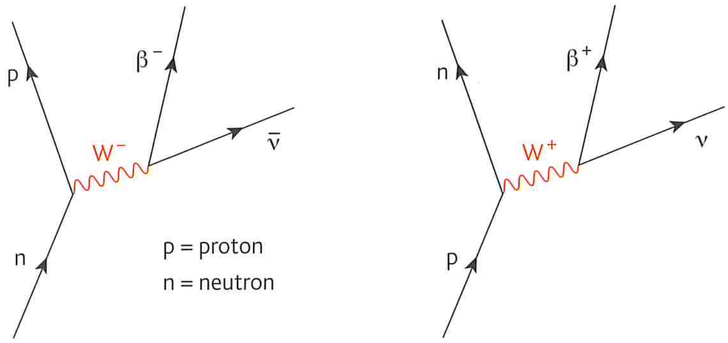
Back to beta decay

So what role does a W boson play in beta decay? You can see from Figure 3 that the W boson in each case meets a neutrino or antineutrino, changing them into a β^- particle (an electron) or a β^+ particle (a positron) respectively. But if no neutrino or antineutrino is present:

- the W^- boson decays into a β^- particle and an antineutrino,
- the W^+ boson decays into a β^+ particle and a neutrino.



a β^- *decay* **b** β^+ *decay*

Figure 4 W bosons in beta decay

Figure 4 shows the Feynman diagram for each of these decay processes. Notice that charge is conserved in both processes.

Electron capture

Sometimes a proton in a proton-rich nucleus turns into a neutron as a result of interacting through the weak interaction with an 'inner-shell' electron from outside the nucleus. Figure 5 shows the Feynman diagram for this process. Notice that the W^+ boson changes the electron into a neutrino.

The same change can happen when a proton and an electron collide at very high speed. In addition, for an electron with sufficient energy, the overall change could also occur as a W^- exchange from the electron to the proton.

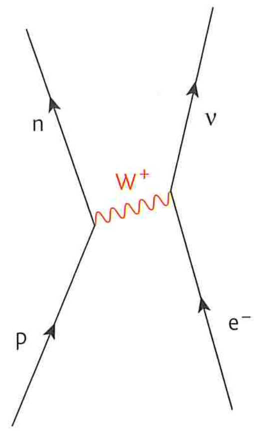


Figure 5 *Electron capture*

Summary questions

$c = 3.00 \times 10^8\,\mathrm{m\,s^{-1}}$

1 Sketch the Feynman diagram for the electromagnetic force between **a** two protons, **b** a proton and an electron, **c** two electrons.

2 Sketch the Feynman diagram for **a** β^+ decay, **b** β^- decay.

3 **a** Sketch the Feynman diagram for the interaction between **i** a neutron and a neutrino, **ii** a proton and an antineutrino.

b State the approximate range of the W boson and estimate its lifetime, given it cannot travel faster than the speed of light.

4 **a** State three differences between a W boson and a virtual photon.

b In both Figure 4b) and Figure 5, a proton changes into a neutron. Describe how these two processes differ.