Physics Unit 3 - Radioactivity

Radioactivity	Becquerel (Bq)
Radiation (dose)	Sievert (Sv)
Length	Centimeter (cm)
Time	Hour, minute, seconds

Isotope: Atoms of the same element with the same number of protons but different number of neutrons.

One Becquerel = One atomic emission per second.

Sievert: Measure of amount of radiation and effect on the body.
- 1 Sv will not kill, but more at risk from dying of cancer after few years.
- 4 Sv likely fatal.
- 10 Sv fatal, stops gut and bone marrow from working.

Dose: Amount of energy absorbed per kilogram by the body.

Geiger-Muller are used to detect ionising radiations.

Alpha Particle: He_2^4

- Release of 2 neutrons and 2 protons (a helium nucleus)
- Ar of 4
- Charge of 2+

Beta Particle: e_{-1}^{0}

- High energy electron - A neutron turns into a proton and electron
- Ar of 1/1860
- Charge of 1-

Gamma Partice:

A wave radiation - high energy electromagnetic radiation.
Ar of 0
Charge of 0

Neutron Radiation: ${}_{0}^{1}n$

- High energy neutron
- Ar of ~~0~~ 1
- Charge of 0
- Penetrate further than other radiation

Physics Unit 3 - Radioactivity

Source:	Stopped by:
Alpha	Paper
Beta	Aluminium Sheet
Gamma	Thick Lead
Neutron	Thick concrete or water

Ionizing:

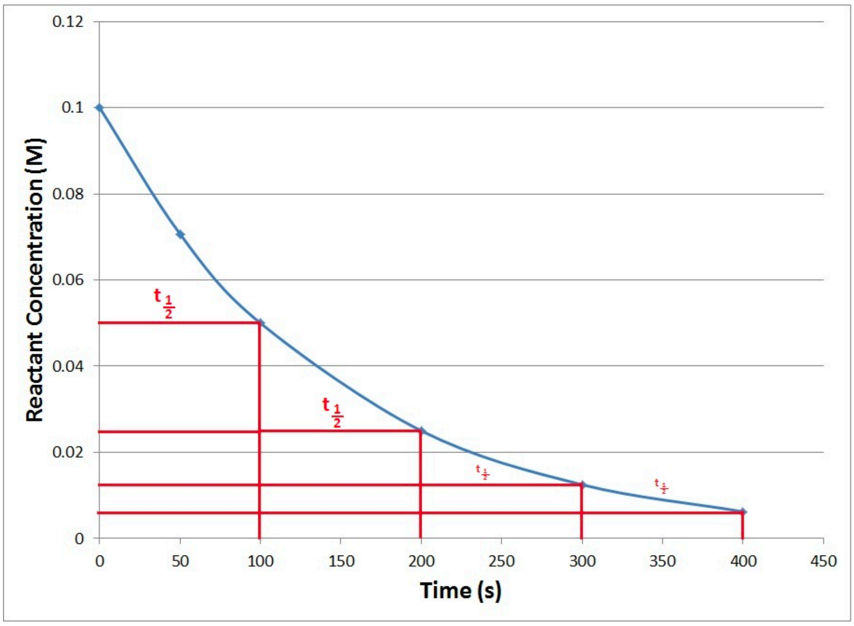
- Alpha, Beta, and Gamma can Ionize cells.
  - Can cause unusual chemical reactions, killing the cells.
  - Can also Ionize DNA molecules, causing them to split. This causes a mutation in the DNA, either killing the cell or cause it to become cancerous.

Source:	Effects:
Alpha	- Does not cause harm to body, as it is unable to penetrate or go through the body. - Dangerous if inside the body, as it is most ionizing.
Beta	- Can be harmful from the outside. - Less ionizing than alpha particles, and causes less damage.
Gamma	- Gamma rays are very penetrating, and can go through the body. - Denser material (like bone) can absorb the rays.

<u>Penetrating force</u> (weak to strong): Alpha —> Beta —> Gamma
<u>Ionizing effect</u> (weak to strong): Gamma —> Beta —> Alpha

Half-Life:

- The time it takes for half the atoms decay (from parent to daughter)
- The fraction left divides by two per half life.
- One half life is 1/2^1 and Two half life is 1/2^2 etc….
- Example graph:



Physics Unit 3 - Radioactivity

Uses of Radiation:

Smoke Alarm: Contains weak source of alpha particles. Alpha particles ionize the air. Smoke interacts with ions produced by alpha particles and ionization is reduced. Less current will flow through the air, detected by the alarm.

Paper milling: Used to control paper thickness in a paper mill. Small amount of Beta released by emitter radiation is picked up by paper. The thicker, the less Beta particles goes through to be detected by the detector. (also used for plastics, sheet steel, etc)

Detecting Cracks in pipe: Radioactive isotope is injected into water. A Beta emitter has to be used, to be detected above the ground (not gamma or alpha - absorbed). Check by a Geiger Muller and notifies place to dig. Isotope must have short half life to prevent contamination.

Sterilization: Gamma rays are used to kill bacteria, mould, and insects In food. It affects taste, but lengthens the shelf life. Gamma rays also used to kill bacteria on medical equipment. Useful with plastics equipment that would be damaged by heat sterilization.

Treat cancer tumours: Radiation source placed inside the patient. Alpha particles emitted and only penetrate a small distance into tissue to kill the tumor but not any further damage. Gamma radiation can also be used to kill tumors. Use low dose with short half life

Handling of Radioactive Sources:

Irradiated - when something is exposed to a radioactive source (when remove, not irradiated)
Contaminated - Radioactive isotopes go somewhere unwanted.

Radioactive materials are often very dangerous to handle without safety precautions as they can contaminate. Precautions include:
- Keep exposure time as short as possible.
- Monitor exposure with film dose badge.
- Label radioactive sources clearly.
- Store radioactive sources in lead lined containers.
- Wear protective clothing such as lead lined apron.
- Use tongs or a robotic arm to handle radioactive materials.
- Keep sources far from people, have a barrier between workers and radioactive sources.

- They can be disposed in unused mines or underground environments, away from humans.
- Can also be disposed in the ocean, as there is lots of volume.

Physics Unit 3 - Radioactivity

Nuclear Fission (splitting):
- Uranium 235, and plutonium 239 is a good example (nuclear reactors and weapons).
- Happens when a stable isotope is struck by a neutron. The isotope absorbs the neutron, becomes unstable, splits apart, and releases neutron particles and lots of energy (Not natural event)
- A very small mass change ($E=mc^2$ or Energy = mass・$(3 \times 10^8)^2$)

Nuclear Reactor:
- Chain reaction: Sequence produced when nuclear fission reaction triggers more reactions.
- Control Rod: Rod lowered into core of a reactor to absorb neutrons and slow chain reaction.
- Core: Main part of nuclear reactor made of moderator, fuel rods, control rods.
- Daughter Nuclei: Nuclei produced when unstable nucleus splits into two during fission.
- Fuel Rods: Rod containing nuclear fuel for nuclear reactor.
- Moderator: Substance in reactor that slows down neutrons to be absorbed by fuel easily.

- A neutron emitted and hit the nucleus causing it to become unstable. Splits and releases lots of energy, along with neutron particles to cause a chain reaction.
- Core of reactor has pipes containing a coolant, that heats up as it flows through core and sent to a heat exchanger. The exchanger energy transfered to heat. Water heats up to steam and spins turbine to produce electricity.

Cons of Fission:

- Can cause mutations in living organisms.
- Radiation can damage cells and tissues.
- Produces nuclear waste - used for making of nuclear weapons.

Nuclear Fusion:

- Small nuclei joining together to form larger nuclei and release energy.

ex. Sun: Hydrogen nuclei fuse to form helium nuclei releasing lots of energy.

- Needs <u>very high pressure and temperature</u> to occur - enough energy to overcome electrostatic repulsion between protons. Lots of energy —> more movement.

- Possible fusion on Earth:

$$^2_1H + ^3_1H \rightarrow ^4_2He + ^1_0n$$

deuterium + tritium → fusion → helium + neutron

- Could be used to produce energy - to do fusion on earth, 6x the hotter than sun core as less pressure on earth.
- Fusion Power Stations: Hydrogen plasma squeezed to produce helium and high energy neutrons. Energy than transfered by water cooling loop and spin turbine.

Advantage:
- Abundant Fuel - Deuterium from water and Tritium from lithium
- Small amount of fuel - 10g of Dt and 15g of Tr make energy for lifetime of avg. person.
- Clean and safe
- Less radioactive waste.
- No weapons material produced.