(d) β - Decay Stability

Prediction of stability against β-decay for members of an isobaric family (For Odd A and Even A isobars)

The β-decay process furnishes an isobaric pair which can be easily studied with the help of semi-empirical mass formula. There are two types of β-decay viz. β^+ and β^-. In the β^--decay, Z increases by 1-unit and in β^+- decay Z decreases by 1-unit, while A remains constant.

Energy Released in β^- -decay $Q_{\beta^-} = M(Z,A) - M(Z+1,A)$; $\quad (Z \to Z+1)$

Energy released in β^+- decay $Q_{\beta^+} = M(Z,A) - M(Z-1,A)$; $\quad (Z \to Z-1)$

(a) Odd A Nuclei Decay

Since only one parabola, there is only one minimum value Z_0. Therefore we expect that for odd-A nuclei there is only one β- stable nucleus.

Only β^-- decay along the left arm and only β^+- decay for the right arm of the parabola because nuclei are driven towards achieving more stable states.

Energy released in β-decay varies with Z. Hence different transitions in the same parabola may release different amount of energy.

Now, energy released in decay is given by β^-- decay,

$$Q_{\beta^-} = M(Z,A) - M(Z+1,A) = \left[M(Z,A) - M(Z_0,A)\right] - \left[M(Z+1,A) - M(Z_0,A)\right]$$

$$Q_{\beta^-} = \gamma(Z-Z_0)^2 - \gamma(Z+1-Z_0)^2 = \gamma\left[-2(Z-Z_0)-1\right] = 2\gamma\left(Z_0 - Z - \frac{1}{2}\right)$$

Thus, $Q_{\beta^-} = 2\gamma\left(Z_0 - Z - \frac{1}{2}\right)$ and similarly, $Q_{\beta^+} = 2\gamma\left(Z - Z_0 - \frac{1}{2}\right)$

(b) Even A Nuclei Decay

Here the pairing term $\delta \neq 0$ and since both odd-odd and even-even nuclei are included, we have two parabola, displaced in binding energy by 2δ or corresponding mass value.

The decay always terminates on the lower parabola because it represents greater stability. (An even-even nucleus makes the lower parabola). In each β- transformation an even-even nuclei changes to odd-odd nuclei and odd-odd nuclei changes to even-even. Hence in each β-transformation there will be jump from one parabola to the other parabola.