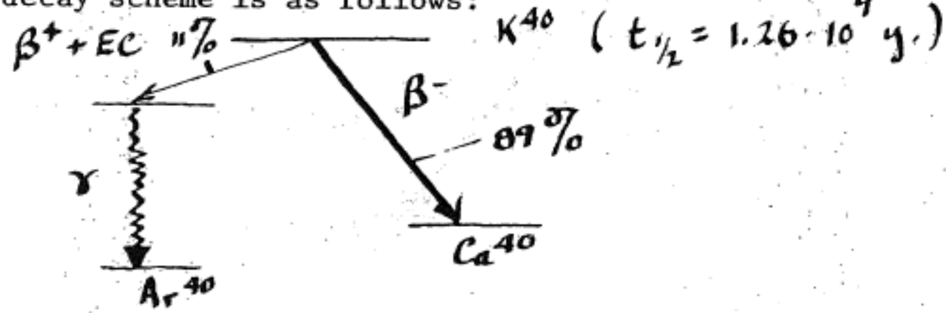
ASTR 536 HW #1 due 9/4/17 in class

10 pts

(1) Consider the problem of determining the age of a sample of the earth (a rock) from the relative abundance of K^{40} and Ar^{40} in that rock. We may safely assume that while the material is molten or gaseous, the Ar^{40} escapes. Thus Ar^{40} slowly builds up from zero abundance starting at the time the rock material last solidified. The relevant decay scheme is as follows:



If one studies a large sample of rocks, one finds that the molar abundance ratio $\frac{A}{K}$ of Ar^{40} to K^{40} is always less than a limiting value:

$$\left.\frac{A}{K}\right)_{max} = 1.23$$

Using this fact and the decay scheme above, first derive a general formula which expresses the age of the rock t in terms of $\frac{A}{K}$ and the partial decay rates to Ar^{40}, Ca^{40}; then compute the maximum rock age t_{max} (= t_{EARTH}).

(2) In 1987 a Supernova went off in the Large Magellenic Cloud about 50 kpc away from us. What has made SN 1987a (the "name" of the supernova) most remarkable is that a burst of neutrinos (ν) were detected by two deep underground detectors, the IMB (in the U.S.) and Kamiokande (in Japan) detector. 8 events were detected in IMB and 11 at Kamiokande. The properties of these bursts were:

10 pts

- Spread in ν energies observed:

$$\delta E_\nu \sim 10 \text{ MeV}$$

- Average energy:

$$\langle E_\nu \rangle \sim (2\text{-}3)\, \delta E_\nu \sim 20\text{-}30 \text{ MeV}$$

- Spread in arrival time:

$$\delta t \sim 10\,\text{s}$$

(is it upper or lower?)

Using this data, place a bound on the ν mass.

Hints: You do not need to know about oscillations. Start with special relativistic relations between mass, energy and momentum. This is an exercise in approximations!