AST 101: INTRODUCTION TO ASTRONOMY
SPRING 2008
Quiz 4
ANSWERS

Name: ____________________  SBU ID:_____________________

You must show all work in order to get partial credit!

1. (4 pts) While stars are on the Main Sequence they produce energy through a set of nuclear reactions. In this reaction process they convert ___hydrogen________ into ____helium______. 

2. (4 pts) We learned about two quite different kinds of Supernovae, Type I and Type II.
   One of these types is identified with the final death throes of massive individual stars. Which type is that? ______Type II__________________
   One type goes Supernova because of additional mass it receives from a companion star. Which type is that? ______Type I__________________

3. (6 pts) When a low-mass star like the Sun reaches the end of its life it will turn into a Planetary Nebula, blowing off its outer gas layers and leaving behind this object: ____white dwarf___________________.
   In contrast, high-mass stars will go Supernova, blowing off their outer gas layers explosively. Stars with masses between 8 and 20 times that of the Sun will leave behind this object: _______neutron star (pulsar OK)__________________.
   Stars more massive than 20 solar masses will instead leave behind this object: ________black hole__________________.

(CONTINUES ON REVERSE)
4. (6 pts) A star is observed to move at high velocity around an invisible object, presumed to be a black hole. The semi-major axis of the star’s orbit is 950 AU, and its period is 15 years.

(a) Using Newton’s form of Kepler’s 3\textsuperscript{rd} law (and being careful of your units!), calculate the mass of the black hole. Assume that the mass of the star is negligible compared with the mass of the black hole. (Show your work)

Using the following form of Kepler’s 3\textsuperscript{rd} law, $P^2 = a^3/M$, and making sure that we use the proper units (years, AU, and solar masses), we can solve for $M$ and then plug right in:

$$M = \frac{a^3}{P^2} = \frac{(950)^3}{(15)^2} = 3.8 \times 10^6 \text{ M}_\odot$$

So the black hole has a mass of about 4 million times the mass of the Sun.

(b) Using the black hole mass you just calculated, what is the Schwartzschild radius of the black hole (again, be careful of your units)? (Show your work)

Use the equation for the Schwartzschild radius, $R_{\text{Schwartz}} = \frac{2GM}{c^2}$ where $G$ = the gravitational constant, $M$ is the black hole mass in kg and $c$ is the speed of light in m/s. First, we need the black hole mass in kg.

$$M = 3.8 \times 10^6 \times 1.99 \times 10^{30} \text{ kg} = 7.56 \times 10^{36} \text{ kg}$$

Plugging in we have:

$$R_{\text{Schwartz}} = \frac{2(6.67 \times 10^{-11})(7.56 \times 10^{36})}{(3 \times 10^8)^2} = 1.12 \times 10^{10} \text{ m} = 1.12 \times 10^{7} \text{ km}$$

So, the Schwartzschild radius is $1.12 \times 10^{7}$ km.

How big is this?? Divide by the radius of the Sun, $1.12 \times 10^{7} \text{ km} / 6.96 \times 10^{5} \text{ km} = 16.1$ and we find the Schwartzschild radius is about 16 times the radius of the Sun.