Practice Problems for Exam #5

1. In a reference frame where you and they are stationary, two firecrackers go off. One is located two light seconds to your left and explodes at t = 0 seconds and the other 4 light seconds to your right and explodes at t = 10 seconds. I am moving from your left to your right at 0.6 times the speed of light.
   a. How far apart would I say the collisions are?
   b. How much time would I say separates the two explosions?

2. A particular subatomic particle lives for 2.21μs in its own, at-rest, reference frame. If I measure the distance between where the particle is created and where it decays to be 1000m
   a. How much time do I say passed between creation and decay?
   b. How fast was the particle going as it moved through my lab?

3. What are the two postulates of Einstein's special theory of relativity?

4. In Mr. Tompkins in Paperback, what did Mr. Tompkins see when he, trying to move quickly, pedaled very hard on his bicycle?

5. Suppose I want to measure the energy of a particle to within 10^{-36}J. What is the minimum duration of my measurement?

6. In a hydrogen atom I could have the electron make a transition from the n = 5 state to the n = 2 state. I could also have the electron move from n = 12 to n = 3. For which transition would the wavelength of the emitted photon be longer?

7. SiO_2, GeS_2, and $GeSe_2$ all exist as crystals with similar structures and properties. Explain why this is true.

8. Look in Appendix B of your textbook. How much energy is released when three helium atoms are combined to make a carbon atom?

9. A particular isotope has a decay constant of 3.51 $seconds^{-1}$.
   a. What is the half-life of this isotope?
   b. If I start with 10^{15} nuclei of this isotope, how many will I have after 6 seconds?

10. At one moment in time I have 10^{10} nuclei of a particular radioactive element. If they are decaying at the rate of 10^4 per second, what is the decay constant?

11. What nuclei combine to form what product for -
    a. A normal, main sequence, star during the bulk of its lifetime?
    b. A star that has used up its primary fuel and is now in the second stage of its life.
       i. What do you call a star in the second stage?
       ii. Can you name an example of such a star?

12. There are several isotopes of uranium that can be made or found. Mostly, the kind you dig up are ^{235}U and ^{238}U. For the purposes of making a nuclear reactor, does it much matter which kind of uranium is used? If so which do you want and why?

Answers

1. Compute γ to be 1.25
    a. 4.8 light seconds
    b. 9.33 seconds Use the metric equation
2. Use the metric equation
    a. 4.00μs
    b. $2.5 \cdot 10^8$m/s
3. See you notes or the book.
4. Read the chapter posted on our website.
5. 105.5 seconds
6. The n = 12 to n = 3 transition emits the photon with the longer wavelength.
7. They each contain one atom from Group 4 of the periodic table and two from Group 6. Elements within each group have similar outermost electrons and so form bonds in much the same way.
8. 7.274MeV
9.
    a. 0.1975s
    b. $7.14 \cdot 10^5$ nuclei
10. 10^{-6}/s
11.
    a. Four hydrogen atoms combine to form a Helium atom plus energy and other stuff.
    b. Three Helium atoms combine to form a Carbon atom plus energy and other stuff.
        i. Red Giant
        ii. Betelgeuse (the bright star that makes Orion's right shoulder)
12. The ^{235}U is far more easily split with neutrons. Reactors need fuel enriched to about 3% ^{235}U to be able to sustain a chain reaction. The largest engineering part of the Manhattan Project was finding out how to separate ^{235}U from ^{238}U.