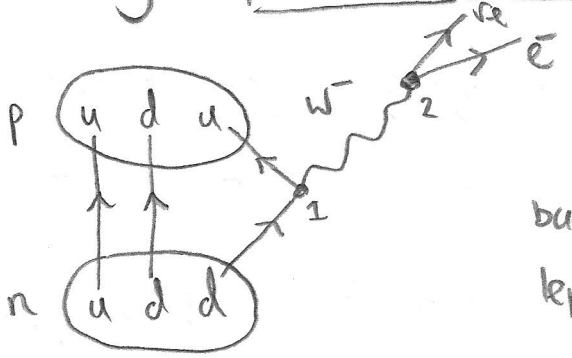
HIGH ENERGY & PARTICLE PHYSICS

(i) β^- decay: $\boxed{n \to p + \bar{e} + \bar{\nu}_e}$



Vertex 1:

$d \to u + W^-$

charge: $-\frac{1}{3}e \to \frac{2}{3}e - 1e$ ✓

baryon #: $\frac{1}{3} \to \frac{1}{3} + 0$ ✓

lepton #: $0 \to 0 + 0$ ✓

Vertex 2: $W^- \to \bar{e} + \bar{\nu}_e$

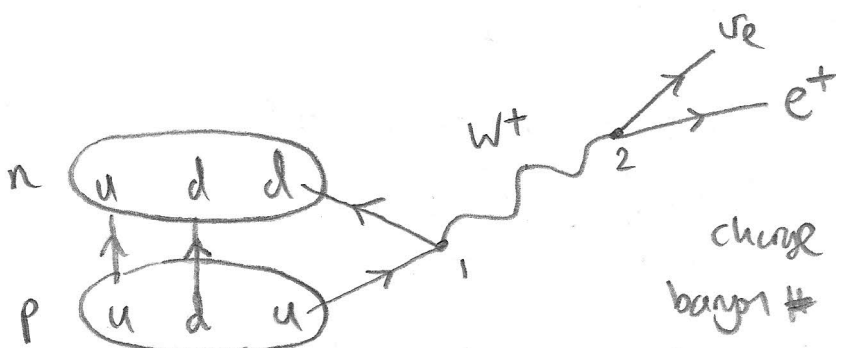
charge: $-e \to -e + 0$ ✓

baryon #: $0 \to 0 + 0$ ✓

lepton #: $0 \to 1 - 1$ ✓

Note ν_e would have a lepton # of $+1$ so it must be an <u>anti</u>neutrino.

(iii) β^+ decay: $\boxed{p \to n + e^+ + \nu_e}$



Vertex 1:

$u \to d + W^+$

charge: $\frac{2}{3}e \to -\frac{1}{3}e + 1e$ ✓

baryon #: $\frac{1}{3} \to \frac{1}{3} + 0$ ✓

lepton #: $0 \to 0 + 0$ ✓

Vertex 2: $W^+ \to \nu_e + e^+$

charge: $1e \to 0 + 1e$ ✓

baryon #: $0 \to 0 + 0$ ✓

lepton #: $0 \to +1 - 1$ ✓

e^+ is the antiparticle of e^-, so has lepton # of -1.

(iii) $\pi^- + p \to n + \pi^- + \pi^+$

Quark content: $\bar{u}d + udu \to udd + \bar{u}d + u\bar{d}$

$$\pi^- + p \longrightarrow n + \pi^- + \pi^+$$

$$\bar{u}d + udu \rightarrow udd + \bar{u}d + u\bar{d}$$

charge/e: $-\frac{2}{3}-\frac{1}{3} + \frac{2}{3}-\frac{1}{3}+\frac{2}{3} \rightarrow \frac{2}{3}-\frac{1}{3}-\frac{1}{3} \; -\frac{2}{3}-\frac{1}{3} + \frac{2}{3}+\frac{1}{3}$

$-1 + 1 \rightarrow 0 \quad -1 + 1$ ✓

baryon #: $-\frac{1}{3}+\frac{1}{3} + \frac{1}{3}+\frac{1}{3}+\frac{1}{3} \rightarrow \frac{1}{3}+\frac{1}{3}+\frac{1}{3} + -\frac{1}{3}+\frac{1}{3} + \frac{1}{3}-\frac{1}{3}$

$0 + 1 \rightarrow 1 + 0 + 0$ ✓

(iv) $k^+ \rightarrow \pi^+ + \pi^0$ kaon decay to pions

$u\bar{s} \rightarrow u\bar{d} + d\bar{d}$ Quark content of these Mesons.

charge/e: $\frac{2}{3}+\frac{1}{3} \rightarrow \frac{2}{3}+\frac{1}{3} + -\frac{1}{3}+\frac{1}{3}$

$1 \rightarrow 1 + 0$ ✓

(v) $m_{k^\pm} c^2 + B_{k^\pm} = M_u c^2 + M_{\bar{s}} c^2$

$B_{k^\pm} = 2.4 + 95 - 0.5261 \times 938.27$ (MeV)

$$\boxed{B_{k^\pm} = -396.2 \text{ MeV}}$$

what does a -ve binding energy mean? Is it like a -ve gravitational potential energy? Interestingly, it appears most of the mass-energy of the kaon is not the mass-energy of the quarks – it is an energy held within the fields associated with the strong force.

$B_{\pi^\pm} = m_u c^2 + M_{\bar{d}} c^2 - M_{\pi^\pm} c^2$

$= 2.4 + 4.8 - 0.14875 + 938.27$ MeV

$= \boxed{-132.4 \text{ MeV}}$