Astronomy 102, Review Exam 1

Solutions

1. **(a)** Indeed, it is correct. With a half life of only a few thousand years (5,700 if you must be precise, but it isn't needed for the argument), over billions of years there will only be an infinitesimal fraction of any sample of C-14 left; this will practically be unmeasurable, and as such C-14 dating isn't useful for billions of years. In fact, C-14 dating is only good up to several tens of thousands of years.

(b) It is not relevant at all. Carbon dating does not contribute to our estimates of the age of the Solar System. For that, we use radioactive elements that have lifetimes that are long enough that they can measure timescales of billions of years.

2. **(a)** One hour from now, two half lives will have elapsed, so $\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{1}{4}$ ofthe original sample will be left.

The number of particles that decay each second is proportional to the number of particles that you have. (In fact, it's numerically equal to the decay probability per second times the number of particles present.) So, if you have 1/4 as many particles 1 hour later, you will have 1/4 as many decays, or $\boxed{\text{5 decays per second}}$.

(b) In principle, you will have to wait *forever*. You can't predict when any given isotope will decay; there's a 50its half-life. Just as you could (in principle) flip hundreds of heads in a row, a particle could survive hundreds of half-lives. If you have a very large initial sample, you will still see the odd count here and there a long term later. (Of course, 20 decays per second is *not* a very large sample if the sample has a half-life of 30 minutes, so in practice after a few days you probably won't hear any more counts; but in principle, you have to wait forever.)

(c) 1/2 ; see homework due 2006/09/08.

3. It tells us nothing about the age of the Solar System. If the K-40/Ar-40 ratio is *higher*, that tells us that there has been *less time* for the K-40 to decay. Thus, this rock is *younger* than 4.6 billion years. However, that doesn't call into question the age estimate from the older rocks; this is just a rock that last solidified after the beginning of the Solar System.

4. **(a)** 2.0×10^{30} kg. The efficiency of the fusion process is 0.007, and if only 10% of the mass is used in fusion, then the sun will only have lost 0.0007 of its mass. This is a smaller fraction than you can measure using only two significant figures.

(b) The rate will be *higher*. You know this simply because the luminosity is higher. If it's putting out more energy every second, it has to be generating more energy each second, and therefore it must be converting more mass to energy each second.

(c) The efficiency will be exactly the same, because it's exactly the same process (Hydrogen fusion).

(This wasn't asked, but : if you think about it, since the efficiency is the same, but the rate of energy generation is 100 times higher, it must be using up fuel at 100 times the rate.)