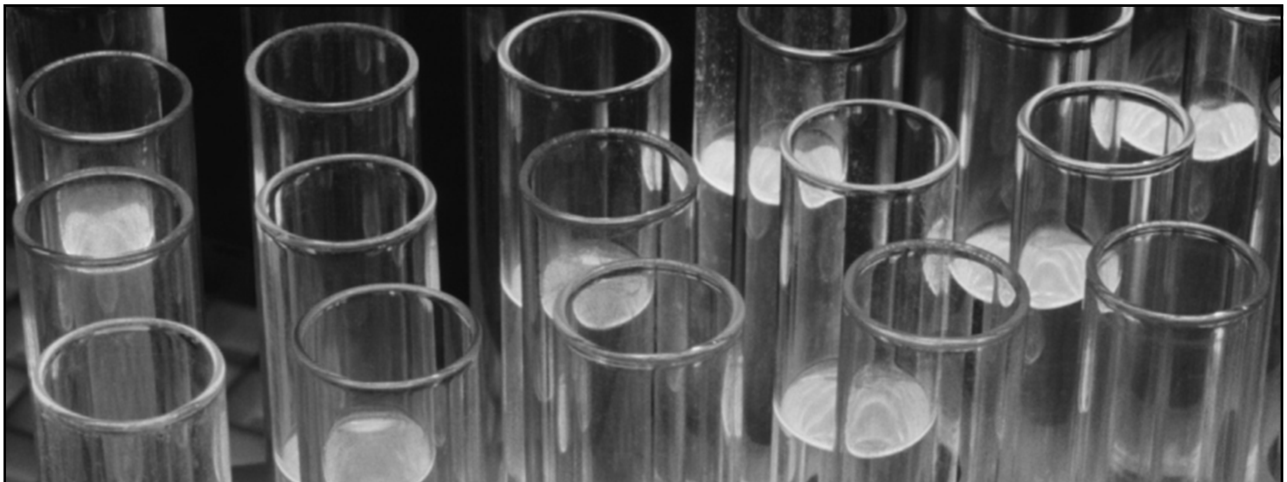


Unit 3
Interactions of Matter

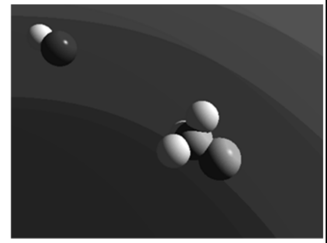
Physical Science | Mrs. Valentine

3.1 Law of Conservation of Mass

- Objective:
  - I will be able to read chemical equations. I will understand how the law of conservation of mass applies to chemical reactions.
- Vocabulary:

Law of Conservation of Mass	Chemical Reaction	Reactant	Product	Activation Energy
Catalyst	Chemical Equation	Inhibitor		

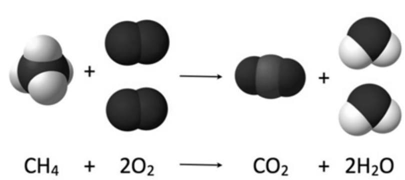
3.1 Law of Conservation of Mass



- Reactions
  - Chemical changes in which bonds are broken and new bonds are created.
  - Chemical reactions required a certain amount of energy to begin, called activation energy.
  - If heat is released (reaction feels warmer), reaction is exothermic. If heat is absorbed (reaction feels colder), reaction is endothermic.
  - A chemical equation is a shorter, easier way to show chemical reactions using symbols instead of words.

3.1 Law of Conservation of Mass

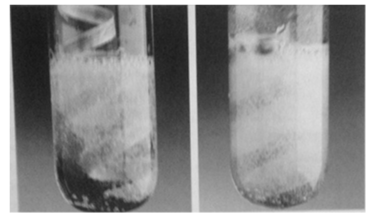
- Parts of a Chemical Equation
  - Reactants are the materials you have at the start of a reaction
  - Products are the materials at the end of a reaction
  - Coefficients are numbers listed before a chemical formula in a chemical equation to indicate the ratio of compounds reacting.



Reactant + Reactant → Product + Product

3.1 Law of Conservation of Mass

- Factors that Affect Reaction Speeds
  - Concentration
    - Increasing the concentration of a reactant can increase the speed of the reaction
    - Increases the number of particles available to react



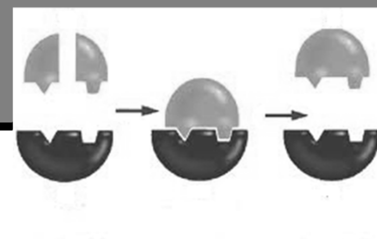
  - Temperature
    - Increasing temperature affects the speed of a reaction.
    - Particles are moving faster, so they come into contact more often, and there is more energy available (quicker to meet activation energy)

3.1 Law of Conservation of Mass

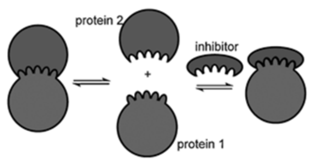
- Surface Area
  - Increasing surface area increases reaction speed
  - More particles are available to react at the same time.

  - Ex: chewing food to make it easier for enzymes in our saliva

3.1 Law of Conservation of Mass

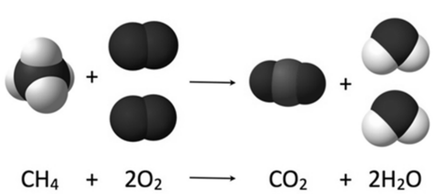


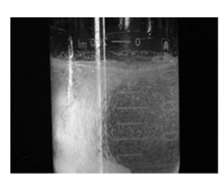
- Catalysts/Inhibitors
  - Catalysts
    - Speed up a reaction by making the reaction require less activation energy
    - Life not possible without enzymes, biological catalysts
  - Inhibitors
    - Slow down or stop reactions by increasing the required activation energy
    - May bond with a reactant to prevent the other chemical from doing so



3.1 Law of Conservation of Mass

- Law of Conservation of Mass
  - The amount of matter involved in a chemical reaction does not change. The total mass of the reactants must equal the total mass of the products.
  - Mass is neither created nor destroyed in chemical reactions.
  - If your reaction beaker seems to have less mass after a chemical reaction, it is most likely that at least one of your products was a gas that escaped.





3.2 Balancing Chemical Equations

- Objective:
  - I will be able to use coefficients to balance chemical equations so that they follow the law of conservation of mass.

- Vocabulary:

Coefficients	Subscript			

3.2 Balancing Chemical Equations

$C_2H_4O_2$ Symbols

Subscripts

- Coefficients vs. Subscripts
  - Subscripts show the ratio of elements in a compound. Since each compound has a specific ratio of elements, THESE DO NOT CHANGE!!!
  - Coefficients show the ratio of one compound to another in a reaction.
  - In order to abide by the law of conservation of mass, the coefficients in a chemical reaction can be changed so that the same number of atoms of each element is present on both sides of the reaction.
  - Multiply a coefficient by a subscript to determine the number of atoms of an element.
  - If no coefficient is listed, it is an assumed 1.

3.2 Balancing Chemical Equations

- Rules for Balancing Chemical Equations
  - Take note of the elements present on each side of the equation (keep polyatomic ions together if they appear on both sides).
  - Count the number of atoms of each element present on each side of the equation.
  - Balance one element/polyatomic ion at a time.
  - If you have a lone element as a reactant or product, save it for last.
  - If your reaction contains only H, C, and O, balance them in that order.
  - In the end, you want the number of each type of atom/ion the same on both sides of the equation.
  - The coefficients should be in the simplest whole-number ratio.

3.2 Balancing Chemical Equations

- Practice
  - $H_2 + O_2 \rightarrow H_2O$
  - $C + Cl_2 \rightarrow CCl_4$
  - $Al_2O_3 \rightarrow Al + O_2$

$\underline{\;2\;}H_2 + \underline{\;1\;}O_2 \rightarrow \underline{\;2\;}H_2O$

	Reactants	Products
H	~~2~~ 4	~~2~~ 4
O	2	~~1~~ 2

$\underline{\;1\;}C + \underline{\;2\;}Cl_2 \rightarrow \underline{\;1\;}CCl_4$

	Reactants	Products
C	1	1
Cl	~~2~~ 4	4

$\underline{\;2\;}Al_2O_3 \rightarrow \underline{\;4\;}Al + \underline{\;3\;}O_2$

	Reactants	Products
Al	~~2~~ 4	~~1~~ 4
O	~~3~~ 6	~~2~~ 6

3.3 Reaction Types

- Objective:
  - I will be able to identify the type of reaction occurring given a chemical equation.
- Vocabulary:

Synthesis	Decomposition	Single Replacement	Double Replacement	Combustion

3.3 Reaction Types

- Synthesis
  - Properties of Reaction Type
    - Two elements are combined to form a new compound.
    - May combine compounds to form a new compound in a synthesis reaction.
    - May have more than two reactants.
  - Examples
    - $C + 2F_2 \rightarrow CF_4$
    - $SO_2 + O_2 + H_2O \rightarrow H_2SO_4$

A+X → AX

3.3 Reaction Types

AX → A+X

- Decomposition
  - Properties of Reaction Type
    - A compound breaks down into two or more new products.
    - The products may be elements, compounds, or some of each.
  - Examples
    - $2H_2O_2 \rightarrow 2H_2O + O_2$
    - $CaCO_3 \rightarrow CaO + CO_2$

3.3 Reaction Types

AX + B → BX + A
AX + Y → AY + X

- Single Replacement
  - Properties of Reaction Type
    - One element replaces another in a compound
    - Reactants are a compound and an element
    - If the elemental reactant (B) is a metal or hydrogen, it will replace the cation in the compound.
    - If the elemental reactant (Y) is a nonmetal, it will replace the anion in the compound
  - Examples
    - $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
    - $2KBr + Cl_2 \rightarrow 2KCl + Br_2$

3.3 Reaction Types

- Double Replacement
  - Properties of Reaction Type
    - Two compounds react together and swap anions.
    - Be careful not to accidentally carry over subscripts (but keep polyatomic ions together). Balance your equation with coefficients afterwards.
  - Examples
    - $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2CO_3$
    - $2NaCl + Ca(OH)_2 \rightarrow 2NaOH + CaCl_2$

$$AX + BY \rightarrow AY + BX$$

3.3 Reaction Types

- Combustion
  - Properties of Reaction Type
    - This type of combustion reacts a hydrocarbon with oxygen to produce carbon dioxide, water, and heat.
    - There are other elements capable of combusting. However, we will not be investigating those.
  - Examples
    - $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
    - $2C_2H_4O + 5O_2 \rightarrow 4CO_2 + 4H_2O$

$$C_xH_yO_z + O_2 \rightarrow H_2O + CO_2$$

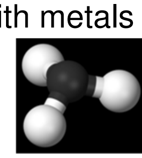
3.4 Acids & Bases

- Objective:
  - I will understand the difference between acids and bases. I will recognize an acid or base using pH. I will be able to recognize neutralization reactions and predict their products.
- Vocabulary:

Acid	Base	pH	pH Scale	Indicator
Hydrogen Ion	Hydroxide Ion	Neutralization	Salt	

3.4 Acids & Bases

- Acids
  - Substances that taste sour, react with metals and carbonates, and turn blue litmus paper red.
  - Produce hydrogen ions in solution



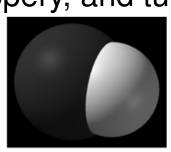
  - Lemons are an excellent example of the sour taste of acids. However, do not use the sour taste as an indicator of an acid in a lab. Not all acids are okay to consume!
  - When acids react with metals, they produce hydrogen gas.
  - When acids react with carbonates, they produce carbon dioxide.

3.4 Acids & Bases

- Litmus is an indicator that changes color when it comes into contact with an acid or base.
- Strong acids easily produce hydrogen in solution, while weak acids have a harder time of it.
- Seven strong acids (HCl, H_2SO_4, HNO_3, HBr, $HClO_3$, HI, $HClO_4$)
- Uses
  - Etching metals
  - Testing if a rock is made of limestone

3.4 Acids & Bases

- Bases
  - Substances that taste bitter, feel slippery, and turn red litmus blue
  - Produce hydroxide ions in solution
  - Opposite of acids
  - Do not react with carbonates to produce carbon dioxide



3.4 Acids & Bases

- Strong bases produce more hydroxide ion than weak bases
- Examples of strong bases include: NaOH, KOH, LiOH
- Ammonia (NH_3) is a weak base
- Uses
  - Soap & Shampoo
  - Cleaning Supplies
  - Antacids

3.4 Acids & Bases

- pH
  - The pH scale is a range of values from 0 to 14 that expresses the concentration of hydrogen ions in a solution.
  - The higher the concentration of hydrogen, the lower the pH.

  - Acids have pH values below 7
  - Bases have pH values above 7
  - A pH value of 7 means that the solution is neutral (neither acidic nor basic)

3.4 Acids & Bases

- Neutralization Reactions
  - A reaction between an acid and a base
  - Usually, though not always, results in a neutral pH. Final pH depends on reactant:
    - Volumes
    - Concentrations
    - Identities
  - Products are a salt and water
    - Salt is any ionic compound that can be made from the neutralization of an acid with a base.
    - Cation from base, anion from acid

$$HCl + NaOH \rightarrow NaCl + H_2O$$

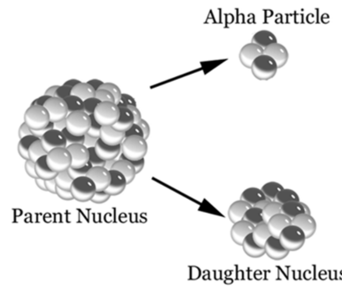
3.5 Radioactive Decay

- Objective:
  - I will be able to compare and contrast the three types of radioactive decay, and know how each is used.
- Vocabulary:

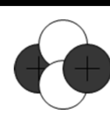
Radioactive Decay	Radioisotopes/ radionuclides	Alpha Decay	Alpha Particle	Beta Decay
Beta Particle	Gamma Decay	Gamma Ray		

3.5 Radioactive Decay

- Radioactive Isotopes
  - Radioactive Decay – Unstable isotopes become stable by releasing different types of particles
  - The elements which undergo this process are called radioisotopes/radionuclides
- Types of Radioactive Decay
  - Alpha Decay
    - Radioactive decay in which a radionuclide gives off an alpha particle



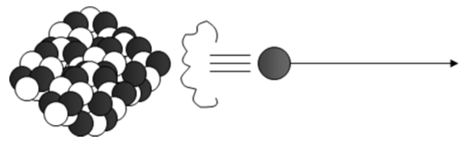
3.5 Radioactive Decay



- An alpha particle
  - Symbols: ${}^{4}_{2}He$ and ${}^{4}_{2}\alpha$
  - is a helium nucleus with two protons and two neutrons
  - Can be stopped with a piece of paper (cannot penetrate most matter)
  - Dangerous if inhaled or ingested.
- Most alpha emitters occur naturally in the environment
- Uses of Alpha Emitters:
  - Ra-226 used to treat cancer
  - Po-210 used as a static eliminator in paper mills
  - Am-241 used in smoke detectors; the alpha emissions used to create electrical current

3.5 Radioactive Decay

- Beta Decay
  - Radioactive decay in which the radionuclide changes a neutron into a proton and an electron
  - Beta Particle
    - Symbols: ${}^{0}_{-1}\beta$ and ${}^{0}_{-1}e$
    - is a fast moving electron given off when the neutron is changed
    - Can be stopped by aluminum foil or plastic
    - Can travel several feet in open air

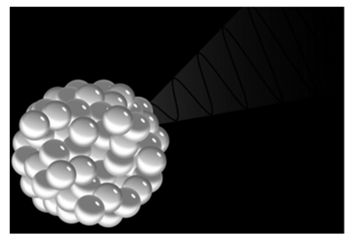


3.5 Radioactive Decay

- Uses of Beta Emitters:
  - I-131 used to treat thyroid disorders
  - Sr-90 used as radioactive tracer in medical and agricultural studies
  - H-3 used in life science and drug metabolism studies
  - C-14 used in carbon-dating (up to 30,000 years old)

3.5 Radioactive Decay

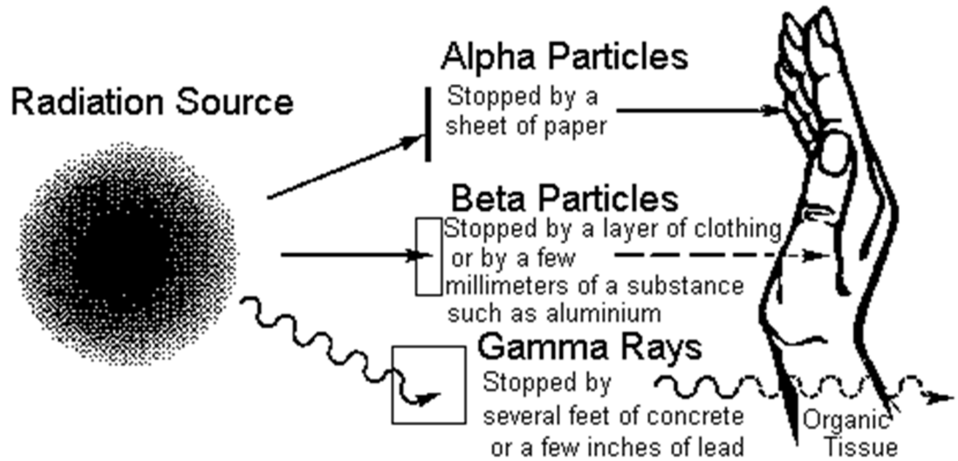
- Gamma Decay
  - The emission of gamma rays after alpha or beta emission if the new atom still has too much energy.
  - Gamma Ray
    - High-energy radiation that has no electrical charge and no mass
    - Have 10,000 times more energy than visible light
    - Released with alpha and beta particles
    - Can travel hundreds to thousands of meters in air before spending their energy



3.5 Radioactive Decay

    - Can pass through human tissue and are dangerous
    - Can be stopped by lead
    - Do not make materials radioactive
  - Uses for Gamma Rays:
    - Co-60 used to sterilize medical equipment, pasteurize certain foods and spices, treat cancer, gauge thickness of metal in steel mills.
    - Ce-137 used to treat cancer; measure and control flow of liquids in industrial processes, investigate subterranean strata in oil wells, measure soil density at construction sites

3.5 Radioactive Decay



3.6 Balancing Nuclear Reactions

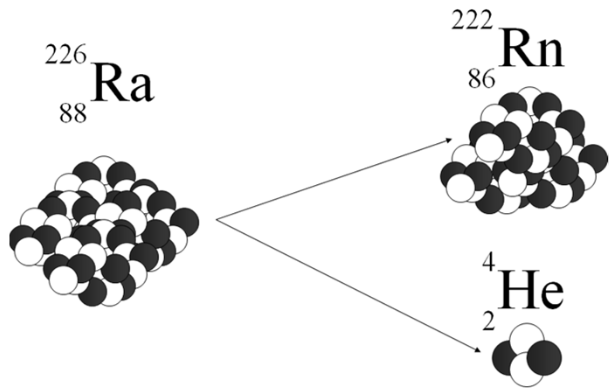
- Objective:
  - I will be able to write equations for nuclear reactions. I will be able to predict the products and/or reactants of each type of decay.

- Vocabulary:

Nuclear Reaction	Daughter Isotope	Parent Isotope	Radioactive Isotope	

3.6 Balancing Nuclear Reactions

- Alpha Decay
  - ${}^{A}_{Z}X \rightarrow {}^{4}_{2}He + {}^{A-4}_{Z-2}Y$
  - ${}^{A-4}_{Z-2}Y$ is a more stable atom
  - Example: ${}^{226}_{88}Ra \rightarrow {}^{4}_{2}He + {}^{222}_{86}Rn$

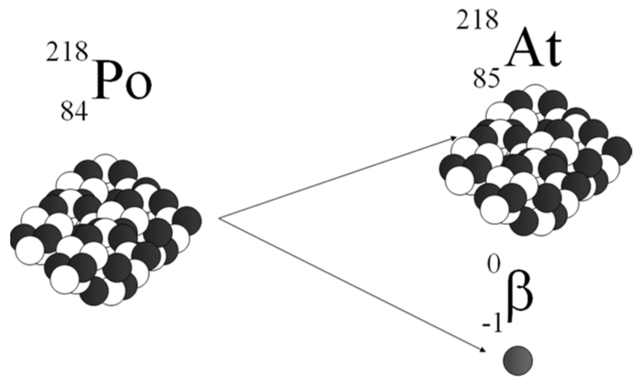


3.6 Balancing Nuclear Reactions

- Practice
  - ${}^{222}_{86}Rn \rightarrow {}^{A}_{Z}Y + {}^{4}_{2}He$ — ${}^{222}_{86}Rn \rightarrow \mathbf{{}^{218}_{84}Po} + {}^{4}_{2}He$
  - ${}^{A}_{Z}X \rightarrow {}^{230}_{90}Y + {}^{4}_{2}He$ — $\mathbf{{}^{234}_{92}U} \rightarrow {}^{230}_{90}Y + {}^{4}_{2}He$
  - ${}^{230}_{90}Th \rightarrow {}^{A}_{Z}Y + {}^{4}_{2}He$ — ${}^{230}_{90}Th \rightarrow \mathbf{{}^{226}_{88}Ra} + {}^{4}_{2}He$
  - ${}^{A}_{Z}X \rightarrow {}^{214}_{82}Pb + {}^{4}_{2}He$ — $\mathbf{{}^{218}_{84}Po} \rightarrow {}^{214}_{82}Pb + {}^{4}_{2}He$

3.6 Balancing Nuclear Reactions

- Beta Decay
  - ${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}Y + {}^{0}_{-1}\beta$
  - ${}_{Z+1}^{A}Y$ is a more stable atom
  - Example: ${}^{218}_{84}Po \rightarrow {}^{218}_{85}At + {}^{0}_{-1}\beta$



3.6 Balancing Nuclear Reactions

- Practice
  - ${}^{234}_{90}Th \rightarrow {}^{A}_{Z}Y + {}^{0}_{-1}\beta$
  - ${}^{A}_{Z}X \rightarrow {}^{210}_{82}Pb + {}^{0}_{-1}\beta$
  - ${}^{210}_{83}Bi \rightarrow {}^{A}_{Z}Y + {}^{0}_{-1}\beta$
  - ${}^{A}_{Z}X \rightarrow {}^{214}_{83}Bi + {}^{0}_{-1}\beta$

${}^{234}_{90}Th \rightarrow \mathbf{{}^{234}_{91}Pa} + {}^{0}_{-1}\beta$

$\mathbf{{}^{210}_{81}Tl} \rightarrow {}^{210}_{82}Pb + {}^{0}_{-1}\beta$

${}^{210}_{83}Bi \rightarrow \mathbf{{}^{210}_{84}Po} + {}^{0}_{-1}\beta$

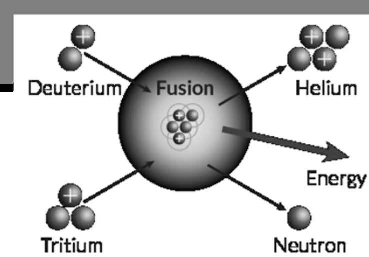
$\mathbf{{}^{214}_{82}Pb} \rightarrow {}^{214}_{83}Bi + {}^{0}_{-1}\beta$

3.7 Nuclear Fusion and Nuclear Fission

- Objective:
  - I will understand the difference between nuclear fusion and nuclear fission. I will be able to predict the products of nuclear fusion reactions.
- Vocabulary:

Nuclear Fusion	Nuclear Fission	Chair Reaction	Critical Mass	

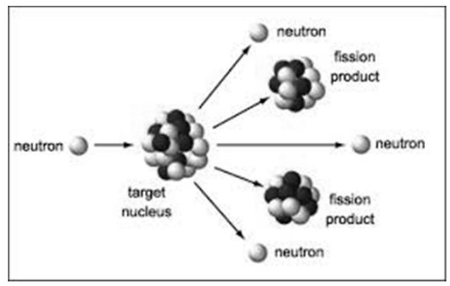
3.7 Nuclear Fusion and Nuclear Fission



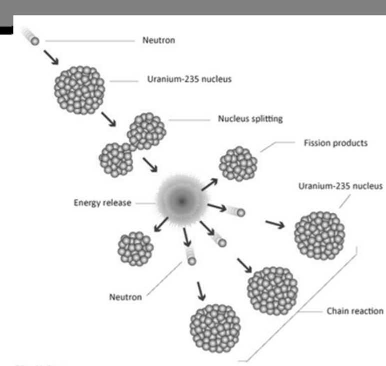
- Nuclear Fusion
  - Atomic nuclei combine to form a larger nucleus, releasing huge amounts of energy in the process.
  - Releases more energy per gram of fuel than nuclear fission
  - Occurs in stars (including the sun).
  - Ex: ${}^{3}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}H + {}^{1}_{0}n + Energy$
  - Uses
    - Solar Power
    - Thermonuclear Weapons

3.7 Nuclear Fusion and Nuclear Fission

- Nuclear Fission
  - A very heavy nucleus splits into more-stable nuclei of intermediate mass
  - Enormous amounts of energy are released
  - Can occur spontaneously or when nuclei are bombarded by particles
  - Ex: ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + Energy$



3.7 Nuclear Fusion and Nuclear Fission



- Chain reaction
  - Reaction in which the material that starts the reaction is also one of the products and can start another reaction
  - The minimum amount of nuclide that provides the number of neutrons needed to sustain a chain reaction is called the critical mass
  - Nuclear reactors use controlled fission chain reactions to produce energy and radioactive nuclides
- Uses
  - Nuclear Power
  - Nuclear Reactors

3.8 Half-Life

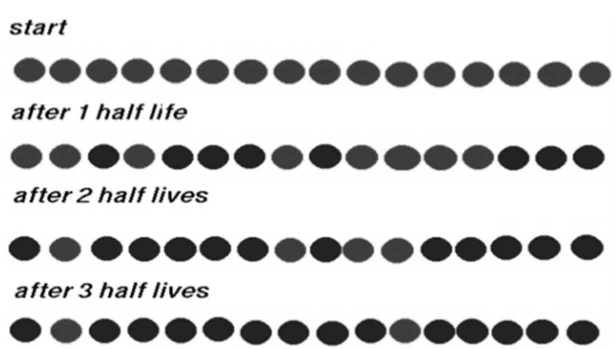
- Objective:
  - I will understand half-life and some practical applications of it. I will be able to calculate half-life and the amount of a substance remaining after a certain amount of time based upon half-life.

- Vocabulary:

Half-Life	Carbon Dating			

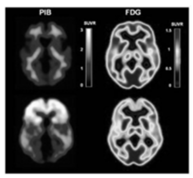
3.8 Half-Life

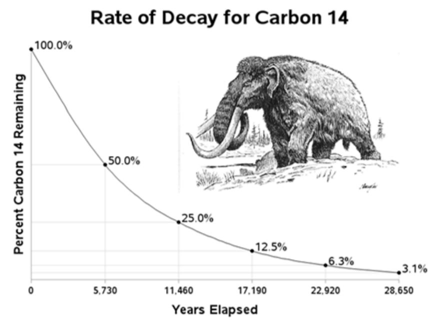
- Define Half-life
  - The time required for half of the nuclei in a sample of a radioisotope to undergo radioactive decay
  - Examples:
    - U-238: 4.5 billion years
    - I-131: 8.07 days
    - Po-194: 0.7 seconds



3.8 Half-Life

- Applications of half-Life
  - Calculating how much will be left for an experiment after being removed from a reactor
  - Carbon dating
  - Calculating how long we must store radioactive waste until they become safe
  - Safe radioactive tracers in medicine





3.8 Half-Life

- Half-Life Calculations
  - Remaining amounts of an isotope can be calculated using the formula:

$$y = (0.5)^n x$$

  - y = remaining amount; n = number of half-lives; x = original amount
  - Practice:
    - An isotope of cesium (cesium-137) has a half-life of 30 years. If 1.0 mg of cesium-137 disintegrates over a period of 90 years, how many mg of cesium-137 would remain?

$$\frac{90 \text{ yrs}}{30 \text{ yrs}} = 3$$

$$y = (0.5)^3 (1.0)$$

$$\boxed{y = 0.125 \text{ mg}}$$

3.8 Half-Life

- Sodium-25 was to be used in an experiment, but it took 3.0 minutes to get the sodium from the reactor to the laboratory. If 5.0mg of sodium-25 was removed from the reactor, how many mg of sodium-25 were placed in the reaction vessel 3.0 minutes later if the half-life of sodium-25 is 60 seconds?

$$\frac{3.0\text{min}}{1.0\text{min}} = 3$$

$$y = (0.5)^3 (5.0)$$

$$\boxed{y = 0.625 \text{ mg}}$$