CH # Nuclear physics:

That branch of physics in which we study Nucleoi, their Structures & properties is Called Nuclear physics.

* Any Nucleus is represented by X.

$_{Z}X^{A}$ ——▶ Nuclide

A = Mass NO/ Nucleon No:-

Z = Charge NO / Number of proton.

[redacted].

Nuclide:- A nuclus with Known charge & mass no.

Average Atomic Size ~ 10^{-10} m

" Nuclear Size ~ 10^{-15} m

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Nuclear Isotopes:- Nuclei of the same elements having same Z but different A's is called Nuclear Isotopes.

Z = 1
A = 1 (P) $_1H^1$ → Protium

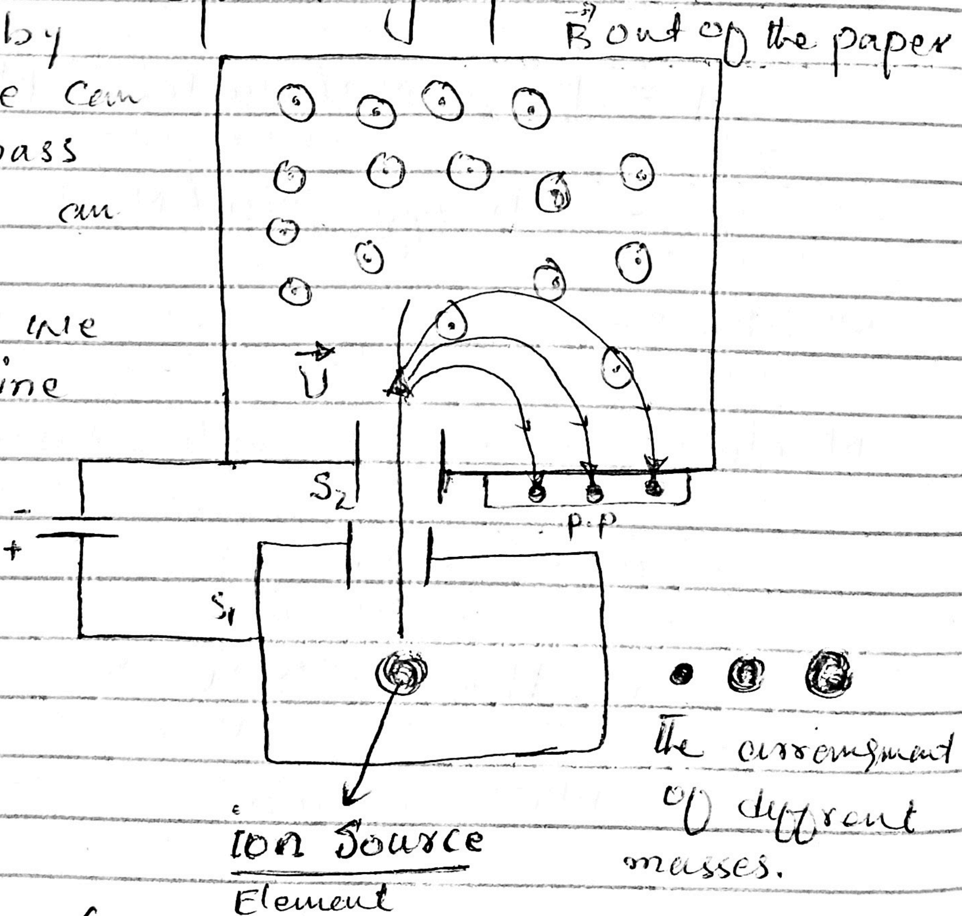
Z = 1
A = 2 (P N) $_1H^2$ → Deutrium

Z = 1
A = 3 (P N N) $_1H^3$ → Tritium

Exam Ques

Mass Spectrometre / Mass Spectrographer:-

A device by which we can detect mass spectra of an element.
OR By which we can determine the nuclear Isotopes of an element.



$$F_c = \frac{mv^2}{r} \quad \text{---(1)}$$

$$\vec{F}_m = q(\vec{v} \times \vec{B})$$

$$\vec{F}_m = qVB\sin\theta\,\hat{n}$$

$$\vec{F}_m = qVB\sin(90^\circ) \quad (V \,\&\, B \text{ are at } 90^\circ)$$

$$F_m = qVB \quad \text{——— (ii)}$$

Compare (i) & (ii):

$$qVB = \frac{mv^2}{r}$$

$$qB = \frac{mv}{r}$$

$$\boxed{r = \frac{mV}{qB}} \quad \text{——— (iii)}$$

This eq shows Circular trajectory.

<u>For V</u>:-

$$K.E = \frac{1}{2}mv^2 \quad \text{——— (iv)}$$

Also $K.E = qV$ ——— (v)

compare (i) & (ii)

$$\frac{1}{2}mv^2 = qV$$

$$v = \sqrt{\frac{2qV}{m}} \quad \text{——— (vi)}$$

put (vi) in (iii)

$$r = \frac{m}{qB}\sqrt{\frac{2qV}{m}}$$

$$r = \sqrt{\frac{2qVm^2}{q^2B^2m}}$$

$$r = \sqrt{\frac{2Vm}{qB^2}} \quad \text{--- (VII)}$$

Different spots shows Different radii. Different radi shows different masses. Diffrent masses shows different Isotopes.

For m :-

$$m = \frac{qB^2r^2}{2V}$$

Nuclear Masses :-

* amu → U (unified Mass Scale)

Mass of 1 mole of ${}_6C^{12}$ nuclus = 12 gm

Mass of 6.023×10^{23} Nucleoi ${}_6C^{12}$ nuclus = 12 gm

Mass of 1 Nuclous of ${}_6C^{12}$ = $\frac{12 \text{ gm}}{6.023 \times 10^{23}}$

Mass of 1 Nucleon of ${}_6C^{12}$ = $\frac{12 g}{12 \times 6.023 \times 10^{23}}$
proton

$$1 \text{ amU} = \frac{1}{6.023 \times 10^{23}}$$

Mass of one Nucleon of $_6C^{12}$ = 1 amu

$1 \text{ amu} = 1.66 \times 10^{-24}$ gm

$1 \text{ amu} = 1.66 \times 10^{-27}$ kg ⇒ Mass of proton.

The Reseprocal of Avogadro's number is called 1 amu.

OR The mass of one Nucleon of $_6C^{12}$ is called one amu.

OR, The mass of one proton is called one amu.

$1 \text{ amu} = 1.66 \times 10^{-27}$ Kg

As

$$E = mc^2$$

$$= (1 \text{ amu})\, c^2$$

$$= (1.66 \times 10^{-27})(3 \times 10^8)^2$$

$$= 1.66 \times 10^{-27} \times 9 \times 10^{16}$$

$$1 \text{ amu} = 1.494 \times 10^{-10} \text{ J}$$

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

(5) 9
(5)
9⁄
(1.494)

1

$$1\ amu = \frac{1.494 \times 10^{-10}}{1.6 \times 10^{-19}}\ eV$$

$$1\ amu = 931 \times 10^{6}\ eV$$

$$\boxed{1\ amu = 931\ MeV}$$

931MeV is the rest mass energy of one proton.

So, "amu is also the unit of energy"

Because mass and Energy are one & the same thing.

Exam Ques

Mass Defect (Deficit) & Binding Energy:-

* Defect ⇒ "Decrease in Mass"

$$\Delta M = (ZM_p + NM_n) - M \quad \text{—— (1)}$$

(M → Nucleus)

The Difference b/w the total mass of the nucleons in free state & the mass of the nucleus is called mass defect (Deficit).

~~Called Mas~~

Binding Energy :-

The Energy required to break a Nuclous into its Constituent particles (Nucleons) is Called Binding Energy.

OR,

The Energy relased during the formation of a Nuclous is called Binding Energy.

$$E_B = (\Delta M) c^2 \quad \text{—— (ii)}$$

put (ii) in (i):

$$E_B = \left[(ZM_p + NM_n) - M \right] c^2 \quad \text{—— (iii)}$$

The Energy Associated with the mass defect is Called Binding Energy.

$$\boxed{E_B = (\Delta M) c^2} \quad (*)$$

The energy equivalence of Mass defect is Called Binding energy.

$_6C^{12} = \frac{1}{12}^{th}$

As,

$$E_B = \left[\left((ZM_p + NM_n) - M\right)c^2\right]$$

÷ B.S by A...

$$\frac{E_B}{A} = \left[(ZM_p + NM_n) - M\right]\frac{c^2}{A} \quad \text{--- (S)}$$

$$\frac{E_B}{A} = \frac{B.E}{Nucleon}$$

* It is called Binding fraction or packing fraction

$\frac{E_B}{A} = f$ — put in (S)

$$f = \left[(ZM_p + NM_n) - M\right]\frac{c^2}{A}$$

(PP NN)

$$f = \frac{20\,MeV}{4} = \frac{5\,MeV}{Nucleon}$$

Nucleoi are of three types:-

(i) Light Nucleoii
(ii) Heavy Nucleoi — f is Less (UNSTABLE)

(iii) Moderate Nucleoi — f is greater (STABLE)

(i) 

Heavy Nuelous

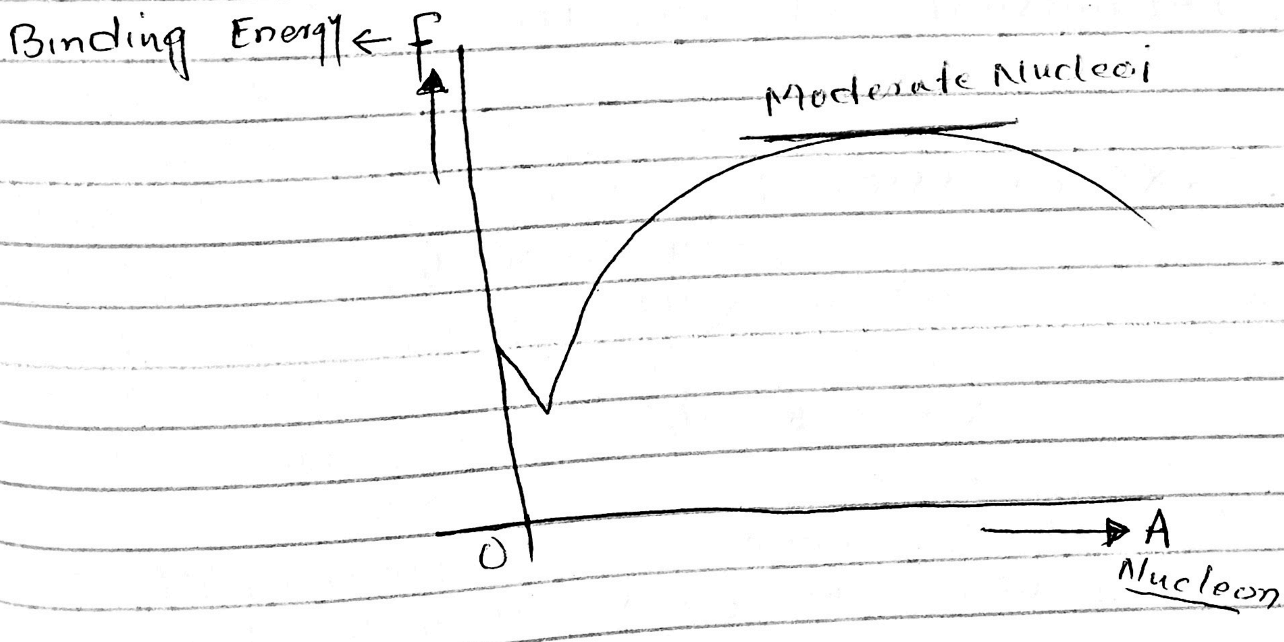
More repulsion b/w proton. So It's Binding Energy is less. It can be easily Break down...

(ii) 

Surface effect

Because Nucleon are at the Surface when Nucleoi is light, and less Nucleon are at the surface, So, attraction decreases and hence Binding Energy decreases.

(iii) Moderate Nucleoi Having High Binding Energy ⟹ They are more Stable.



* 29 Dec 2017 *

Natural Radioactivity :-

$Z > 82 \Rightarrow$ Unstable $\Rightarrow$ Radiactive.

~~b α Emissio~~

Nucleoi which radiate α, β & γ radiation without any external Agency are Called Radioactive nucleoi & the process is Called Radioactivity.

1. α - Emission ⇒ Positively charged
2. β - Emission ⇒ Negatively charged
3. γ - Emission ⇒ Photon, Neutral...

1. α - Emission :-

$\alpha \Rightarrow$ (2P, 2N) $A = 4$, $Z = 2$

$\alpha \longrightarrow {}_2He^4$

α-particle consist of 2 Neutron & 2 proton Becz Nuclons having a potential barrier which is overcomed by 2 proton &

2 Neutron... [MCQ]

$$ {}_{Z}X^{A} \longrightarrow {}_{Z-2}X^{A-4} + {}_{2}He^{4} $$

$$ {}_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_{2}He^{4} $$

$$ {}_{88}Ra^{226} \longrightarrow {}_{86}Rn^{222} + {}_{2}He^{4} $$

2. **β - Emission:-** There are two types of β - emission...

(a) ${}_{-1}\beta^{0} \rightarrow$ Electron

(b) ${}_{+1}\beta^{0} \rightarrow$ positron

$$ {}_{Z}X^{A} \longrightarrow {}_{Z+1}X^{A} + {}_{-1}\beta^{0} + \bar{\nu} $$

$\bar{\nu}$ → Anti-Neutrino (bar → Anti)
* In order to conserve momentum...

* The mass of β - particle is not zero bt its mass no. is zero.

$$ {}_{Z}X^{A} \longrightarrow {}_{Z-1}X^{A} + {}_{+1}\beta^{0} + \nu $$

ν → Neutrino
* spin is opposite to $\bar{\nu}$

Nutron:-

Mass ← 1, charge ← 0

$${}_0n^1 \longrightarrow {}_1P^1 + {}_{-1}\beta^0 + \bar{\nu}$$

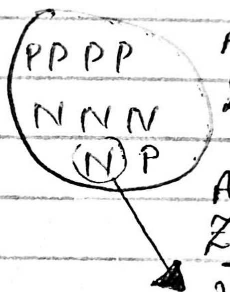
Proton:-

$${}_1P^1 \longrightarrow {}_0n^1 + {}_{+1}\beta^0 + \nu$$

$$Th \longrightarrow {}_{91}Pa^{234} + {}_{-1}\beta^0 + \bar{\nu}$$

$${}_6C^{14} \longrightarrow {}_7N^{14} + {}_{+1}\beta^0 + \bar{\nu}$$

$${}_6C^{11} \longrightarrow {}_5B^{11} + {}_{+1}\beta + \nu$$



$A = 10$
$Z = 4$

$A = 10$
$Z = 5$

$\bar{\nu} + {}_{-1}\beta$

(iii) γ- Emission :-

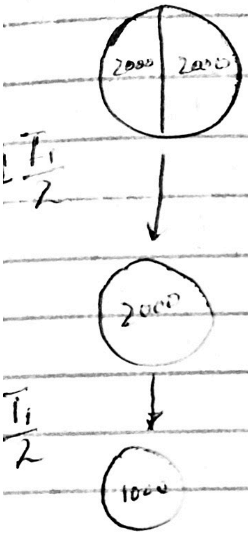
γ- rays are photon.

* Rest mass & charge is zero.

$$({}_ZX^A)^* \longrightarrow {}_ZX^A + \gamma\text{-rays}$$

Half Life :-

The time taken by a radioactive Sample to disintegrate Into its half is Called Half Life.



* Half life is a parametre.
* It is probability (chance)....

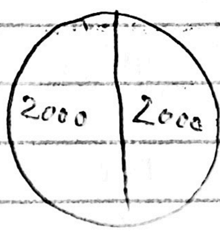
Half life	No. of atoms remaining	Disin No. of atoms
$1 \frac{T_1}{2}$	$\frac{N_0}{2}$	$\frac{N_0}{2}$
$2 \frac{T_1}{2}$	$\frac{N_0}{4}$	$\frac{3N_0}{4}$
$3 \frac{T_1}{2}$	$\frac{N_0}{8}$	$\frac{7N_0}{8}$
$4 \frac{T_1}{2}$	$\frac{N_0}{16}$	$\frac{15N_0}{16}$
$5 \frac{T_1}{2}$	$\frac{N_0}{32}$	$\frac{31N_0}{32}$

Exam ques

Law's of Radioactive Disintegration:

This law states that

" The time rate of desintegration of a readioactive Sample is dirrectly proportional to the no. of atoms present at any time "t".



$T_{\frac{1}{2}} = 10s$ $\qquad$ $T_{\frac{1}{2}} = 10sec$

$\frac{1000}{10s} = \boxed{\frac{100 \text{ atoms}}{sec}}$ $\qquad$ $= \boxed{\frac{200 \text{ atoms}}{sec}}$

Rate of desintegration:

Decrease
Decay ⟹ $-\left(\frac{\Delta N}{\Delta t}\right) \propto N$

$$-\left(\frac{\Delta N}{\Delta t}\right) = \lambda N \quad \text{---} \quad (1)$$

λ = Decay constant or

Constant of Radioactivity.

$$\lambda = \frac{-\left(\frac{\Delta N}{\Delta t}\right)}{N} \quad \text{—— (II)}$$

Rate of Disintegration per atom is called λ.

λ = Activity.

i) λ = less ⇒ Activity is high Half life is less.

Re-arranging...

$$\text{(I)} \Rightarrow \frac{\Delta N}{N} = -\lambda \Delta t \quad \text{—— (III)}$$

Using Calculus / Integrating (III) i wie geti

$$\boxed{N = N_o e^{-\lambda t}}$$

N = No of atoms remaing

No = Initial no of atoms

e = exponintial..

$\because \quad t = T_{1/2}$

$$N = \frac{N_0}{2}$$

$$\Rightarrow \frac{N_0}{2} = N_0 e^{-\lambda T_{1/2}}$$

$$\frac{1}{2} = e^{-\lambda T_{1/2}}$$

$$\frac{1}{2} = \frac{1}{e^{\lambda T_{1/2}}}$$

$$e^{\lambda T_{1/2}} = 2$$

Taking Natural log : (ln)

$$\ln e^{\lambda T_{1/2}} = \ln 2$$

$$\lambda T_{1/2} \ln e = 0.693$$

$$\because \ln e = 1$$

$$\lambda T_{1/2} = 0.693$$

$$\boxed{T_{1/2} = \frac{0.693}{\lambda}}$$

* 01/01/2018 * My last class)

α, β & γ rays

Interaction of Nuclear Radiations with matter:-

* Interaction means penetration & Ionization.

It depends upon:-

(I) Mass

(II) charge

(III) Energy

(IV) Density of matter

① α-particle:-
(*) Low penetrating power
(*) Low Range.

(*) High Ionizing power. Due to double positive charge.

(*) It's track is straight in matter due to their mass.

(II) β-particle:- (*) High penetration power
(*) Low Ionizing power.

(*) β-particle remove $\bar{e}$s by (I) Collision
(II) Due to charge.

(iii) γ-rays:-

1. if $E < 0.1$ MeV $\Rightarrow$ P.E.E

if $E \sim 0.1$ MeV ~ 1 MeV $\Rightarrow$ C.E

if $E \geq 1.02$ MeV $\Rightarrow$ pair production

$$I = I_0 e^{-\mu x}$$

x = Thickness of matter

I_0 = Intensity of incoming γ-rays

I = Intensity of outgoing matter

μ = Coefficient of Absorbtivity

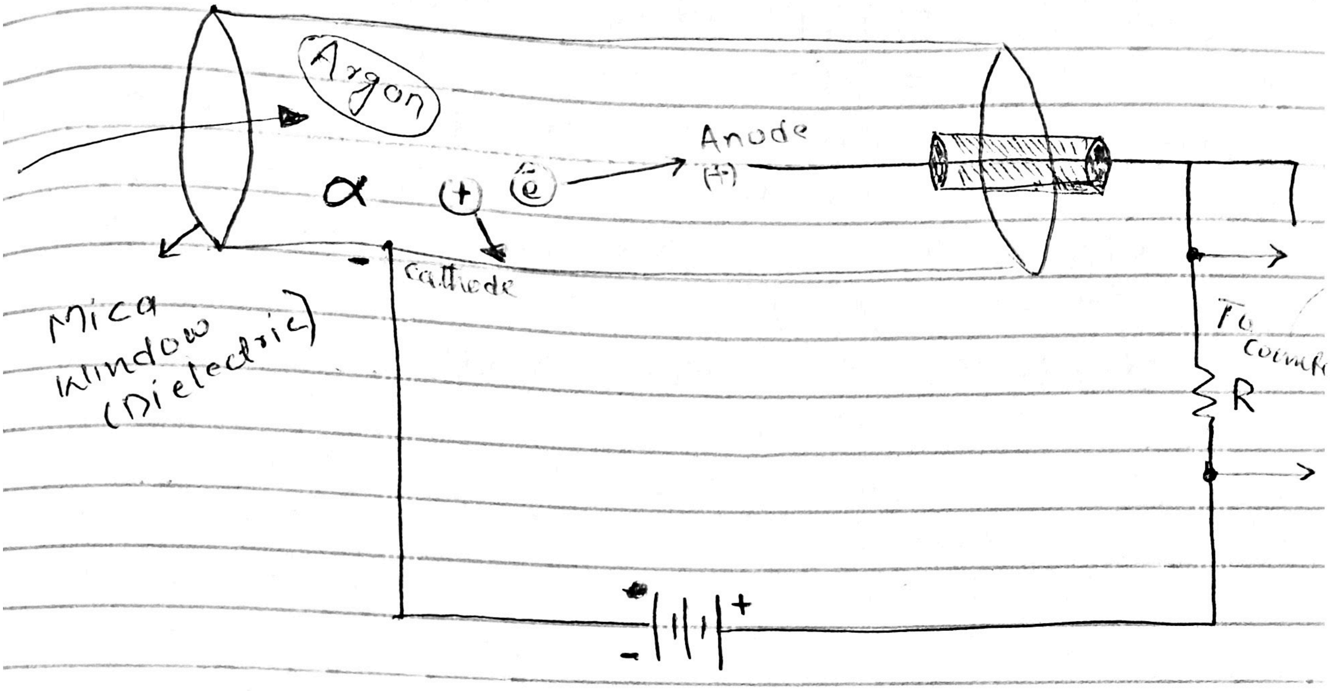
-ive sign shows that energy decrease or Intensity decreases.

* Neutron can also penetrate inside the matter...

Nuclear Radiation Detectors:-

By which Nuclear radiations are Detected...

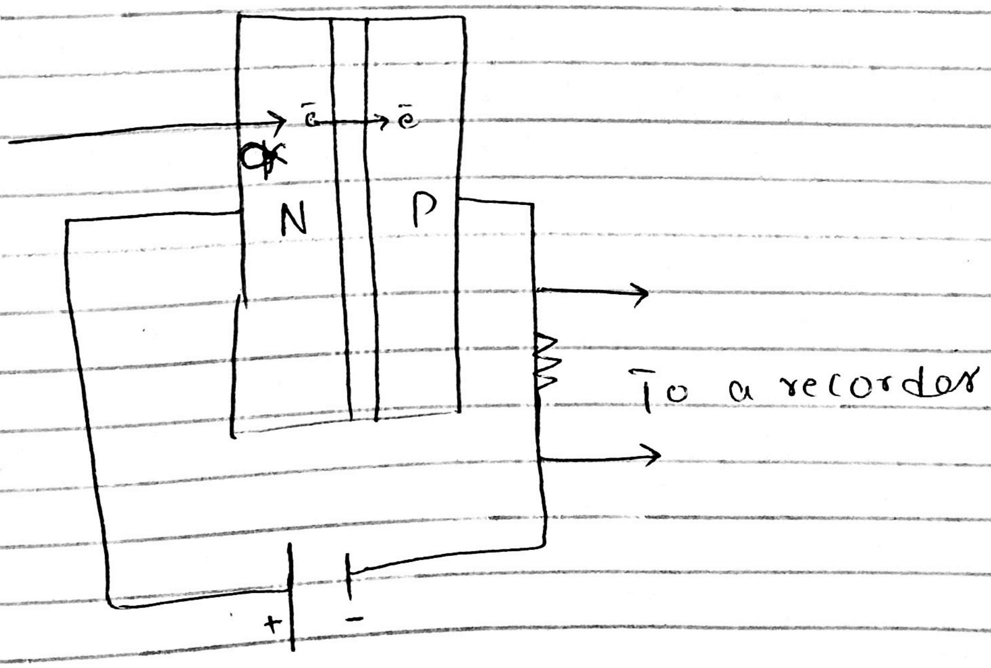
1. G.M Counter



G.M Counter

(ii) Solid State Dectori -

We use PN - junction (Diode).



Comon Solid State Dectector Can't defect γ-reys. For the Detection of γ-rays Special solid state dectors are designed.