June 15, 2006 Name:_____

# Astronomy 102: Stars and Galaxies

# Practise/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**

$$R_\odot = 6.96 \times 10^5 \text{ km}$$
$$M_\odot = 1.99 \times 10^{30} \text{ kg}$$
$$T_\odot = 5,600 \text{ K}$$
$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$
$$h = 6.626 \times 10^{-34} \text{ J Hz}^{-1}$$
$$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$$

$$1 \text{ pc} = 3.26 \text{ lyr}$$
$$1 \text{ pc} = 206,265 \text{ AU}$$
$$1 \text{ AU} = 1.496 \times 10^{11} \text{ m}$$
$$1 \text{ km} = 1,000 \text{ m}$$
$$1 \text{ mi} = 1.609 \text{ km}$$
$$1 \text{ Å} = 10^{-10} \text{ m}$$
$$1 \text{ Hz} = 1 \text{ s}^{-1}$$

$$f\lambda = c$$
$$E = hf$$

$$L = A\,\sigma\,T^4$$
$$L = 4\pi {R_\odot}^2\,\sigma\,T^4$$
$$B = \frac{L}{4\pi\,d^2}$$

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

$$z = \frac{\lambda_{\text{obs}} - \lambda_{\text{orig}}}{\lambda_{\text{orig}}}$$
$$z = \frac{v}{c} \quad \text{for } v \ll c$$

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

Age of Solar System: $4.6 \times 10^9$ years

Age of Universe: $13.7 \times 10^9$ years

**1.** 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 does this rock say about the age of the 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. How many decays per second will you measure from this sample one hour from now?

**3.** You observe an astronomical source with a spectrometer. The spectrum you observe has *both* absorption and emission lines. The emission lines are all *blueshifted*, whereas the absorption lines show no shift at all.

You determine that you are looking at a very unusual sort of star which is *behind* a cold, dark, intervening cloud of low-density gas. Almost none of the atoms in this intervening gas cloud have electrons in excited orbitals.

Explain the following. Where are the emission lines coming from? Where is the light being absorbed to make the absorption lines? How can you explain the difference in the Doppler shift of the emission and the absorption lines? (Also, what is unusual about the star?)

**4.** A commonly observed astronomical emission line known as H$\alpha$ is seen in red light at 6563Å.

**(a)** What is the frequency of an H$\alpha$ photon?

**(b)** What is the energy of an H$\alpha$ photon?

**(c)** A 90mph fastball thrown by a baseball pitcher has about 120 Joules (120 J) of kinetic energy. How many H$\alpha$ photons would you need to equal this much energy?

**(d)** Suppose the fastball has a H$\alpha$ emitter on it. Suppose also that the batter is an astronomer with a spectrometer. At what wavelength will the batter observe the light emitted by the baseball?

**5.** Sirius is the brightest star in the sky at night. (Think: what is the brightest star in the sky during the day?) In fact, Sirius is a binary star system. Sirius A, the brighter star, has a surface temperature of about 10,000 K. Sirius B, the dimmer star, has a surface temperature of about 30,000 K. Because it is a binary star, the two components are very close to the same distance away from us.

**(a)** Sirius A appears about 9,200 times brighter than Sirius B to an Earthbound observer. What is the ratio of the radius of Sirius A to the radius of Sirius B?

**(b)** Sirius is about 8.6 light-years away from our Solar System. If Sirius A is 25 times as luminous as the Sun, what is the ratio of the brightness of Sirius A to the brightness of the Sun?