November 19, 2003 Name:_____

Astronomy 102: Stars and Galaxies
REVIEW TEST for Examination 4

Do not open the test until instructed to begin.

Instructions: No books, notes, or assistance from anyone is allowed. You will need a calculator. Please **write legibly and be brief and to the point!** The exam has 13 questions: eight multiple choice (1-8) and five short answer (9-13). You have 50 minutes in which to answer them. All exams must be turned in at the end of the period. Each problem indicates the number of points it is worth; there are a total of 64 points available.

Possibly Useful Constants and Formulae

O B A F G K M
← bluer redder→
← hotter cooler→

Low-mass: $M < 8\,M_\odot$
High-mass: $M > 8\,M_\odot$

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

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

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

$$R_{EH} = \frac{2\, G\, M}{c^2}$$

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

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

Multiple Choice Questions: The first eight questions are multiple choice. Except where explicitly noted, only one answer is correct for each question. Circle the letter of the correct answer. Each multiple choice question is worth **4 points**

1. Which of the following is found only in a binary or multiple star system? (**More than one may be correct; circle all that apply.**)
   - **(a)** A nova
   - **(b)** A Type Ia (thermonuclear) supernova
   - **(c)** A Type II (core collapse) supernova
   - **(d)** A star whose mass we can measure without resorting to theories of stellar evolution
   - **(e)** A star whose luminosity we can measure without resorting to theories of stellar evolution
   - **(f)** A pulsar
   - **(g)** A white dwarf
   - **(h)** A star with planets

2. The moon suddenly and unexpectedly collapses and becomes black hole (while keeping the same mass). Which of the following happens? (Only one is correct.)
   - **(a)** The moon would develop an event horizon which is 3 km in radius.
   - **(b)** Tides on the Earth would become much more extreme, because tidal forces from the moon-mass black hole would be greater than those from the Moon.
   - **(c)** The Earth would be sucked into the black hole where the Moon used to be.
   - **(d)** We would thereafter have no way of knowing where the moon was.
   - **(e)** None of the above.

3. In a planetary nebula, the shell of expelled material is glowing intensely. What is the source of energy for this glow?
   - **(a)** Beams of particles and electromagnetic waves emitted from the magnetic poles of the central spinning star.
   - **(b)** The explosion of the dying star.
   - **(c)** Ultraviolet radiation from the hot star at the center.
   - **(d)** The fusion of hydrogen into helium in the expelled shell.
   - **(e)** The change of electrons and protons into neutrons.

4. Which of the following statements about the life of a star with a mass like the Sun is correct?
   - **(a)** After the main sequence stage, there is no further fusion of hydrogen anywhere in the star.
   - **(b)** As the star is dying, a considerable part of its mass will be lost into space.
   - **(c)** The core of this star will be too massive to form a white dwarf.
   - **(d)** Before the star dies, it will fuse dozens of different elements in its core.
   - **(e)** At the end of its life, the star will explode as a supernova

5. Once a black hole forms, the *size* of the event horizon is determined only by:

(a) The size of the star that collapsed into the black hole

(b) The time since the black hole formed

(c) The composition of the material that formed the black hole

(d) All black holes have the same size for their event horizon

(e) The mass inside the event horizon

6. In a cluster of stars (which all formed at the same time), you find three stars: a main sequence star, a red giant, and a white dwarf. Rank these stars from least massive to most massive, considering the mass of the star *at the time when it began its main sequence lifetime* (i.e. don't worry about any mass loss that has happened between then and now, including the significant mass loss of a planetary nebula).

(a) Main Sequence, Red Giant, White Dwarf.

(c) Main Sequence, White Dwarf, Red Giant.

(b) White Dwarf, Main Sequence, Red Giant.

(d) Red Giant, Main Sequence, White Dwarf.

(e) It is impossible to rank-order them by original mass from the information given.

Bonus: [0 points] From the information given, can you set a minimum age on this cluster? What is that minimum age? (This bonus question is open-book.)

(7.) Energy from the core of the Sun is brought to the surface by:

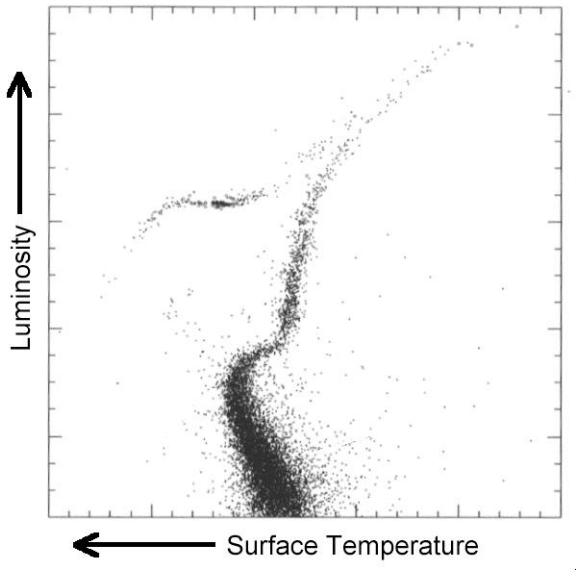
(a) Photons which move freely through the radiative zone, followed by hot gasses rising in the convective zone.

(b) Photons which are repeatedly absorbed, scattered, and re-emitted throughout the radiative zone, followed by hot gasses rising in the convective zone.

(c) Neutrinos which move freely through most of the mass of the sun and are converted to energy (light) at the Sun's surface.

(d) The gravitational attraction of the Sun's mass, which counteracts the pressure of the Sun and pushes the radiation to the Sun's surface.

8. Consider the following H-R diagram:



This is the H-R diagram of: (**more than one answer may be correct; circle as many as apply**)

(a) A young group of stars.

(b) An old group of stars.

(c) A group of stars that formed in a short period of time.

(d) A group of stars which have been forming throughout the lifetime of the Galaxy.

(e) A group of stars rich in heavy elements.

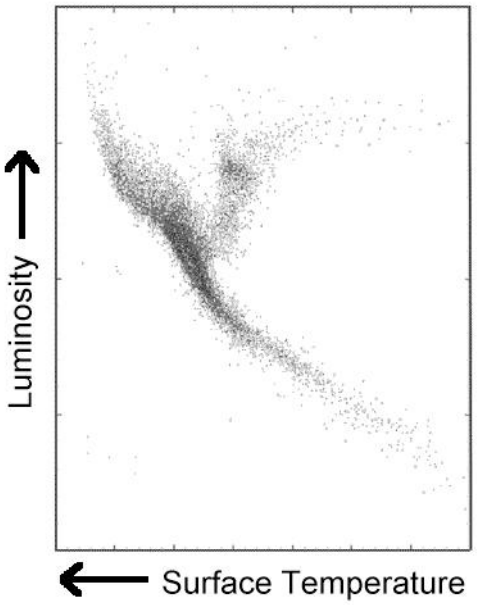
(f) A group of stars more massive than the Sun.

(g) A group of stars characteristic of the stars near the Sun in the Galaxy.

(h) A group of stars characteristic of the brightest stars we can see from the Earth.

Short Answer Questions: Answer questions in the space provided. Indicate clearly if you must continue on the back of the page. Include any calculations or diagrams necessary. Some questions require only a word or a few words, others will require a sentence or two of explanation, and others will require a calculation. **Be brief and to the point.**

9. Consider the following H-R diagram:



(a) The stars in this H-R diagram were selected from (circle one):
the nearest stars the Galaxy a globular cluster an open clusters

(b) Circle and indicate with "(b)" the major group of stars on the diagram which have the largest physical sizes (i.e. radius).

(c) Circle and indicate with "(c)" a group of stars on the diagram for which you are sure that all the stars you circled are young (i.e. less than a few tens of millions of years old).

(d) Circle and indicate with "(d)" the stars which undergoing burning Hydrogen fusion at their core.

10. An astronomer discovers a glowing cloud of ionized gas. What might she expect to find near or inside this cloud? List two possibilities, and explain in a few words or a couple of sentences why she might expect to find that and what that would tell her about the glowing gas cloud.

11. For the first week or so after the explosion of a Type II supernova, we observe the supernova to continuously get a lot brighter. We also observe its temperature to drop from about 60,000 K to 10,000 K during the same time period. From just these two facts, what can we conclude about the part of the supernova emitting the light that we can see?

12. [8 points] Consider two familiar stars in the winter sky: Betelgeuse and Sirius. For each of these star systems (described in more detail below), indicate what future astrophysical phenomena we might possibly observe from them (were we to live the requisite huge number of years). In each case, there may be more than one possibility based on the information provided.

(a) Betelgeuse is a red supergiant star of spectral type M which is 130pc distant. It is very large, with a radius of $\sim$ 600 times that of the Sun. Betelgeuse almost certainly started its main sequence life with a mass greater than $12\,M_\odot$; however, it has undergone a lot of mass loss, and is still shedding mass. As such, we are not sure if it will stay over $8\,M_\odot$ throughout its tenure as a supergiant. What are possible astrophysical phenomena that future astronomers might observe from Betelgeuse?

(b) Sirius, the brightest star in the sky, is in fact a binary star system less than 3pc away from the Sun, although only one star is bright enough to see with the naked eye. The brighter star (Sirius A) is a main sequence star of spectral type A; it is about twice as massive as the Sun. The dimmer star (Sirius B) is a carbon white dwarf star in an eccentric orbit about Sirius A with a semi-major axis of about 20 AU. Sirius B has a mass similar to that of the Sun, but is smaller than the Earth. What are possible astrophysical phenomena that future astronomers might observe from Sirius?

13. [8 points] An astronomer makes a startling discovery: a main sequence star in the Milky Way whose spectrum shows that the star is composed *only* of Hydrogen and Helium; the spectrum shows no evidence of Oxygen, Iron, or other heavy elements.

(a) The astronomer is very excited about this discovery; why is it so astronomically significant?

(b) Is this star likely to have a planetary system? Why or why not?

(c) Can this star be more massive than the Sun? Why or why not?