VIVEKANANDA COLLEGE THAKURPUKUR KOLKATA-700063

NAAC ACCREDITED ‘A’ GRADE

Topic: Alpha decay, α-disintegration energy

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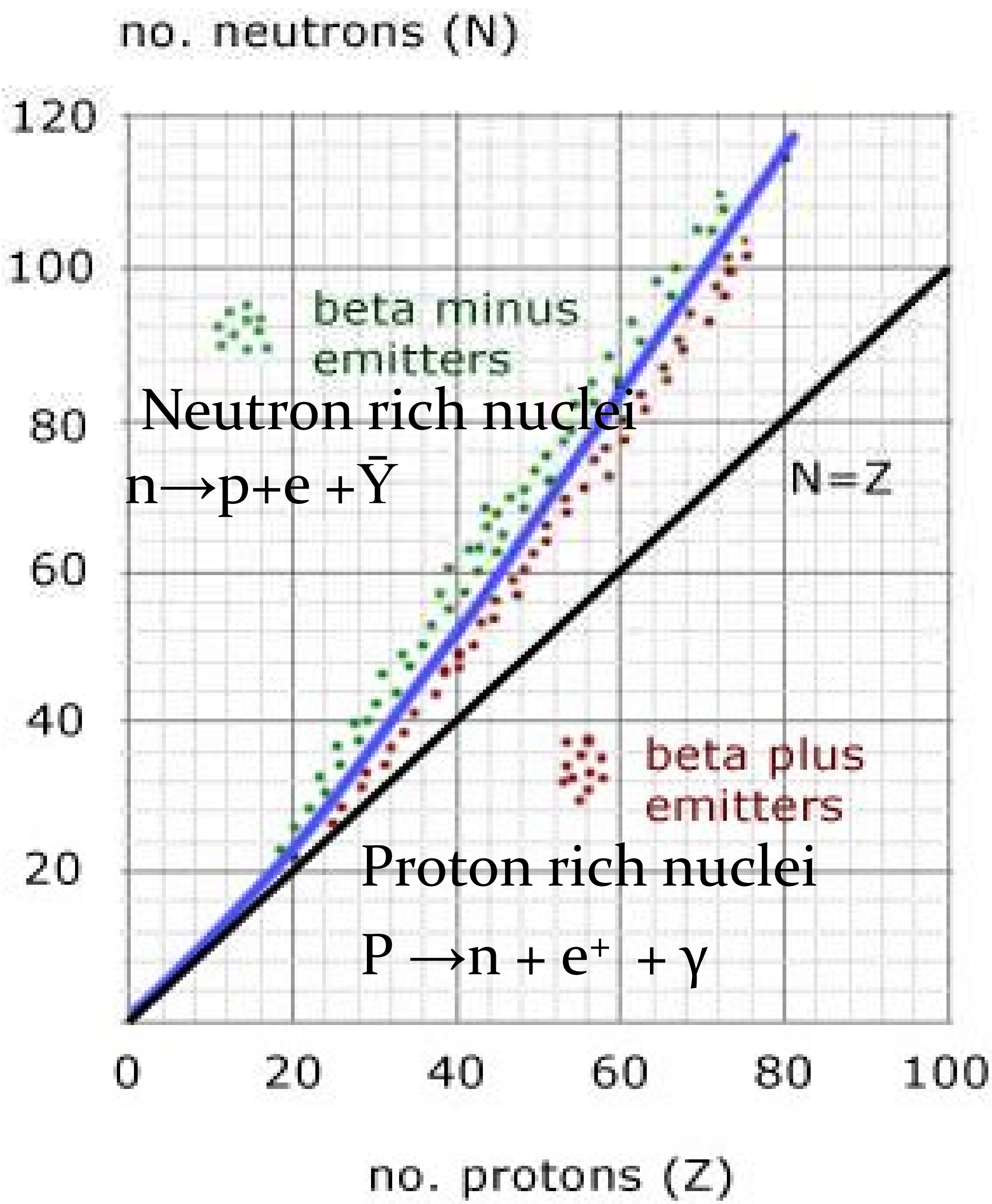
Name of the Department: Physics

Alpha decay

<u>α-disintegration energy</u>



Neutron rich nuclei

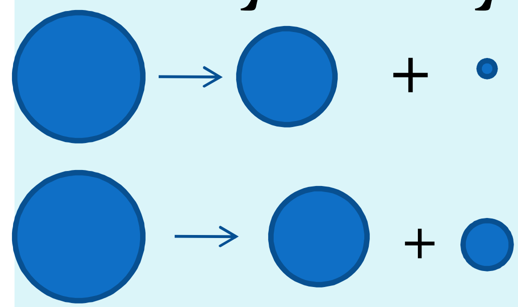
$n \rightarrow p + e + \bar{Y}$

Proton rich nuclei

$P \rightarrow n + e^{+} + \gamma$

Stable state is the minimum energy state of the nucleus

For very heavy nuclei



N=125

Z=85

A=210

$$^{A}_{Z}X \rightarrow ^{A-4}_{Z-2}Y + ^{4}_{2}He + Q$$

For α-particle emission for Q>o i.e. +Ve, the above equation represents that the rest mass energy of parent nucleus is larger than the rest mass energy of the two product. I.e. $M > M_{\alpha} + M_{d}$

Therefore the parent nucleus is in the higher energy state, so it disintegrate.

This +ve Q energy is sheared between the products. Among them the α-particle being lighter carries mos of the energy.

$$Q = [m(^{A}_{Z}X) - m(^{A-4}_{Z-2}Y) - m(^{4}_{2}He)]C^{2}$$

Alfa disintegration energy

At the time of α- emission, the parent nucleus is at rest, having zero momentum. So the products of α-disintegration must have zero momentum.

Now if the residual nuclei takes a momentum P_d

And α-particle takes Pα, then according to conservation of momentum

$$P_d = P\alpha \quad \Rightarrow \quad M_d v_d = M_\alpha v_\alpha$$

If Q be the α-disintegration energy, which is the tota energy released in the disintegration process, we can write

$$Q = \frac{1}{2} M_\alpha v_\alpha^2 + \frac{1}{2} M_d v_d^2$$
$$= \frac{1}{2} M_\alpha v_\alpha^2 + \frac{1}{2} \frac{M_d^2 v_d^2}{M_d}$$

$$= \frac{1}{2} M_\alpha v_\alpha^2 + \frac{1}{2} \frac{M_\alpha^2 v_\alpha^2}{M_d}$$

$$= \frac{1}{2} M_\alpha v_\alpha^2 (1 + \frac{M_\alpha}{M_d})$$

$$= E_\alpha (\frac{M_d + M_\alpha}{M_d})$$

Since the masses of the nuclei in the unit of atomic masses are close to their mass numbers, So we can write $M_d \approx A-4$ and $M_\alpha \approx 4$, so that

$$Q = E_\alpha (\frac{A}{A-4})$$

Measuring E_α , Q can be determined from above equation.

For ${}^{210}_{84}Po$,the α-energy is E_α =5.305 Mev

Which gives $Q = 5.305(\frac{210}{206})$ =5.408 Mev

Again we have $E_\alpha = Q\frac{A-4}{A}$

For example A=210

$$E_\alpha = Q(1 - \frac{4}{210})=Q(0.981)$$

i.e. more than 98% of energy is taken by α- particle.