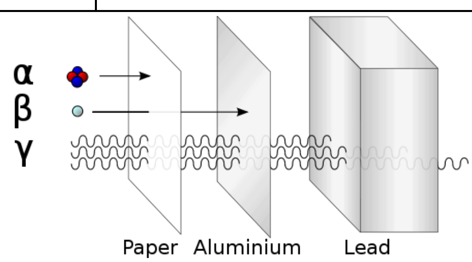
Nuclear Radiation

- Unlike chemical reactions, nuclear reactions are not affected by changes in temperature, pressure or the presence of catalysts. Nuclear reactions of a given radioisotope cannot be slowed down, speeded up or stopped

Radioactivity: The spontaneous emission of rays or particles from certain elements, like uranium
Nuclear Radiation: The rays and particles emitted from a radioactive source
Radioisotope: Unstable isotopes from which nuclear reactions begin with
Alpha Particle: Contains 2 protons and 2 neutron and has a double positive charge.
Beta Particle: An electron resulting from the breaking apart of a neutron in an atoms is a beta particle. The neutron breaks apart into a proton, which remains in the nucleus, and a fast-moving electron is released
Gamma Ray: A high-energy X-ray emitted by a radioisotope. No mass, no charge, is not a particle.

Type	Consists of	Symbol	Charge	Mass (amu)	Common Source	Penetrating Power
Alpha Radiation	Alpha Particles (Helium Nuclei)	α, ${}^{4}_{2}He$	2+	4	Radium-226	Low
Beta Radiation	Beta Particles (electrons)	β, e^-	1-	1/1837	Carbon 14	Moderate
Gamma Radiation	High- Energy electromagnetic radiation	γ	0	0	Cobalt-60	High



Nuclear Transformations

- The neutron-to-proton ratio in a radioisotope determines the type of decay that occurs
- During each half-life, half of the remaining radioactive atoms decay into atoms of a new element

Nuclear Force: An attractive force that acts between all nuclear particles that are extremely close together, such as protons and neutrons in a nucleus
Positron: A particle with the mass of an electron but with a positive charge
Half-Life: The time required for ½ of the nuclei in a radioisotope to decay to products

Transmutation:In a nuclear reaction the nucleus of one element becomes the nucleus of another element. Identity changes, number of protons changes

- The nucleus of an atom changes if it is unstable
- An unstable nucleus will keep emitting radiation until it becomes stable
- The neutron to proton ratio determines the stability of the nucleus
- The greater the difference between the neutrons and protons, the more radioactive a nucleus
- Atoms in periodic table from 1-82 are considered stable nuclei. 83 and up are all radioactive
- An isotope that emits radiation is called radioisotope

Natural Transmutation: Occur as result of unstable neutron-to-proton ratio.Or by radioactive decay. Occurs in nature, spontaneous.

Artificial Transmutation: Bombarding nucleus with high-energy particles brings about the change

Transuranium Elements: Elements with atomic numbers above 92, atomic number of uranium

Fission and Fusion: In a chain reaction, some of the emitted neutrons react with other fissionable atoms, which emit neutrons that react with still more fissionable atoms

Fission:When the nuclei of certain isotopes are bombarded with neutrons, the nuclei split into smaller fragments . To split a heavy nucleus into lighter nuclei

Fusion:When the nuclei combine to produce a nucleus of a greater mass, release much more energy than fission reactions, in which large nuclei split apart to form smaller nuclei

- Most common examples occurs in the sun where hydrogen nuclei react in a series to produce helium molecules
- Extremely high temperatures and pressures are needed to allow the positively charged hydrogen nuclei to fuse into helium
- 1 major advantage as an energy source is that the product are not highly radioactive, like the products of fission reactions
- In a nuclear reaction, mass of the products is less than the mass of the reactants. Mass lost is converted into energy E= mc^2
- Mass defect: Mass unaccounted for when protons and neutrons are put together in a nucleus.

Radioactive decay at a constant rate is not dependent on factors such as temperature, pressure or concentration. It is a random event

- The time it takes for half of the atom in a given sample of an element to decay is called the half life of an element
- the shorter the half- lives and the mode by which they decay

Nuclei Stability

- When an unstable nucleus decays, it emits radiation in the form of alpha particles, beta particles, positrons and/or gamma radiation.
- Radiation can be harmful when it interacts with living things. Serious damage occurs when radioactivity causes ionization of normal tissues.
  When molecules in a cell are ionized, they may no longer carry on their normal functions and this may cause the death of the cell

Alpha Decay: Atomic number decreases by 2 : Number of protons and neutrons decrease by 2

- Mass number decreases by 4

Beta Decay : Atomic number increases by 1 : Number of protons increases by 1

- Number of neutrons decreases by 1 : Mass number remains the same

Positron Emission : Atomic number decreases by 1: Number of protons decreases by 1

- Number of neutrons increases by 1: Mass number remains the same

Conversion of Matter to energy

- E=mc^2
  E is energy, m is mass and c is the speed of light which is 3.00*10^8 m/s (168,000 mi/s)
- Energy produced by nuclear reactions if far greater than ordinary chemical reactions. This conversion of matter into energy occurs when protons and neutrons are combined into nuclei. The total mass of the nucleus is less than the sum of the masses of the individual protons and neutrons. The matter that has been converted into energy is called the mass defect.

- In a chemical reaction only the valence electrons react
- Mass and charge must be conserved in all reactions
- Only valence electrons react identity remains the same

Uses and Dangers of Radioisotopes

- C-14 (carbon 14) is best known for its use in dating previously living materials. After about 4 half lives, C-14 becomes ineffective as a method for dating materials because there is too little C-14 left to be accurately measured
- Scientists can use the ratio of U-238 : P-206 to date rocks and other geological formations.
- **Chemical Tracers:** Ability to detect radioactive materials and their decay products makes it possible to determine their presence or absence in a substance. Any radioisotope used to follow the path of a material in a system is called a tracer. (i.e.P-31 is present in fertilizer given to plants, the uptake of phosphorous can be traced by detectors. C-14 is used to map the path of carbon in metallic processes.
- I-131 haas uses both in detection and treatment of thyroid conditions. I-131 can be given in large doses to destroy some of the thyroid and reduce the production of thyroid.
- C-60 (cobalt) emits gamma radiation as it decays. Can be used at cancerous tumors. The rapidly growing cells of tumor are more likely to be killed by gamma rays rather than normal cells. Likewise, intense beams of gamma radiation can be used to irradiate foods to kill bacteria.
- Co-60 and Ce-138 are 2 of the elements used to produce gamma rays to treat anthrax bacilli.
- When Te-99 is given to patients with cancerous tumors it accumulates in the tumors. When radioisotopes are used for diagnostic purposes, it is advantageous if they have a short half life and are quickly eliminated by the body so they do not damage healthy tissue.
- **Industrial Applications:** Radioactive isotopes and gamma rays are absorbed in varying amounts will by different materials. The thicker the material, the more radiation that will be absorbed. x Radiation products can be used to measure the thickness
- Radiation Risks: Can be used to kill cancerous cells but can cause deaths, mutations. Nuclear power plants a poses certain problems, they contain many decay products and many have long half lives and is difficult to store and dispose of waste products. The 1936 accident at Chernobyl in Ukraine destroyed farmland that will probably be unusable for generations.