D PRACTICE MULTIPLE CHOICE PROBLEMS

Multiple choice exams are a staple of many astronomy courses with large enrollments. This appendix provides a sampling of multiple choice problems in which students can test their mastery of the material: terms, principles, and applications.

Some problems involve calculation. For a review of math techniques, refer to Chapter 1. Also, some questions may have two or more answers that seem similar; choose the best answers. For example, a question asking about the nature of the Milky Way might provide one option that it is a galaxy and one that it is a cluster of stars. In this case the galaxy answer would be the better one. That the Milky Way is a cluster of stars (a very large cluster!) is true, but incomplete; for example, the Milky Way also contains a dark matter halo and clouds gas.

The problems are grouped into relatively broad sections of the sky, historical development of astronomy, physical principles, the Solar System, stars, galaxies and cosmology, and miscellaneous (such as exoplanets and the search for life in the universe).

D.1 The Sky

1. A constellation is

    a) a car model.
    b) an alignment of planets.
    c) an apparent pattern of stars in the sky.
    d) another name for circles on the celestial sphere.

2. The apparent rising and setting of the Sun, as viewed from Earth, is caused by

    a) the Sun's rotation.
    b) the Sun's revolution.
    c) Earth's revolution.
    d) Earth's rotation.

3. The path of the Sun through the sky over the course of one year is called the

    a) ellipse.
    b) edgeomatic.
    c) ecliptic.
    d) endgame.
    e) enigma.

4. The ecliptic line in the sky passes through the constellations of

    a) the Zodiac.
    b) the Strip.
    c) the Conglomeration.
    d) the Great Wall.
    e) the Milky Way band.

5. You observe the North Star near the horizon, where are you?

    a) Near the North Pole.
    b) Near the South Pole.
    c) Near the equator of the Earth.
    d) Near Greenwich, England.

6. Where on Earth would you be if Polaris were at your zenith?

    a) The North Pole.
    b) The South Pole.
    c) The Tropic of Cancer.
    d) The Equator.
    e) It lies overhead everywhere on Earth.

7. What curve on the celestial sphere is created by our revolution around the Sun?

    a) The Equator.
    b) The Prime Meridian.
    c) The Enigmatte.
    d) The Ecliptic.
    e) The Galactic Plane.

8. The Earth's orbit is nearly a circle of 1 AU radius. Suppose the orbit of Mars could be approximated as a circle of 1.5 AU radius. Compare the angular size of Mar at opposition to its size at conjunction. (Hint: Draw a figure. The answer is a ratio. You will need the formula for angular size of an object.)

a) Mars is 1.5 times larger in appearance at opposition.
b) Mars is 1.5 times smaller in appearance at opposition.
c) Mars is 5 times bigger in appearance at opposition.
d) Mars is 5 times smaller in appearance at opposition.
e) The apparent size of Mars never changes.

9. Which planet cannot be at opposition?

a) Mars
b) Saturn
c) Jupiter
d) Neptune
e) Venus

10. The seasons on Earth are a consequence of

a) Solar activity.
b) Lunar tides.
c) the ellipticity of the Earth's orbit.
d) the industrial revolution.
e) the tilt of the Earth's rotation axis.

D.2 Historical Development of Astronomy

11. Aristotle inferred that

a) the Earth is spherical because the Earth's shadow is always a stripe across the Moon.
b) the Earth is spherical because different constellations could be seen from different latitudes.
c) the Earth is flat because the Earth's shadow is always curved across the Moon.
d) the Earth is flat because different constellations could be seen from different latitudes.

12. Who found that Venus shows phases that are consistent with the heliocentric model?

a) Kepler
b) Copernicus
c) Aristotle
d) Galileo
e) Brahe

13. If a new planet were found at 200 Astronomical Units (200 AU), what would its orbital period around the Sun be?

a) 34 years
b) 200 years
c) 300 years
d) 2800 years
e) 3 billion years

14. At aphelion, a planet moves

a) at its slowest speed.
b) at its fastest speed.
c) at its average speed.
d) none of the above.

15. Tycho Brahe is famous for

a) being the first to look at planets with a telescope.
b) confirming the heliocentric model.
c) being the greatest observer before the telescope.
d) his mathematical models of elliptical orbits.

16. Which Greek composed a model of the Earth-Moon-Sun system that most closely resembles our modern view?

a) Pythagoras
b) Hipparchus
c) Ptolemy
d) Erastothenes
e) Aristarchus

17. Imagine a planet with semi-major axis of $a = 14$ AU. What is its orbital period in years?

a) 21 years
b) 14 years
c) 6 years
d) 52 years

e) 28 years

18. Determine the distance from the Sun at which an object would be in synchronous orbit with the Sun's rotation period of 25 days. (Hint: Use Kepler's 3rd law with correct units.)

    a) 1 AU
    b) 36 solar radii
    c) 25 AU
    d) 42,000 km
    e) 3.8 solar radii

19. Who is closely associated with having summarized the geocentric model.

    a) Aristotle
    b) Ptolemy
    c) Galileo
    d) Brahe
    e) Kepler

20. Stellar parallax is an easy way to confirm the heliocentric model. Why didn't the ancients confirm the heliocentric model with this method?

    a) No one knew how to spell parallax in those days.
    b) No one was aware of the idea of parallax in those days.
    c) Parallax of stars does not involve geometry.
    d) Parallax of stars is too small to measure with the human eye alone.
    e) No one tried to measure it.

21. Two orbits have semi-major axes of 56 AU. But one of these is a circular orbit, and the other is elliptical. Regarding the orbital periods for the two,

    a) the circular orbit has the longer orbital period.
    b) the circular orbit has the shorter orbital period.
    c) the two have the same orbital period.
    d) the two orbital periods cannot be compared without knowing the eccentricity of the elliptical one.

D.3 Physical Principles

22. In space above the Earth,

    a) your mass drops to zero.
    b) your weight drops to zero.
    c) you would experience weightlessness because you are in free-fall.
    d) you would experience weightlessness because there is no gravity there.

23. If a car drives in a circle, does it experience a force?

    a) There is a net force acting on it directed away from the center of the circle.
    b) There is a net force acting on it directed toward the center of the circle.
    c) There is a net force directly ahead of it.
    d) There is a net force directly behind it.
    e) There is no net force if it moves with constant speed.

24. Which of the following correctly lists wavebands in order of increasing frequency?

    a) infrared, radio, X-ray, visible
    b) gamma-ray, ultraviolet, visible, radio
    c) infrared, microwave, gamma-ray, ultraviolet
    d) radio, ultraviolet, infrared, gamma-ray
    e) radio, infrared, visible, X-ray

25. The force of gravity between two objects

    a) increases linearly with the masses, but decreases linearly with their separation.
    b) increases linearly with the masses, but decreases with the square of their separation.
    c) increases with the cube of their masses, but decreases linearly with their separation.
    d) decreases linearly with the masses, and decreases linearly with their separation.
    e) decreases linearly with the masses, but increases with the square of their separation.

26. There is a force of gravity from the Earth acting on you.

    a) This force is bigger than the force of gravity acting on the Earth because of you.
    b) This force is smaller than the force of gravity acting on the Earth because of you.
    c) There is no force of gravity acting on the Earth because of you.
    d) This force is equal to the force of gravity acting on the Earth because of you.

27. Of the following, which radiation is typical of sources that are millions of degrees hot?

    a) X-rays
    b) ultraviolet
    c) radio
    d) visible
    e) infrared

28. If you quadruple the temperature of a blackbody, what will happen to its brightness?

    a) Increase by 256 times.
    b) Decrease by 256 times.
    c) Increase by 16 times.
    d) Decrease by 16 times.
    e) Increase by 8.

29. A radio beam is sent to Venus, which is reflected by its surface. One side of Venus shows a redshift from the Doppler effect, and the other a blueshift. This tells you that

    a) Venus is moving toward us.
    b) Venus is moving away from us.
    c) Venus is falling into the Sun.
    d) Venus is periodically expanding and shrinking.
    e) Venus is rotating.

30. The three laws dealing with the appearance of spectra are named after

    a) Newton.
    b) Fraunhofer.
    c) Kirchoff.
    d) Bohr.
    e) Kepler.

31. What is "seeing"?

    a) The faintness limit of a telescope.
    b) The brightness limit of a telescope.
    c) The spectral resolution of a spectroscope.
    d) A limit to the crispness of images owing to air stability.
    e) The range of electromagnetic radiations that penetrate the atmosphere.

32. Wien's law describes

    a) how color depends on temperature.
    b) how energy depends on frequency.
    c) how brightness depends on temperature.
    d) how orbital period depends on orbital size.
    e) how the force of gravity depends on mass and separation.

33. The Stefan-Boltzmann law describes

    a) how color depends on temperature.
    b) how energy depends on frequency.
    c) how brightness depends on temperature.
    d) how orbital period depends on orbital size.
    e) how the force of gravity depends on mass and separation.

34. A blackbody is

    a) a perfect reflector.
    b) a perfect emitter.
    c) a perfect tan.
    d) a perfect absorber.

35. A beam of light originally emitted at 6563 Å is measured at 6560 Å owing to the Doppler shift. What is the *percent change* in the wavelength?

a) 3%
b) 0.46%
c) 0.046%
d) 0.0046%
e) 0.00046%

36. In the Bohr atom,

a) electrons can only be at certain distances from the nucleus.
b) electrons can only be found in the nucleus.
c) electrons are never found in atoms.
d) electrons are neutral charged particles.

37. Consider a world like the Earth where the temperature of the gas is 9 times higher, but the atmosphere consists of particles that are also 9 times more massive. How will the thermal speed of those gas particles compare to one on Earth?

a) 9 times bigger than Earth particles.
b) 3 times bigger than Earth particles.
c) the same as Earth particles.
d) 3 times smaller than Earth particles.
e) 9 times smaller than Earth particles.

38. The advantage of building larger telescopes for conducting observational astronomy is that

a) bright objects are easier to see.
b) faint objects are easier to see.
c) clouds do not affect big telescopes.
d) larger telescopes can see more electromagnetic bands than small ones.

39. In the following list of elements, which is the most abundant elemental species in the universe?

a) C
b) Fe
c) He
d) O
e) N

40. A beam of light originally emitted at 6563 Å is measured at 6566 Å owing to the Doppler shift. What is the relative motion between the receiver and the emitter?

a) 137 km/s
b) 1,370 cm/s
c) 0.14 km/s
d) 14 m/s
e) None of the above

D.4 The Solar System

The Sun and General Solar System Properties

41. The Sun is best described as

a) a huge ball of hydrogen gas.
b) a huge ball of luminous liquid.
c) an extremely hot metallic solid.
d) a gravitationally confined ball of molten rock.

42. The glow of the Sun is powered by

a) its hot corona.
b) slow gravitational contraction.
c) chemical combustion.
d) nuclear fusion in its core.
e) the dynamo mechanism.

43. What keeps the Sun from collapsing under its own gravity?

a) The outward force exerted by intense magnetic fields in its core.
b) The fact that its interior is liquid and therefore cannot be compressed.
c) The fact that its interior is mostly iron.
d) The outward force exerted by gas pressure.
e) None of the above.

44. Why are astronomers interested in solar neutrinos?

a) They are the only products of nuclear reactions in the Sun which directly escape from the Sun.

b) They are the only probles of the sunspot cycle.

c) A sudden burst of neutrino activity might imperil astronauts if outside their spacecraft.

d) Their detection would mean that the Sun has exhausted its nuclear fuel.

45. The temperature in the center of the Sun is closest to

a) one billion K.

b) ten million K.

c) 6000 K.

d) 3000 K.

e) 300 K.

46. A solar flare erupts and its particles reach the Earth after 4 days. Given that the Sun is 1 AU from the Earth, how fast were the particles moving?

a) 430 km/sec

b) 1.5×10^6 km/sec

c) 4×10^7 km/sec

d) 0.25 km/sec

47. It is true that

a) the denser planets tend to have larger orbits in the Solar System.

b) the denser planets tend to have smaller orbits in the Solar System.

c) all the planets have the same density.

d) all the planets have densities close to that of rock.

e) all the planets have densities close to that of water.

48. Which is the correct ordering of objects in terms of increasing size (from small to large)?

a) Mars, Moon, Earth, Venus

b) Mercury, Mars, Venus, Earth

c) Earth, Mars, Mercury, Moon

d) Mars, Venus, Mercury, Earth

e) Mercury, Moon, Venus, Earth

49. Why do all of the planets orbit in the same direction and in nearly the same plane?

a) Gravity from the Sun forces them to orbit in the same plane.

b) The Sun's magnetic fields force them to orbit in the same direction.

c) Darn lucky.

d) They formed out of an accretion disk.

50. The volume of a sphere is $V = 4\pi R^3/3$, and the density is the ratio of mass to volume, or $\rho = M/V$. If a world has 25% the mass of the Earth and is 80% as large in radius, how does its density compare to the Earth's, as a percentage? (Hint: set up a proportion.)

a) 0.005%

b) 1000%

c) 205%

d) 10%

e) 49%

51. The Earth's orbital speed around the Sun is about 30 km/sec. At 0.3 AU, what is Mercury's orbital speed? Use the fact that for circular orbits, the speed goes like $v \propto 1/\sqrt{r}$ for r the orbital radius. (Hint: Set up a proportion.)

a) 9 km/sec

b) 16 km/sec

c) 55 km/sec

d) 100 km/sec

The Earth and Moon

52. The Earth has a circumference of 40,000 km, and rotates once in 24 hours. Determine the speed of rotation at the Earth's equator.

a) 40,000 km/sec

b) 17,000 km/sec

c) 28 km/sec

d) 2.9 km/sec

e) 0.46 km/sec

53. The atmospheric layer of the Earth that protects us from harmful solar ultraviolet light is

a) the hydrosphere.
b) the ozone layer.
c) the ionosphere.
d) the ochre zone.
e) the exolayer.

54. The region around the Earth where magnetic fields trap ions and electrons is called

a) the Van Allen Belts.
b) the exosphere.
c) the corona.
d) the aurorae.
e) the Goddard Loops.

55. Planets are round, and so every planet with an atmosphere will have a basic weather pattern, even in the absence of rotation, described by

a) the Coriolis force.
b) the brainstorm.
c) the Hadley cell.
d) the centripetal force.
e) Hooke's law.

56. A rocket is fired from the equator directly south over land. How will its motion appear if mapped by a satellite overhead?

a) The rocket will appear to curve eastward.
b) The rocket will appear to curve westward.
c) The rocket will appear to slow up.
d) The rocket will appear to speed up.

57. The atmosphere of the Earth has a density of about 10^{19} molecules per cubic centimeter. Working out the numbers, the total number of air molecules is about 4×10^{43}. However, some gas is lost to space at the outer edge of our atmosphere, at about 10^{28} molecules per year. How long can our atmosphere last?

a) 10^{15} years
b) 10^{-15} years
c) 10^{71} years
d) 10^{-71} years

58. Which is the preferred model for the formation of the Moon?

a) Fission theory
b) Binary theory
c) Capture theory
d) Impact theory
e) Tidal theory

59. What nation was first to put humans on the Moon?

a) Soviet Union
b) USA
c) China
d) Japan
e) Britain

60. The cratering of lunar highlands shows us that

a) they are younger than the maria.
b) they are older than the maria.
c) they were formed from plate tectonic activity.
d) they were formed from lava flows.

61. The far side of the Moon is

a) only visible at New Moon.
b) only visible at 1st and 3rd Quarter phases.
c) only visible at Full Moon.
d) always visible at some time when the Moon is above the horizon.
e) is never visible from the Earth.

62. You are out watching a meteor shower, and you notice the Moon is on the local meridian. If it is 3 am, what is the phase of the Moon?

a) 1st Quarter
b) Waxing Gibbous
c) 3rd Quarter
d) Waning Gibbous
e) Waxing Crescent

63. You see a Waxing Crescent Moon rising at the Eastern horizon. What time must it be?

a) 9am
b) Noon
c) 3pm
d) 9pm
e) Midnight

64. The Moon orbits the Earth about monthly. Why don't we have a solar eclipse every month?

a) The Moon's orbit is not inclined to the ecliptic.
b) The Moon's orbit is inclined to the ecliptic.
c) The Moon is not always the right size.
d) The Sun is not always the right size.

The Terrestrial Planets

65. One way that Mercury is different from the Earth is

a) Mercury has a relatively larger iron core (as percentage of volume).
b) Mercury has more mass.
c) Mercury has no craters.
d) Mercury has a thick carbon-dioxide atmosphere.
e) Mercury has larger oceans.

66. Why does Venus not have much of a magnetic field?

a) No iron core.
b) Its core is cold.
c) It is too near the Sun.
d) It rotates slowly.
e) Its atmosphere is too thick.

67. Venus and Earth are sometimes called "sister planets" because they are similar in

a) surface temperature.
b) their atmospheric content.
c) having polar ice caps.
d) mass and size.
e) their rotation period.

68. Venus has large old craters but few small or new ones. This is because

a) of resurfacing.
b) no small craters were made.
c) Venus formed much later than the Moon did.
d) Venus is a world of sulfuric acid oceans.

69. The tilt of Mars is very like that of the Earth, but Mars has more severe seasonal changes during its year. Why is this?

a) The rotation of Mars is much faster.
b) The orbit of Mars is much more eccentric.
c) The rotation of Mars is much slower.
d) The atmosphere of Mars is much cloudier.
e) The orbit of Mars is almost perfectly circular.

70. On what world is the largest volcano in the Solar System found?

a) Venus
b) Earth
c) Mars
d) Mercury
e) Moon

71. Let's combine some sci-fi with some economics. In the movie "The Red Planet", scientists sent algae to Mars to establish an oxygen-rich atmosphere there. Suppose this algae will one day be developed, and that enough to cover the entire suppose of Mars with a layer of algae of depth $h = 1$ mm thick is one day sent. The volume of algae is then $4\pi R^2 h$, where R is the radius of Mars. If it costs \$100 to get a single kilogram of mass off the Earth and into space, and if the density of the algae were only 100 kg/m^3 (about 10% of water), estimate the cost of "teraforming" the atmosphere of Mars. (Hint: Make sure h and R are in meters. Find the volume of algae. Multiply by density to get the mass in kg. Take it from there.)

a) $\$1.5 \times 10^{18}$ (or 1.5 million trillion dollars)

b) $\$1.5 \times 10^{15}$ (or 1500 trillion dollars)

c) $\$1.5 \times 10^{13}$ (or 15 trillion dollars)

d) $\$1.5 \times 10^{11}$ (or 150 billion dollars)

72. Which of the following suffers from a runaway Greenhouse effect?

a) Mars

b) Venus

c) Earth

d) Luna

e) Mercury

73. Earth has life, and the other Terrestrial worlds do not. What else does Earth possess that none of the other worlds have?

a) Water oceans.

b) A runaway greenhouse effect.

c) Weather.

d) Past volcanic activity.

74. For a Hohmann orbit transfer, an object that wants to get from Mars to Earth would travel along an ellipse of what semi-major axis value?

b) 1 AU

b) 2.5 AU

c) 1.5 AU

d) 0.5 AU

e) 1.25 AU

The Jovian Planets

75. Who first discovered the major moons of Jupiter?

a) Galileo

b) Cassini

c) Huygens

d) Copernicus

e) Herschel

76. Jupiter sports an extremely strong magnetic field. This is because of its

a) hydrogen rich atmosphere.

b) extensive moon system.

c) metallic hydrogen interior.

d) considerable distance from the otherwise magnetically interfering Sun.

77. Saturn's ring is composed of

a) metallic chunks.

b) icy chunks.

c) a single solid icy band.

d) a single solid metallic band.

78. Which world hosts the Great Red Spot?

a) Uranus

b) Jupiter

c) Neptune

d) Saturn

79. Which world does not show "internal heat"?

a) Neptune

b) Jupiter

c) Uranus

d) Saturn

80. Neptune was a surprise for astronomers when Voyager 2 flew by, because unlike Uranus, it showed

a) considerable atmospheric activity.

b) a magnetic field.

c) rotation.

d) a number of moons.

e) planetary rings.

81. Which world does not have planetary rings?

a) Jupiter

b) Neptune

c) Saturn

d) Uranus

e) All of these have rings.

82. Why does the helium content of Saturn appear to be smaller than Jupiter?

a) Saturn is too cold to keep helium.

b) Saturn is too hot to keep helium.

c) Some of Saturn's helium has sunk toward its center.

d) Jupiter sucked up all of the helium when it formed, leaving little for Saturn.

e) Helium combines with oxygen to form heavy water at Saturn.

83. Who discovered Uranus?

a) Adams
b) Lowell
c) Leverrier
d) Tombaugh
e) Herschel

84. Jupiter is about 10 times larger than the Earth. However, it rotates in only 10 hours instead of 24 hours. How much faster is Jupiter rotating at its equator as compared to the Earth? (Hint: Make a comparison of rotation speeds at the respective equators by setting up a proportion).

a) 24 times
b) 29 times
c) 10 times
d) 9 times
e) same speeds

Minor Bodies of the Solar System

85. Which moon shows strong volcanic activity?

a) Europa
b) Io
c) Callisto
d) Titan
e) Ganymede

86. The Roche limit refers to

a) the distance at which something moves slower than the planetary escape speed.
b) the maximum allowable mass of a planet.
c) the maximum allowable mass of a moon.
d) how close an object can approach a planet before being ripped apart by tidal forces.
e) how close an object can approach a planet before melting.

87. Triton is a moon in a retrograde orbit. Suppose its orbit degrades at an average rate of 1 km per century, and that its current distance from Neptune's upper atmosphere is about 1.5×10^9 meters. Approximately how long before Triton will fall into Neptune?

a) 1.5×10^{11} years
b) 1.5×10^{10} years
c) 1.5×10^{8} years
d) 1.5×10^{7} years
e) 1.5×10^{6} years

88. Which of the following is not a Dwarf Planet?

a) Pluto
b) Ceres
c) Charon
d) Eris

89. Most rocky asteroids are found between

a) Earth and Mars.
b) Mars and Jupiter.
c) Jupiter and Saturn.
d) Saturn and Uranus.
e) Uranus and Neptune.

90. The nucleus of a comet is closest to

a) 1 meter in size.
b) 10 kilometers in size.
c) 10,000 kilometers in size.
d) 10 million kilometers in size.
e) 10 AU in size.

91. A meteor streaks across the sky with a speed of 20 km/sec. If the U. S. is about 3000 miles across, and 1 mile equals 1.6 km, how long does it take the meteor to move across the U. S.?

a) About 4 minutes.
b) About 9 seconds.
c) About 9 hours.
d) About 1.5 seconds.
e) About 1.5 minutes.

92. Suppose that you have a 100 kg sample of a substance with a half-life of 6 months. How long must you wait until only 6 kg of the original substance remains?

    a) about 6 years
    b) about 0.5 years
    c) about 0.03 years
    d) about 8 years
    e) about 2 years

93. Who discovered Pluto?

    a) Adams
    b) Lowell
    c) Leverrier
    d) Tombaugh
    e) Herschel

94. Which moon has a thick nitrogen-rich atmosphere?

    a) Mimas
    b) Ganymede
    c) Hyperion
    d) Titan
    e) Miranda

95. Eris has an orbital period of 557 years. Its moon orbits once every 15.8 days. How many orbits will the moon make of Eris in the time it takes Eris to orbit the Sun once?

    a) About 560 times
    b) About 5,800 times
    c) About 203,000 times
    d) About 8,800 times
    e) About 13,000 times

96. Cometary orbits are extremely elliptical, so much so that their farthest distance d from the Sun is approximately equal to the major axis size ($d = 2a$) of their orbit. If a comet orbits once in 3 million years, approximately what is the greatest distance it achieves from the Sun?

    a) 3.0×10^6 AU
    b) 5.2×10^9 AU
    c) 2.0×10^6 AU
    d) 2.1×10^4 AU
    e) 4.2×10^4 AU

97. The main reservoir of comets at the edge of the Solar System is called

    a) the Ignace Assemblage.
    b) Halley's Harbor.
    c) the Oort Cloud.
    d) the Zodiacal Band.
    e) the Kuiper Belt.

D.5 The Stars

98. Which stars among the following spectral types are most *rare*?

    a) A stars
    b) B stars
    c) G stars
    d) M stars
    e) O stars

99. A parsec is

    a) a unit of interstellar distance.
    b) the angular size of the Moon.
    c) a type of binary star.
    d) a unit for proper motion.
    e) a fundamental particle, like an electron or proton.

100. Stars #1 and #2 have the same radius. Suppose that star #1 is hotter.

    a) Both stars will have the same luminosity
    b) Star #1 will be more luminous.
    c) Star #2 will be more luminous.
    d) Nothing can be determined about the luminosities without knowing the temperature value.

101. If a star is of spectral type B,

    a) it is a cool, blue star.
    b) it is a cool, red star.

c) it is a hot, blue star.

d) it is a hot, red star.

102. Cool star spectra can show absorption features from molecules but not so for hot star spectra. Why?

a) Hot stars lack the right kinds of elements to form molecules.

b) Molecules cannot survive at high temperature because they become dissociated.

c) Cool stars lack hydrogen so that molecules are easier to form.

d) Hot stars have too much hydrogen to form molecules.

e) Spectral features of molecules in hot star atmospheres are present only as emission lines, not absorption lines.

103. Protostars sustain their ability to shine with an energy source based on

a) chemical release of energy.

b) nuclear fusion of H to He.

c) magnetic release of energy.

d) gravitational contraction.

104. You observe an eclipsing binary star. Suppose that both stars have exactly the same radius, and the system is seen exactly edge-on. When the faint star is in front, the brightness of the system drops by 67%. When the bright star is in front, the brightness of the system drops by 33%. How then does the luminosity of the bright star (#1) compare to the faint star (#2)? (So find the ratio of L_1/L_2. It helps to sketch the light curve.)

a) $L_1 = 4L_2$

b) $L_1 = 2L_2$

c) $L_1 = L_2$

d) $L_2 = 2L_1$

e) $L_2 = 4L_1$

105. How are stellar masses determined from visual binaries?

a) Use orbital period and orbital velocity along with Newton's 1st law.

b) Use orbital period and orbital velocity along with Kirchoff's 1st law.

c) Use orbital period and orbit size along with Kepler's 3rd law.

d) Use orbital period and orbit size along with Hooke's law.

106. For a star that is 4 times more massive than the Sun, how will its expected Main Sequence lifetime compare to the Sun?

a) About 4 times longer

b) About 4 times shorter

c) About the same

d) About 16 times shorter

e) About 16 times longer

107. The mass-luminosity relation for Main Sequence stars is given approximately by $L/L_\odot = (M/M_\odot)^3$, where L is the luminosity of a star and M is its mass. Consider a star that is 46 times more luminous than the Sun. What is the mass of this star?

a) $0.3M_\odot$

b) $3M_\odot$

c) $6.8M_\odot$

d) $3.6M_\odot$

e) $46M_\odot$

108. A star shows a parallax angle of 0.012 arcseconds. A star with a parallax that is 4 times smaller is at what distance?

a) 330 parsecs

b) 12 parsecs

c) 83 parsecs

d) 9 parsecs

e) 21 parsecs

109. Stars of all masses can burn

a) iron.

b) oxygen.

c) carbon.

d) helium.

e) iridium.

110. Why do we say a solar-like star has run out of fuel after it has only used up about 10% of its total mass of hydrogen?

a) Because stars are only hot enough to fuse hydrogen in the very center, a region that holds only about 10% of the star's mass.

b) Because stars always collapse before the other 90% can undergo fusion.

c) Because stars are only hot enough to fuse hydrogen in the atmosphere, a region that holds only about 10% of the star's mass.

d) If a star released more than 10% of its total mass as energy, it would blow itself apart.

111. A planetary nebula is

a) the result of a supernova explosion.

b) a cloud out of which a planet forms.

c) the outer atmospheric layers of low-mass stars that are blown into space via a stellar wind.

d) another term for the "Solar Nebula".

112. The Sun has an equatorial rotation speed of about 2 km/sec, but many stars rotate much faster. If the Sun rotates once in 25 days, what is the rotation speed of a star of the same radius that rotates once in 15 hours?

a) 3 km/s

b) 30 km/s

c) 80 km/s

d) 2 km/s

e) 12 km/s

113. Which of these stars is most likely to end up as a Black Hole?

a) A 0.5 solar mass star.

b) A 1 solar mass star.

c) A 6 solar mass star.

d) A 25 solar mass star.

114. The "pulsing" effect of pulsars results from a combination of

a) rotation and beaming.

b) rotation and starquakes.

c) pulsation and beaming.

d) pulsation and magnetism.

115. One day the Sun will become

a) a neutron star.

b) a white dwarf.

c) a black hole.

d) a pulsar.

116. In the H-R Diagram, the largest stars are located where

a) stars are hot and luminous.

b) stars are hot and not very luminous.

c) stars are cool and not very luminous.

d) stars are cool and highly luminous.

117. The Crab Nebula has a pulsar. What kind of supernova led to this pulsar?

a) A Type Ia supernova.

b) A Type II supernova.

c) A supernova involving a white dwarf and normal star.

d) A supernova involving a 95 solar mass star.

118. You obtain a color-magnitude diagram for a cluster of stars. You observe that the Main Sequence turn-off point corresponds roughly to stars of mass $M = 4M_{\odot}$. If the lifetime of Main Sequence stars is given by $t \approx 10\ \mathrm{Gyr}\ (M/M_{\odot})^{-2}$, determine the approximate age of this cluster.

a) 10 Gyr

b) 0.6 Gyr

c) 4 Gyr

d) 16 Gyr

e) 0.3 Gyr

D.6 Galaxies and Cosmology

119. A cluster of older stars located well away from the Milky Way plane is characteristic of what?

    a) An open cluster.
    b) A globular cluster.
    c) A merging cluster.
    d) A galactic cluster.

120. Elliptical galaxies have few if any new stars. Why is this?

    a) The central black holes of ellipticals have consumed all the gas that would have made new stars.
    b) Ellipticals never have central black holes, and it is these that would normally stimulate star formation.
    c) Ellipticals form without any gas.
    d) All the gas has been used up in previous generations of star formation.
    e) The gravity of ellipticals is too small to keep any gas.

121. Why is it that galaxy mergers produce a lot of star formation (referred to as a "starburst")?

    a) The collision leads to the compression of gas clouds, and so higher densities and rapid cloud collapse.
    b) The collision of the central black holes of the two galaxies forces them to "burp" all the stars they have ever previously engulfed.
    c) The collision leads to stars hitting each other, resulting in splits and the production of extra stars.
    d) The collision leads to stars passing close to each other, and this gravitationally "rips" off the outer atmospheric layers of the stars to form new clouds of gas and new star formation.

122. In the Milky Way galaxy, the Sun is located

    a) in the halo component of the MW.
    b) in the disk component of the MW at a distance of 8.5 kpc from the center.
    c) in the outer parts of a globular cluster.
    d) very near the bulge of our Galaxy.
    e) inbetween spiral arms at a distance of 20 kpc from the center..

123. Galactic cannibalism refers to

    a) the merging of galaxies.
    b) the destruction of a galaxy's globular clusters by the galaxy's nucleus.
    c) galaxies drawing their gas from the intergalactic medium.
    d) the destruction of a galaxy's stars by its central black hole.

124. Approximately how many stars are in the Milky Way galaxy?

    a) dozens
    b) thousands
    c) millions
    d) billions

125. The rotation curve of the Milky Way is "flat" at about 220 km/s for most stars, just like the Sun's circular orbital speed. Consider a star that is only one third of the distance from the Galactic Center as the Sun. How long will it take this star to orbit once around the Milky Way as compared to the Sun's orbital period? (Drawing a sketch helps.)

    a) 1/9 the time
    b) 1/3 the time
    c) the same amount of time
    d) 3 times longer
    e) 9 times longer

126. The Cosmological Principle involves which one of the following:

    a) The Doppler effect and Euclidean geometry.
    b) Newtonian mechanics and relativity.
    c) Homogeneity and isotropy of the Universe.
    d) Hubble's Law and the curvature of the Universe.
    e) Great taste and less filling.

127. Why does the presence of quasars at great distances (and only at great distances) from our Galaxy imply that the Perfect Cosmological Principle is not valid?

a) The distances and radial velocities for the quasars violate the Hubble relation.

b) They show that the Universe was generally different at an earlier time.

c) The quasars are so bright that no known energy source can possibly power them.

d) All of the above.

128. The Principle of Equivalence states that

a) Before inflation, there was an epoch in which all four forces were combined into one.

b) The Microwave Background Radiation has a temperature equivalent to that of a perfect radiator ("black body") of 3 K temperature.

c) Gravitational attraction and accelerated motion are equivalent.

d) Light can be described both as a particle and as a wave.

e) After inflation, our Universe evolved into a flat geometry.

129. One of the curious results of General Relativity and curved spacetime is gravitational redshift. When light is emitted by a star, its wavelength changes (gets longer) as it travels outward through space. The formula for this shift is $\Delta\lambda/\lambda_0 = GM/Rc^2$, where M is the mass of the star, R its radius, G the gravitational constant, and c is the speed of light. The new wavelength is $\lambda = \lambda_0 + \Delta\lambda$, for λ_0 the original wavelength. Consider a neutron star of $2M_\odot$ and 10 km. If light of 3000 Å is emitted at the surface of the star, what wavelength will it have upon reaching the Earth?

a) 900 Å

b) 2110 Å

c) 3000 Å

d) 3900 Å

130. What observational fact is explained by inflation?

a) The existence of black holes.

b) The isotropy of our Universe.

c) The primordial abundances of H and He.

d) The formation of elliptical galaxies.

131. In Special Relativity observers moving at different speeds fail to agree on simultaneity. One of the consequences is a thing called time dilation: Moving clocks tick slower. Suppose you have a friend who is an astronaut. In a test flight, the astronaut reaches escape speed from the Earth at 11 km/s. Your friend's watch ticks slower than yours by the factor $\Gamma = \sqrt{1 - v^2/c^2}$, where c is the speed of light, and v is the rocket speed. Determine the **difference** in these clock rates, $1 - \Gamma$. (This means when 1 second passes on your watch, some fraction of a second Γ will pass on your friend's watch. Find the difference between the two values.)

a) 6.72×10^{-10} seconds

b) 1.34×10^{-9} seconds

c) 0.99999 seconds

d) 0.5 seconds

132. The flatness and horizon problems

a) show that the Big Bang theory is wrong.

b) are solved if there was a sudden inflation at a very early stage in the big bang.

c) imply that the universe was once much hotter than it is now.

d) imply that the universe must be infinite in extent.

e) show that dark matter must be a small fraction of the total mass of the universe.

133. Active galactic nuclei such as quasars are explained using

a) gravitational lenses to intensify radiation coming from them.

b) a massive black hole at the center of a galaxy which has consumed all the matter in its vicinity.

c) a massive black hole in the center of a galaxy which is being fed large amounts of matter.

d) an accretion disk around a neutron star.

e) different lines of sight towards an elliptical galaxy.

134. A "flat rotation curve" for the Milky Way and many other spiral galaxies indicates

a) that spiral galaxies have super-massive black holes.

b) that spiral galaxies are all infinite in extent.

c) that spiral galaxies have dark matter.

d) that spiral arms in spiral galaxies will eventually go away.

D.7 Miscellaneous

Math Review and Applications

135. Solve the equation $y^2 = 8$.

a) $y = 2.83$

b) $y = 4.00$

c) $y = 8.00$

d) $y = 16.00$

136. Solve the equation $y^3 = 27$

a) $y = 3$

b) $y = 9$

c) $y = 24$

d) $y = 81$

137. What is 43,040 in scientific notation?

a) 4.304×10^3

b) 4.304×10^4

c) 4.304×10^5

d) 4.304×10^6

e) 4.304×10^7

138. Suppose that $y = x^3 - 16$ and $x = 4$. Determine the value of y.

a) -4

b) 64

c) 0

d) 80

e) 48

139. An order of magnitude problem, find out roughly how many stars are visible to the unaided human eye on a clear night from a dark sight?

a) dozens

b) hundreds

c) thousands

d) millions

e) billions

140. Let's do a little signal-to-noise (S/N) evaluation. Without explanation, suppose that a telescope achieves $S/N = 100 \times \sqrt{t}$, where t is observing time in *hours*. A S/N of 100 means the data have 1% errors. To detect an Earth-like planet through eclipse, the amount of stellar light blocked by the planet will only be 0.01%. How long must this telescope observe the star to achieve just barely the needed accuracy to detect the eclipse?

a) 10,000 hours

b) 1,000 hours

c) 100 hours

d) 10 hours

e) 1 hour

141. The Earth moves through space around the Sun at about 30 km/s. Convert this to miles per hour (mph). Use the fact that 1 mile equals 1.6 km.

a) 67,500 mph

b) 30 mph

c) 1.6 mph

d) 48 mph

e) 172,800 mph

Exoplanets and Life in the Universe

142. Most extra-solar planets have been discovered with the

a) microlensing method.

b) doppler shift method.

c) astrometric method.

d) transit method.

e) photometric method.

143. There are about 100 billion stars in the Milky Way galaxy. Thinking in terms of the Drake equation, suppose that the probability of a star having a planetary system is $\mathcal{P} = 80\%$. Suppose that the probability of having a planet in the habitable zone is $\mathcal{P} = 5\%$. Suppose the chance of such a planet having life is $\mathcal{P} = 0.01\%$, and finally that the life would be technologically advanced is $\mathcal{P} = 0.001\%$. How many intelligent civilizations would be predicted for our Galaxy?

a) 4×10^8

b) 4×10^6

c) 4×10^3

d) 4

e) 4×10^{-3}

144. There are about 100 billion stars in the Milky Way galaxy. Suppose each star is on average separated by about 10 light-years (LY). If there were 10^7 advanced civilizations with whom we could communicate, statistically speaking, how far away would the nearest one be? (Hint: Find the volume of a cube surrounding one star. Drawing a picture helps. Determine the total volume for all stars. Determine the average volume per civilization. Take the cube root.)

a) 200 LY

b) 20 LY

c) 10^5 LY

d) 10,000 LY

e) 5×10^6 LY

145. Consider an Earth-like planet orbiting a Sun-like star. The orbit has the properties of a semi-major axis with $a = 1$ AU, an orbital period of $P = 1$ year, and an eccentricity $e = 0.6$. If the habitable zone stretches from 0.9 to 1.3 AU, might you expect to find life on this planet?

a) No, life does not exist on Earth-sized planets.

b) No, life does not exist in the habitable zone.

c) No, the planet's orbit is not always inside the habitable zone.

d) Yes, the planet's orbital period is just right for life.

e) Yes, the planet's orbit is always inside the habitable zone.

146. Let's play a silly game called the Cosmic Postman. Suppose that every star has one planet with an intelligent civilization. They have all being launching info "packages" every year for the age of the Milky Way. Doing the math, this works out to a number density of randomly "floating" packages at about $n = 2 \times 10^{-31}$ per cubic kilometer. Statistically, the amount of time before one of these packages randomly strikes the Earth is $t \approx 1/(n\pi R^2 v)$, where $R = 6400$ km for the radius of the Earth, and $v = 6.6 \times 10^9$ km/year for the speed of the Earth around the Milky Way as it is carried along by the Sun. Estimate the number of years before the Earth hits a package.

a) 2×10^{20} years

b) 2×10^{16} years

c) 5,900 billion years

d) 2×10^5 years

e) 0.0059 years

147. If we ever looked at the spectrum of a planet and saw evidence for the presence of molecular Oxygen, the presence of life there would be almost a certainty. Why?

a) Only terrestrial planets like the Earth can maintain Oxygen in their atmospheres over long periods.

b) Only living organisms are capable of producing and maintaining large levels of molecular Oxygen in an atmosphere.

c) The presence of Oxygen implies that any Carbon Dioxide in the atmosphere has been broken down into Oxygen (for the atmosphere) and Carbon (for living organisms).

d) Molecular Oxygen requires at least some crude technology to produce in vast quantities, hence life would have to be present.

e) None of the above.

D.8 Additional Practice Problems

148. The sum of 1.2 gigayears and 230 megayears is

    a) 1.2 gigayears
    b) 231.2 gigayears
    c) 1.43 gigayears
    d) 231.2 megayears
    e) 1.43 megayears

149. The rising and setting of the Sun as seen from Earth is

    a) an annual motion.
    b) a synchronous orbit.
    c) a didactic motion.
    d) an orbital resonance.
    e) a diurnal motion.

150. What two properties did the ancient Greeks assume about celestial motions of planets?

    a) Motions were circles and variable speed.
    b) Motions were ellipses and variable speed.
    c) Motions were circles and constant speed.
    d) Motions were ellipses and constant speed.
    e) Motions were erratic.

151. In the distant future, the Moon's orbit will become larger. Its orbital period will increase to about 47 days. If its current distance is 384,000 km, and its current orbital period is 27.3 days, use Kepler's third law to determine the size of its orbit when the period has increased to 47 days.

    a) 223,000 km
    b) 267,000 km
    c) 384,000 km
    d) 552,000 km
    e) 661,000 km

152. At perihelion, a planet moves

    a) at its slowest speed.
    b) at its fastest speed.
    c) at its average speed.
    d) at its slowest speed.

153. The radius of the Earth is 6,370 km. The acceleration due to gravity at the surface of the Earth is $g_E = 9.8$ m/s^2. At low Earth orbit of 300 km off the surface of the Earth (or 6,670 km from the center of the Earth), what is the acceleration due to gravity, g?

    a) 2.9 m/s^2
    b) 4.9 m/s^2
    c) 6.9 m/s^2
    d) 8.9 m/s^2
    e) 10.9 m/s^2

154. The Sun has a temperature $T_\odot \approx 5,800$ K at its photosphere. As a blackbody, its wavelength of peak brightness is 5,000 Å. For a star of temperature $T = 28,000$, what is the wavelength at which peak brightness occurs? (Hint: Use Wien's Law.)

    a) 1,040 Å
    b) 32,400 Å
    c) 5,800 Å
    d) 11,900 Å
    e) 5,000 Å

155. A spectrum of the Sun reveals numerous absorption lines in the visible band of light. Such spectral features occur when

    a) electrons jump from inner energy levels of an atom to outer ones.
    b) electrons drop from outer energy levels of an atom to inner ones.
    c) atoms become ionized.
    d) atoms undergo nuclear fusion.
    e) atoms undergo radioactive decay.

156. A spectrum of the Sun reveals numerous emission lines in the X-ray band of light. Such spectral features occur when

    a) electrons jump from inner energy levels of an atom to outer ones.
    b) electrons drop from outer energy levels of an atom to inner ones.
    c) atoms become ionized.
    d) atoms undergo nuclear fusion.

e) atoms undergo radioactive decay.

157. In the core of the Sun, what is the result of the proton-proton chain?

a) Carbon is converted to oxygen.

b) Iron is converted to cobalt.

c) Hydrogen is converted to helium.

d) Neon is converted to sulfur.

e) Helium is converted to nitrogen.

158. The human body has around 100 kg of mass. If all that mass could be converted to energy, for how long could it power a 100 Watt light bulb? (Hint: Use $E = mc^2$. Recall that 1 Watt is 1 Joule per second. If $c = 3.0 \times 10^8$ m/s, then E will be in Joules.)

a) 3 seconds

b) 3 years

c) 3 million years

d) 3 billion years

e) None of the above