Your name: _____

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AST 10: Homework 3

1. Let's check how much energy there is in $1\,\text{gm}$ of matter. The unit of energy below will be an "erg." A $100\,\text{Watt}$ bulb uses 10^9 ergs/second. A gallon of gas yields 12×10^{14} ergs of energy.

   a) The speed of light is $c = 3 \times 10^{10}\,\text{cm/sec}$. Calculate $E = mc^2$ for $m = 1\,\text{gm}$.

   b) How many seconds would that power a $100\,\text{W}$ bulb?

   c) How many seconds are there in a year? Convert the answer in (b) to years.

   d) How many gallons of gas is the answer in (a) equivalent to?

2. We said in class that the sun emits 3.9×10^{26} Joules of energy every second. In these units, the speed of light is 3×10^8 meters/sec.

   a) Using this value of c, and rearranging $E = mc^2$, calculate how much mass the sun most lose every second to account for this energy output. (The unit will automatically be kg.)

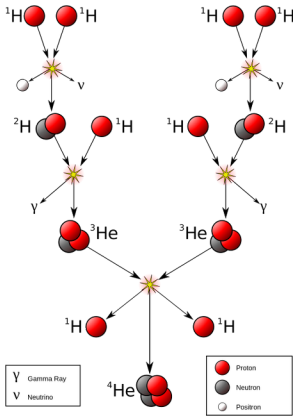
   b) Rounding off the value we found in class, each $4\text{H} \rightarrow \text{He}$ process loses $5 \times 10^{-29}\,\text{kg}$. How many such processes do you need to power the sun?

3. As said in the class, fusion in stars is a three-step process:

i) Two protons collide to produce deuterium (a variant of hydrogen), a positron (an anti-electron), and a neutrino.

ii) A proton collides with the deuterium to produce a another helium variant (helium-3) and a gamma ray (high-frequency electromagnetic wave).

iii) Two helium-3s collide to produce a normal helium nucleus, releasing two protons.



   a) At what stage(s) is energy released that can escape from the star?

   b) At what stage is light released that can escape from the star?

   c) Which form of energy gets out quicker?

4. In which part of a star do the nuclear reactions that "fuel" it occur? (Throughout the star? The outer layers? The inner core?) Why just in that region?