Beta Decay

There exists three varieties of β decay:

1) β^-, 2) β^+, 3) Electron capture ⟵ In all these types A remains constant

β^- decay:

How come a nucleus emit an $\bar{e}$ if there aren't any $\bar{e}$'s inside the nucleus?

Actually if we free a n from the nucleus, it decays in about 15 min.

$$n \longrightarrow p + \underset{e^-}{\beta^-} + \bar{\nu}_e$$

electron antineutrino (more in particle phys.)

For β^- decay to occur, the mass of the original neutral atom should be larger than that of the final atom.

Ex: β decay of ${}^{60}_{27}Co$, an odd-odd unstable nucleus which is used in medical & industrial applications of radiation

$${}^{60}_{27}Co \longrightarrow {}^{60}_{28}Ni + \beta^- + \bar{\nu}_e$$

NB: Unlike the α-decay where there were two decay products, in the β-decay we cannot predict precisely how will the energy be shared among decay products

The β^- decay occurs with nuclides that have too large a N/Z ratio

(obviously after decay we get $\frac{N}{Z} \to \frac{N-1}{Z+1}$)

β^+ decay

For nuclides having N/Z too small, they emit a e^+ for stability.

The basic process is:

$$p \rightarrow n + \beta^+ + \nu_e$$

β^+ decay can occur wherever the mass of the original neutral atom is at least two e^- masses larger than that of the final atom.

e^- capture

There are a few nuclides for which β^+ emission is not energetically possible but in which an orbital $\bar{e}$ (usually in the K shell) can combine with a proton in the nucleus to form a n and a ν_e. The n stays in the nucleus and ν_e is emitted. The basic process is:

$$p + \beta^- \rightarrow n + \nu_e$$ ← This reaction also helps to explain the formation of neutron stars.

e^- capture can occur wherever the mass of the original neutral atom is larger than that of the final atom.

Note that <u>all</u> these three β decays occur within a nucleus.

β^- decay can also occur outside the nucleus

β^+ decay is forbidden by conservation of mass-energy for a p outside nucleus.

The $\bar{e}$ capture can occur outside the nucleus only with the addition of some extra energy, in a collision.