September 8, 2006 Name:________________________

Astronomy 102: Stars and Galaxies

Review Examination 1

Do not open the test until instructed to begin.

Instructions: Write your answers in the space provided. If you need additional space, continue on the back of each page, but indicate **clearly** that you have done so. No books, notes, or assistance from anyone is allowed. You are allowed to use, and will need, a calculator. Please **write legibly and be brief and to the point!** The exam has seven questions; each question has equal weight.

Possibly Useful Constants and Formulae

$$R_\odot = 6.96 \times 10^5 \text{ km}$$
$$M_\odot = 1.99 \times 10^{30} \text{ kg}$$
$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$

$$1\,\text{pc} = 3.26 \text{ lyr}$$
$$1\,\text{pc} = 206,265 \text{ AU}$$
$$1\,\text{AU} = 1.496 \times 10^{11}\,\text{m}$$
$$1\,\text{km} = 1,000\,\text{m}$$

$$E = m\,c^2$$
$$eff = \frac{E_{\text{produced}}}{m\,c^2}$$

Process	Efficiency
Chemical Reactions	$\sim 10^{-10}$
Nuclear Reactions	$\sim 10^{-2}$
Total Conversion	1

Age of Solar System: 4.6×10^9 years

Age of Universe: 13.7×10^9 years

1. Some websites raise an objection to the scientific evidence for the age of the Solar System which goes as follows: Carbon dating is not effective at measuring ages of billions of years.

(a) Is this statement correct? Explain.

(b) Supposing this statement is correct (whether or not it is really correct), is this statement relevant to the scientific evidence for a 4.6 billion year old solar System? Explain.

2. You have a sample of a radioactive isotope with a half life of 30 minutes. You use a Geiger counter to measure the decay rate, and measure 20 decays per second.

(a) How many decays per second will you measure from this sample one hour from now?

(b) How long will you have to wait until you will hear no more clicks forevermore from the sample? Explain.

(c) After you've waited the first half-hour, you pick out a single isotope that has managed to survive through that first-half hour. What is the probability that this one isotope will decay in the *next* half-hour?

3. We have found rocks (meteorites) that have a Potassium-40/Argon-40 ratio of about 0.08, and from this have concluded that the Solar System is 4.6 billion years old. Suppose you find a rock that has a Potassium-40/Argon-40 ratio of 0.2. What, if anything, does this rock say about the age of the Solar System? (Give a qualitative answer; I don't expect hard numbers.) Explain your reasoning.

4. Later in the Sun's life, it will swell and become a Red Giant; it will be enough bigger that its luminosity (amount of energy generated each second) will have gone up by a factor of 100. The first part of the red giant phase of the Sun's life will last less than 10% of the phase we're currently in. During the first part of the red giant phase, the Sun will still be generating energy via Hydrogen fusion at its core.

(a) By $E = mc^2$, knowing that the Sun is right now using up some of its mass to genearte energy, approximately what (to two significant figures) will be the Sun's mass at the *beginning* of this phase? (Ignore any mass loss due to the Solar Wind or other mass ejections.)

(b) Will the rate at which mass is converted to energy be *higher*, *the same*, or *lower* when the Sun is a red giant, as compared to now? Explain.

(c) How will the *eff* (efficiency) of the energy generation process during the first part of the Sun's red giant phase compare to the *eff* of the energy generation process in the Sun right now?