

Radiopharmaceuticals

ISOTOPES

Nuclides having the same number of protons but different number of neutrons are termed as isotopes

The nuclides which undergo spontaneous nuclear change so as to attain stability by emitting radioactivity are termed as radionuclides or radio isotopes.

Half life of radioelement:

Units of radioactivity are curie, roentgen, RAD, REM.

If certain amount of radionuclide is taken and number of disintegrations per second is measured, then after certain time, half of original atoms would have got disintegrated and only half original active atoms left behind. The decay time to its half is constant irrespective of quantity present. This time is called half life of the radionuclide. Half life $t_{1/2} = 0.693/\lambda$

$\lambda =$

Eg. polonium 212 = 3×10^{-7} sec

Half will decide the its utility in medicine

Properties of alpha rays

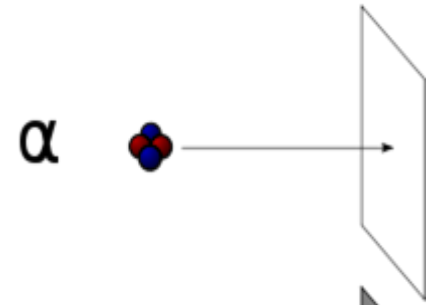
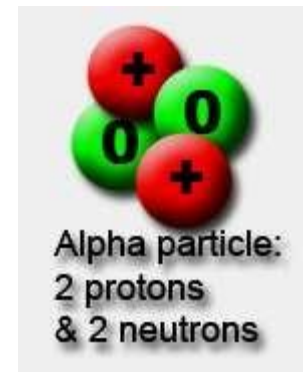
Alpha particles carry positive charge of proton which is equal to the charge of He nucleus. Mass is roughly 4 times that of hydrogen atom i.e., equal to mass of He nucleus

- Alpha particles are deflected by electric and magnetic fields
- The velocity of alpha particle ranges between $1.4 \times 10^7 \text{ m/s}$ to $2.1 \times 10^7 \text{ m/s}$ depending upon source emitting it
- Because of large mass the penetrating power is very low compared to other emissions
- Alpha particle have large ionizing power .it produces thousands of ions before being absorbed

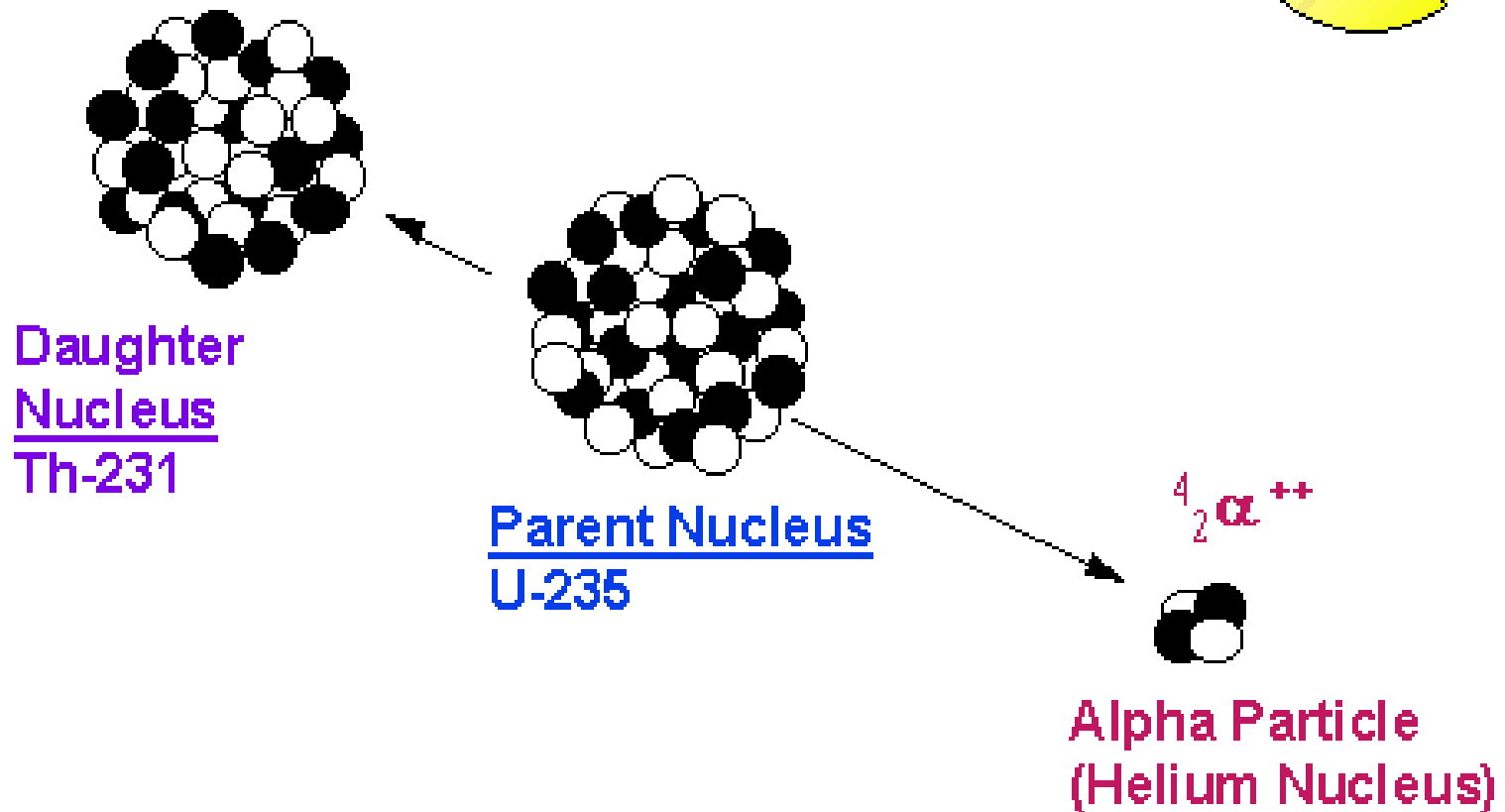
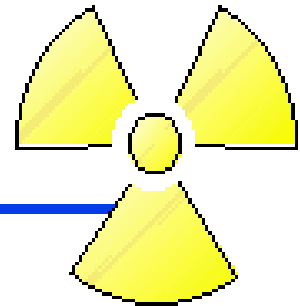
- Range of alpha particles in air depends on radioactive source producing it
- Alpha particles produce fluorescence in certain substances like Ba-platinocyanide and zinc sulphide
- Alpha particles are scattered while passing through thin metal foils

1- Alpha particle decay:

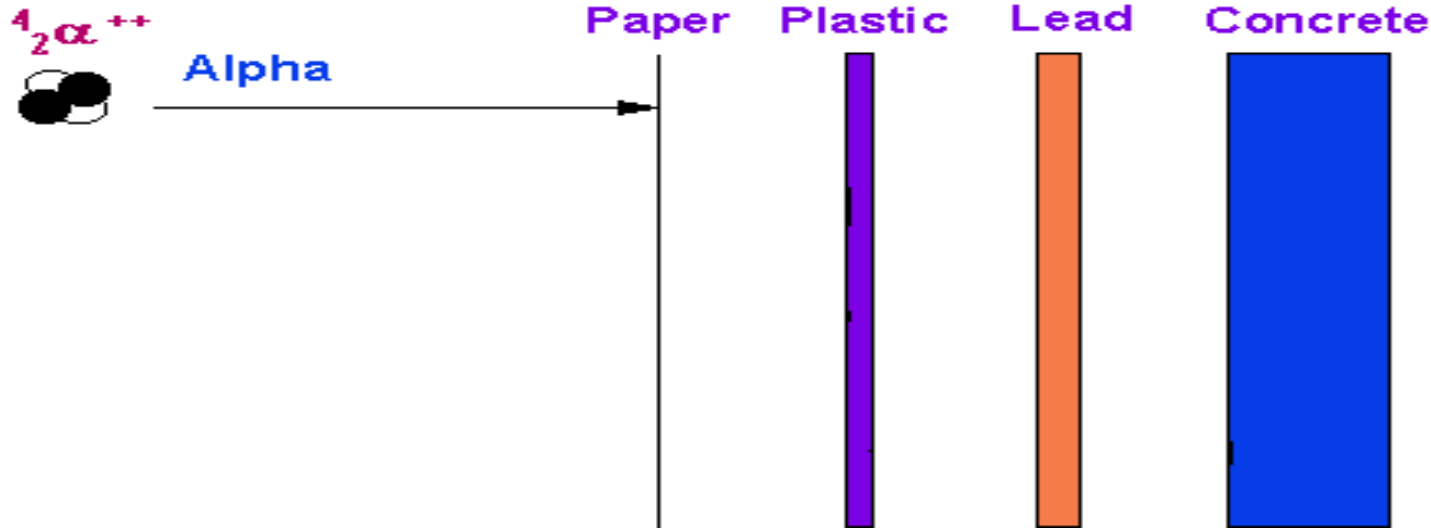
- Alpha particles are made of **2 protons and 2 neutrons**.
- We can write them as ${}^4_2\alpha$, or ${}^4_2\text{He}$, because they're the same as a helium nucleus.
- This means that when a nucleus emits an alpha particle, its atomic number decreases by 2 and its **atomic mass decreases by 4**.
- Alpha particles are relatively **slow** and **heavy**.
- They have a **low penetrating power** - you can stop them with just a sheet of **paper**.
- Because they have a large charge, alpha particles ionise other atoms strongly.
- Alpha-decay occurs in very heavy elements, for example, **Uranium and Radium**.



Alpha Particle Radiation



Penetrating Distances



Since alpha particles cannot penetrate the dead layer of the skin, they do not present a hazard from exposure external to the body.

However, due to the **very large number of ionizations** they produce in a very short distance, alpha emitters can present a serious hazard when they are in close proximity to cells and tissues such as the lung. Special precautions are taken to ensure that **alpha emitters are not inhaled, ingested or injected.**

2- Beta particle decay:

- Beta particles have a charge of **minus 1**. This means that beta particles are **the same as an electron**.

We can write them β^- or e^- , because they're the same as an electron.

- This means that when a nucleus emits a β^- particle: **the atomic mass is unchanged**
the atomic number increases or decreases by 1.

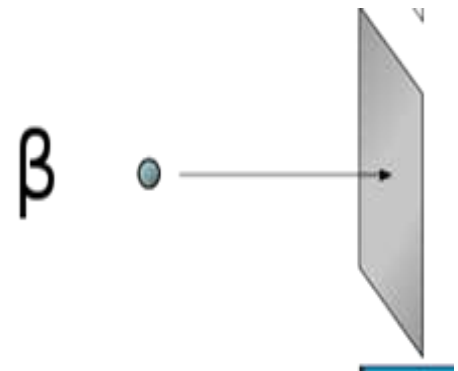
- They are **fast, and light**.

- Beta particles have a **medium penetrating power** - they are stopped by a sheet of **aluminium**.

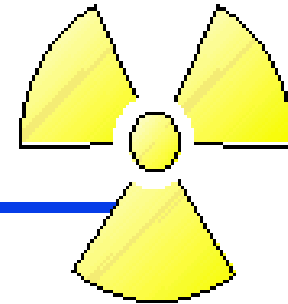
- Example of radiopharmaceutical emits **phosphorus-32**,

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- Beta particles ionise atoms that they pass, but not as strongly as alpha particles do.



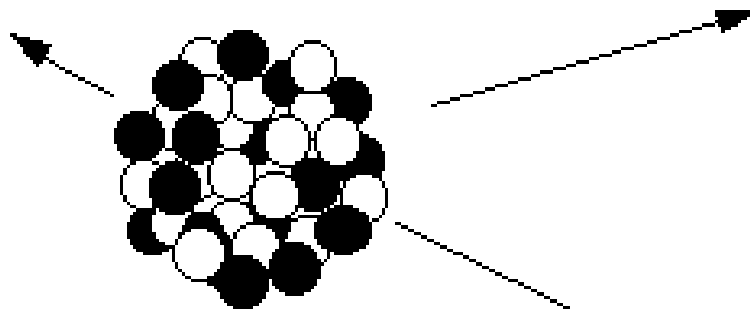
Beta Particle Radiation



Daughter
Nucleus
Calcium-40



Antineutrino

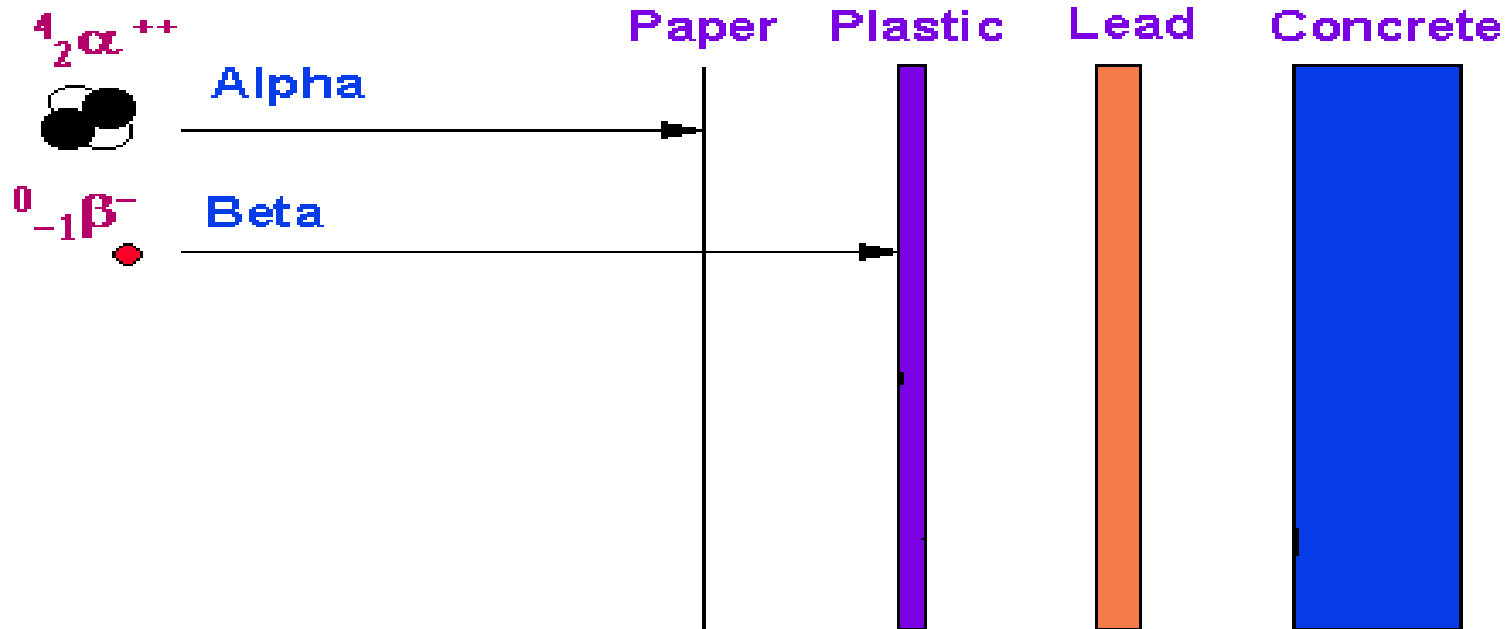
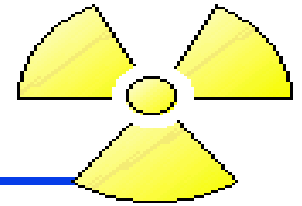


Parent Nucleus
Potassium-40



Beta Particle

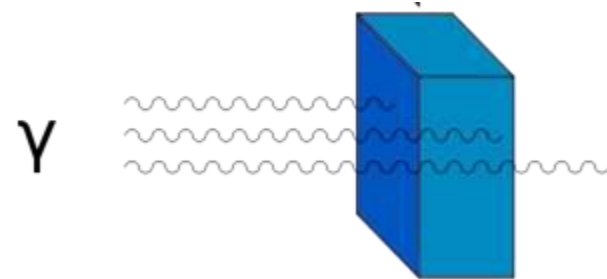
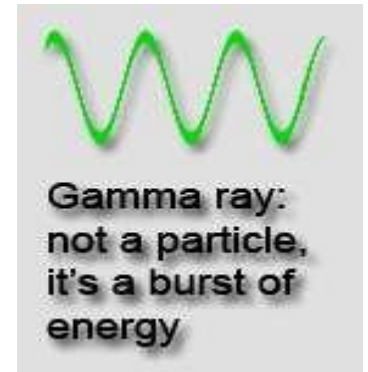
Penetrating Distances



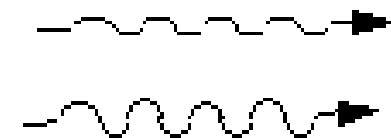
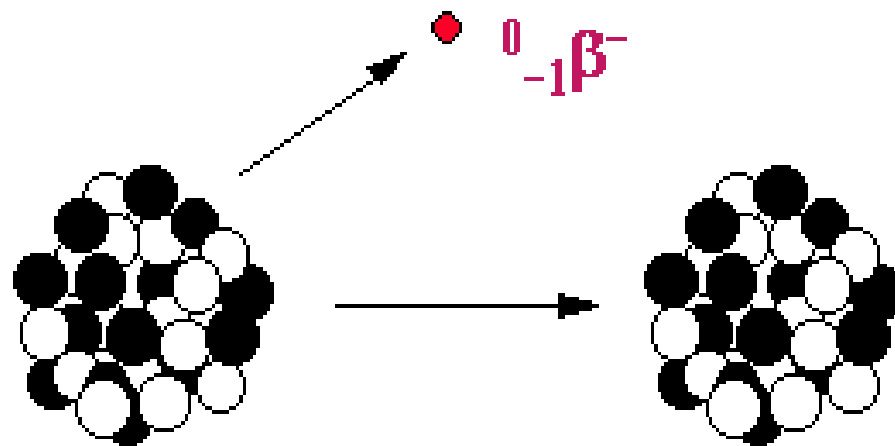
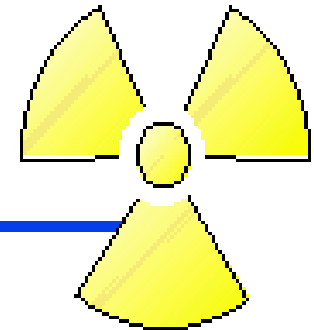
Beta particles are *much less massive and less charged* than alpha particles and *interact less intensely* with atoms in the materials they pass through, which gives them a longer range than alpha particles.

3- Gamma ray:

- Gamma rays are **waves, not particles**. This means that they have **no mass and no charge**.
- **in Gamma decay:**
 - **atomic number unchanged**
 - **atomic mass unchanged**.
- Gamma rays have **a high penetrating power** - it takes a thick sheet of metal such as **lead** to reduce them.
- Gamma rays do not directly ionise other atoms, although they may cause atoms to emit other particles which will then cause ionisation.
- We don't find pure gamma sources - gamma rays are emitted along side alpha or beta particles.



Gamma-Ray Radiation

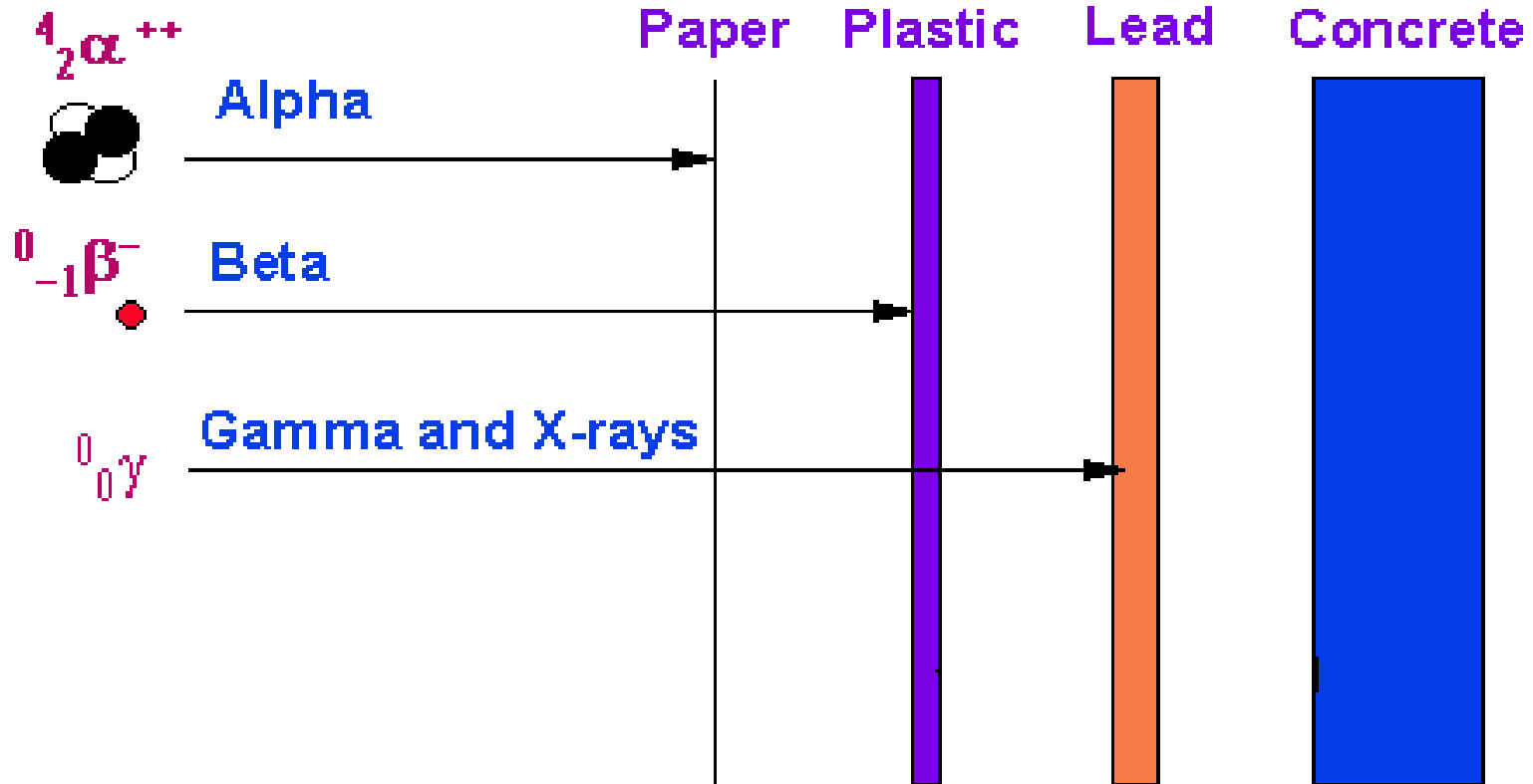
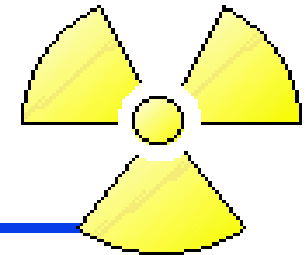


Gamma Rays

Parent Nucleus
Cobalt-60

Daughter Nucleus
Ni-60

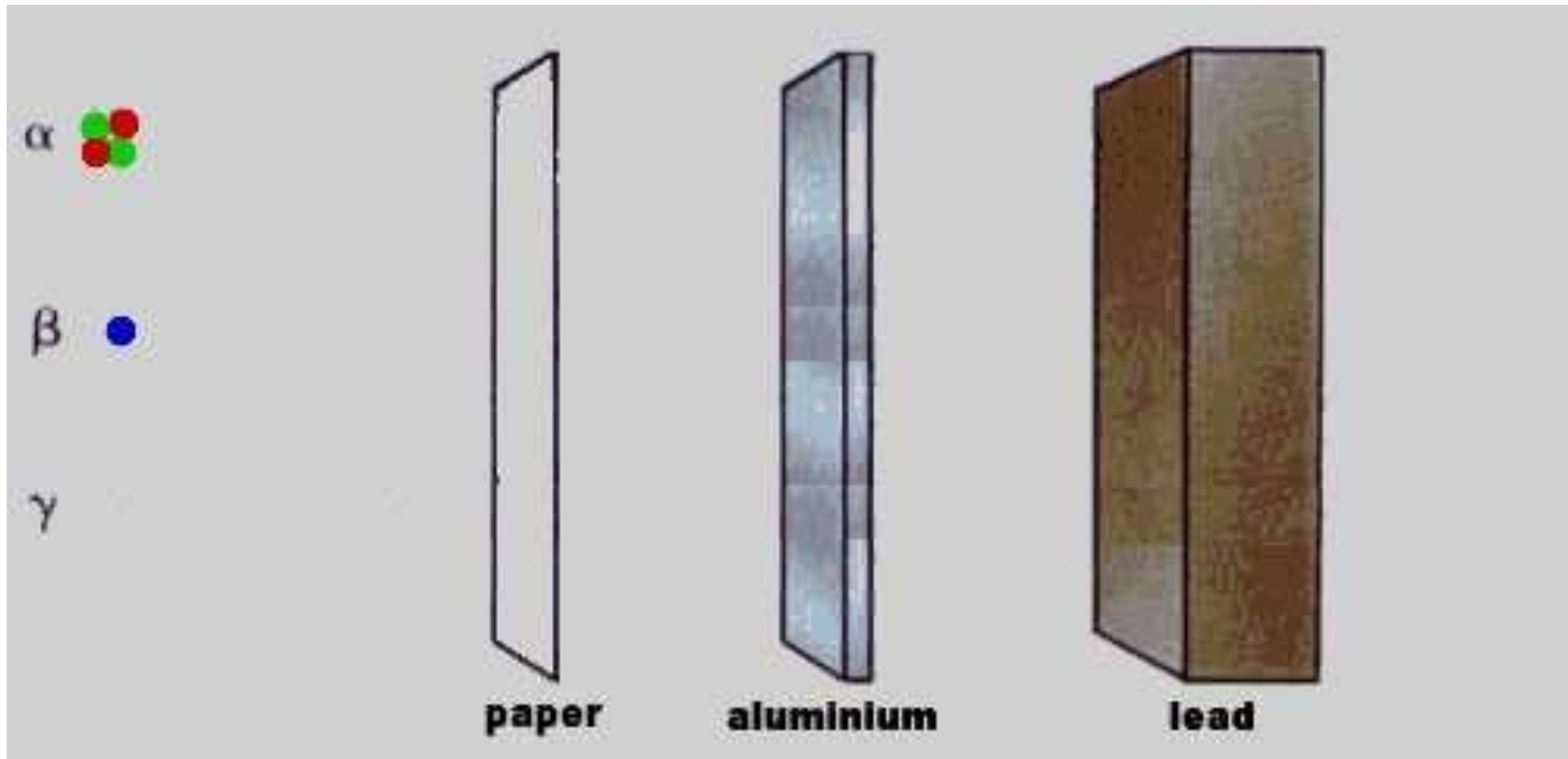
Penetrating Distances



3- Gamma ray:

- Useful gamma sources include **Technetium-99m**, which is used as a "tracer" in medicine.
- This is a combined beta and gamma source, and is chosen because betas are less harmful to the patient than alphas (**less ionisation**) and because Technetium has a **short half-life** (just over 6 hours), so it decays away quickly and reduces the dose to the patient.

Alpha particles are easy to stop,
gamma rays are hard to stop.



Mode of radioactive decay:

Type of Radiation	Alpha particle	Beta particle	Gamma ray
Symbol	${}^4_2\alpha$ or ${}^4_2\text{He}$	β^-	γ
Charge	+2	-1	0
Speed	slow	fast	Very fast
Ionising ability	high	medium	0
Penetrating power	low	medium	high
Stopped by:	paper	aluminium	lead

Production of radionisotopes

- Reactor irradiation-fissionable material(uranium) taken In moderator and neutron fluxing on uranium forms isotopes.
- Cyclon Irradiation-Bambarding of atoms causes generation of radioactive isotopes.

Measurement of radioactivity

- 1. Ionization of Chamber-Ionization chamber filled with gases and fitted with two electrodes. When radiation passes over it, causes ionization of gas molecules and forms ions. that ions moves to cathode and anode and produce electricity. According electricity ampilcity determines radioactivity
- 2. Proportional counters-in this application of potential electones causes bursting of gases and forms more electron. This electron moves to anode. Generates electric current. Showes radioactivity in terms of curie.
- 3. Geiger-Muller counter-These are most popular Radiation detectors. They can detect alpha, beta, gamma radiation. Geiger Muller contains chamber filled with gas under low atmospheric pressure. Ionization of gas molecule by radiation forms electric current. electric current showes activity in terms of curie

Handelling and storage of Radioactive isotopes

➤ Precaution during handling and storage of radioactive substances

1. One should not touch radioactive emitter with hand but it should be handeled by means of foreceps
2. Smoking,eating and drinking activity should not be done in laboratory where the radioactive materials handeled
3. Sufficient protective clothing have to be used while handling the materials
4. Radiactive materials have to be stored in suitable labelled containers,shielded by lead bricks
5. Area where radioactive materials have to been stored or used should be monitored.
6. Disposal of radioactive materials should be carried out with great care

Application of Isotopes

1. Radiation source in therapy-it produces destructive role because radiation has ability to cause radiation.they destruct cancerous cell by ionization.e.g Sodium phosphate is(^{32}p) used in therapy of blood cancer
2. Diagnostic purposes-Labeled cyanocobalamine finds use for measuring glomerular filtration rate and sodium rose bengal used in liver function test
3. Research-In research isotopes are used as tracers
4. Sterilization-Radiation are use in sterilization of instrument in hospital and final packed container.Radiation cause ionization of bacteria,viruses,fungi,pathogenic bacteria.Hence it is used in sterilization.e.g Cesium used for sterlization of surgical instrument.
5. Determination of hypothyroidism and hyperthyroidism

Radio-Opaque contrast media

- ❑ **Defination** -are the substances having property of casting shadow on x-ray films. These substances are having ability to stops X-ray and hence appear opaque on x-ray examination.such preparation is known as x-ray contrast media.
- ❑ X-ray passes through high atomic number.The bone is very harder hence by passing x-ray gives x-ray film image.hence it is used for diagnosis
- ❑ But soft tissue having less atomic number can able to pass x-ray hence we cant take x-ray of soft tissue.hence for imaging or casting the x-ray of soft tissue the radio-opaque contrast media are used
- ❑ These compounds administered by systemic i.e orally and intravenously
- ❑ These compounds have been successfully for examination of gastrointestinal tract,kidney,liver,gall bladder,blood vessels of heart
- ❑ E.g Barium Sulphate
- **Classification of Radio-opaque contrast media**
 1. Water soluble contrast media
 2. Water insoluble contrast media

Ideal requirement of radio-opaque contrast media

1. It should have high solubility
2. It should have high stability
3. It should not have any pharmacological effects
4. It should excrete rapidly with no toxic effects
5. It should stay in the body for sufficient x-ray visualisation
6. It should concentrate selectively in the concerned organs
7. It should have adequate radio-opacity

Barium Sulphate

Synonym - barium meal, shadow meal

Molecular formula- BaSO_4

Molecular wt-233.4

Properties-Fine, odourless, tasteless, odourless, free from grittiness. It is insoluble in water

Storage-It should be stored in a well closed container

Use-Barium sulphate is a diagnostic drug which is used medicinally in x-ray examination. It is administered by enema before x-ray examination in the form of barium meal to make intestine opaque to x-ray examination