2.7 Conservation rules

When particles interact or decay, only certain outcomes are permissible. This is determined by conservation rules. Conservation means that a quantity remains the same before and after an event. For example, we are already familiar with 'conservation of momentum' and 'conservation of energy' from other areas of physics. We have also seen that 'mass-energy' is conserved in particle physics.

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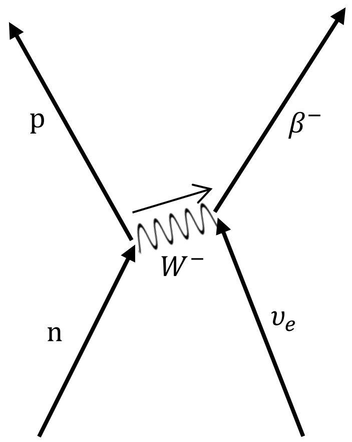
For particle interaction/decay, the following must be conserved:

- Charge Q
- Lepton numbers L_e, L_μ, L_τ
- Baryon number B
- Strangeness number S (Only for strong interactions. For weak interactions S can change by ±1)

Let us consider an example. A neutron interacts with an electron neutrino and the neutron changes to a proton, and a beta minus is produced. The Feynman diagram for this is shown below:



We can write an equation for this interaction:

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

Let us check on conservation.

	before	**after**
Q	0 + 0 = 0	+1 -1 = 0 ✓
L_e	0 + 1 = +1	0 + 1 = +1 ✓
L_μ	0 + 0 = 0 (no muon/anti-muon)	0 + 0 = 0 ✓
L_τ	0 + 0 = 0 (no tau/anti-tau)	0 + 0 = 0 ✓
B	+1 + 0 = +1	+1 + 0 = +1 ✓
S	0 + 0 = 0 (no strange quarks)	0 + 0 = 0 ✓

These quantities are the same on both sides of the equation, so they are conserved. The interaction is permissible.

(1)✏Beta minus decay involves a neutron changing to a proton and releasing a beta minus particle (an electron) and an anti-electron neutrino. Show that the quantities listed, above, are conserved in this decay.

(2)✏A sigma baryon (Σ^-) consists of a strange quark and two down quarks (sdd). In the following interaction, a negative pion combines with a proton to produce a positive kaon and a sigma baryon. Work out Q, L_e, L_μ, L_τ, B, S on both sides of the equation and determine if this interaction is permissible. (Hint: use the quark properties from section 2.6.)

$$\pi^- + p \rightarrow K^+ + \Sigma^-$$