ASTR-3415-001: Astrophysics
Review Questions for Exam 3

1. Describe the details of electron degeneracy. How is it related to the Pauli Exclusion principle? Compare and contrast Maxwellian-Boltzmann statistics to Fermi-Dirac statistics. Assume a white dwarf has a constant internal density of 10^7 gm/cm^3. What is the Fermi energy of the degenerate electron gas? What is the pressure of this gas? Compare this pressure to what the ideal gas law predicts if the temperature of the gas is 10^8 K.

2. What is the Chandrasekhar limit? What happens if a white dwarf exceeds this limit?

3. How is a neutron star form? Physically, what are happening to the atomic nuclei in this star as the neutron star forms?

4. We see a supernova explosion occurring for a star that has a magnitude of $V = 6.7$ in the night sky. We measure a neutrino flux from this event which indicates a neutrino energy release of 10^{44} ergs/s at the star's location. What will be the maximum brightness that the star will appear in the night sky? (Hint: Make use of data given on page 514 in the textbook.)

5. Describe how supernova remnants are able to shine brightly at radio wavelengths. What would be the vertex angle (in degree measure not radians) of the beamed radiation coming from a 20 MeV electron?

6. What are pulsars? How were they first discovered?

7. What is the Ether and what did the Michelson-Morley experiment do to predict the existence of the Ether?

8. What are the postulates of special relativity? Give the equation of an event line element. Compare and contrast Galilean transformations with Lorentz transformations.

9. Assume you are on a spaceship traveling at 0.98 c. How long would your clock take to tick off one hour for a stationary observer observing you? Your spaceship is 0.24 km long, assuming you are traveling in the same direction as the long axis of your spaceship, how long would a stationary external observer measure it? What would be the mass of your 10^4 kg spaceship as measured by this external observer? If a person on the ship shines a sodium lamp, with its bright Na I D1 line at 5895.923 Å, in your direction, at what wavelength would you see this spectral line?

10. What are the postulates of general relativity? How does general relativity describe gravity? Write down the Schwarzschild metric equation and define all terms. What is the significance of r_s? What is an event horizon?

11. Assume there is a bizarre race of beings living on a neutron star who is at war with a neighboring country. If they fired a missile with a velocity of 1/4 c straight up, how high would this missile get? Are these aliens smart?

12. What is the Schwarzschild radius of a 30 $M_\odot$ black hole? What about a 1 billion $M_\odot$ black hole?

13. What are the Planck length and Planck time?

14. You are falling into a 10 $M_\odot$ black hole with a nice big watch — big enough for an external viewer a few light years away to see. How long will an hour on your watch take to pass for this external viewer if you are 3 times the distance from the singularity as the event horizon? What about 2 times the event horizon distance?

15. If an hour passes for the distant observer in the problem above from his last observation when you were twice the event horizon distance, how far would he have seen you move during this hour?

16. Let's say you decide to have one last smoke before dying in the gravity well of the black hole in the 16 problems above. As you strike your match, the Na I D1 line ($\lambda_\circ$ = 5895.923 Å) emitted by the match is seen at what wavelength by the external viewer? What might this external viewer say about you as you light up?

17. Describe the curvature of space-time in the vicinity of a black hole. What is the Einstein-Rosen bridge, wormhole, and hyperspace in this model?

18. What observational characteristics are required for stellar black hole candidates? What are the best stellar black hole candidates that we know about?

19. Draw an edge-on and a face-on view of the Milky Way and label the halo, disk, spiral arms, globular star clusters (edge-on view only), and the Sun's position in the Galaxy. List all physical characteristics about each component of the Galaxy.

20. Know the definitions of these terms: star gauging, luminosity function, galactocentric system, local standard of rest (LSR), dynamical LSR, kinematic LSR, peculiar motion, solar motion, and solar apex.

21. We observed the Mg I b_1 line at 5186.032 Å in a stellar spectrum, which in the lab is measured to be at 5183.604 Å. This star has a parallax of 0.102 arcsecs and a proper motion of 0.521 arcsec/yr. Determine the radial, tangential, and space velocities of this star. Would you expect this star to be a Population I or a Population II star? A disk star or a halo star?

22. If the star in the previous problem is 52.7° away from the solar apex and 60% of the star's proper motion is in the direction of the solar apex, what is the peculiar velocity of this star?

23. What are the differences between mean, secular, and statistical parallaxes? What is the distance to the Pleiades, if the cluster appears to radiate from a point with a dispersion angle θ of 110 arcmin, a radial velocity of +7.0 km/s, and the stars show an average proper motion of 5.9 arcsec/yr? The Pleiades span 1.83° on the sky, what is the linear diameter of this cluster?

24. What are spiral tracers? What type of transition is the 21-cm line of hydrogen? What does this mean?

25. What are the differences between Population I and Population II stars? Draw the two-color diagram for Population I main sequence stars and compare it to blackbody data. Why do the two deviate? Describe the physical reasons that causes the shape of the main sequence two-color sequence. How does interstellar reddening affect stars plotted on the two-color diagram?

26. What is the abundance of Fe to the total particle density in a star that has a hydrogen abundance of 0.908 and [Fe/H] = -1.2? Is this a Pop I or a Pop II star?

27. Compare and contrast galactic to globular star clusters.

28. A star at galactic longitude +86° and galactic latitude +22° is measured to loose 2.7 magnitudes of visible light as its light travels through an interstellar gas cloud. What is the fractional decrease of the intensity of this starlight at these wavelengths?

29. Draw and label the 3-phase model of the ISM.

30. We measure a star's apparent magnitude to be 6.54 and it's $B - V$ color excess to be 0.13. If this star's spectrum indicates that it is a G2 V star, at what distance is this star?

31. Assume you live in a spiral galaxy far, far away which has an evil galactic empire that rules your life. You decide that you want to go fight the enemy and start calculating your flight through the galaxy. The first thing you do is measure an Oort's A constant to be 21 km/s/kpc and an Oort's B constant to be -16 km/s/kpc. If the planetary system you are in is in the disk of the galaxy, what is the angular orbital velocity of your star system through the galaxy? After observing the positions of RR Lyr stars, you find that you are at a distance of 12.3 kpc from the center of the galaxy. What is the galactic orbital velocity of you star system? From the above information, how much mass does your galaxy contain within the orbit of your star?

32. How do we know that the Milky Way has a massive halo and that this halo is composed of primarily dark matter?

33. Describe the density wave theory and the differential rotation theory for the spiral structure of the Milky Way. Why does one of them fail?

34. EUVE found evidence that the ISM has a very low density in the solar neighborhood which has been called the Local Bubble. How were they able to deduce this and what gave rise to this bubble?

35. Describe the central nuclear region of the Milky Way.

36. Draw the Hubble Tuning Fork Diagram. What are the characteristics of each galaxy on this diagram? Why isn't the tuning fork diagram an evolutionary sequence?

37. Plot the surface brightness distribution for an elliptical and spiral galaxy as a function of distance from the center of these galaxies. Assuming both galaxies have the same central scale length and that the spiral is 10 times brighter at its center than the elliptical, at what position in the two galaxies do their surface brightness equal each other?

38. Compare and contrast the Tully-Fisher relation to the Faber-Jackson relation. What are both of these relationships used to determine?

39. What are distance indicators? List all the distance indicators and describe when each is used.

40. What is Hubble's Law and what does it tell us about the Universe? We observed the Mg I b_1 line at 5805.6 Å in a galaxy's spectrum, which in the lab is measured to be at 5183.6 Å. If we use the Tully-Fisher relation to find this galaxy is at 554 Mpc, what is Hubble's constant? We now observe a quasar's spectrum and find this Mg I b_1 line to be at 9382.3 Å. What is the distance to this quasar?

41. How are the Virgo cluster and the Local Group related? How are they different? What is the most massive member of the Local Group and the Virgo cluster? What is a supercluster?

42. Compare and contrast radio galaxies, Seyfert galaxies, N galaxies, BL Lac objects, QSO's, and quasars. Describe the evolutionary model of a radio galaxy. What is meant by superluminal motion?

43. What is the Local Hypothesis and how does gravitational lensing disprove it?

44. Describe the basics of galaxy evolution.

45. What is Olber's paradox and why is it not really a paradox?

46. Assume Hubble's constant is 90 km/s/Mpc. What is the maximum age of the Universe and why does that present a problem?

47. Assume the mass density of the Universe is 7×10^{-31} gm/cm^3 and that the current radius of the Universe is 10^{41} cm. What is the total mass of the Universe? What is the Schwarzschild radius of the Universe? What does this tell you about the Universe?

48. Describe the results of the COBE and WMAP missions with respect to the CMB.

49. Compare and contrast the Minkowski metric to the Robertson-Walker metric. What are geodesics and what is meant by a null geodesic? How are these related to light cones?

50. What does the Big Bang Theory state and what are the assumptions in which this theory is formulated? List 2 different observational evidences to support the Big Bang Theory. At what wavelength does the cosmic microwave background radiation emit most of its light? Assuming this light is at a redshift of 1000, at what wavelength was

this maximum brightness? What was the temperature of the Universe at this epoch (prove it, just don't state it).

51. Write down the equation of motion of the Universe. What is the significance of the $\Lambda R(t)/3$ term? Describe various universe histories for $\Lambda < 0$, $\Lambda = 0$, and $\Lambda > 0$.

52. Starting from the definition of the deceleration parameter $q_\circ$, show that $q_\circ$ can be described as only a function of the universal constants G, $\rho_\circ$, and $H_\circ$. Derive an expression for the recession velocity of the Universe whose constants only involve $q_\circ$, $H_\circ$, k, c, and Λ.

53. What is the observational evidence to support that the Universe's expansion is currently accelerating? Who's solution to the field equations does this data best fit?

54. Compare and contrast open, closed, and flat universes.

55. Describe the processes involved in galaxy formation.

56. Give significant events that took place in each Era of the history of the Universe. Things to address include inflation, deuterium bottleneck, and opacity of the Universe.