November 29, 2004 Name:_____

Astronomy 102: Stars and Galaxies

Review Exam 4

Instructions: Write your answers in the space provided; indicate clearly if you continue on the back of a page. No books, notes, or assistance from anyone is allowed. You are allowed to use, and will need, a calculator. The exam has five questions, each with equal weight.

Possibly Useful Constants and Formulae

Earth-Sun Distance: 1.000 AU

Baryonic Products of Big Bang: 75% H, 25% He

Heavy Elements: Everything not H or He

Lifetime of 8 $M_\odot$ star: 80 million yaers

Age of Universe: 13.6 billion years.

$$L = A\,\sigma\,T^4$$

$$L = 4\pi\,R^2\,\sigma\,T^4$$

$$B = \frac{L}{4\pi\,d^2}$$

$$F = \frac{G\,M_1\,M_2}{d^2}$$

$$v = H_0\,d$$

$$t_H = \frac{1}{H_0}$$

$$E = m\,c^2$$

$$c = 3.00 \times 10^8\,\mathrm{m\,s^{-1}}$$

$$G = 6.67 \times 10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$$

$$1\,\mathrm{W} = 1\,\mathrm{J\,s^{-1}}$$

$$z = \frac{\lambda_{\mathrm{obs}} - \lambda_{\mathrm{emit}}}{\lambda_{\mathrm{emit}}} = \frac{\Delta\lambda}{\lambda}$$

$$z = \frac{v}{c} \quad (\mathrm{for}\ \ v \ll c)$$

$$(1+z) = \frac{\mathrm{Size\ Now}}{\mathrm{Size\ Then}}$$

1. An astronomer is very excited to find a star with no heavy elements at all.

(a) Why is the astronomer excited?

(b) Roughly what is mass of this star likely to be, in comparison to the mass of the Sun? How do you know?

2. Consider each of the following astrophysical phenomena: the Big Bang, a main sequence star, a red giant star, a supernova. Which of these events must at least some of the atoms in your body have been through before they had the good fortune to become part of you? Explain *briefly* why you know this must be the case for each of the four phenomena.

3. In the movie *Star Trek: Generations*, a mythical substance is able to stop the nuclear reactions inside a star. Suppose that you were magically able to stop all of the nuclear reactions inside the Sun.

(a) At some point after you had done this, you would start to see the effects of it on the surface of the star. When you first started to see these effects, what do you expect would happen to the luminosity, temperature, and size of the Sun? For each one, write a sentence to explain why.

(b) A key plot point of that movie was that after the nuclear reactions in a star had been stopped, the star's gravitational influence on other astronomical objects was eliminated. Given what you know about gravity, is this reasonable? Why or why not?

4. **(a)** How should the heavy element abundance observed by an astronomer looking at that star change during the star's main sequence lifetime?

(b) Some red giants form interstellar dust particles in their outer atmosphere. These particles are formed from (among other things) carbon. More carbon is present than was present at the surface of the star when the star formed.

What heat transport mechanisms must be present (at least sometimes) in these red giants? Explain.

5. Consider a star cluster that is at least a couple of billion years old. Should the number of stars that are red giants increase, decrease, or stay the same with time? Explain.