Answer Key -- SSSS 2017

1. a) Population III
   b) Massive stars form extremely quickly
   c) Lower metallicity, less metals than the sun
   d) CNO cycle
   e) $1.89*10^{33}$ W
   f) Radiation pressure would overcome gravity and the star would be torn apart

2. a) Color-Magnitude
   b) 149 pcs
   c) Main-Sequence Turn-Off
   d) Herzsprung Gap
   e) Stars evolve very quickly through this stage
   f) Open Cluster
   g) In the galactic plane
   h) Reflection Nebula
   i) Star γ

3. a) 2032 L_O
   b) 38,667 K
   c) 1.01 R_O
   d) Mass loss
   e) WR stars have shed their outer hydrogen-rich layers
   f) O-type stars are progenitors for WR stars
   g) Ib/c supernova

4. a) Zero Age Main Sequence
   b) Instability Strip
   c) Variability
   d) Blue Supergiant
   e) Luminous Blue Variable
   f) Wolf Rayet
   g) C
   h) D
   i) Core-Collapse Supernova

5. a) Type II-L
   b) Iron
   c) Iron fusion is an endothermic reaction; rather than yield energy, it uses up energy
   d) Neutronization and photodisintegration
   e) Neutrinos
   f) 630,957 pcs
   g) C: Andromeda Galaxy

6. a) 12 days
   b) 5:3 or 1.667
   c) 0.173 AU

d) Star A
e) Gravitational waves
f) D: General relativity
g) Short Gamma Ray Burst

7. a) $1.639*10^{-12}$ sec/sec
b) Conservation of Angular Momentum
c) neutron degeneracy pressure
d) Tolman-Oppenheimer-Volkoff Limit
e) Synchrotron radiation
f) Pulsar glitch
g) Thorne-Zytkow Object

8. a) Swift or Fermi or Chandra
b) Long Gamma Ray Burst
c) Core collapse of massive stars
d) Long GRB's are found exclusively in star-forming regions
e) Mass extinctions
f) WR 124, Eta Carinae, WR 104, etc.

9. a) 15-25 solar masses
b) 103 km
c) Hawking Radiation
d) $3.035*10^{12}$ N
e) Spaghettification

Miscellaneous:

a) A: The Moon; the Milky Way and the Andromeda Galaxy are roughly the same size and the gravitational force between them is strong enough to cause them to collide. If an object the size of Earth was placed in the moon's orbit, it would collide with Earth; however if it were placed at any of the other distances, it would have very little effect on Earth.

b) WR 124

c) Jocelyn Bell, Annie Jump Cannon, Vera Rubin, Cecilia Payne, etc.

d) Infrared; Light with short wavelengths (visible, UV, etc.) is easily scattered by the thick nebulae that surrounds forming stars. Thus infrared, with its longer wavelength is necessary to observe star formation. Infrared is also necessary to observe the formation of galaxies because young galaxies are all billions of light years away. Their visible light has been redshifted into infrared.

Q1: e) Find the Eddington Limit of a 150 $M_\odot$ star.

$F_{grav} = F_{rad}$ ← def. of Eddington Luminosity

$$\frac{GMm}{r^2} = \frac{L}{c} \cdot \frac{1}{4\pi r^2} \cdot km$$

$$L = \frac{4\pi GMc}{k}$$

$$L = \frac{4\pi \cdot 6.67E{-11}\ m^3 kg^{-1} s^{-2} \cdot 150\,(1.99E30)\ kg \cdot 3E8\ ms^{-1}}{0.0397\ m^2 kg^{-1}}$$

~~[illegible]~~ $L = 1.89E33\ W$

Q2: b) Find the distance of a star w/ a parallax of 0.0067 arcsec.

$$d = \frac{1}{p}$$

$$d = \frac{1}{0.0067}$$

$$d = 149.25\ pc$$

Q3: a) Find the Luminosity of a star w/ an absolute mag of -3.5.

$$M_{abs} = 4.77 - 2.5 \log\left(\frac{L}{L_\odot}\right)$$

$$-3.5 = 4.77 - 2.5 \log\left(\frac{L}{L_\odot}\right)$$

$$L = 2032\ L_\odot$$

b) Find the temp of a star with a peak wavelength of 75 nm.

$$\lambda_{peak} = \frac{2.9E6}{T}$$ ← Wein's Law

$$75\ nm = \frac{2.9E6}{T}$$

$$T = 38{,}667\ K$$

c) Find the radius of the star.

$$\frac{L}{L_\odot} = \left(\frac{R}{R_\odot}\right)^2 \left(\frac{T}{T_\odot}\right)^4$$

$$2032 = \left(\frac{R}{R_\odot}\right)^2 \left(\frac{38,667}{5800}\right)^4$$

$$R = 1.01\ R_\odot$$

Q5: f) Find the distance to the supernova.

$$m - M = 5 \log d - 5$$

$$6 - (-17) = 5 \log d - 5$$

$$d = 630,957 \text{ pcs}$$

Q6: b) Find the mass ratio between star A & B.

$$\frac{M_A}{M_B} = \frac{V_B}{V_A}$$

$$\frac{M_A}{M_B} = \frac{50 \text{ ms}^{-1}}{30 \text{ ms}^{-1}}$$

$$\frac{M_A}{M_B} = 5:3, \ 1.667$$

c) Find the separation between A & B.

$$p^2 = \frac{a^3}{M}$$

$$\left(\frac{12}{365}\right)^2 = \frac{a^3}{4.8}$$

$$a = 0.173 \text{ AU}$$

Q7: a) Find the rate that the pulsar is slowing down.

$$\frac{dP}{dt} = \frac{LP^3}{\frac{8}{5}\pi^2 M R^2}$$

$$\frac{dP}{dt} = \frac{3.2E32 \text{ W} \cdot (0.040 \text{ s})^2}{\frac{8}{5}\pi^2 \cdot 1.9(1.99E30 \text{ kg}) \cdot (12000 \text{ m})^2}$$

$$\frac{dP}{dt} = 1.639E-12 \ \frac{s}{s}$$

Q9: d) Find the tidal forces on the rocket from the black hole.

$$F_T = \frac{2GMmd}{r^3}$$

$$F_T = \frac{2 \cdot 6.67E\text{-}11\, m^3 kg^{-1} s^{-2} \cdot 2.97E6\, kg \cdot 35(1.99E30)\, kg \cdot 1E6\, m}{110^3\, m^3}$$

$$F_T = 3.035E12\, N$$