

Astronomy II (ASTR1020) — Final Exam

Test No. fB

13 December 2001

The answers of this multiple choice exam are to be indicated on the Scantron with a **No. 2 pencil**. Don't forget to write your name and the **Test No.** (*e.g.*, fB) on the Scantron sheet. You may keep these test questions. There are 100 questions on this exam and you will be graded out of 100 points.

Useful Constants

$G = 6.673 \times 10^{-11} \text{ m}^3/\text{s}^2/\text{kg}$	$g = 9.80 \text{ m/s}^2$
$c = 3.00 \times 10^5 \text{ km/s}$	$h = 6.626 \times 10^{-34} \text{ J s}$
$k = 1.38 \times 10^{-23} \text{ J/K}$	$H_\odot = 50 \text{ km/sec/Mpc}$
$M_{\text{moon}} = 7.35 \times 10^{22} \text{ kg}$	$M_\odot = 1.99 \times 10^{30} \text{ kg}$
$M_\oplus = 5.98 \times 10^{24} \text{ kg}$	$R_\oplus = 6.38 \times 10^6 \text{ m}$
$R_\odot = 6.96 \times 10^8 \text{ m}$	$T_\odot = 5800 \text{ K}$
$1 \text{ AU} = 1.50 \times 10^{11} \text{ m}$	$L_\odot = 3.90 \times 10^{26} \text{ W}$
$e = 1.60 \times 10^{-19} \text{ C}$	$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2/\text{K}^4$
$m_e = 9.11 \times 10^{31} \text{ kg}$	$m_p = 1.67 \times 10^{-27} \text{ kg}$
$1 \text{ ly} = 9.46 \times 10^{15} \text{ m}$	$1 \text{ pc} = 3.09 \times 10^{16} \text{ m}$
$1 \text{ km} = 10^3 \text{ m}$	$1 \text{ hr} = 3600 \text{ s}$
$1 \text{ mi} = 5280 \text{ ft}$	$1 \text{ mi} = 1.609 \text{ km}$
$1 \text{ day} = 24 \text{ hrs}$	$1 \text{ yr} = 365.24 \text{ days}$
$1 \text{ \AA} = 10^{-10} \text{ m}$	$1 \text{ nm} = 10^{-9} \text{ m}$
$10^3 = \text{one thousand}$	$10^6 = \text{one million}$
$10^9 = \text{one billion}$	$10^{12} = \text{one trillion}$

Useful Equations

$D = \frac{\alpha d}{206265}$ $r_p = a(1 - e)$ $v_t = 4.74 \mu d \text{ (km/s)}$ $P^2 = \left[\frac{4\pi^2}{G(m_1 + m_2)} \right] a^3$ $L = 4\pi R^2 F = 4\pi\sigma R^2 T^4$ $\lambda_{\max} = \frac{0.0029 \text{ m K}}{T}$ $m_2 - m_1 = -2.5 \log \left(\frac{f_2}{f_1} \right)$ $M_{\text{bol}} - M_{\text{bol}}(\odot) = -2.5 \log \left(\frac{L}{L_{\odot}} \right)$ $t_{\text{MS}} = \left(\frac{M_{\odot}}{M} \right)^3 \times 10^{10} \text{ yr}$ $z = \frac{\Delta\lambda}{\lambda_o} = \frac{\sqrt{1 + v_r/c}}{\sqrt{1 - v_r/c}} - 1$ $T = \frac{1 \text{ (km/s/Mpc)}}{H_o} \times 10^{12} \text{ yr}$	$e = \frac{h}{2a} = \frac{a - b}{a}$ $r_a = a(1 + e)$ $\frac{v_r}{c} = \frac{\lambda - \lambda_o}{\lambda_o} = \frac{\Delta\lambda}{\lambda_o}$ $F = G \left(\frac{m_1 m_2}{r^2} \right)$ $\frac{L}{L_{\odot}} = \left(\frac{R}{R_{\odot}} \right)^2 \left(\frac{T}{T_{\odot}} \right)^4$ $E = h\nu = \frac{hc}{\lambda}$ $m - M = 5 \log d - 5$ $M_1 + M_2 = \frac{a^3}{P^2}$ $v_{\text{esc}} = \sqrt{\frac{2GM}{R}}$ $z = \frac{\Delta\lambda}{\lambda_o} = \frac{v_r}{c} \quad (v_r \ll c)$ $q_o = \frac{8\pi G}{3} \frac{\rho}{H_o^2}$	$E = mc^2$ $2a = r_p + r_a$ $\nu = c/\lambda$ $F = \sigma T^4$ $d = 1/p$ $P_{\text{yr}}^2 = a_{\text{AU}}^3$ $F = ma$ $v = \sqrt{v_r^2 + v_t^2}$ $v_r = H_o d$ $\frac{L}{L_{\odot}} = \left(\frac{M}{M_{\odot}} \right)^4$
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1. Which of the following Local Group members are in orbit about the Milky Way Galaxy?

- a) M 87 b) LMC & SMC c) 3C 373
d) M 31 & M 32 e) SMC & Fornax I

2. Which of the following is not part of the cosmological principle?

- a) Redshifts of galaxies are caused by the expansion of the Universe.
b) The Universe looks the same in every direction.
c) Matter is uniformly distributed in space on a very large scale.
d) That energy and matter are equivalent as shown by the equation $E = mc^2$.
e) Physical laws are the same everywhere in the Universe.

3. According to the *Cosmos* video “The Edge of Forever” what was the name of the mule-team driver that helped Hubble determine that the Universe was expanding?

- a) Humason b) Shapley c) Kepler
d) Einstein e) Sagan

4. Which *element* is life on Earth based upon?

- a) water b) hydrogen c) carbon d) iron e) silicon

5. Approximately what is the current temperature of the Universe?

- a) 1 F b) 98 F c) 301 K d) 1 K e) 3 K

6. Biological evolution takes place on Earth through natural selection coupled with

- a) mutations b) beta decay c) deuterium d) accretion e) none of these

7. Which of the following is the strongest force in nature?

- a) strong b) friction c) gravity d) electromagnetic e) weak

8. Which of the following best describes an Irregular II type galaxy?

- a) It is disklike with evidence of spiral structure, but not well organized.
- b) It has no “regular” shape at all with large amounts of interstellar dust and gas.
- c) Spheroidal in shape with a very low mass and luminosity.
- d) It is a disklike galaxy with no spiral structure.
- e) They are large and extremely elliptical in shape with virtually no interstellar dust or gas in them.

9. Electrons came into existence during which era of the Big Bang?

- a) Inflationary b) Lepton c) Quantum d) Matter e) Electron

10. Hubble’s galaxy classification scheme is called the

- a) evolutionary sequence b) Tully-Fisher relation c) kappa effect
- d) tuning fork diagram e) HR diagram

11. Particles which have half-integer spins are called

- a) hadrons b) bosons c) leptons d) fermions e) baryons

12. What happened during the inflationary era?

- a) All of the forces acted as one.
- b) The Universe expanded at an exponential rate.
- c) The Universe became transparent to photons.
- d) All the leptons came into existence.
- e) Photons decoupled from intermediate vector bosons.

13. Which of the following is not a property of a quasar?

- a) They appear as point sources at visible wavelengths.
- b) Most show relativistic redshifts.
- c) They contain supermassive black holes that are responsible for the large energy output.
- d) Their light variation is due to pulsating red giant stars.
- e) Emission lines are typically seen on a continuum in the spectra of these objects.

14. The most massive galaxies in the Universe are of Hubble type

- a) elliptical b) normal spiral c) barred spiral
- d) irregular e) lenticular

15. Spiral galaxies with unusually tiny bright cores and are bright at infrared wavelengths are called

- a) IR galaxies b) quasars c) radio galaxies
- d) BL Lac objects e) Seyfert galaxies

16. Based on the most recent observations, the Milky Way's Hubble classification is

- a) Sa b) Sb c) SBb d) Irr e) SBa

17. Which of the following is the measure of the range of speeds of particles or stars in a group or cluster with random internal motions?

- a) velocity dispersion
- b) Kepler velocity
- c) Doppler effect
- d) rotation curve
- e) speed of light

18. According to the “Shape of Space” video we saw in class, a universe that can be represented as a cube with opposite sides attached to each other is called a

- a) 2-torus
- b) 3-cylinder
- c) 3-sphere
- d) 3-torus
- e) 2-sphere

19. Particles which have zero or integer spin are called

- a) hadrons
- b) baryons
- c) leptons
- d) bosons
- e) fermions

20. Which of the following do not belong in the Hubble classification of galaxies?

- a) bipolar
- b) ellipticals
- c) lenticulars
- d) barred spirals
- e) normal spirals

21. For nearby galaxies at distances less than 6 Mpc, what objects do we use to determine their distance?

- a) giant H II regions
- b) white dwarf stars
- c) Cepheid variables
- d) Mira variables
- e) brightest galaxy in a cluster

22. Why do the “radio” lobes of a radio galaxy shine so brightly at radio wavelengths?

- a) Extraterrestrials are signaling us with these lobes.
- b) The gas is very cool so λ_{\max} is at long wavelengths.
- c) Electrons are spiraling around intense magnetic fields.
- d) Gluons are spiraling around intense electric fields.
- e) None of these are correct.

23. The hypothesis that quasars are relatively nearby and are not at cosmological distances is referred to as what?

- a) isotropy
- b) local hypothesis
- c) homogeneity
- d) QSO hypothesis
- e) big bang hypothesis

24. Measurements of the current density of the Universe indicate that

- a) the Universe is contracting.
- b) the Universe will continue to expand forever.
- c) the Universe will reach a maximum size, then begin to contract.
- d) there are a lot of fat people in it.
- e) the deceleration parameter is equal to zero.

25. The equation used to estimate the number of communicable societies in the Galaxy is called

- a) Einstein-Rosen’s relation
- b) Hubble’s Law
- c) Drake’s equation
- d) Wien’s law
- e) Stefan-Boltzmann’s equation

26. The building blocks of proteins are called

- a) DNA
- b) mesons
- c) RNA
- d) cells
- e) amino acids

27. The region around a star where liquid water can exist on planetary surfaces is referred to as the

- a) terrestrial zone
- b) water hole
- c) radiative zone
- d) life zone
- e) end zone

28. Which of the following best describes the Big Bang Theory?

- a) The Universe is eternal, infinite in size, and static.
- b) As the Universe expands, matter is continuously created to keep the average density constant.
- c) The Universe arose at the same time as the Earth and is about 6000 years old.
- d) The Universe started out extremely small, dense and hot, and has been continuously expanding since coming into existence.
- e) The Universe behaves in a chaotic manner, that is, it follows no laws of physics.

29. Almost all of the deuterium we currently see in the Universe formed in which era?

- a) quark
- b) nucleosynthesis
- c) GUTs
- d) hadron
- e) lepton

30. Of the following, which is the best observational evidence that supports the Big Bang Theory?

- a) cosmic background radiation
- b) activity in galaxies
- c) Cepheid periods
- d) Hubble galaxy classification
- e) quasar luminosities

31. Which of the following cannot be used to determine stellar temperature?

- a) Measure spectral line shifts due to the Doppler effect.
- b) Measure the wavelength of the peak emission of light coming from the star.
- c) Determine the color index of a star.
- d) Measure the ratio of abundances of ions with respect to neutrals of an atomic species in the gas.
- e) Measure the total flux emitted from the star.

32. The *spring cleaning* stage of a star during stellar birth is called the

- a) Mira phase
- b) T Tauri stage
- c) Herbig-Haro stage
- d) cocoon stage
- e) raccoon phase

33. Which of the following best describes an asymptotic giant branch star?

- a) hydrogen core burner
- b) hydrogen shell burner
- c) helium shell burner
- d) helium core burner
- e) collapsing protostar

34. Why are Cepheids used as a distance indicator to external galaxies?

- a) They are bright and following a period-luminosity law.
- b) They are bright hence it is easy to use trigonometric parallax.
- c) They are found in clusters which allows us to use the moving cluster method.
- d) Their pulsation period is directly related to their distance.
- e) All Cepheids are the same brightness hence their apparent brightness tells us their distance.

35. Why is astrology called a pseudoscience?

- a) Even though it uses the language of science, it doesn't follow the scientific method.
- b) Newton said it was.
- c) It doesn't use the equation $F = ma$.
- d) It doesn't take the Earth's precession into account when formulating horoscopes.
- e) It is not a pseudoscience, it actually is a science.

36. Which of the following is not true about globular star clusters?

- a) contains 10^5 to 10^6 stars
- b) contain Pop II stars
- c) spherical in shape
- d) entirely found in galactic disk
- e) all are true

37. When the signals from pulsars were first discovered, they were thought to be

- a) Mass exchange between a normal star and a white dwarf.
- b) Mass exchange between a normal star and a black hole.
- c) Signals from an extraterrestrial intelligence.
- d) Stars in the process of collapsing down to a black hole.
- e) Mass exchange between a normal star and a neutron star.

38. We observe emission lines from highly-ionized metals in a stellar spectrum. What must be true about this star based on this observational fact?

- a) It has a planetary system.
- b) It has a chromosphere.
- c) It has a corona.
- d) It is a binary star.
- e) It is a variable star.

39. Of the following reaction chains, which is not part of the proton-proton chain?

- a) $^{12}\text{C} + ^1\text{H} \longrightarrow ^{13}\text{N} + \gamma$
- b) $^3\text{He} + ^3\text{He} \longrightarrow ^4\text{He} + ^1\text{H} + ^1\text{H}$
- c) $^1\text{H} + ^1\text{H} \longrightarrow ^2\text{H} + e^+ + \nu$
- d) $^1\text{H} + ^2\text{H} \longrightarrow ^3\text{He} + \gamma$
- e) All of the above reactions are part of the proton-proton chain.

40. Which of the following is not a conservation law used in determining nuclear reactions?

- a) Baryon number must be conserved.
- b) Mass-energy must be conserved.
- c) Charge must be conserved.
- d) Lepton number must be conserved.
- e) All of these are used.

41. The science that describes the physics of electrons and other subatomic particles is called

- a) quantum mechanics
- b) special relativity
- c) classical mechanics
- d) general relativity
- e) electronics

42. What is a gamma (γ) particle?

- a) a photon
- b) a neutron
- c) a helium nucleus
- d) an electron
- e) a proton

43. What drives the strong stellar winds seen in M-type giant stars?

- a) Momentum coupling of gas with acoustic (sound) waves.
- b) Radiation pressure on dust.
- c) Momentum coupling of ionized gas with magnetic Alfvén waves.
- d) Radiation pressure on atomic lines.
- e) Radiation pressure on electrons.

44. The total energy flux emitted over the entire surface of an object is called the *what* of the object?

- a) intensity
- b) spectrum
- c) luminosity
- d) temperature
- e) magnitude

45. A blackbody spectrum is represented by what type of curve?

- a) Planck curve
- b) Bohr curve
- c) parabolic curve
- d) elliptical curve
- e) hyperbolic curve

46. Which of the following best describes Newton's Law of Universal Gravity?

- a) $F = Gm_1m_2/r^2$
- b) $P_{yr}^3 = a_{AU}^2$
- c) $F = ma$
- d) A body will stay in uniform motion unless acted upon by an external force.
- e) Whenever one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body.

47. Massive stars end their thermonuclear lives by blowing themselves up. Astronomers call these explosions

- a) supernova
- b) nova
- c) gamma ray bursters
- d) big bangs
- e) none of these

48. Which of the following is true about main sequence stars with $M > 2 M_{\odot}$?

- a) They have radiative cores and convective envelopes.
- b) They all have chromospheres and coronae.
- c) They have spectral types of G, K, or M.
- d) They produce most of their energy via the CNO cycle.
- e) They are stable due to electron degeneracy.

49. Which of the following best describes a red giant branch star?

- a) hydrogen core burner
- b) hydrogen shell burner
- c) helium shell burner
- d) collapsing protostar
- e) helium core burner

50. The top of the solar convection zone can be seen in the photosphere as

- a) sunspots
- b) granules
- c) faculae
- d) neutrinos
- e) flares

51. What is the brightest absolute magnitude of a Type I supernova?

- a) -17
- b) -5
- c) -19
- d) -13
- e) -26

52. Which of the following energy mechanisms does the Sun currently derive its energy?

- a) fission of uranium
- b) fusion with proton-proton chain
- c) coal burning
- d) fusion with CNO cycle
- e) photoelectric effect

53. What is the meaning of the term *extrasolar planet*?

- a) A planet that does not resemble the Earth.
- b) A planet in orbit about the Sun exterior to the asteroid belt.
- c) A planet that does not resemble a star.
- d) A planet that does not resemble the Sun.
- e) A planet in orbit around a star other than the Sun.

54. Which best describes the solar constant?

- a) The constant h in the equation $E = h\nu$.
- b) The energy flux of the Sun at the top of the Earth's atmosphere.
- c) The steady brightness of the Sun's surface.
- d) The constant σ in the equation $F = \sigma T^4$
- e) None of these are correct.

55. Spectral lines that are only seen in low density gas, such as the interstellar medium (*i.e.*, they are not seen in stellar atmospheres), are called what type of lines?

- a) allowed b) unallowed c) permitted d) forbidden e) chorus

56. The Chandrasekhar limit is

- a) the maximum mass of a main sequence star.
- b) the maximum mass of a neutron star.
- c) the maximum mass of a white dwarf star.
- d) the region that marks the position around a black hole where $v_{esc} = c$.
- e) how many beers Chandrasekhar can have before becoming blitzed.

57. What is a beta (β) particle?

- a) a proton b) an electron c) a neutron
d) a helium nucleus e) a photon

58. Which of the following equations is the distance modulus formula?

- a) $d = 1/p$ b) $F = \sigma T^4$ c) $m - M = 5 \log d - 5$
d) $m_2 - m_1 = -2.5 \log(f_2/f_1)$ e) $E = mc^2$

59. The statement that two electrons cannot exist in the same quantum state at the same time is better known as the

- a) Russell Diagram b) Dirac Notation c) Pauli Exclusion Principle
d) Hertzsprung Criterion e) Bohr Model

60. How is a horizontal branch star similar to a red giant clump star?

- a) Both are burning hydrogen in their cores.
b) Both are burning helium in their cores.
c) Both are of the same metallicity.
d) Both are supported by degenerate electron pressure.
e) Both are collapsing down to the main sequence stage.

61. What is the brightest absolute magnitude of a Type II supernova?

- a) -26 b) -19 c) -13 d) -17 e) -5

62. Supernovae with hydrogen Balmer lines seen in their spectra results from what process?

- a) Rapid mass transfer onto a white dwarf.
- b) The iron-core bounce of a massive star.
- c) Gradual mass transfer onto a white dwarf.
- d) Gradual mass transfer onto a neutron star.
- e) A run away He-flash.

63. When the UV photons from a collapsed core lights up the *detached* shell of a star's outer envelope, the shell is called a(n)

- a) supernova remnant
- b) reflection nebula
- c) H II region
- d) planetary nebula
- e) none of these

64. Which of the following is not part of the scientific method?

- a) A hypothesis is made, which is an *educated guess* as to how something works.
- b) The hypothesis is debated by scientists, and if debated successfully, becomes a theory.
- c) The hypothesis is tested through repeated experimentation and/or observations.
- d) If the hypothesis passes these experiments/observations, it becomes a theory.
- e) None of these are part of the scientific method.

65. The relative *flatness* of an ellipse is measured by a quantity called

- a) eccentricity
- b) semiminor axis
- c) ellipticity
- d) semimajor axis
- e) temperature

66. One of the two closest white dwarfs to the solar system is

- a) Proxima Centauri
- b) Bernard's star
- c) Procyon A
- d) Sirius B
- e) Wolf 359

67. Self-sustaining star formation means that

- a) supernova explosions cause new stars to form, then they evolve and supernova causing further star formation, and so on.
- b) stars can form all by themselves without help from spiral density waves or supernovae.
- c) stars always produce planetary systems that can support life.
- d) stars produce their energy through thermonuclear reactions.
- e) none of the above

68. The middle layer of the Sun's atmosphere is the

- a) chromosphere
- b) photosphere
- c) radiation zone
- d) convection zone
- e) corona

69. Main sequence stars are burning hydrogen into helium through thermonuclear reactions in their cores. In the Sun, the dominant reaction process is

- a) CNO cycle
- b) HCN cycle
- c) HCO chain
- d) proton-proton chain
- e) hydrogen cycle

70. Objects that have $M < 0.01 M_{\odot}$ are called

- a) brown dwarfs
- b) white dwarfs
- c) planets
- d) black dwarfs
- e) main sequence stars

71. The theory of relativity is a theory because

- a) Einstein said so.
- b) it has been validated through repeated experiments.
- c) its model was the simplest.
- d) force is equal to mass times acceleration.
- e) its equations are known by all scientists.

72. Which one of the following items below is not necessarily a characteristic of an observable black hole candidate?

- a) There must be a rapidly fluctuating X-ray signal from a binary star system.
- b) It must be an unseen companion in a binary star system.
- c) The unseen companion in a binary star system must have a mass greater than $3M_{\odot}$.
- d) The candidate must be close enough for a trigonometric parallax to be obtained.
- e) The black hole must have an accretion disk around it.

73. Currently the Sun is in which spiral arm?

- a) Cygnus b) Sagittarius c) Orion d) Perseus e) Pegasus

74. The kappa effect refers to

- a) the oscillation between ionization and recombination in a zone below the photosphere which causes a star to pulsate.
- b) the linear expansion of the Universe — also called the *Hubble flow*.
- c) the initiation of helium fusion in a degenerate stellar core.
- d) the initial event that caused the galaxies to form.
- e) the initial collapse of a giant molecular cloud during stellar formation.

75. Which of the following describes a black dwarf?

- a) An old white dwarf star that has cooled off.
- b) A rapidly spinning neutron star with an intense magnetic field.
- c) Another name for a mini-black hole.
- d) A massive collapse star whose escape velocity exceeds the speed of light.
- e) One of Snow White's dwarfs.

76. There is substantial observational evidence that *what* exists at the center of the Milky Way?

- a) a supermassive black hole
- b) a stellar black hole
- c) a large magnetar
- d) a large pulsar
- e) the Borg

77. The rotation curve of the Milky Way stays rather flat instead of falling off in a Keplerian fashion in the outer regions of the Galaxy. On the other hand, light that is emitted from matter in the Galaxy falls off rather sharply in the outer regions. This indicates that there is a lot of *what* in the halo of the Galaxy?

- a) O and B stars
- b) dark matter
- c) photons
- d) supernovae
- e) shock waves

78. The *gradual* transfer of mass from a normal star onto a white dwarf will cause a

- a) Type I supernova
- b) nova
- c) Type II supernova
- d) gamma ray burster
- e) wormhole

79. General relativity postulates that an experiment could not be performed such that one could tell the difference between acceleration caused by the motion of an object and acceleration due to a gravitational field. This postulate is better known as the

- a) Hubble's law
- b) Pythagoras theorem
- c) Oscam razor
- d) Wien's law
- e) principle of equivalence

80. An object in thermal equilibrium emits what type of spectrum?

- a) absorption line
- b) bolometric
- c) emission line
- d) blackbody
- e) absolute

81. Supernovae that are produced the iron-core bounce of a massive star are called

- a) Type III supernova
- b) nova
- c) Type I supernova
- d) X-ray bursters
- e) Type II supernova

82. Which of the following best describes Newton's 3rd Law?

- a) $P_{yr}^3 = a_{AU}^2$
- b) A body will stay in uniform motion unless acted upon by an external force.
- c) $F = ma$
- d) $F = Gm_1m_2/r^2$
- e) Whenever one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body.

83. What are the strongest spectral features in the Sun's visual spectrum?

- a) TiO bands
- b) H₂O bands
- c) Band on the Run
- d) Ca II H & K lines
- e) none of these

84. Which of the following is not a spiral tracer?

- a) H II regions
- b) OB associations
- c) neutral hydrogen gas
- d) white dwarfs
- e) all of these are tracers

85. The spectral classes from coolest to hottest stars are

- a) BOFGAKM b) OBAFGKM c) OBFAKGM
- d) ABFGKMO e) MKGFABO

86. Pulsating stars fall on what strip on the H-R Diagram?

- a) Chandrasekhar b) main sequence c) sub dwarf
- d) instability e) Eddington

87. What is the opacity source that causes the kappa effect to function?

- a) Balmer lines b) Rayleigh scattering c) Lyman lines
- d) H^- e) electron scattering

88. Stars going through their spring cleaning phase often show bipolar jets. At the end of these jets we see

- a) FU Ori stars b) Herbig-Haro objects c) cocoons
- d) raccoons e) comets

89. The oldest Population I stars that are found in the disk of the Galaxy are sometimes called

- a) RR Lyrae stars b) W Virginis stars c) disk population stars
- d) Population II stars e) Population III stars

90. Which one of these best describes Kepler's 3rd law of planetary motion?

- a) $P_{yr}^2 = a_{AU}^3$
- b) $a_{AU}^2 = P_{yr}^3$
- c) A planet's velocity will increase as it moves closer to the Sun.
- d) All planets orbit the Sun in elliptical paths.
- e) None of these

91. Which of the following best describes a photon?

- a) It transmits audio signals through a vacuum.
- b) It behaves both like both a wave and a particle.
- c) It orbits about the nucleus of atoms.
- d) It is a particle that make up nucleons (*i.e.*, protons and neutrons).
- e) It can travel at any velocity less than c in a vacuum.

92. Of the following sample, which would be considered the *oldest* stellar type?

- a) Population I stars
- b) Population II stars
- c) Population III stars
- d) Disk Population stars
- e) all have the same age

93. What is an alpha (α) particle?

- a) a photon
- b) an electron
- c) a neutron
- d) a proton
- e) a helium nucleus

94. Main sequence stars with $3M_{\odot} < M < 8M_{\odot}$ will

- a) supernova via an Fe-core bounce.
- b) collapse directly into a black hole.
- c) helium flash and finally end up as a white dwarf.
- d) never become red giant stars.
- e) supernova via carbon detonation in a degenerate core.

95. How many hydrogen nuclei are fused into one helium nucleus in the proton-proton chain?

- a) 1
- b) 2
- c) 4
- d) 16
- e) 8

96. As cloudlets shrink in size they spin faster due to the conservation of

- a) hydrostatic equilibrium
- b) linear momentum
- c) baryons
- d) energy
- e) angular momentum

97. For stars within 10 parsecs of the solar system, we determine their distances with which method?

- a) trigonometric parallax
- b) moving cluster method
- c) spectroscopic parallax
- d) radar
- e) sonar

98. Why do main sequence stars stay fairly stable in both size and luminosity?

- a) Non-local thermodynamic processes dominate their interiors.
- b) They are in both thermal and hydrostatic equilibrium.
- c) They are continuously creating new matter as they lose mass through stellar winds.
- d) Degenerate electron pressure is balanced by degenerate neutron pressure.
- e) The interior of a star is a vacuum and hence cannot change.

99. Electromagnetic radiation emitted by electrons spiraling around an intense magnetic field is called

- a) alpha radiation
- b) synchrotron radiation
- c) thermal radiation
- d) cyclotron radiation
- e) beta radiation

100. Stars that have $0.08M_{\odot} < M < 0.4M_{\odot}$ are/will

- a) go through a helium flash.
- b) not massive enough to support nuclear fusion.
- c) completely convective.
- d) supernova.
- e) last 10% of their lifetime as a red giant.