# Astronomy 103 – Final Exam – December 17, 2014

**Instructions:**

**No books, notes or calculator are allowed.** You have 2 hours to complete the exam, and please do not turn to the next page until instructed to do so.

**You may find the following information helpful:**

- 1 AU $= 3 \times 10^8$ km
- speed of light $c = 3 \times 10^8$ m/s
- Kepler's 3rd law:

  $$a^3 = P^2$$

  with the period $P$ in years and semi-major axis $a$ in AU.
- Newton's law of gravity:

  $$F = \frac{GMm}{r^2}$$

- Peak wavelength and temperature of blackbody radiation:

  $$\lambda = \frac{3 \times 10^6}{T} \text{ nm}$$

  with wavelength $\lambda$ in nm (1 nm = $10^{-9}$ m) and temperature $T$ in Kelvin.
- Relationship between frequency $f$ and wavelength $\lambda$ of light:

  $$\lambda = \frac{c}{f}$$

- Conversion of mass into energy: $E = mc^2$
- Relationship between brightness $B$ and distance $d$:

  $$B_2 = B_1 \times \frac{d_1^2}{d_2^2}$$

- Relationship between luminosity $L$, temperature $T$ and radius $R$ of stars:

  $$L = 4\pi\sigma T^4 R^2$$

  where $4\pi\sigma$ are constants.
- Hubble's law:

  $$v = H \times d$$

  where $v$ is velocity in km/s, $d$ is distance in Mpc, and $H$ is the Hubble constant, $H = 70$ km/s/Mpc.

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1. Which of the following choices lists the objects in order of increasing distance from the Sun?
   a) Saturn, Venus, Proxima Centauri, the Andromeda Galaxy, the Virgo Cluster
   b) Proxima Centauri, Saturn, Venus, the Virgo Cluster, the Andromeda Galaxy
   c) The Virgo cluster, the Andromeda Galaxy, Proxima Centauri, Venus, Saturn
   **d) Venus, Saturn, Proxima Centauri, the Andromeda Galaxy, the Virgo Cluster**
   e) Venus, Saturn, Proxima Centauri, the Virgo Cluster, the Andromeda Galaxy

2. Evaluate $(3 \times 10^4) \times (2 \times 10^7)$
   a) $5 \times 10^{10}$
   b) $5 \times 10^{11}$
   c) $6 \times 10^{10}$
   **d)** $6 \times 10^{11}$
   e) $5 \times 10^{28}$

3. The average temperature is hotter in summer than winter. This is ultimately caused by
   a) the fact that the Sun emits more energy per second in the summer than it does in the winter
   b) the fact that the Earth is closer to the Sun in summer.
   **c) the tilt of the Earth's axis relative to the Earth's orbit.**
   d) the greenhouse effect that warms the Earth by trapping infrared radiation.

4. Describe the daily motion of Polaris:
   a) It rises due east and sets due west once in every 24-hour period.
   b) It moves eastward by slightly less than 1 degree per day.
   **c) It stays nearly fixed in the northern sky above our North Pole.**
   d) It rises due west and sets due east once in every 24-hour period.

5. The Sun is directly over the equator on the
   **a) at neither solstice**
   b) summer solstice
   c) winter solstice
   d) at both solstices

6. Where on Earth are you if Polaris is on your horizon?

   a) north pole
   b) south pole
   c) Tropic of Cancer
   d) Tropic of Capricorn
   **e) equator**

7. Willa is on the asteroid Xu. She starts from one pole of Xu and walks without turning until she reaches a place where the stars appear to move in horizontal circles, never rising or setting. If she has walked 10 km, what is the circumference of Xu?

   a) 10 km
   **b) 20 km**
   c) 40 km
   d) 100 km

8. If the Moon's orbit were exactly in the plane of the Earth's orbit about the Sun, one would expect an eclipse of the Moon to occur about once every

   a) 2 weeks
   b) week
   c) never
   **d) month**
   e) year

9. What causes the Moon's phases?

   a) The Earth's shadow covers part of the Moon.
   **b) As the Moon orbits the Earth, the part of the Moon that is lit is a changing fraction of the part that faces the Earth.**
   c) Depending on where the Moon is in its orbit, light from the Sun lights up a larger or smaller part of the Moon's surface.
   d) The Earth interferes with the Sun's rays in a way that depends on where the Moon is in its orbit.

10. At full moon, as seen from the Earth, the Moon lies

    **a) opposite the Sun**
    b) 90 degrees east of the Sun
    c) 90 degrees west of the sun
    d) close to the Sun in the sky

11. A rock is in circular orbit about the Sun with a radius 4 AU. What is its period?

    a) 1/16 year
    b) 1 year
    c) 2 years
    d) 4 years
    **e) 8 years**

12. The ice planet Hoth has the same radius as the Earth but has 0.5 times the Earth's mass. If you weigh 100 pounds on Earth, how many pounds would you weigh on Hoth?

    a) 25 pounds
    **b) 50 pounds**
    c) 200 pounds
    d) 400 pounds

13. The absorption lines of oxygen have the same wavelength as its emission lines.

    **a) true**
    b) false

14. The peak wavelength of the light from a star is 300 nm. What is the temperature of its surface?

    a) 300 K
    b) 1000 K
    c) 3000 K
    **d) 10,000 K**
    e) 30,000 K

15. When an object is heated, the light it emits is:

    a) brighter and with longer average wavelength
    b) dimmer and with longer average wavelength
    **c) brighter and with shorter average wavelength**
    d) dimmer and with shorter average wavelength

16. Light of which of the following kinds is observed by earthbound telescopes?

    **a) radio waves and visible light**
    b) visible light and x-rays
    c) x-rays and gamma rays
    d) radio waves and x-rays

17. An electron jumps to a more distant orbit when an atom:

    a) emits light
    **b) absorbs light**
    c) electrons do not change orbits

18. An element can be identified by looking at its:

    **a) spectral lines**
    b) continuous spectrum
    c) gamma-ray bursts

19. Why are satellites used to detect x-rays?

    a) space-based detectors are more sensitive
    b) they avoid atmospheric turbulence
    **c) air absorbs x-rays**

20. When hydrogen fuses to helium, what fraction of its mass changes to energy?

    a) 100%
    b) 70%
    c) 50%
    d) 5%
    **e) 0.7%**

21. The luminosity of a star is $9 \times 10^{25}$ watts. How much mass does it change to energy each second?

    **a) $1 \times 10^{9}$ kg**
    b) $3 \times 10^{9}$ kg
    c) $1 \times 10^{17}$ kg
    d) $3 \times 10^{17}$ kg
    e) $9 \times 10^{17}$ kg

22. The primary source of the Sun's energy is

    **a) fusion of light nuclei to make heavier ones**
    b) fission of heavy nuclei into lighter ones
    c) the slow release of heat left over from the Sun's formation
    d) the solar magnetic field

23. How many times more massive is the Sun than the Earth?

a) 100
**b) 300,000**
c) 100 million

24. About how hot is the Sun's photosphere?

a) 3 K
b) 300 K
c) 3000 K
**d) 6000 K**

25. The visible light we see from the Sun comes from what part of the Sun?

**a) photosphere**
b) corona
c) chromosphere
d) core

26. The Sun is a stable star in which

a) the rate at which energy is emitted by the core is equal to the rate at which energy is absorbed in the corona
b) the rate of fusion equals the rate of fission
c) radiation and convection balance one another
**d) gravity balances the force from pressure**

27. What is the most abundant element in the Sun?

**a) hydrogen**
b) helium
c) carbon
d) oxygen
e) iron

28. Compared to a main-sequence star of type G, a main-sequence star of type B is:

a) hotter and less massive
**b) hotter and more massive**
c) cooler and less massive
d) cooler and more massive

29. Which of the following lists gives the spectral types of stars in order from the type corresponding to stars with the hottest surfaces to the type corresponding to stars with the coolest surfaces?

    a) F, B, G, O, M
    b) A, B, F, G, O
    **c) O, B, F, G, M**
    d) K, M, F, G, B
    e) B, G, F, M, K

30. Star A appears brighter than star B, as seen from Earth. Therefore, start A must be closer to Earth than star B.

    a) True
    **b) False**

31. Stars of spectral class M do not show strong lines of hydrogen in their spectra because

    a) they contain very little hydrogen
    **b) their surfaces are so cool that most hydrogen is in the ground state**
    c) their surfaces are so hot that most hydrogen is ionized
    d) the hydrogen lines are swamped by even stronger lines of other elements

32. Compared to a star with mass equal to the mass of the Sun, a main sequence star of 10 solar masses is:

    a) cooler and less luminous
    b) cooler and more luminous
    c) hotter and less luminous
    **d) hotter and more luminous**

33. What is plotted on an H-R diagram?

    a) luminosity versus mass
    **b) luminosity versus surface temperature**
    c) mass versus surface temperature
    d) mass versus abundance of hydrogen, or
    e) none of these is correct

34. About what fraction of stars are on the main sequence?

    a) less than 10%
    b) about 50%
    **c) more than 90%**

35. Stars with cool surfaces can be very luminous if they are very

    a) small
    b) hot
    **c) large**
    d) close to our solar system

36. Saturn is 10 AU from the Sun. The brightness of sunlight on the Earth is about 1400 watt/meter$^2$ . What is the brightness of sunlight on Saturn?

    a) 140 watt/meter$^2$
    **b) 14 watt/meter$^2$**
    c) 1.4 watt/meter$^2$
    d) 0.14 watt/meter$^2$

37. Two clouds of interstellar gas, A and M, contract to form stars. Suppose that no mass is lost in the contraction and that when they stop contracting, cloud A is a type A star and cloud M is a type M star. Compared to cloud M, cloud A has:

    a) a larger percentage of hydrogen
    b) a smaller percentage of hydrogen
    **c) more mass**
    d) less mass

38. A main-sequence star with a mass of 15 times the mass of the Sun has a lifetime that is

    a) much longer than the Sun's.
    **b) much shorter than the Sun's.**
    c) about the same as the Sun's.

39. When visible light from a star passes through interstellar dust, the light

    a) ionizes the dust, which then emits red and infrared light
    b) ionizes the dust, which then emits blue and ultraviolet light
    c) is dimmed and becomes bluer
    d) is Doppler shifted
    **e) is dimmed and reddened**

40. What is the source of energy of a protostar, before it has reached the main sequence?

    a) Contraction of the core and fusion of hydrogen to helium in a shell
    b) Fusion of helium to carbon in the core
    **c) Contraction of the entire star**
    d) Fusion of hydrogen to helium in the core

41. Which is the energy source of a star in its first red-giant stage?

    **a) Contraction of the core and fusion of hydrogen to helium in a shell**
    b) Fusion of helium to carbon in the core
    c) Contraction of the entire star
    d) Fusion of hydrogen to helium in the core

42. Which provides the energy of a main sequence star?

    a) Contraction of the core and fusion of hydrogen to helium in a shell
    b) Fusion of helium to carbon in the core
    c) Contraction of the entire star
    **d) Fusion of hydrogen to helium in the core**

43. Which of these is an energy source for a star just after the helium flash?

    a) Contraction of the core and fusion of hydrogen to helium in a shell
    **b) Fusion of helium to carbon in the core**
    c) Contraction of the entire star
    d) Fusion of hydrogen to helium in the core

44. What is the ejected outer part of a star whose core becomes a white dwarf.

    a) Type II supernova
    b) Type I supernova
    **c) Planetary nebula**
    d) Nova

45. What is the explosion that results from hydrogen from a companion star falling onto a white dwarf and suddenly fusing to helium when it gets hot enough to ignite.

    a) Type II supernova
    b) Type I supernova
    c) Planetary nebula
    **d) Nova**

46. What is the explosion that results from the gravitational collapse of the iron core of a massive star when it approaches its upper mass limit.

    **a) Type II supernova**
    b) Type I supernova
    c) Planetary nebula
    d) Nova

47. What is the explosion that results from the gravitational collapse of a white dwarf when it approaches or reaches its upper mass limit.

    a) Type II supernova
    **b) Type I supernova**
    c) Planetary nebula
    d) Nova

48. One billion years from now the Sun will be a

    a) red giant
    **b) main-sequence star**
    c) white dwarf
    d) none of the above

49. What is the next stage in the Sun's evolution?

    **a) red giant**
    b) neutron star
    c) type F main-sequence star
    d) white dwarf
    e) red dwarf

50. Who found the upper limit on the mass of white dwarfs

    **a) Chandrasekhar**
    b) Franz Zwicky and Walter Baade
    c) Jocelyn Bell and Antony Hewish
    d) Annie Jump Cannon

51. Who first to discover pulsars.

    a) Chandrasekhar
    b) Franz Zwicky and Walter Baade
    **c) Jocelyn Bell and Antony Hewish**
    d) Annie Jump Cannon

52. Who classified the spectra of 400,000 stars.

    a) Chandrasekhar
    b) Franz Zwicky and Walter Baade
    c) Jocelyn Bell and Antony Hewish
    **d) Annie Jump Cannon**

53. Who first proposed that supernovae were the result of the gravitational collapse of a star to form a neutron star.

a) Chandrasekhar
**b) Franz Zwicky and Walter Baade**
c) Jocelyn Bell and Antony Hewish
d) Annie Jump Cannon

54. The fastest-spinning neutron star known rotates about

a) once a day
b) once an hour
c) once a second
d) 30 times a second
**e) 700 times a second**

55. A black hole is likely to be the end of stellar evolution for what type of mainsequence star?

a) A
b) G
c) M
**d) O**

56. What can escape from within a black hole?

**a) Neither light nor matter**
b) Light only
c) Both light and matter
d) Matter only

57. Compared to terrestrial planets, Jovian planets are

a) larger and denser
b) smaller and denser
**c) larger and less dense**
d) smaller and less dense

58. Most of the solar system's mass is in

    a) comets
    b) asteroids
    c) planets
    d) meteoroids
    **e) the Sun**

59. Why do all of the planets have orbits that lie in nearly the same plane and that are in the same direction – counterclockwise looking down on the solar system from far above the Earth's North Pole?

    a) When they were captured by the Sun, the Sun was moving past a cluster of planets, and all of those planets were on one side of its path.
    b) Shortly after they formed, the planets were moving in random directions. In the 4 1/2 billion years since then, the Sun's gravity has pulled them into the same plane
    **c) The planets and Sun all formed from a cloud of gas and dust that contracted as it cooled. As the cloud contracted, its spin increased and it flattened. By the time the planets formed, the cloud was a flat spinning disk.**

60. The Earth's atmosphere is primarily

    **a) nitrogen and oxygen**
    b) nitrogen and water vapor
    c) carbon dioxide and oxygen
    d) water vapor and carbon dioxide
    e) methane and ammonia

61. The terrestrial planet whose crater-covered surface most closely resembles the Moon's.

    a) Mars
    **b) Mercury**
    c) Earth
    d) Venus
    e) None of these

62. Because of the greenhouse effect, this planet has the hottest surface in the solar system.

    a) Mars
    b) Mercury
    c) Earth
    **d) Venus**
    e) None of these

63. The planet that is closest in size to the Earth (not including the Earth itself).

a) Mars
b) Mercury
c) Earth
**d) Venus**
e) None of these

64. Which of these is the smallest of the terrestrial planets.

a) Mars
**b) Mercury**
c) Earth
d) Venus
e) None of these

65. They often pass the Sun once and then leave the solar system.

**a) comets**
b) meteoroids
c) asteroids

66. Jupiter-mass planets that are found very close to their parent stars are called:

a) Superearths
**b) Hot Jupiters**
c) Goldilocks planets
d) Cold Jupiters

67. Comet tails extend from the comet in what direction?

**a) away from the Sun**
b) away from the Sun when the comet is approaching the Sun and toward the Sun when the comet is moving away
c) toward the Sun

68. Which one of these methods is not a way to find planets around stars other than the Sun?

**a) radar**
b) radial velocity
c) transits
d) microlensing

69. A quasar is thought to be powered by

a) collisions of stars in the the galaxy's core
b) radiation from supermassive stars
c) supernovae triggered by density waves in the galaxy's bulge
**d) radiation from matter accreting onto a supermassive black hole**

70. In what century were galaxies first shown to lie outside the Milky Way?

a) 5th century BC
b) 17th century
c) 18th century
d) 19th century
**e) 20th century**

71. These galaxies have little gas and dust and few new stars.

**a) elliptical galaxies**
b) irregular galaxies
c) spiral galaxies

72. These galaxies have new stars in their disk.

a) elliptical galaxies
b) irregular galaxies
**c) spiral galaxies**

73. These galaxies have new stars but no disk.

a) elliptical galaxies
**b) irregular galaxies**
c) spiral galaxies

74. These are the reddest of the three types of galaxies.

**a) elliptical galaxies**
b) irregular galaxies
c) spiral galaxies

75. Spiral and irregular galaxies are bluer than elliptical galaxies because

    a) they have smaller redshifts.
    **b) unlike elliptical galaxies, they have young O and B stars.**
    c) unlike elliptical galaxies, they have almost no O and B stars.
    d) The question is misleading, because irregular galaxies are redder than ellipticals.

76. Most of the mass of the Milky Way galaxy is

    a) in the spiral arms
    b) in the disk, but not in the spiral arms
    c) in the nuclear bulge
    **d) invisible and in the halo**
    e) in the brightest, most massive stars of halo

77. How are galaxies spread out throughout the universe

    a) They are grouped into clusters that are spread more-or-less evenly throughout space
    **b) They are grouped into clusters that in turn are clumped into superclusters**
    c) Galaxies are densest near us, and become more spread out as we look further out
    d) Galaxies are densest near a distant point in space, which can be interpreted as the center of the universe, and are ore spread out as one looks way from that point.

78. Hubble's law states that

    **a) the speed at which galaxies move away from us is proportional to their distance from us.**
    b) all galaxies move away from us at the same uniform speed
    c) the redshift of galaxies is proportional to the speed at which they move away from us
    d) the redshift of galaxies is proportional to the speed at which they move toward us
    e) anything that can go wrong with an astronomical observation will go wrong

79. A galaxy is moving away from us at 7000 km/s. How far away is it? Use Hubble's constant of 70 km/s/Mpc.

    **a) 100 Mpc**
    b) 1000 Mpc
    c) 4900 Mpc
    d) 490,000 Mpc

80. The Local Group is

a) a cluster of galaxies including M87
**b) a cluster of galaxies including the Milky Way**
c) a cluster of stars including the Sun and alpha Centauri
d) a globular cluster

81. The rotation curve of a galaxy is

**a) the orbital speed of stars and gas around a galaxy at different radii from the center.**
b) the shape of the orbits of stars around a galaxy.
c) the rotation of dark matter around a galaxy.
d) a measurement that shows that all the matter in a galaxy is due to stars.

82. Because of the presence of dark matter, the rotation curve of galaxies

a) goes down at large radius
b) goes up at large radius
**c) flattens at large radius**
d) none of the above.

83. From the velocity of galaxies in galaxy cluster, we can tell that most of the mass of the cluster is in

a) intracluster gas
**b) dark matter**
c) dark energy
d) galaxies

84. Why is 21 cm radio emission useful for studying the structure of the Milky Way

a) The waves penetrate dusty cocoons to reveal star formation
b) The waves are not absorbed by Galactic black holes
**c) It can be used to map the hydrogen gas in the spiral arms**
d) Radio waves provide a distance measurement like parallax

85. The intracluster gas in a galaxy cluster

a) is the hot gas between galaxies in a galaxy cluster
b) contains most of the ordinary matter in a galaxy cluster
c) is smaller than the amount of matter needed to explain the velocities of galaxies in a galaxy cluster

**d) all of the above**

86. Which of these is evidence for dark matter?

a) rotation curves of galaxies
b) velocity of galaxies in galaxy clusters
c) gravitational lensing
**d) all of the above**

87. Galaxy collisions

a) induce star formation in the galaxies
b) change galaxies of one type to another
c) can drive gas to the central supermassive black holes
**d) all of the above**

88. Major mergers between galaxies typically

a) make irregular galaxies
b) make spiral galaxies
**c) make elliptical galaxies**
d) make dwarf galaxies

89. The process by which galaxies form from merging smaller galaxies is called

a) galactic acquisition
**b) hierarchical merging**
c) dark matter
d) quasar epoch

90. Large surveys of galaxies shows that galaxies are distributed

a) evenly across the universe
**b) in large filaments separated by voids**
c) in small clumps
d) at random

91. The galactic distances used to measure the acceleration of the universe are determined using

**a) the brightness of Type Ia supernovae**
b) Hubble's law
c) the brightness of main-sequence stars (spectroscopic parallax)

d) parallax
e) the period-luminosity relation of Cepheid variables

92. The age of the universe is estimated to be
    a) less than the Earth's age
    b) the same age as the Sun
    **c) about 14 billion years**
    d) 6.2 trillion years

93. The cosmic microwave background is
    **a) leftover radiation from the Big Bang**
    b) proof that the universe is getting warmer
    c) a result of the hot intergalactic gas between clusters
    d) the observable form of dark energy

94. Which of the following elements were created in stars and not created in the Big Bang?
    a) helium
    b) deuterium
    **c) carbon**

95. Most of the energy content of the universe is in
    a) normal matter
    b) dark matter
    **c) dark energy**
    d) Normal matter, dark matter and dark energy contribute equal fractions to the energy content of the universe

96. Compared to the universe today, the early universe was
    **a) hotter and denser**
    b) cooler and less dense
    c) hotter and less dense
    d) cooler and denser

97. By measuring the size of spots in the cosmic microwave background, we can tell that the universe is
    a) closed

b) curved
**c) flat**
d) open

98. Which two problems in our model of the universe does the theory of inflation solve?

a) the acceleration of the universe and the horizon problem
**b) the horizon problem and the flatness problem**
c) the flatness problem and the origin of dark matter
d) the origin of dark matter and the acceleration of the universe

99. The universe is observed to be

a) coasting
**b) accelerating**
c) deaccelerating
d) contracting

100. Olber's paradox is resolved by

**a) the finite age of the universe**
b) the mass-luminosity relation
c) the cosmic microwave background
d) the period-luminosity relation