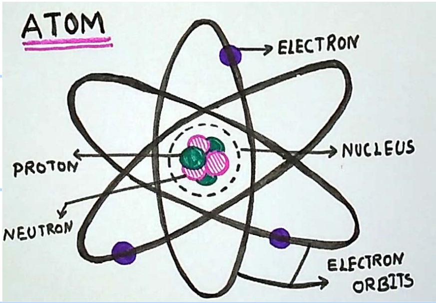
Nuclear Physics (Atomic Physics)

Structure of an Atom.

Particles	Relative Charge	Relative Mass
Proton	+1	1
Neutron p e^-	0	1
Electron.	-1	$\frac{1}{1840}$



Isotopes & Radioactive Decay

atomic mass ← 4
atomic number ← 2

$^{4}_{2}He$

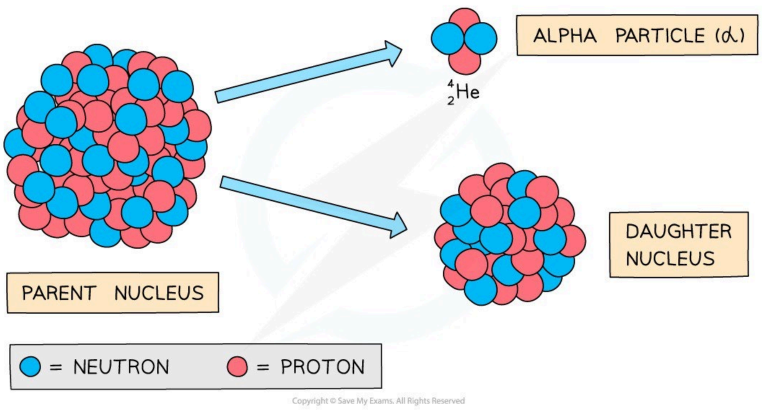
different mass number ← 5

$\boxed{^{5}_{2}He}$ → Isotope of helium

same proton number

Isotopes : Same element with same proton number but different neutron number

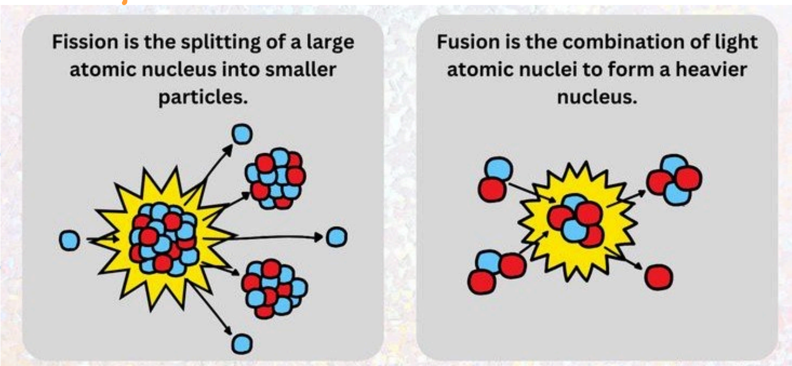
Radio active Decay: When an unstable nucleus emits radiation to become stable.



Nuclear Reactions

${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He$

Fission Fusion



Examples of Fussion & Fission

Fission: ${}^{235}_{95}U + {}^{1}_{0}n \rightarrow {}_{56}Ba + {}^{92}kr + 3\,{}^{1}_{0}n$

Fusion: ${}^{2}_{1}H + {}^{3}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{0}n$

Radioactive Emissions

Type	Description	Equivalent	Symbol	Penetrating Power
Alpha	Dense (+) charged particle	Helium nucleus	${}^{4}_{2}He$ (α)	Stopped by thick paper
Beta	(-) charged particle	High speed electron	${}^{0}_{-1}e$ ${}^{0}_{-1}\beta$	Stopped by 6mm of Al
Gamma	Type of energy	High energy photons	${}^{0}_{0}\gamma$	Stopped by several cm of Pb

Property	α-particles	β-particles	γ-rays
Nature	Particle consist of 2 protons & 2 neutrons	Fast-moving electrons	High frequency electromagnetic radiation
Range in air	A few cm	A few m	A few hundred m
Charge	Positive (+2)	Negative (-1)	No charge
Mass	High	Low	No mass
Speed	Up to 10% speed of light	90% speed of light	Speed of light
Ionising effect (ions per mm in air)	Strong (10^5)	Weak (10^2)	Very weak (1)
Relative penetrating power	Skin or thin sheet of paper - has a range of few centimetres in air	Thin aluminium - has a range of several metres in air	Thick lead or concrete - has a range of 120 metres in air

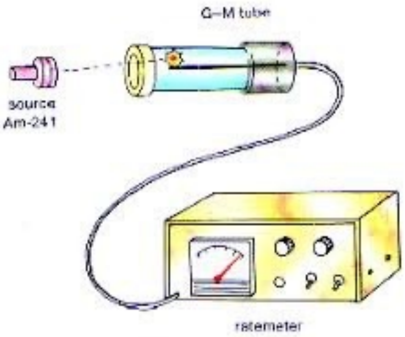
How do Beta decay work?

${}^{14}_{6}C \rightarrow {}^{0}_{-1}\beta + {}^{14}_{7}N$

$14 = 0 + y$ $6 = -1 + x$

$y = 14$ $x = 7$

How to detect background radiation?



Geiger-Muller (GM) tube.

Sources of Background radiation.

(i) Cosmic Rays (Sun)

(ii) Radon gas in Air

(iii) Underground Rocks & Buildings.

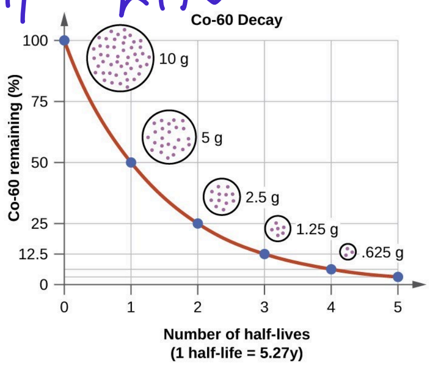
Nature of Radioactive Decay.

(i) It decreases over time

(ii) It's Random

(iii) It's spontaneous & random.

Half-Life



Definition: time taken for number of unstable nuclei to decrease by half.

Equation: $N(t) = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$

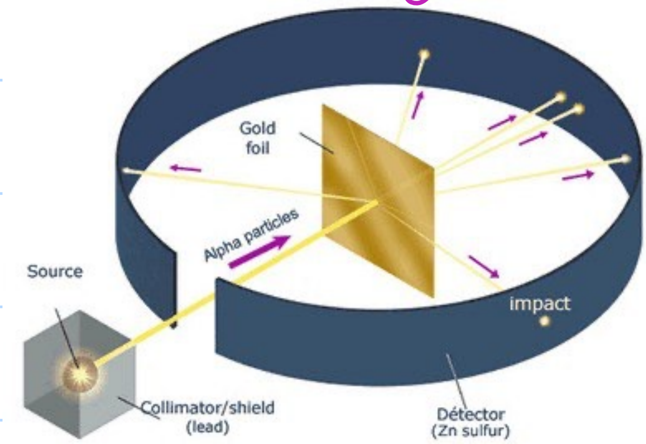
$N(t)$: quantity of the substance remaining

N_0: initial quantity of the substance

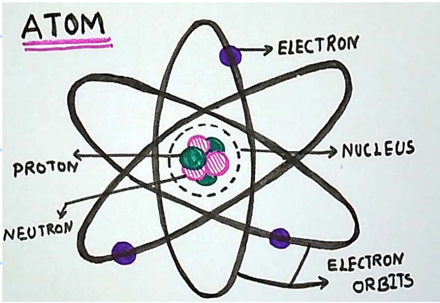
t: time elapsed

$t_{\frac{1}{2}}$: half-life of the substance.

Alpha Scattering Experiment



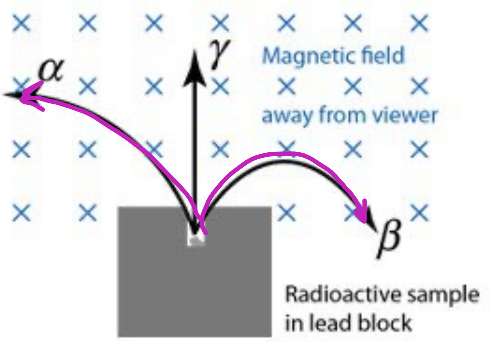
Observation	Description	Proof of atomic model
Most α-particles	Passed through the gold foil without deflection.	Atom is mostly empty space.
Some α-particles	Deflected at small angles.	Presence of a dense, positively charged nucleus which repels the α-particles
Approximately 1 in 8000 α-particles	Deflected back towards the source at large angles.	Nucleus is very small and dense compared to the rest of the atom.

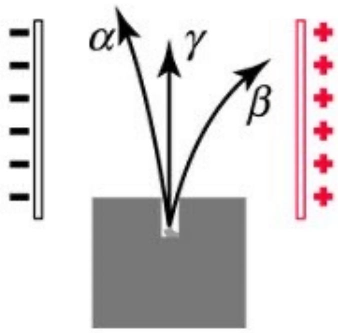


Conclusions

- Positively charged nucleus of an atom
- Atoms are mostly empty space.
- Negatively charged electrons orbiting at a great distance.

Interaction of radiation in magnetic fields and electric fields.





Use:

Fleming's left: Alpha particles (α)

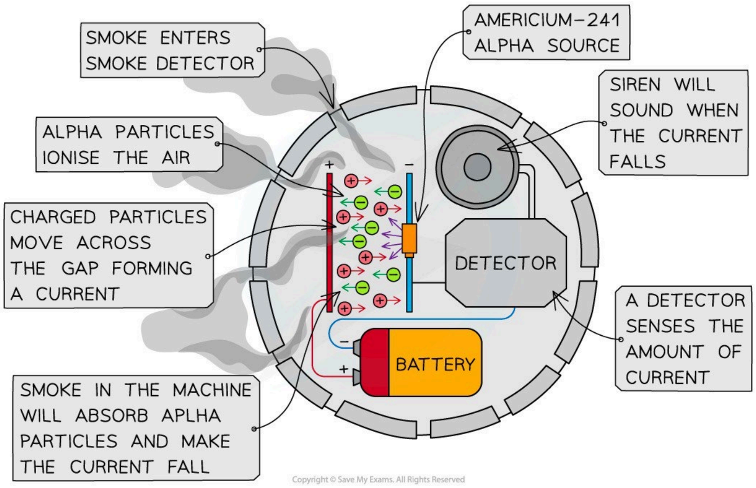
Fleming's right: Beta particles (B)

Gamma (γ) no interaction with magnetic & electric fields.

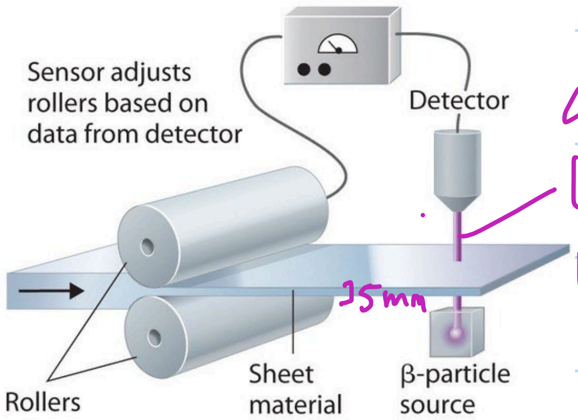
Application of Radioactivity.

- Smoke Detectors
- Sterilization of medical equipment
- Irradiating food
- Treatment of cancer using Gamma rays (radiotherapy)
- Thickness Measurement of Paper/Aluminum foil
- Checking for broken underground pipes

Aplication of Alpha particles (α) Smoke detectors



Aplication of Beta particles (β) Material Meassurement



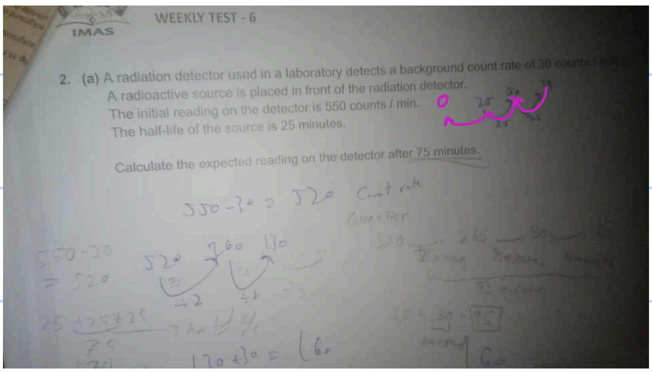
9 counts
10 counts
11 counts

w < 5mm
w > 5mm

Safety Precautions

- Safe storage of radioactive material (lead boxes)
- Reducing exposure time
- Increasing distance between source & living tissue (use tongs)
- Using shields to absorb radiation.

Tongs



WEEKLY TEST - 6

2. (a) A radiation detector used in a laboratory detects a background count rate of 30 counts / min.
A radioactive source is placed in front of the radiation detector.
The initial reading on the detector is 550 counts / min.
The half-life of the source is 25 minutes.

Calculate the expected reading on the detector after 75 minutes.

$550 - 30 = 520$

$N(t) = 520\left(\frac{1}{8}\right)$

$N(t) = \boxed{65 \text{ counts}}$

$N(t) = 65 + 30$

$= 95$ counts

$\boxed{\boxed{95}}$