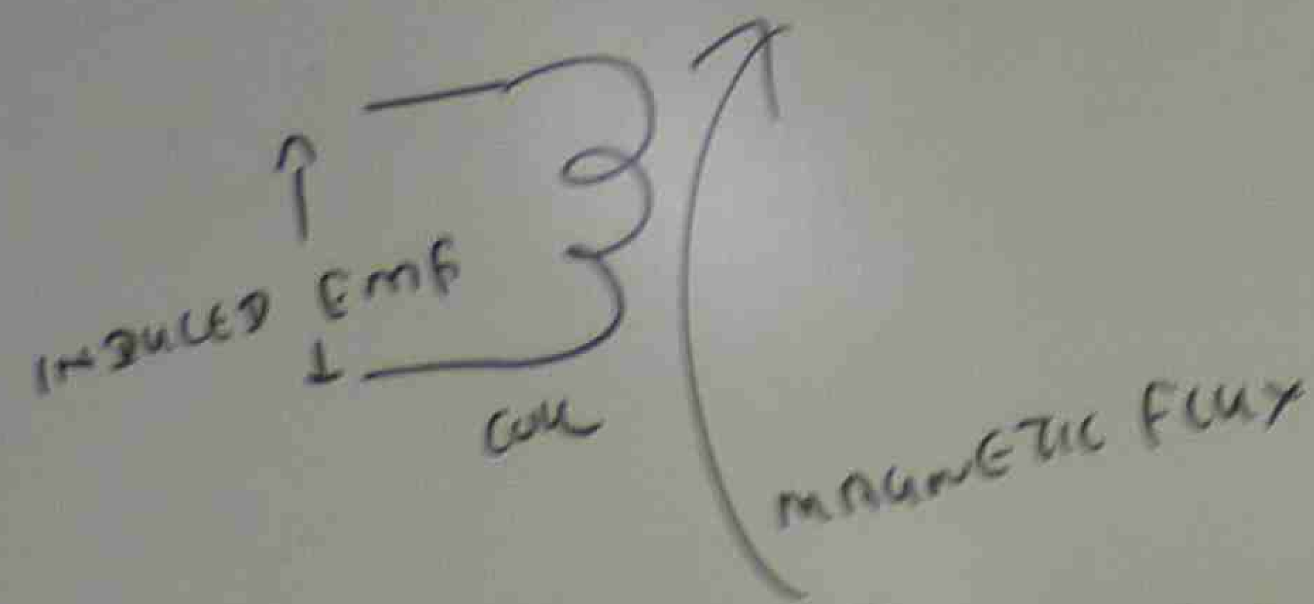
## FARADAY'S LAW OF INDUCTION




AN EMF IS INDUCED IN THE LOOP WHEN THE PASSING FLUX IS CHANGING.

$$\phi = \int \vec{B} \cdot d\vec{A}$$

$$\phi = B \cdot A$$

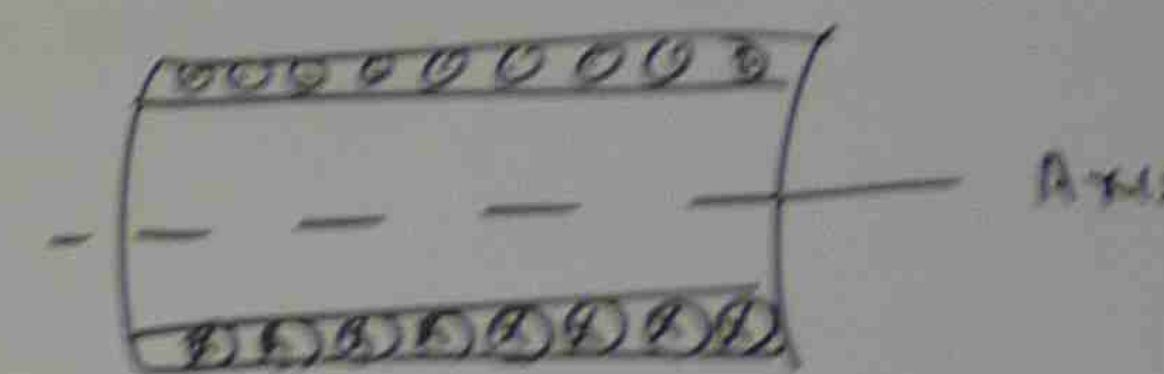
$$E = -N \frac{d\phi}{dt}$$

E: INDUCED VOLTAGE

N = NO. OF TURN

$\frac{d\phi}{dt}$ = RATE OF CHANGE OF FLUX

(P) THE LONG SOLENOID COIL HAS 22
A CURRENT $I = 1.5$ Amp. IT'S
AT THIS CENTER, 130 TURNS ARE
IS 2.1 cm. THE CURRENT
TO ZERO AT STEADY RATE IN
EMF ?




$$\phi = B \cdot A = \mu_0 I A$$

$$= 4\pi \times 10^{-7} \times 1.5$$

$$= 1.44 \times 10^{-5}$$

$$\frac{d\phi}{dt} = \frac{0 - 1.44 \times 10^{-5}}{25 \times 10^{-3}} = -$$

$$E = -N \frac{d\phi}{dt} = -(130) \times$$

$$= 75 \times 10^{-3} V$$

INDUCTION

LUX

IN THE LOOP

UX IS CHANGING.

$\int \vec{B} \cdot d\vec{A}$

$. \; A$

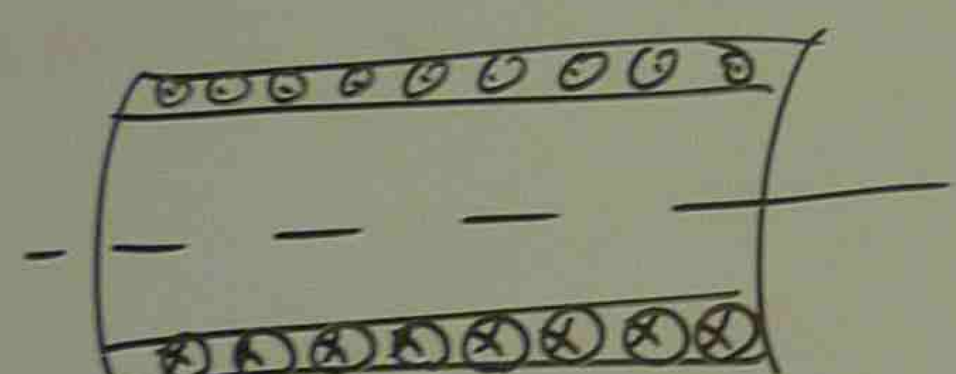
$= -N \dfrac{d\phi}{dt}$

E

NO. OF TURN

RATE OF CHANGE OF FLUX

Pb THE LONG SOLENOID COIL HAS 220 TURNS/CM AND CARRIES A CURRENT I = 1.5 Amp. IT'S DIAMETER "D" IS 3.2 Cm. AT THIS CENTER, 130 TURNS ARE WOUND. THE COIL DIAMETER IS 2.1 Cm. THE CURRENT IN THE SOLENOID IS REDUCED TO ZERO AT STEADY RATE IN 25 ms. WHAT IS INDUCED EMF?




$$\phi = B \cdot A = \mu_0 I A$$

$$= 4\pi \times 10^{-7} \times 1.5 \times \left(220 \text{ TURNS}/\text{cm} \times 100\right) \text{TURN/m} \times \frac{\pi}{4} \times (3.2 \times 10^{-2})^2$$

$$= 1.44 \times 10^{-5} \text{ wb}$$

$$\frac{d\phi}{dt} = \frac{0 - 1.44 \times 10^{-5}}{25 \times 10^{-3}} = -5.76 \times 10^{-4} \text{ V} \,|\, \text{TURN}$$

$$E = -N \frac{d\phi}{dt} = -(130) \times (-5.76 \times 10^{-4})$$

$$= 75 \times 10^{-3} \text{ V} = 75 \text{ mV}$$

LENZ'S LAW

AN INDUCED CUR

THE MAGNETIC FIEL

CHANGE IN THE M

Pb A COIL

AND A

(a) IF A

COIL, HOW

MAGNET

BUILT

(b) AFTER

THIS

THE

AND CARRIES
'' IS 3.2 cm.
...THE COIL DIAMETER
...NOID IS REDUCED
...HAT IS INDUCED

$\times 100)\ \text{TURN}/m \times \frac{\pi}{4} \times (3.2\times10^{-2})^2$

/ | TURN

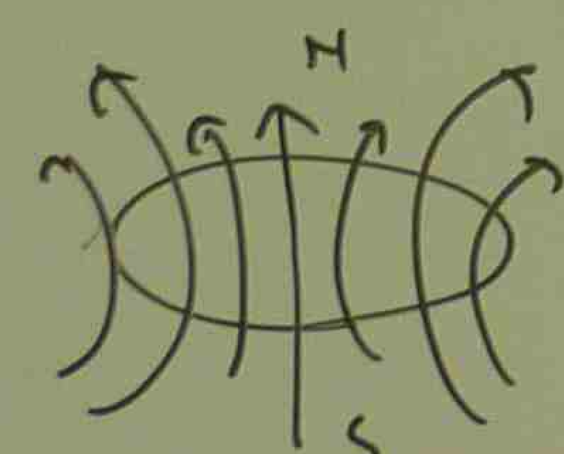
)

## LENZ'S LAW

AN INDUCED CURRENT HAS A DIRECTION SUCH THAT THE MAGNETIC FIELD DUE TO THE CURRENT OPPOSES THE CHANGE IN THE MAGNETIC FLUX THAT INDUCES THE CURRENT.


$$\text{MAGNETIC ENERGY} = \int_0^i L i\, di$$

$$U = \frac{1}{2} L i^2$$




Pb A COIL HAS AN INDUCTANCE OF 53 mH AND A RESISTANCE OF 0.35Ω.

(a) IF A 12V EMF IS APPLIED ACROSS THE COIL, HOW MUCH ENERGY IS STORED IN THE MAGNETIC FIELD AFTER THE CURRENT HAS BUILT UP TO IT'S EQUILIBRIUM VALUE?

(b) AFTER HOW MANY TIME CONSTANT WILL HALF THIS EQUILIBRIUM ENERGY BE STORED IN THE MAGNETIC FIELD?

(a) $i = \frac{E}{R} = \frac{12}{0.35} = 34.3\text{ A}$

$U = \frac{1}{2} L i^2 = \frac{1}{2} \times 53\times10^{-3} \times (34.3$

(b) $\frac{1}{2}\left(\frac{1}{2} L i^2\right) =$ HALF OF ENERGY

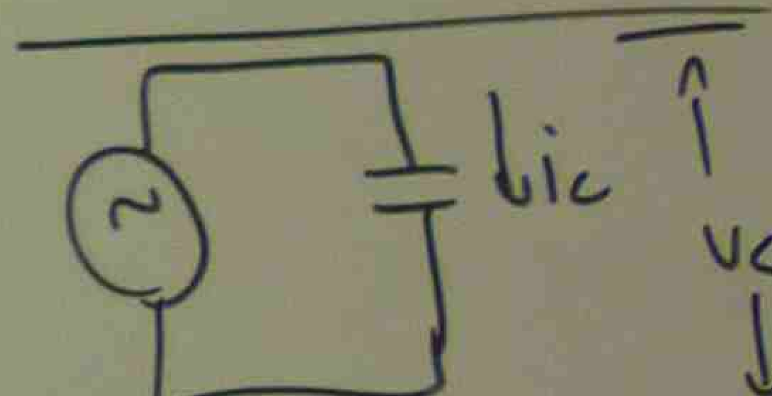
$\frac{1}{2}\left(\frac{i^2}{2} L\right) = \frac{1}{2} \times \left(\frac{i}{\sqrt{2}}\right)^2$

$I(0)\left(1 - e^{-t/\tau}\right) = \frac{I(0)}{\sqrt{2}}$

$e^{-t/\tau} = 1 - \frac{1}{\sqrt{2}} = 0.$

TIME CONSTANT $= 0.293$

CAPACITIVE LOAD



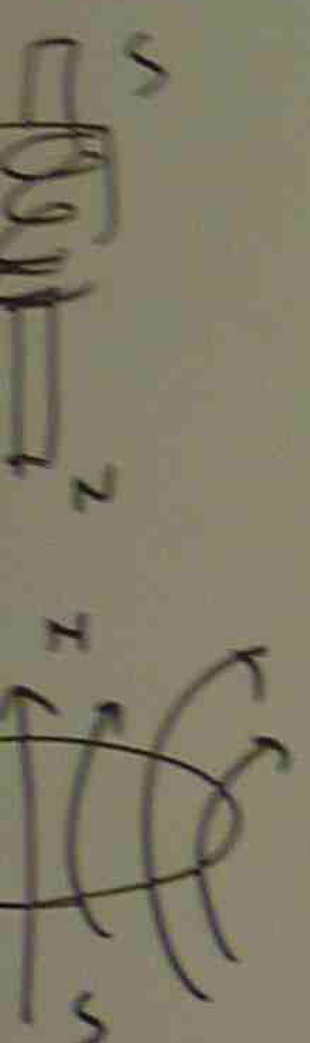

$i_C =$

$V_C =$

$i_C = \omega C V_C \cos$

$X_C = \frac{1}{\omega C}$

...RRENT HAS A DIRECTION SUCH THAT
...ELD DUE TO THE CURRENT OPPOSES THE
...MAGNETIC FLUX THAT INDUCES THE CURRENT.




MAGNETIC ENERGY $= \int_0^i Li\,di$

$U = \frac{1}{2} L i^2$

...AS AN INDUCTANCE OF 53 mH
...ISTANCE OF 0.35Ω.
... EMF IS APPLIED ACROSS THE
...H ENERGY IS STORED IN THE
...ELD AFTER THE CURRENT HAS
...O IT'S EQUILIBRIUM VALUE?
...MANY TIME CONSTANT WILL HALF
...LIBRIUM ENERGY BE STORED IN
...ETIC FIELD?

(a) $I = \frac{E}{R} = \frac{12}{0.35} = 34.3\,A$

$U = \frac{1}{2} L i^2 = \frac{1}{2} \times 53 \times 10^{-3} \times (34.3)^2 = 31\,J$

(b) $\frac{1}{2}\left(\frac{1}{2} L i^2\right) =$ HALF OF ENERGY

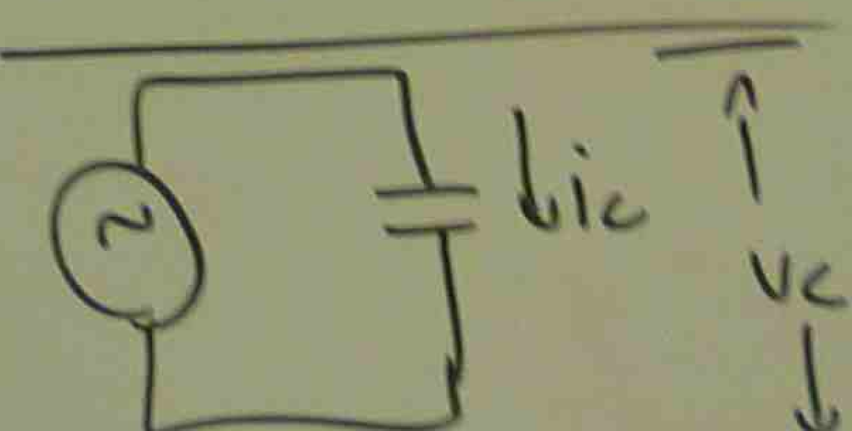
$\frac{1}{2}\left(\frac{i^2}{2} L\right) = \frac{1}{2} \times \left(\frac{i}{\sqrt{2}}\right)^2 \times L$

$I(0)\left(1 - e^{-t/\tau}\right) = \frac{I(0)}{\sqrt{2}}$

$e^{-t/\tau} = 1 - \frac{1}{\sqrt{2}} = 0.293$

TIME CONSTANT = 0.293

CAPACITIVE LOAD




$i_c = \frac{dq_c}{dt}$

$v_c = V_c \sin \omega t$

$i_c = \omega C V_c \cos \omega t$

$X_c = \frac{1}{\omega C}$

(11) CAPACITANCE C IS ...
DEVICE OPERATES AT A...
60HZ (a) WHAT AR...
$V_c(t)$ A...
AMPLITU...
(b) WHAT AR...
CIRCUIT AS...
AMPLITUDE...

(a) $V_c = E_m = 36$...

$V_c(t) = E(t)$...

$\omega = 2\pi f$...

$V_c(t) =$ ...

(b) $i_c = I_c \sin$...

$X_c = \frac{1}{2\pi f \ldots}$

$I_c = \frac{V_c}{X_c} =$ ...

$i_c(t) =$ ...

ph CAPACITANCE C IS 15 μF AND SINUSOIDAL AC Emf DEVICE OPERATES AT AMPLITUDE $E_m = 36V$, FREQUENCY 60HZ (a) WHAT ARE THE POTENTIAL DIFFERENCE $V_c(t)$ ACROSS THE CAPACITANCE AND AMPLITUDE $V_c$ of $V_c(t)$

(b) WHAT ARE THE CURRENT $i_c(t)$ IN THE CIRCUIT AS A FUNCTION of TIME AND THE AMPLITUDE $I_c$ of $i_c(t)$?

(a) $V_c = E_m = 36\ V$

$v_c(t) = E(t) = E_m \sin \omega t$

$= 36 \sin \omega t$

$\omega = 2\pi f = 2\pi \times 60 = 120\pi$

$v_c(t) = 36 \sin 120\pi t$

(b) $i_c = I_c \sin(\omega t - \phi) = I_c \sin(\omega t + \frac{\pi}{2})$

$X_c = \dfrac{1}{2\pi f C} = \dfrac{1}{2 \times 3.1416 \times 60 \times 15 \times 10^{-6}}$

$= 177\Omega$

$I_c = \dfrac{V_c}{X_c} = \dfrac{36}{177} = 0.203\ A$

$i_c(t) = 0.203 \sin(120\pi t + \frac{\pi}{2})$ Amp

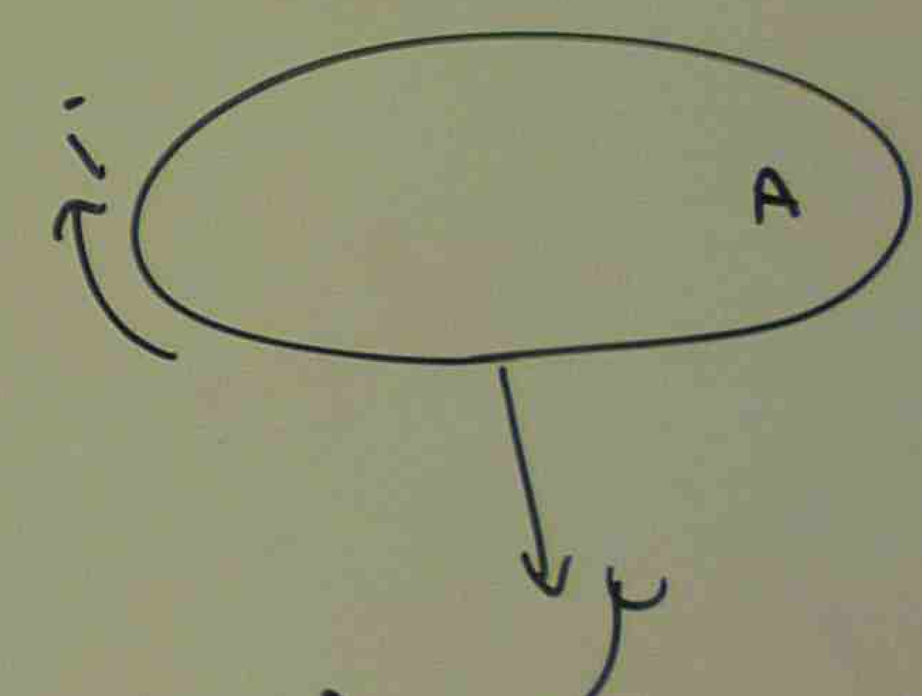
SPIN MAGNETIC DIPOLE MOMENT

$\vec{\mu} = -\dfrac{e}{m}\vec{S}$

$\mu = \dfrac{eh}{4\pi m}$

POTENTIAL ENERGY of MAGNETIC FIELD

$u = -\mu B$




$\mu_{ORB} = i A$

MAGNETIC DIPOLE MOMENT of A CURRENT LOOP

MAGNETIC

DIMAGNETI

PARA MAGNE

FERRO MAG

TRA

ENERGY SOURC

LD

## MAGNETIC MATERIALS

**DIMAGNETISM** – WEAK MAGNETIC DIPOLE MOMENTS ARE PRODUCED IN THE ATOMS OF MATERIAL WHEN THE MATERIAL IS PLACED IN EXTERNAL MAGNETIC FIELD.

**PARAMAGNETISM** – THE MAGNETIC FIELD DISAPPEARS WHEN THE FLUX DENSITY "B" IS REMOVED

**FERROMAGNETISM** THE MAGNETIC FIELD PARTIALLY PERSISTS WHEN THE EXTERNAL MAGNETIC FIELD IS REMOVED.

$$E = E_m \sin(kx - \omega t)$$

$$B = B_m \sin(kx - \omega t)$$

K = CONSTANT

$\omega = 2\pi f$

$f$ = FREQUENCY

E = VOLTAGE

B = MAGNETIC FIELD DENSITY.

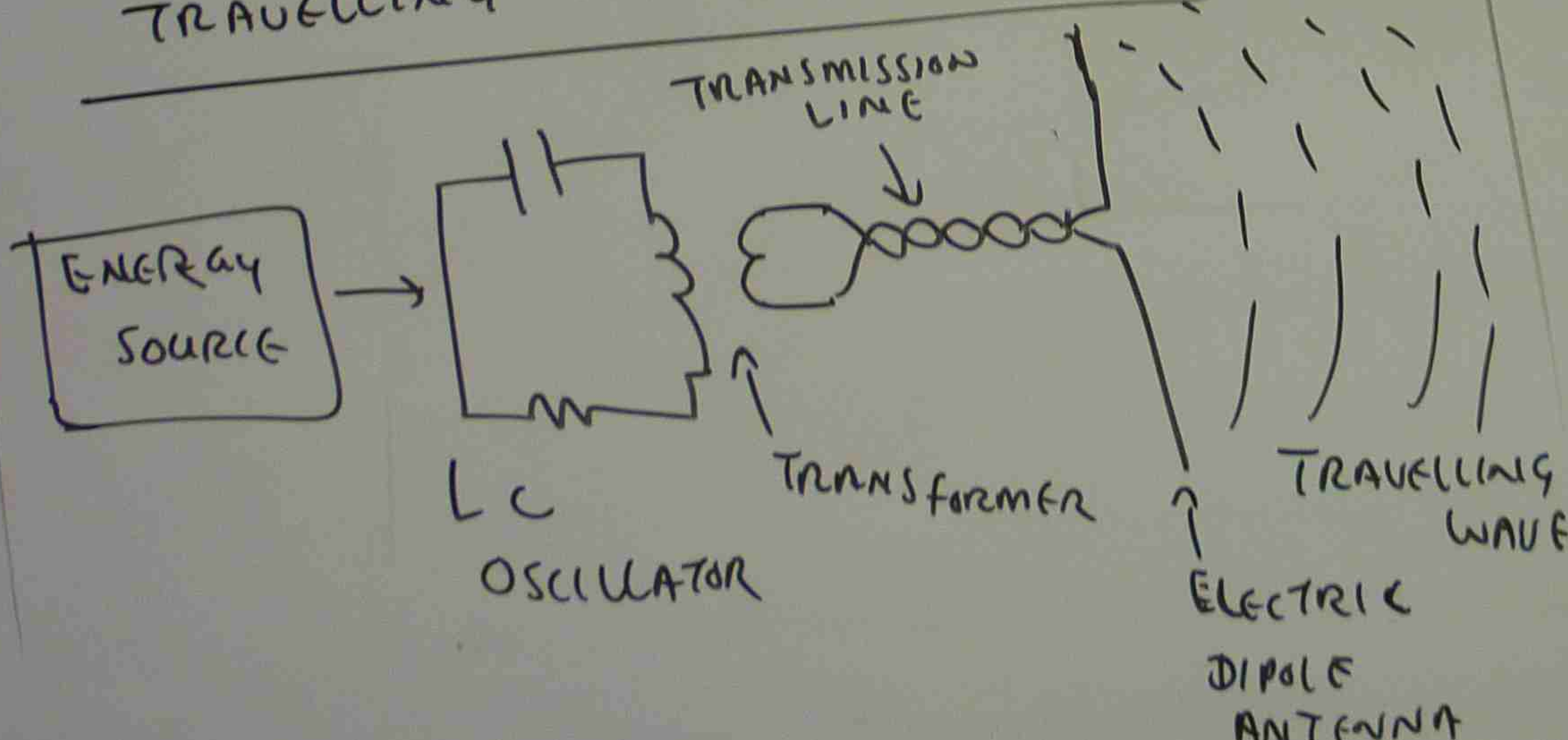
## SPEED OF ELECTROMAGNETIC WAVE

$$c = \frac{1}{\sqrt{\mu_0 E}}$$

$\mu_0$ = PERMEABILITY

E = VOLTAGE

## TRAVELLING ELECTRO MAGNETIC WAVE



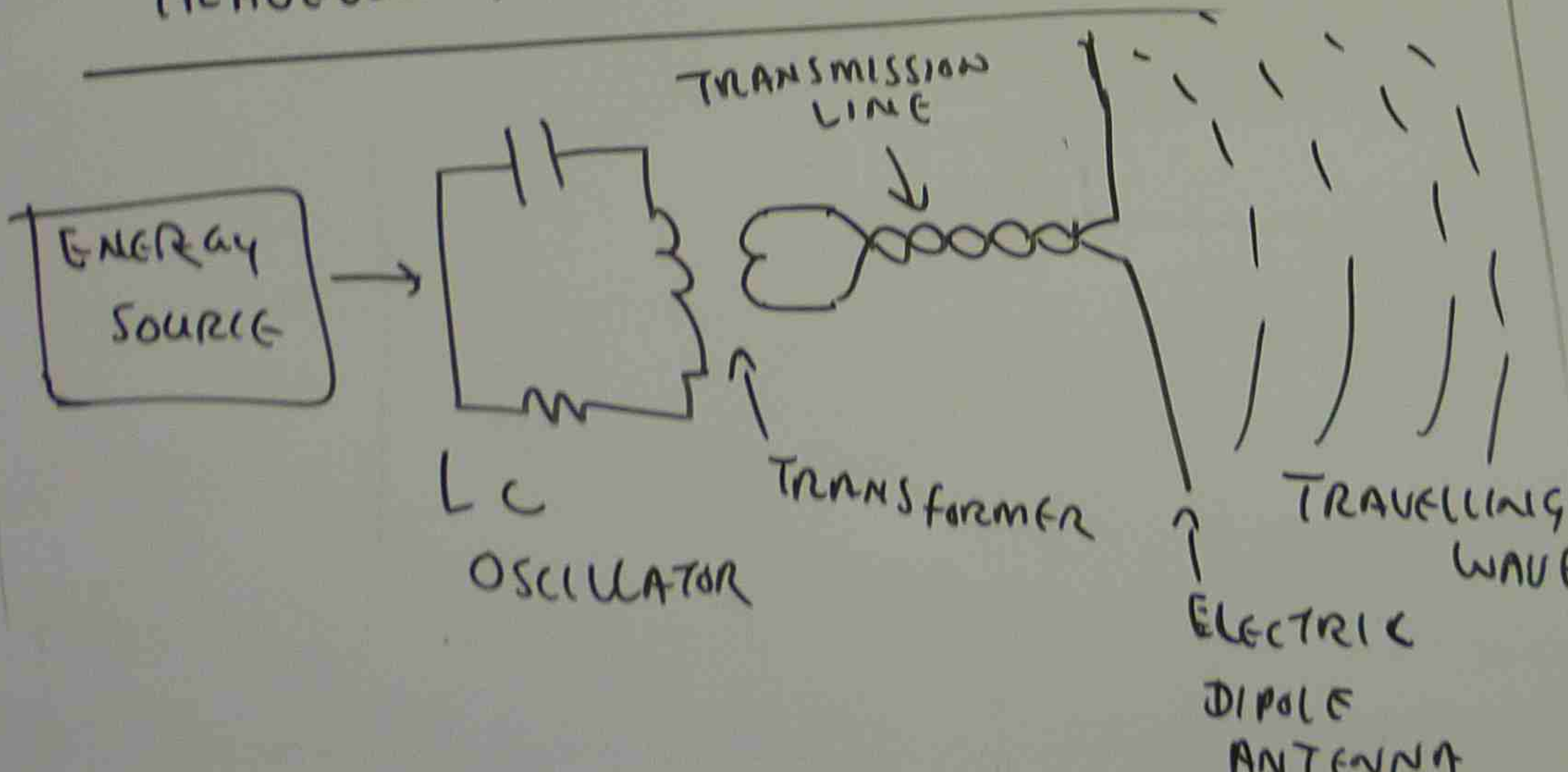
## MAGNETIC MATERIALS

**DIMAGNETISM** - WEAK MAGNETIC DIPOLE MOMENTS ARE PRODUCED IN THE ATOMS OF MATERIAL WHEN THE MATERIAL IS PLACED IN EXTERNAL MAGNETIC FIELD.

**PARAMAGNETISM** - THE MAGNETIC FIELD DISAPPEARS WHEN THE FLUX DENSITY "B" IS REMOVED

**FERROMAGNETISM** THE MAGNETIC FIELD PARTIALLY PERSISTS WHEN THE EXTERNAL MAGNETIC FIELD IS REMOVED.

## TRAVELLING ELECTROMAGNETIC WAVE




$E = E_m \sin(kx - \omega t)$

$B = B_m \sin(kx - \omega t)$

K = CONSTANT

$\omega = 2\pi f$

f = FREQUENCY

E = VOLTAGE

B = MAGNETIC FIELD DENSITY.

## SPEED OF ELECTROMAGNETIC WAVE

$$c = \frac{1}{\sqrt{\mu_0 E}}$$

$\mu_0$ = PERMEABILITY

E = VOLTAGE

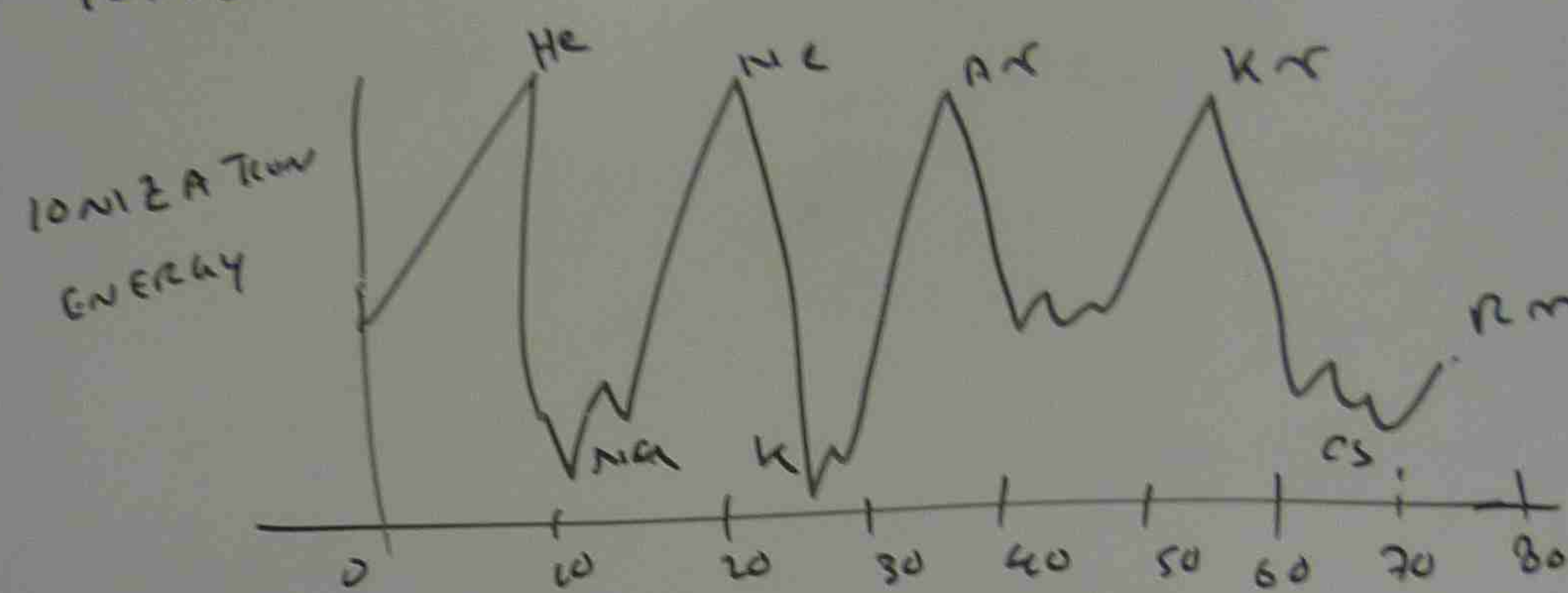
ment

netic field

of A

## ATOM

- ATOMS ARE STABLE
- ATOMS COMBINE WITH EACH OTHER
- ATOMS ARE PUT TOGETHER SYSTEMATICALLY IN ACCORDANCE WITH IONIZATION ENERGY




## ATOMS EMIT AND ABSORB LIGHT

$$hf = E_{HIGH} - E_{LOW}$$

## METALS, SEMICON

THREE ELECTRICA
USED TO DISTIN
SOLIDS ARE RESI
COEFFICIENT OF RE
DENSITY OF CHAR

SOLIDS CAN BE B
CATEGORIES : IN
METAL ( LOW ρ
SEMI CONDUCTOR(

## INSULATOR

THE HIGHEST
COMPLETELY FILL
THE VACANT BA
SO LARGE THAT
NEVER BECOM
TO JUMP ACRO

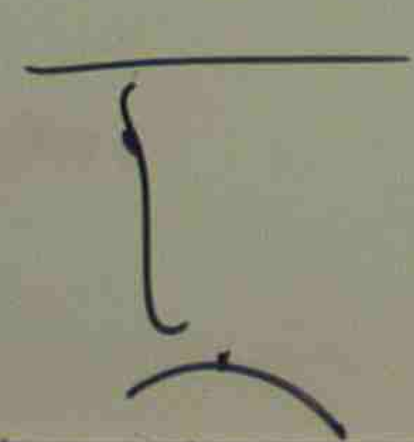
## METALS, SEMICONDUCTOR, INSULATOR

THREE ELECTRICAL PROPERTIES THAT CAN BE USED TO DISTINGUISH AMONG CRYSTALLINE SOLIDS ARE RESISTIVITY ($\rho$), TEMPERATURE COEFFICIENT OF RESISTIVITY ($\alpha$) AND NUMBER DENSITY OF CHARGE CARRIERS. ($n$)

SOLIDS CAN BE BROADLY DIVIDED INTO THREE CATEGORIES : INSULATOR (VERY HIGH $\rho$), METAL (LOW $\rho$, POSITIVE AND LOW $\alpha$, LARGE '$n$')
SEMICONDUCTOR (HIGH $\rho$, HIGH $\alpha$, SMALL '$n$')

### INSULATOR

THE HIGHEST BAND CONTAINING ELECTRON IS COMPLETELY FILLED AND IS SEPARATED FROM THE VACCANT BAND ABOVE IT BY AN ENERGY GAP SO LARGE THAT THE ELECTRONS CAN ESSENTIALLY NEVER BECOME THERMALLY AGITATED ENOUGH TO JUMP ACROSS THE GAP.



### METAL

THE HIGHEST BAND THAT CONTAINS ANY ELECTRON IS ONLY PARTIALLY FILLED. THE ENERGY OF THE HIGHEST FILLED LEVEL AT A TEMPERATURE OF 0°K IS CALLED FERMI ENERGY $E_f$ FOR METAL

FOR COPPER $E_f = 7$ eV

THE ELECTRONS IN THE PARTIALLY FILLED BAND ARE THE CONDUCTION ELECTRONS AND THEIR NUMBER IS

$$\begin{pmatrix}\text{NUMBER OF}\\ \text{CONDUCTION}\\ \text{ELECTRONS}\\ \text{IN SAMPLE}\end{pmatrix} = \begin{pmatrix}\text{NO. OF ATOMS}\\ \text{IN SAMPLE}\end{pmatrix} \times \begin{pmatrix}\text{NUMBER OF VALANCE}\\ \text{ELECTRON PER ATOM}\end{pmatrix}$$

$$\begin{pmatrix}\text{NO. OF ATOMS}\\ \text{IN SAMPLE}\end{pmatrix} = \frac{\text{SAMPLE MASS } M_{sam}}{\text{ATOMIC MASS}}$$

$$= \frac{\text{SAMPLE MASS } M_{sam}}{\text{MOLAR MASS } M / N_A}$$

METAL

THE HIGHEST BAND THAT CONTAINS ANY ELECTRON IS ONLY PARTIALLY FILLED. THE ENERGY OF THE HIGHEST FILLED LEVEL AT A TEMPERATURE OF 0 K IS CALLED FERMI ENERGY $E_f$ FOR METAL

FOR COPPER $E_f = 7\ eV$

THE ELECTRONS IN THE PARTIALLY FILLED BAND ARE THE CONDUCTION ELECTRONS AND THEIR NUMBER IS

NUMBER OF CONDUCTION ELECTRONS IN SAMPLE = NO. OF ATOMS IN SAMPLE × NUMBER OF VALANCE ELECTRON PER ATOM

$$\text{No. of ATOMS IN SAMPLE} = \frac{\text{SAMPLE MASS } M_{sam}}{\text{ATOMIC MASS}} = \frac{\text{SAMPLE MASS } M_{sam}}{\text{MOLAR MASS } m / N_A}$$

$$= \frac{(\text{METERIAL DENSITY}) \times (\text{SAMPLE VOLUME } V)}{(\text{MOLAR MASS } m)/N_A}$$

$$\text{THE DENSITY OF CONDUCTION ELECTRON} = \frac{\text{NUMBER OF CONDUCTION ELECTRONS IN SAMPLE}}{\text{SAMPLE VOLUME } V}$$

DENSITY STATE

$$N(E) = \frac{8\sqrt{2}\,\pi\, m^{3/2}}{h^3} E^{1/2}$$

$$\text{OCCUPANCY PROBABILITY } P(E) = \frac{1}{e^{(E-E_F)/kT} + 1}$$

$N_o(E) = N(E)\,P(E)$ DENSITY OF OCCUPIED STATE

$$\text{FERMI ENERGY } E_F = \left(\frac{3}{16\sqrt{2}\,\pi}\right)^{2/3} \frac{h^2}{m}\, n^{2/3}$$

$$= 0.121 \frac{h^2}{m} n^{2/3}$$

(a)

(b)

×( Sample volume V)

m)/ NA

$= \dfrac{\text{Number of conduction electrons in sample}}{\text{Sample volume } V}$

$\dfrac{8\sqrt{2}\,\pi\, m^{3/2}}{h^3} \quad E^{1/2}$

$= \dfrac{1}{e^{(E-E_F)/kT}+1}$

) P(E) Density of occupied state

$\Big)^{2/3} \dfrac{h^2}{m} \; n^{2/3}$

$\dfrac{h^2}{m} \; n^{2/3}$

## Nuclear Physics

$$A = Z + N$$

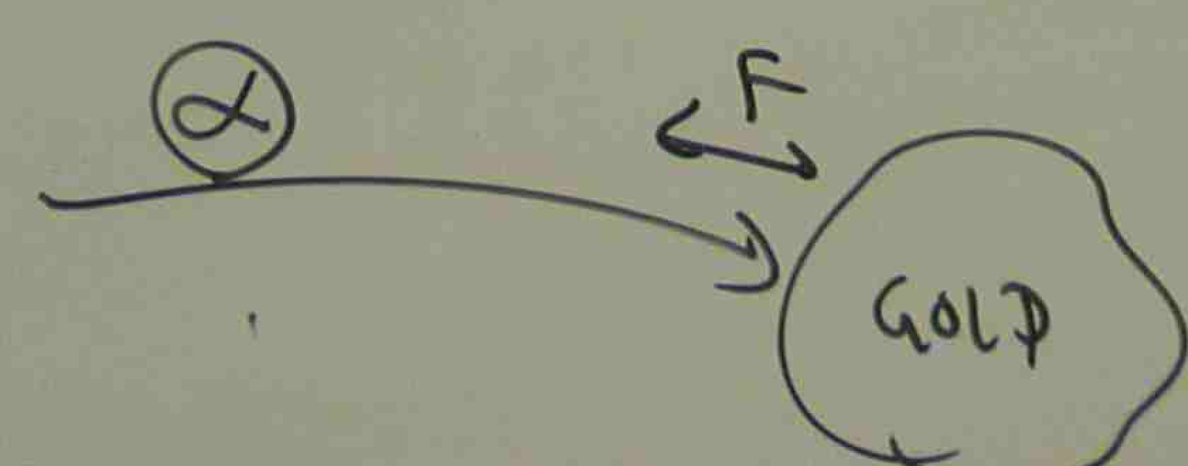
Z = Atomic number
no. of proton

A = mass number

N = neutron number.

Neutrons and protons are collectively considered as nucleons.

Pb A 5.3 MeV alpha particle happens by chance to be headed directly toward the nucleus of an atom of gold which contains 79 protons. How close does the alpha particle get into the centre of nucleus before coming momentarily to the rest and reversing it's motion.




$K_\alpha = \dfrac{1}{4\pi\varepsilon_0}$

$d = \dfrac{\varepsilon_0}{4\pi}$

$= \dfrac{(2e)}{4\pi\varepsilon}$

$= \dfrac{(2\times 1.6}{4\pi\varepsilon}$

= 4.

Proton number Z

## NUCLEAR PHYSICS

$$A = Z + N$$

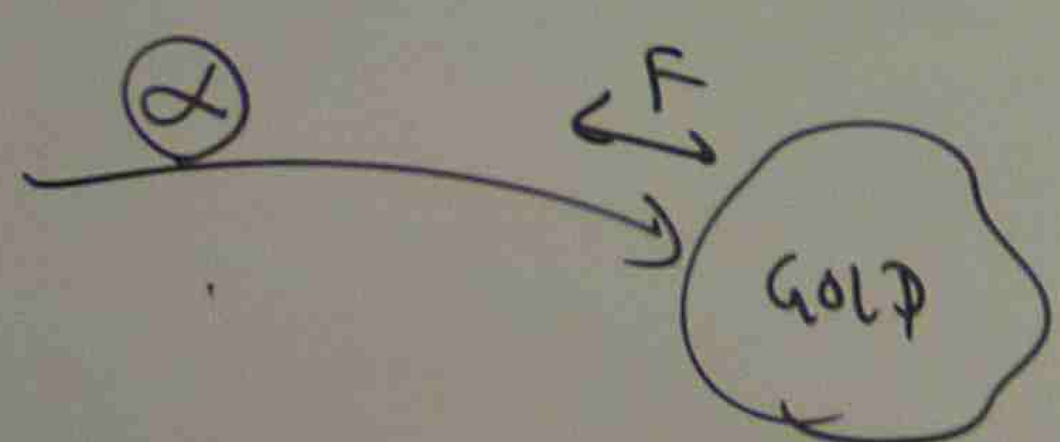
Z = ATOMIC NUMBER
no. of PROTON

A = MASS NUMBER

N = NEUTRON NUMBER.

NEUTRONS AND PROTONS ARE COLLECTIVELY CONSIDERED AS NUCLEONS

Pb A 5.3 MeV ALPHA PARTICLE HAPPENS BY CHANCE TO BE HEADED DIRECTLY TOWARD THE NUCLEUS OF AN ATOM OF GOLD WHICH CONTAINS 79 PROTONS. HOW CLOSE DOES THE ALPHA PARTICLE GET INTO THE CENTRE OF NUCLEUS BEFORE COMING MOMENTARILY TO THE REST AND REVERSING IT'S MOTION.



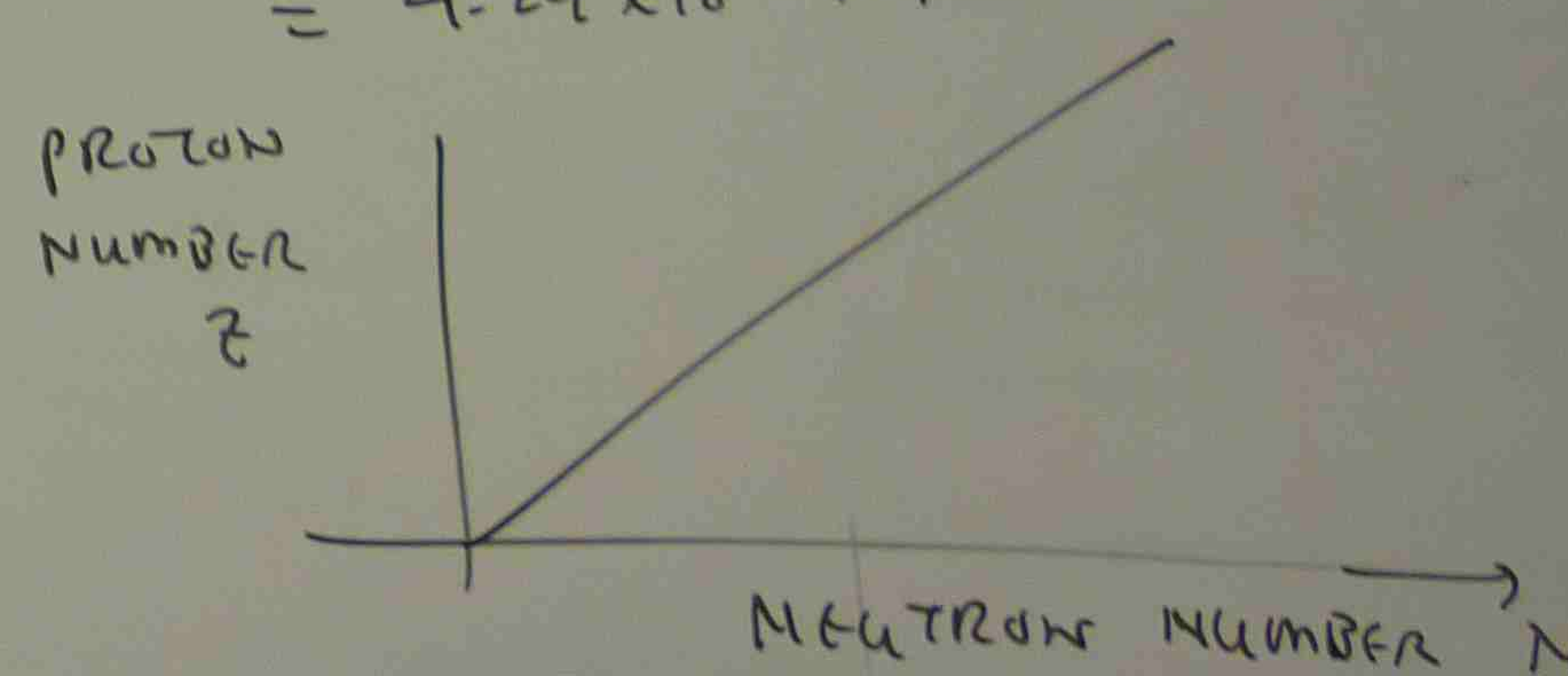

$$K_\alpha = \frac{1}{4\pi\varepsilon_0}\frac{q_0\, q_{Au}}{d}$$

$$d = \frac{q_0\, q_{Au}}{4\pi\varepsilon_0 K_\alpha}$$

$$= \frac{(2e)(79e)}{4\pi\varepsilon_0 K_\alpha}$$

$$= \frac{(2\times 1.6\times 10^{-14})\times(79\times 1.6\times 10^{-19})}{4\pi\varepsilon_0 \underbrace{(5.3\ \text{meV})(1.6\times 10^{-13}\ \text{J/meV})}_{= K_\alpha}}$$

$$= 4.29\times 10^{-14}\ \text{m}$$



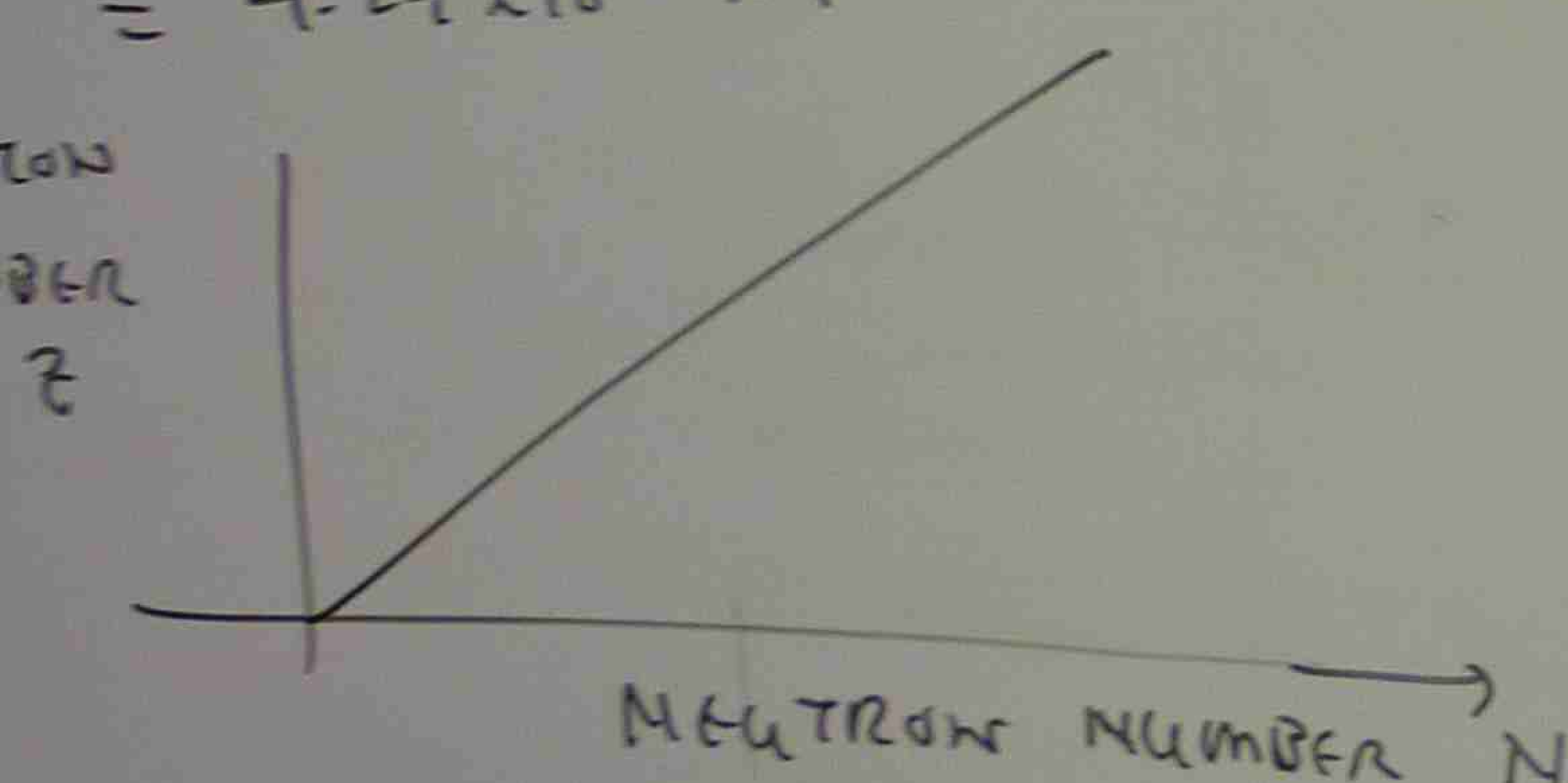
$$= \frac{1}{4\pi\varepsilon_0}\,\frac{q_\alpha\, q_{Au}}{d}$$

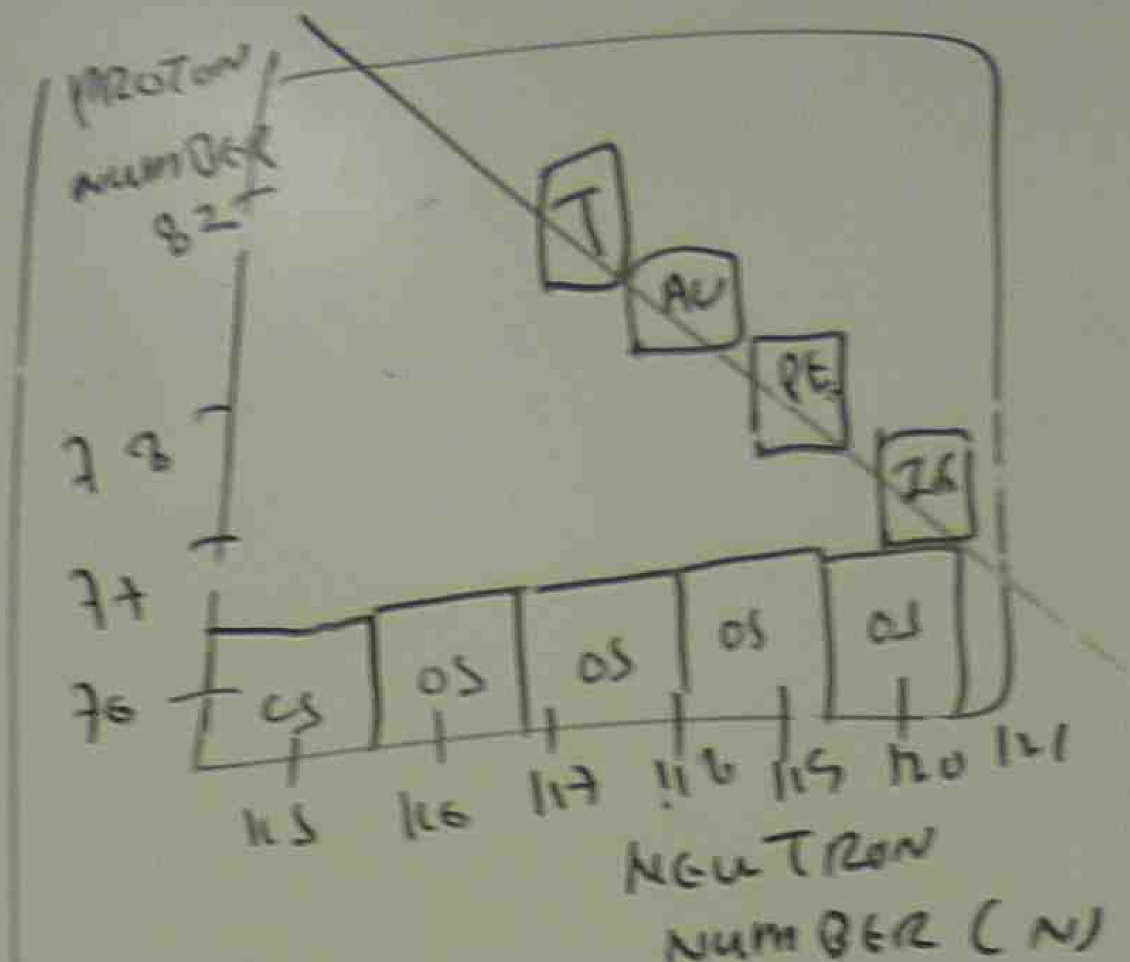
$$= \frac{q_\alpha\, q_{Au}}{4\pi\varepsilon_0\, r_\alpha}$$

$$= \frac{(2e)(79e)}{4\pi\varepsilon_0\, r_\alpha}$$

$$= \frac{(2\times 1.6\times 10^{-19})\times(79\times 1.6\times 10^{-19})}{4\pi\varepsilon_0\,\underbrace{(5.3\ \mathrm{MeV})(1.6\times 10^{-13}\ \mathrm{J/MeV})}_{= K_\alpha}}$$

$$= 4.29\times 10^{-14}\ \mathrm{m}$$




## NUCLEAR RADII

1 FEMTOMETER = 1 FERMI = 1 fm = $10^{-15}$ m

$r = r_0 A^{1/3}$ A = MASS NUMBER

$r_0 = 1.2$ fm

## ATOMIC MASSES

$1\,u = 1.66053886\times 10^{-27}$ kg

ATOMIC UNIT

ENERGY UNIT $c^2 = 931.494013$ MeV/u

EXCESS MASS $\Delta = M - A$

m = ACTUAL ...

A = MASS ...

NUCLEAR B...

$\Delta E_{be} =$ ...

m = ...

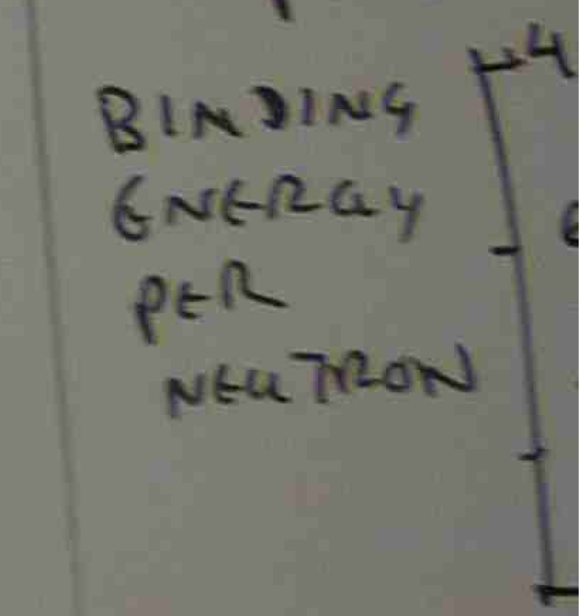
THE MASS ...

TOTAL MA...

AND NEUTR...

BINDI...

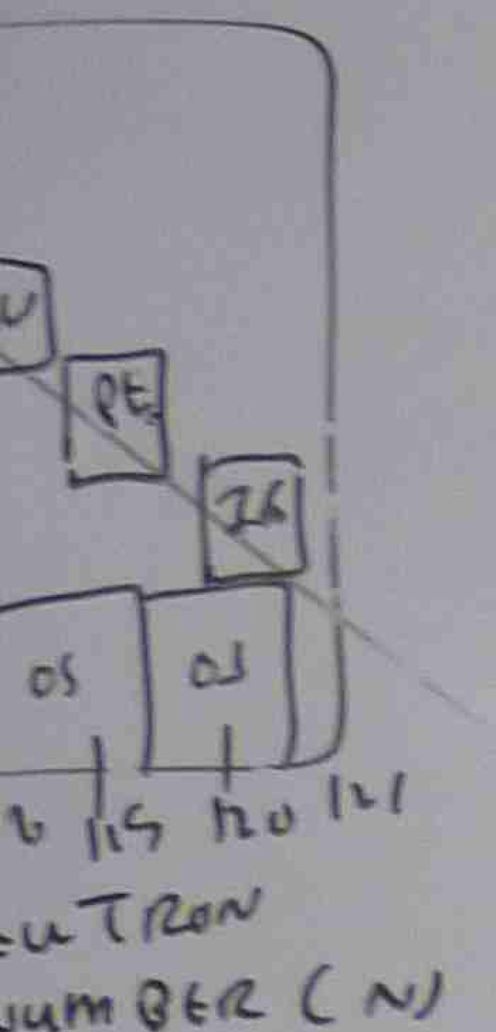
PER N...




NUCLEAR ...

ENER...

NUCLEUS-...




## ...RADII

...ER = 1 FERMI = 1 fm = $10^{-15}$ m

$... r_0 A^{1/3}$

A = MASS NUMBER

$r_0 = 1.2$ fm

## ...ASSES

... = $1.66053886 \times 10^{-27}$ kg

...OMIC UNIT

...GY UNIT $c^2 = 931.494013$ MeV/u

...SS MASS $\Delta = M - A$

m = ACTUAL MASS of ATOM IN ATOMIC MASS UNIT

A = MASS NUMBER

## NUCLEAR BINDING ENERGY

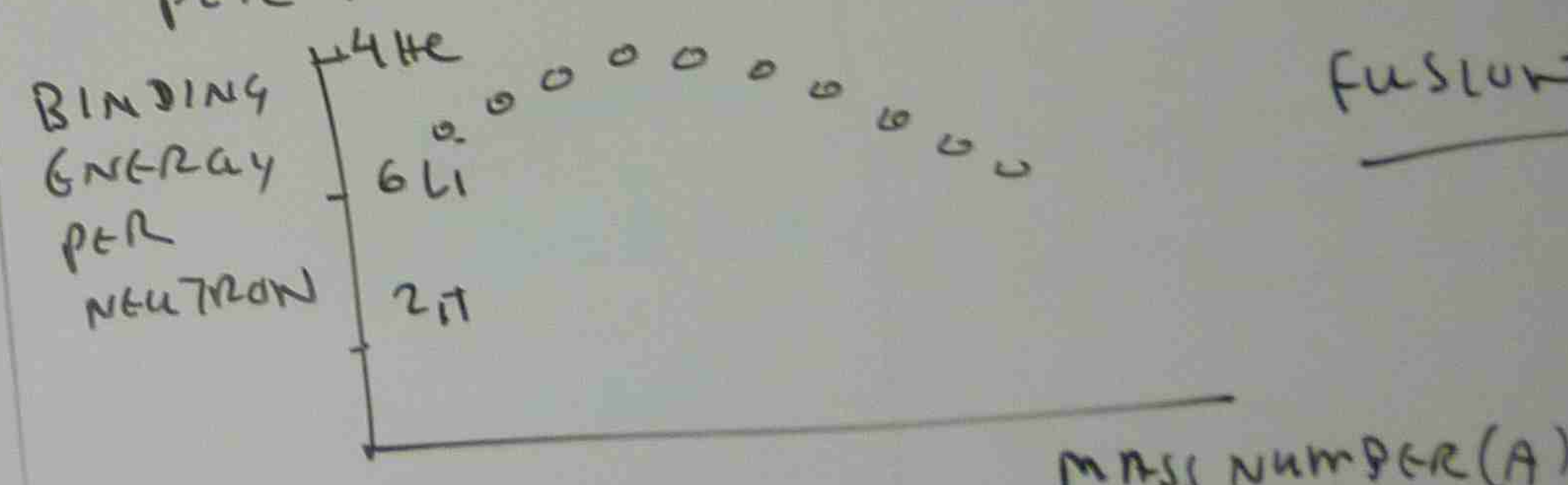
$$\Delta E_{be} = \sum mc^2 - Mc^2$$

m = MASS of NUCLEUS

THE MASS (M) of A NUCLEUS IS LESS THAN THE TOTAL MASS $\sum m$ of IT'S INDIVIDUAL PROTONS AND NEUTRONS.

BINDING ENERGY PER NEUTRON $\Delta E_{ben} = \dfrac{\Delta E_{be}}{A}$

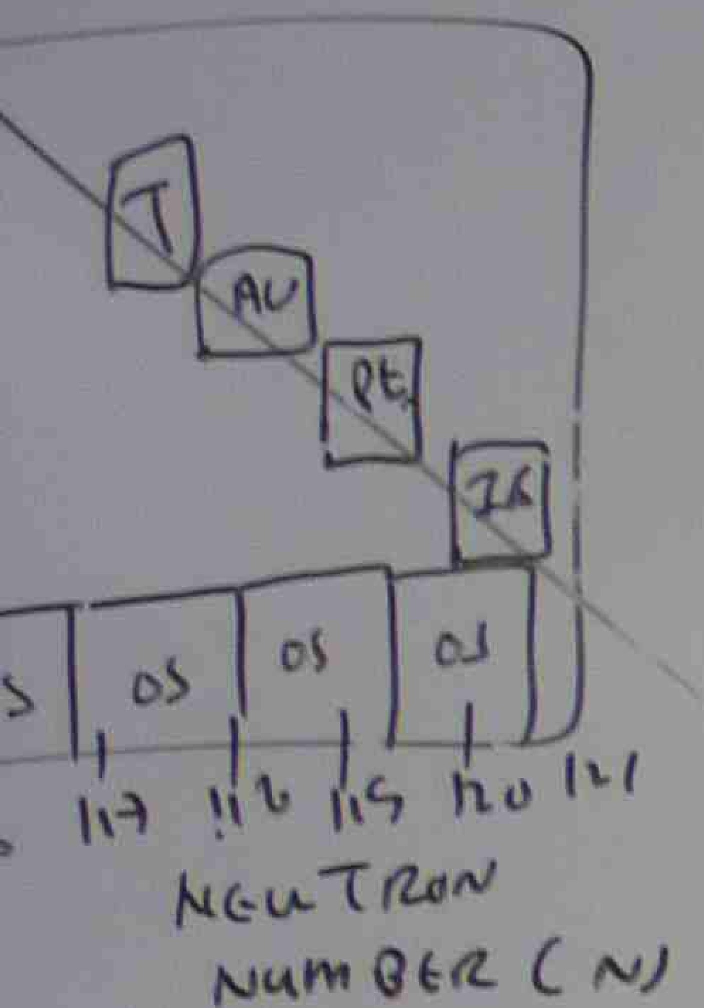
FUSION




## NUCLEAR ENERGY LEVEL

ENERGY SCALE - MILLION of ELECTRON VOLT

NUCLEUS - MAKES A TRANSITION FROM ONE LEVEL TO LOWER LEVEL
— EMIT PROTON.




AR RADII

OMETER = 1 FERMI = $1 f_m = 10^{-15}$ m

$= r_0 A^{1/3}$

A = MASS NUMBER

$r_0 = 1\text{-}2$ fm

C MASSES

$1u = 1.66053886 \times 10^{-27}$ kg

ATOMIC UNIT

ENERGY UNIT $c^2 = 931.494013$ MeV/u

EXCESS MASS $\Delta = M - A$

m = ACTUAL MASS OF ATOM IN ATOMIC MASS UNIT

A = MASS NUMBER

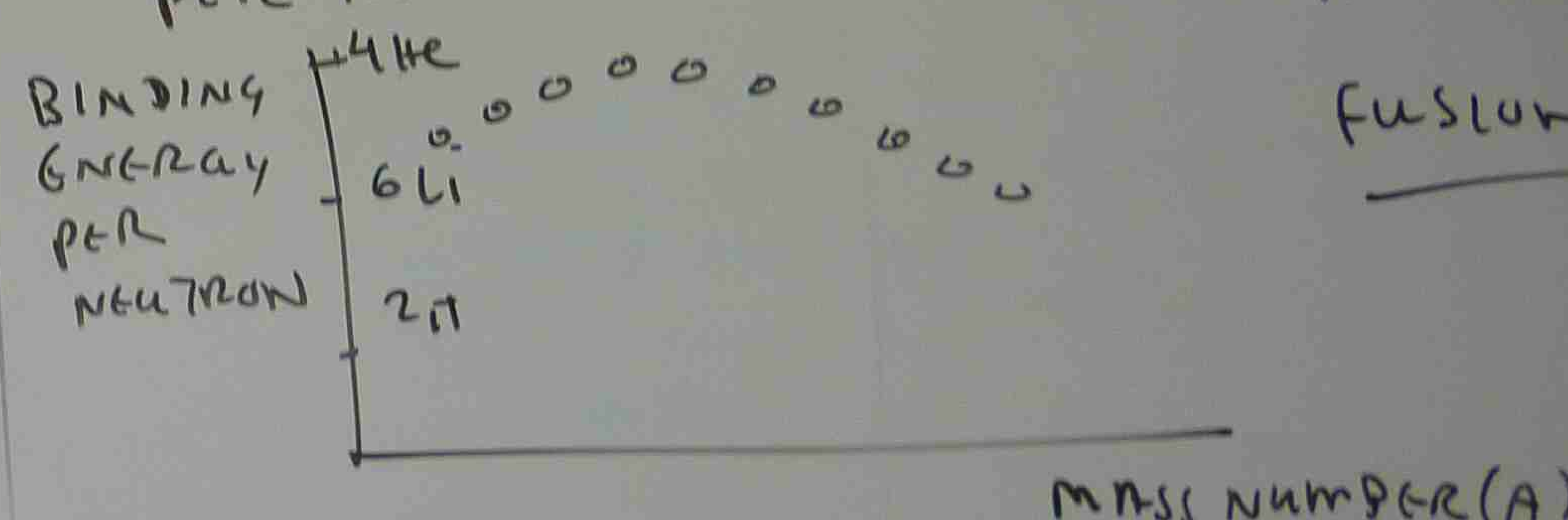
NUCLEAR BINDING ENERGY

$$\Delta E_{be} = \sum mc^2 - Mc^2$$

m = MASS OF NUCLEUS

THE MASS (M) OF A NUCLEUS IS LESS THAN THE TOTAL MASS $\sum m$ OF IT'S INDIVIDUAL PROTONS AND NEUTRONS.

BINDING ENERGY PER NEUTRON $\Delta E_{ben} = \dfrac{\Delta E_{be}}{A}$




FUSION

NUCLEAR ENERGY LEVEL

ENERGY SCALE - MILLION OF ELECTRON VOLT

NUCLEUS - MAKES A TRANSITION FROM ONE LEVEL TO LOWER LEVEL

- : EMIT PROTON.