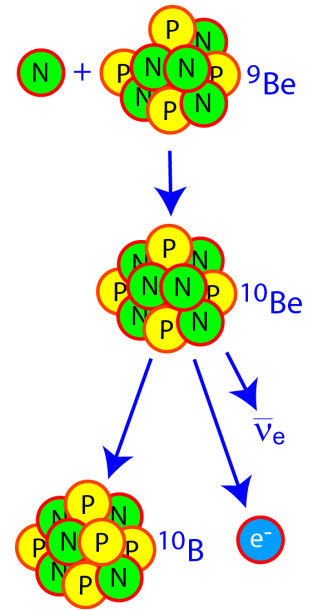


# Neutron Capture Processes

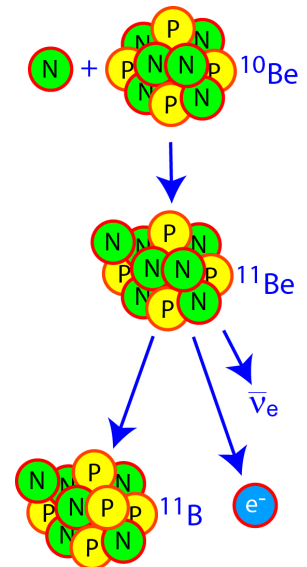
Many elements are created by fusion in stars, but heavy elements can't be! Those elements may result from neutron capture processes:

1. Free neutrons are created by nuclear reactions in a red giant star.
2. A stable nucleus in the star ( ${}^9\text{Be}$  in the example at right) absorbs a neutron, making a neutron-rich and unstable  ${}^{10}\text{Be}$ .
3. The  ${}^{10}\text{Be}$  nucleus releases energy/becomes stable by beta-minus decay, turning a neutron into a proton and forming  ${}^{10}\text{B}$ .
4. Thus, a Beryllium nucleus has been turned into a heavier element, Boron!
5. This new stable Boron nucleus might absorb a neutron, and the whole process continues.



## Capture or decay first?

In a star with loose neutrons around, stable nuclei might absorb them every so often. Unstable nuclei might too, as long as they didn't decay first. Consider the  ${}^{10}\text{Be}$  above... its half-life is over 1 million years. *If neutrons were abundant enough that a nucleus would normally capture one every ten years, would  ${}^{10}\text{Be}$  be more likely to capture or decay first?*



A  ${}^{10}\text{Be}$  nucleus capturing a neutron would become  ${}^{11}\text{Be}$ , which has a half-life of 13.8 seconds. *With the same assumptions above, would it be more likely to capture or decay first?*

The number of neutrons available and the half-life of each isotope determines whether it is more likely to capture a neutron or decay!

## Creating a model

Note the "legend" at right: on a chart of the nuclides, neutron capture moves a nucleus to the right, while beta decays go up & left or down & right. **Remember this for the next part!**

Let's construct a simple model of how neutron capture occurs in a red giant star. In our model:

1. Neutrons capture every 10 yr
2. Isotopes with half-lives longer than 10 yr will capture, while isotopes with half-lives shorter than 10 yr will decay.

Using that model, you can make a prediction of the "s-process", a set of slow neutron capture reactions that may occur in a red giant star!

