

Here are 726 sample multiple choice questions. The answers are scrambled... the correct answer corresponds to different letters in different questions. Many of the questions on the quizzes and final will be drawn from this set, but also included here are many things that I will not cover in the course and therefore will not ask you about. NOTE: Latex-style special symbols are used. ^ indicates that the following character (or set of characters enclosed by {}) is a superscript.

1. The term Zodiac refers to
 - A) the light from Saturn's rings.
 - B) a method for making astrological predictions.
 - C) a group of constellations lying near the ecliptic.
 - D) the head of the Celestial Empire.
 - E) all constellations named after animals.-----
2. You have just won 100 million dollars on that hit TV survival show ``Astronomy Midterm No. 1". How much money is this?
 - A) $\$10^8$
 - B) $\$100,000$
 - C) $\$10^6$
 - D) $\$10^{\{100\}}$
 - E) Enough for a 20-minute phone call.-----
3. In current scientific opinion, Stonehenge is considered to have been
 - A) the site of ancient fertility rites.
 - B) an ancient burial ground.
 - C) an ancient flying saucer base.
 - D) an astronomical observatory.
 - E) the site of early Christian rituals.-----
4. You have just won $\$10^4$ dollars on that hit TV survival show ``Astronomy Midterm No. 1". How much money is this in real money?
 - A) $\$40,000$
 - B) $\$100,000$
 - C) $\$10,000$
 - D) $\$40$
 - E) Enough for a 20-minute phone call.-----
5. If the Moon is very close to a certain star in the sky, how long will it be before the Moon is again close to the same star?
 - A) 24 hours
 - B) one year
 - C) one week
 - D) one month
 - E) 23 hours 56 minutes-----

6. Which of the following is NOT an example of the conservation of angular momentum?
 - A) Kepler's 2nd law (planets sweep out equal areas in their orbits in equal amounts of time).
 - B) A bicycle does not fall over when it is moving.
 - C) A rocket is propelled forward by hot gas shooting out the back.
 - D) All of the other answers are examples of the conservation of angular momentum.
 - E) A student spinning on a stool pulls in his arms and speeds up.-----
7. In ancient times, how did people primarily tell the difference between planets and stars?
 - A) The planets moved relative to the stars.
 - B) None of the other answers is correct.
 - C) The planets looked bigger.
 - D) The planets showed phases.
 - E) The planets didn't twinkle.-----
8. A planet moves slowest in its orbit
 - A) the closer it is to its satellites.
 - B) when it is farthest from the Sun.
 - C) when it is closest to the Sun.
 - D) when it is in opposition.
 - E) the greater its mass.-----
9. Most Greek astronomers believed that the Earth is immobile because they did not observe
 - A) eclipses of the Sun.
 - B) retrograde motion of the planets.
 - C) All of the other answers are correct.
 - D) stellar motion.
 - E) parallaxes for the stars.-----
10. A planet moves fastest in its orbit
 - A) when it is in opposition.
 - B) when it is closest to the Sun.
 - C) the greater its mass.
 - D) when it is farthest from the Sun.
 - E) the closer it is to its satellites.-----
11. In the geocentric concept of the universe, which direction does the celestial sphere appear to rotate about the stationary Earth? In the heliocentric universe, which direction does the earth rotate?
 - A) geocentric: east to west; heliocentric: west to east
 - B) geocentric: west to east; heliocentric: west to east
 - C) geocentric: west to east; heliocentric: east to west
 - D) geocentric: east to west; heliocentric: east to west-----
12. The rings of Saturn were discovered by
 - A) Kepler.
 - B) Ptolemy.

- C) Copernicus.
- D) Galileo.

13. Aristotle concluded that the Earth is spherical from the

- curvature of its shadow on the
- A) Sun during a solar eclipse.
- B) Earth during a lunar eclipse.
- C) Earth during a solar eclipse.
- D) Moon during a lunar eclipse.
- E) Moon during a solar eclipse.

14. Sunspots were discovered by

- A) Newton.
- B) Kepler.
- C) Galileo.
- D) Copernicus.

15. Aristarchus argues

- A) for a flat Earth.
- B) for a geocentric universe.
- C) that planets move on epicycles.
- D) that the Sun is twice as large as the Moon.
- E) for a heliocentric universe.

16. The higher the frequency of light

- A) the longer (larger) its wavelength.
- B) the shorter (smaller) its wavelength.
- C) the greater its velocity in a vacuum.
- D) the redder it will be.

17. Aristarchus estimated the relative distances to the Sun and

Moon by observing the

- A) angle between the half Moon and the Sun in the sky.
- B) shape of the Earth's shadow on the Moon.
- C) shape of the crescent Moon.
- D) apparent size of the Sun and Moon.
- E) time it took a letter to reach the Sun and Moon.

18. The smaller the wavelength of light

- A) the larger its frequency.
- B) the smaller its frequency.
- C) the greater its velocity in a vacuum.
- D) the redder it will be.

19. The difference in the lengths of shadows simultaneously cast

by identical sticks placed vertically in the ground at two

different points on a meridian indicates that

- A) the Moon is spherical.
- B) the Sun is spherical.
- C) the Earth is spherical.
- D) the Earth is not flat.

20. The spectral lines of a star are observed to be shifted toward larger wavelengths. This shows that

- A) the star is very hot.
- B) the star is approaching us.
- C) the star is rather cool.
- D) the star is sad.
- E) the star is receding from us.

21. In order to account for the retrograde motion of the

planets, Ptolemy introduced the

- A) epicycle.
- B) equant.
- C) deferent.
- D) center of eccentric.
- E) ecliptic.

22. The spectral lines of a star are observed to be shifted toward smaller wavelengths. This shows that

- A) the star is rather cool.
- B) the star is very hot.
- C) the star is receding from us.
- D) the star is approaching us.
- E) light is moving more slowly than usual.

23. In the Copernican theory, day and night are accounted for by

- A) the rotation of the Earth.
- B) the rotation of the celestial sphere.
- C) the revolution of the Sun about the Earth.
- D) the revolution of the Earth about the Sun.
- E) the rotation of the Sun.

24. A continuous spectrum is formed by

- A) all of the other answers are correct.
- B) a glowing steel ingot in a blast furnace.
- C) a hot frying pan.
- D) the photosphere of the Sun.

25. Ptolemy and Copernicus both

- A) believed the Sun went around the Earth.
- B) believed the Earth went around the Sun.
- C) believed Mars would look faintest when at opposition.
- D) used uniform circular motion to explain planetary motion.
- E) made very accurate predictions of planetary motion.

26. A continuous spectrum is formed by

- A) the expanding shell of gas in a Planetary Nebula.
- B) the fluorescent lights in the classroom.
- C) all of the other answers are correct.
- D) the photosphere of the Sun.
- E) gas that emits do to the de-excitation of electrons.

27. The Copernican model of the solar system allowed, for the

- first time, the measurement of
A) the relative distances of the planets.
B) the mass of the Earth.
C) the relative masses of the planets.
D) the distance of the Sun.

28. The spectrum of a cloud of cool gas seen against a bright background black body would show

- A) a Doppler shift.
B) a continuous spectrum.
C) either bright or dark lines, depending on distance.
D) dark (absorption) lines.
E) bright (emission) lines.

29. By using a Heliocentric model for the solar system,

Copernicus was able to find for the first time the

- A) synodic periods of the planets.
B) distance to the Moon.
C) cause of tides in the Earth's oceans.
D) sidereal periods of the planets.
E) diameters of the planets.

30. The spectrum of a cloud of hot gas seen against a dark background would show

- A) dark (absorption) lines.
B) bright (emission) lines.
C) either bright or dark lines, depending on distance.
D) a Doppler shift.
E) a continuous spectrum.

31. Which of the following planets never reaches opposition (as seen from the Earth)?

- A) Venus
B) Jupiter
C) Saturn
D) Mars

32. As a glowing black body gets cooler, what happens to its color and what happens to the brightness of the light it emits?

- A) color gets more blue; doesn't change brightness.
B) color gets more blue; emits less light.
C) color gets more blue; emits more light.
D) color gets more red; emits more light.
E) color gets more red; emits less light.

33. If Venus is seen in the west after the Sun sets, next morning it will

- A) appear to have a considerably different phase.
B) rise before the Sun.
C) Venus is never in the west after sunset.

- D) rise after the Sun rises.
E) go behind the Sun.

34. As a glowing black body gets hotter, what happens to its color and what happens to the brightness of the light it emits?

- A) color gets more blue; emits more light.
B) color gets more blue; doesn't change brightness.
C) color gets more red; emits more light.
D) color gets more red; emits less light.
E) color gets more blue; emits less light.

35. Venus is closest to Earth at

- A) quadrature.
B) greatest elongation.
C) opposition.
D) superior conjunction.
E) inferior conjunction.

36. You are observing a star about 95 trillion km (10 lightyears) away. How old is the most recent information you can get about this star?

- A) 100 years
B) 300,000 seconds
C) This can't be determined without having more information.
D) 95 trillion seconds
E) 10 years

37. At the time Mars is observed to be at western quadrature, an observer on Mars would see the Earth at

- A) greatest western elongation.
B) inferior conjunction.
C) eastern quadrature.
D) greatest eastern elongation.
E) opposition.

38. You are observing a star about 950 trillion km (100 lightyears) away. How old is the most recent information you can get about this star?

- A) 100 years
B) 300,000 seconds
C) 10 years
D) This can't be determined without having more information.
E) 950 trillion seconds

39. The time between oppositions of Mars is known as Mars'

- A) rotation period.
B) sidereal period.
C) eccentric period.
D) period of revolution.
E) synodic period.

40. Which of the following is the smallest?

- A) the Earth
- B) the Universe
- C) a galaxy
- D) the Sun

41. The astronomer Tycho Brahe was known for his,

- A) use of the telescope.
- B) accurate observations of planet positions.
- C) theory of epicycles.
- D) observation of the Moon's features.
- E) measurement of the Earth's rotation.

42. Which of the following is the largest?

- A) a galaxy
- B) the Universe
- C) the Sun
- D) the Earth

43. The discovery that planets move in elliptical orbits with

the Sun at the focus was made by

- A) Halley.
- B) Giordano Bruno.
- C) Tycho Brahe.
- D) Kepler.
- E) Galileo.

44. Which of the following is NOT one of the four fundamental forces?

- A) Angular Momentum
- B) Electromagnetism
- C) Gravity
- D) Strong nuclear force
- E) Weak nuclear force.

45. A planet moves faster in its orbit

- A) when it is farthest from the Sun.
- B) the greater its mass.
- C) when it is in opposition.
- D) the farther it is from it's satellites.
- E) when it is nearer the Sun.

46. Which of the following is NOT one of the four fundamental forces?

- A) Gravity
- B) Strong nuclear force
- C) Kinetic energy
- D) Electromagnetism
- E) Weak nuclear force.

47. If there had been no oceans on the Earth, the Earth's

present atmosphere would be largely composed of

- A) water
- B) nitrogen

- C) oxygen
- D) carbon dioxide
- E) carbon monoxide

48. What does the term "parallax" refer to?

- A) The apparent jump of the position of a foreground object relative to distant objects when we look from two different points.
- B) The reversal of the apparent motion of the planets with respect to the background stars.
- C) Two axes.
- D) The shape of the orbit of the planets.
- E) The apparent slowing of time when it is measured from a rapidly moving frame of reference.

49. The oldest rocks thus far found on the Earth's surface have ages of about

- A) 3.5 million years
- B) 3.5 billion years
- C) 35 years
- D) 3.5 thousand years

50. When we view a foreground object from two different points and see it appear to jump relative to the distant background, the effect is called

- A) parallax
- B) retrograde motion
- C) conservation of angular momentum
- D) hyperventilation
- E) precession

51. Galileo's studies of moving objects led to the idea that a

moving object

- A) will go faster the heavier it is.
- B) will seek its natural state of rest.
- C) is subject to the Universal Law of Gravity.
- D) requires a force to keep it moving.
- E) comes to rest only if a force stops it.

52. According to Kepler's first law, the planets each move in an elliptical orbit with the sun

- A) at the geometrical center.
- B) at one focus.
- C) at both foci.
- D) on the opposite side of the same ellipse.

53. The four large moons around Jupiter were discovered by

- A) Copernicus.
- B) Kepler.
- C) Ptolemy.
- D) Tycho Brahe.
- E) Galileo.

54. Kepler's first law says that the planets move in elliptical orbits with the sun at one focus of the ellipse. What is at the other focus?

- A) Empty space.
- B) The Earth
- C) The Moon.
- D) Your ISP205 instructor.
- E) The planet in question.

55. Galileo's observation that Venus shows all of the phases was

important because it discredited

- A) Newton's law of gravitation.
- B) the Copernican theory.
- C) Kepler's Harmonic Law.
- D) the Ptolemaic theory.

56. If a distant light source that emits isotropically (i.e. equally in all directions) is moved to 1/2 of its previous distance, how much does its flux change by? (how many times brighter does it appear to be?)

- A) 1/2
- B) 1
- C) 1/4
- D) 4
- E) 2

57. The rate of change of the velocity of a body is called the body's

- A) momentum
- B) applied force.
- C) mass.
- D) acceleration.
- E) kinetic energy.

58. If a distant light source that emits isotropically (i.e. equally in all directions) is moved to twice its previous distance, its new flux is how many times its previous flux?

- A) 1
- B) 1/2
- C) 2
- D) 4
- E) 1/4

59. "For every action there is an equal and opposite reaction"

is a statement of

- A) Kepler's first law of planetary motion.
- B) Newton's third law of motion.
- C) the correspondence principle.
- D) the theory of relativity.
- E) Galileo's theory of motion.

60. The reason that bicycles don't fall over once you get moving along is

- A) training wheels.
- B) the direction of the axis of spin of their wheels is trying to stay constant.
- C) their gravitational potential energy would increase if they fell over.
- D) quantum mechanics shows that they can only be in the upright state.

61. Newton's law of gravitation states that the attractive force

between any two masses in space is in proportion to the product of the (1)_____ and in inverse proportion to the

- A) (1) masses; (2) distance between them
- B) (1) distances between them; (2) masses
- C) (1) inverse masses; (2) distance between them
- D) (1) reciprocal distances between them; (2) masses

62. The reason that bicycles don't fall over once you get moving along is

- A) quantum mechanics shows that they can only be in the upright state.
- B) training wheels.
- C) conservation of angular momentum.
- D) their gravitational potential energy would increase if they fell over.

63. The Earth has an equatorial bulge because of

- A) the Earth's precession.
- B) the Earth's revolution around the Sun.
- C) the gravitational pull of the Sun.
- D) the Earth's rotation.
- E) the gravitational pull of the Moon.

64. When you shoot a cannonball upwards from the surface of the Earth with less than the "escape velocity", what will happen?

- A) It will slow down, but will not fall back to Earth.
- B) It will keep moving at a constant speed and not fall back to Earth.
- C) It will slow down and eventually fall back to Earth.
- D) It will speed up as it moves away from Earth.

65. An important cause of the slowing down of the Earth's rotation is the

- A) tides caused by the gravity of the Moon.
- B) pull of the Moon on the Earth's magnetic field.
- C) pull of the Earth's equatorial bulge on the Moon.
- D) gravitational increase in the size of the Earth's orbit.
- E) pull of the Moon on the Earth's equatorial bulge.

66. When you shoot a cannonball upwards from the surface of the Earth with more than the "escape velocity", what will happen?
A) It will speed up as it moves away from Earth.
B) It will slow down, but will not fall back to Earth.
C) It will keep moving at a constant speed and not fall back to Earth.
D) It will slow down and eventually fall back to Earth.

67. The first physical proof of the rotation of the Earth on its axis was demonstrated
A) by Bradley with the discovery of stellar aberration.
B) by Foucault in 1851 using the pendulum experiment.
C) by observing the day-to-day motion of the Sun.
D) by noting the differences between solar and sidereal time.
E) by Galileo, when he observed the motions of Jupiter's

68. Pluto has a very elliptical orbit about the Sun, so sometimes it is closer to the Sun and sometimes it is farther away. Which stays constant?
A) Two of the other answers are correct.
B) Its gravitational potential energy.
C) Its kinetic energy.
D) Its total energy.
E) None of the other answers are correct.

69. Which of the following is a proof of the Earth's revolution around the Sun?
A) rising and setting of the Sun.
B) the Foucault pendulum experiment.
C) parallax of stars.
D) seasons.

70. I throw a baseball up the air and watch its motion. Which stays constant?
A) Its total energy.
B) Two of the other answers are correct.
C) Its kinetic energy.
D) Its gravitational potential energy.
E) None of the other answers are correct.

71. Because of the precession of the equinoxes
A) Polaris will not always be our pole star.
B) All of these answers are correct.
C)
D) the declinations of the stars change slowly with time.
E) the Vernal Equinox moves with respect to the stars.

72. Red light has a wavelength which is twice that of blue light. Therefore, photons of red light each carry _____ as much energy as is carried by photons of blue light.
A) twice
B) half
C) one fourth
D) four times

73. One side of the Moon always faces the Earth because the
A) rotation rate about the Sun equals the revolution rate.
B) Moon does not spin on its axis.
C) revolution rate about the Earth equals the rotation rate.
D) Earth always has the same side facing the Moon.

74. Blue light has a wavelength which is half that of red light. Therefore, photons of blue light each carry _____ as much energy as is carried by photons of red light.
A) half
B) four times
C) one fourth
D) twice

75. Total solar eclipses, when they occur, are visible from
A) a narrow path on the Earth.
B) any place on the Earth.
C) any place on the Earth where the Sun is visible.
D) any place on Earth where the Sun and Moon are visible.

76. The correct arrangement of light at different wavelengths, in order from smallest to largest FREQUENCY, is:
A) infrared - ultraviolet - visible
B) gamma rays - ultraviolet - visible - radio
C) They all have the same frequency. It is the energy per photon that differs.
D) radio - infrared - visible - xrays

77. If the ecliptic and the orbit of the Moon were in the same plane
A) we would see the entire surface of the Moon.
B) the Earth would cease to precess.
C) there would be a lunar eclipse each month.
D) the Moon would collide with the Sun.
E) as seen from Earth, the Moon would no longer show phases.

78. The correct arrangement of light at different wavelengths, in order from smallest to largest WAVELENGTH, is:

- A) radio - infrared - visible - xrays
- B) infrared - ultraviolet - visible
- C) They all have the same wavelength. It is the energy per photon that differs.
- D) gamma rays - ultraviolet - visible - radio

79. Name the planet which is largest in diameter.

- A) Jupiter
- B) Uranus
- C) Mercury
- D) Venus

80. All of the naturally occurring chemical elements heavier than hydrogen, helium and lithium were created in nuclear reactions having to do with the evolution of stars. Where did hydrogen come from?

- A) It came from the radioactive decay of Uranium.
- B) Nobody knows how it got there.
- C) It was synthesized during the Big Bang (the initial phases of the expansion of the universe).
- D) It was synthesized in supernova explosions.

81. Mars and Mercury have similar velocities of escape, yet Mars

The difference is probably due to

- A) Mercury's rotation rate being faster than that of Mars.
- B) Mars having a slower velocity in its orbit than Mercury.
- C) initial differences in the compositions of the planets.
- D) Mercury having a higher surface temperature than Mars.
- E) None of the other answers is correct.

82. Most of the hydrogen and helium and lithium that we see in the universe were formed during the initial "Big Bang" (the initial phases of the expansion of the universe). Where did the rest of the naturally occurring chemical elements (carbon, nitrogen, iron, etc.) come from?

- A) They existed before the Big Bang.
- B) They were created in laboratory experiments.
- C) They are a byproduct of the process used to make Hostess Twinkies.
- D) They were also formed during the Big Bang.
- E) They were produced by nuclear reactions in stars.

83. Which planets have mainly carbon dioxide (CO₂) for an atmosphere?

- A) Jupiter and Saturn

- B) Venus, Mars, and Saturn
- C) Venus, Earth, and Mars
- D) Mars and Jupiter
- E) Venus and Mars

84. Which of the following statements about photons is FALSE?

- A) All photons have the same energy.
- B) Photons behave like particles.
- C) Higher energy photons have a higher frequency.
- D) In a vacuum, photons always travel at the speed of light.
- E) A gamma-ray photon is more energetic than a visible light photon.

85. Where is all the carbon dioxide which should be present in the Earth's atmosphere?

- A) gone into space
- B) air
- C) Earth's ice caps
- D) oceans
- E) rocks

86. Which of the following statements about photons is FALSE?

- A) Higher energy photons have a higher frequency.
- B) In a vacuum, photons always travel at the speed of light.
- C) Low energy photons move more slowly than high energy photons.
- D) Photons behave like particles.
- E) A gamma-ray photon is more energetic than a visible light photon.

87. Most lunar craters were apparently caused by

- A) We have no good ideas for their cause.
- B) bursting bubbles of gas from the interior.
- C) spacecraft landings.
- D) meteoric impacts.
- E) volcanoes.

88. When an electron jumps spontaneously from an outer orbit to an inner orbit

- A) a photon is absorbed.
- B) the atom changes its electrical charge.
- C) the electron changes its atomic number.
- D) a photon is emitted.
- E) the electron gains energy.

89. Which part of the Moon is oldest?

- A) the rilles.
- B) the maria and the highlands are the same age.
- C) the lowlands.
- D) the maria.
- E) the highlands.

90. When an atom emits a photon as part of a sharp emission line, what has to happen to one of the electrons in orbit around the atom's nucleus?

- A) It has to jump from a higher energy orbit to a lower energy orbit.
- B) It has to jump from a lower energy orbit to a higher energy orbit.
- C) It changes into a neutron.
- D) It is knocked completely loose from the atom.
- E) It changes into a proton.

91. Most of the craters on the Moon

- A) are seen most easily at full Moon.
- B) were predicted to exist by Aristotle.
- C) occur in the younger parts of the Moon's surface.
- D) were formed in the Moon's first billion years of
- E) were created by volcanoes.

92. Newton discovered that gravity can be described as:

- A) A spring-like connection between any two masses.
- B) A universal attraction between masses which gets stronger with distance.
- C) A force which is independent of the masses of the objects involved.
- D) An attraction between like electrical charges.
- E) A universal attraction between any two masses, which falls off as distance².

93. The surface of Mercury most closely resembles

- A) the surface of Venus.
- B) the Moon's surface.
- C) the Earth's surface.
- D) the lunar maria.

94. Newton's law of gravitation states that the attractive force between any two masses in space is in proportion to the product of the (1)_____ and in inverse proportion to the square of the (2)_____.

- A) (1) inverse masses; (2) distance between them
- B) (1) reciprocal distances between them; (2) masses
- C) (1) masses; (2) distance between them
- D) (1) distances between them; (2) masses

95. Which of the following has little or no atmosphere?

- A) Earth
- B) Venus
- C) Jupiter
- D) Mars
- E) Mercury

96. What was the major advance incorporated in the heliocentric model?

- A) it explained the phases of the moon.

B) it used more adjustable parameters to describe the same data than did previous models.

C) it was realized that the Earth is not at the center of the solar system or the Universe.

D) it established that the Earth is round.

E) conservation of angular momentum was properly taken into account.

97. The atmospheric pressure on the surface of Venus is about how many times that at the surface of Earth?

- A) 0.01
- B) 8.9
- C) 1000
- D) 100
- E) 0.9

98. Who is credited with the idea that the Earth moves in orbit around the Sun, rather than having the Earth be stationary at the center of things?

- A) Copernicus
- B) Ptolemy
- C) Newton
- D) Kepler

99. One use of radar astronomy in planetary research has been to

- A) find water on Neptune.
- B) discover features on the Moon.
- C) detect mountains on Jupiter.
- D) detect volcanoes on Mars.
- E) detect mountains on Venus.

100. Magnetism is not a separate force, but instead is always produced by

- A) movie stars and presidential candidates (in that order).
- B) the strong nuclear force acting on electrons.
- C) electric charges that are in motion.
- D) light moving through a vacuum.
- E) the gravitational pull of the Earth.

101. Lightning on Venus tends to occur where?

- A) uniformly over the entire planet.
- B) in rolling planes.
- C) near volcanoes.
- D) near the north pole.
- E) over continents.

102. "A changing magnetic field creates a changing electrical field which in turn creates a changing magnetic field." This describes

- A) how the gravitational force interacts with the electrostatic force.
- B) how sound waves propagate through the atmosphere.
- C) Einstein's Special Theory of Relativity.

- D) the cause of Retrograde Motion.
- E) how light waves propagate through empty space.

103. The warmest temperatures on Mars are

- A) like a cold winter day in East Lansing.
- B) hot enough to melt lead.
- C) cold enough to freeze dry ice.
- D) like a warm spring East Lansing day.
- E) near the boiling point of water on Earth.

104. Newton's Second Law of Motion showed that the acceleration of a body depends on

- A) its mass and velocity.
- B) its velocity and the force on it.
- C) its mass and the force on it.
- D) its velocity and density.

105. Extraterrestrial dust and sand storms have been observed on

- A) Mercury
- B) Venus
- C) None of these planets.
- D) Jupiter
- E) Mars

106. Newton's Second Law of Motion states that the acceleration of a body when acted on by an external force is

- A) proportional to its density.
- B) inversely proportional to its mass.
- C) directly proportional to its mass.
- D) zero.
- E) independent of its mass.

107. The air pressure at the Viking landing sites on Mars was

- A) .1
- B) 100
- C) 10
- D) 1000
- E) 1

108. If a planet has an average distance from the sun (semi-major axis of its orbit) of 4 astronomical units, what is the period of its orbit? Hint: Use Kepler's 3rd law.

- A) 1 year
- B) 4 years
- C) 64 years
- D) 12 years
- E) 8 years

109. Space probes have indicated that Mars has

- A) simple life forms.
- B) a dense atmosphere.
- C) three moons.

- D) aurorae.
- E) ice caps of frozen carbon dioxide and water.

110. If a planet has an average distance from the sun (semi-major axis of its orbit) of 4 astronomical units, what is the period of its orbit? Hint: Use Kepler's 3rd law.

- A) 8 years
- B) 1 year
- C) 12 years
- D) 64 years
- E) 4 years

111. We believe that at one time water flowed on Mars because of observations of

- A) fossilized stern-wheeler paddle steamers.
- B) polar ice caps.
- C) sedimentary rock near Mars' equator.
- D) features which look like dried-up river beds.
- E) erosion on rocks photographed by Viking.

112. If the mass of the Sun suddenly became twice as large, by what amount would the Sun's gravitational acceleration of the Earth change?

- A) 4 times as large.
- B) unchanged.
- C) 1/4 as large.
- D) half as large.
- E) twice as large.

113. The Great Red Spot on Jupiter is

- A) sulfurous clouds over the vertex of a solid obstacle.
- B) the top of a gigantic volcano.
- C) a violent cyclonic storm.
- D) an island floating in a sea of molecular gases.
- E) reddish dust.

114. If the mass of the Sun suddenly became half as large, by what amount would the Sun's gravitational acceleration of the Earth change?

- A) half as large.
- B) 4 times as large.
- C) unchanged.
- D) twice as large.
- E) 1/4 as large.

115. On which objects in the solar system have volcanos been observed actually erupting?

- A) Earth
- B) Earth, Mars, and Io
- C) Mercury, Earth, and Mars
- D) Moon, Earth, Mars, and Jupiter
- E) Earth and Io

116. If Mars were moved twice as far from the Sun as it is at the present moment, the gravitational force that the Sun exerts on Mars would become

- A) half as large.
- B) unchanged.
- C) 4 times as large.
- D) twice as large.
- E) 1/4 as large.

117. The outer Galilean moons of Jupiter are thought to consist primarily of

- A) hydrogen, methane, and ammonia.
- B) rock with a little water (liquid or solid).
- C) metals and rock.
- D) carbon dioxide and nitrogen.
- E) water (liquid or solid), with some rock.

118. If Mars were moved twice as close to the Sun as it is at the present moment, the gravitational force that the Sun exerts on Mars would become

- A) 4 times as large.
- B) unchanged.
- C) twice as large.
- D) 1/4 as large.
- E) half as large.

119. Question deleted

120. As viewed from the Earth, some planets appear to double back in their orbits for a while (retrograde motion). This is due to:

- A) none of the other answers is correct.
- B) the planets really do reverse their motion through space, because of outside forces.
- C) the planets move on secondary orbits called epicycles, whose centers are in orbit about the Earth.
- D) the fact that the planets are in orbit about the Sun rather than about the Earth.
- E) precession - the wobble of the Earth's axis of rotation.

121. One satellite known to possess an atmosphere is

- A) Phobos
- B) Oberon
- C) Ceres
- D) Titan
- E) Ganymede

122. Ancient Greek astronomers believed that the Earth is immobile, and therefore at the center of the universe, because they did not observe

- A) curvature of the Earth.
- B) eclipses of the Sun.
- C) All of the other answers are correct.
- D) parallaxes for the stars.
- E) retrograde motion of the planets.

123. William Herschel, while mapping the sky in 1781, accidentally discovered

- A) Mars
- B) Neptune
- C) Saturn
- D) Pluto
- E) Uranus

124. Kepler's third law can be stated as

- A) $P=a$
- B) $F=ma$
- C) velocity = distance per unit time.
- D) $P^2 = a^3$

125. Uranus appears as a greenish disk due to the presence of

- A) hydrogen
- B) ammonia
- C) nitrogen
- D) helium
- E) methane

126. "For every action there is an equal and opposite reaction", or "action-reaction", are statements of

- A) Galileo's theory of motion.
- B) Kepler's first law of planetary motion.
- C) the correspondence principle.
- D) the theory of relativity.
- E) Newton's third law of motion.

127. To the best of our present knowledge, the composition of Pluto is most similar to

- A) the terrestrial planets.
- B) the Jovian planets.
- C) Io.
- D) typical satellites of Jovian planets.
- E) the Earth's Moon.

128. In the process known as diffraction, when a wave comes to a narrow opening, the wave will:

- A) pass through the opening, and then start to spread out.
- B) pass through the opening, and then become focused on one point.

- C) pass through the opening, and then continue on looking just like it did before the opening.
- D) be reflected backwards.
- E) turn into a Tsunami.

129. The two planets whose orbits cross (i.e. one planet periodically gets closer to the Sun than the other planet) are

- A) Mercury and Venus
- B) Venus and Earth
- C) Uranus and Neptune
- D) Neptune and Pluto
- E) Mars and Jupiter

130. A certain amount of energy is added to an atom to lift an electron from one orbit to another. If the electron then goes back to the initial orbit,

- A) a larger amount of energy is released.
- B) the same amount of energy must be added again.
- C) the same amount of energy is released.
- D) a smaller amount of energy is released.

131. The first person known to have looked at the heavens through a telescope was

- A) Tycho
- B) Galileo
- C) Ptolemy
- D) Newton
- E) Kepler

132. An atom can absorb light if the energy of the light

- A) is less than that of an electron.
- B) is less than that of a proton.
- C) moves an electron to a lower orbit.
- D) exceeds the energy difference between electron orbits.
- E) equals the energy difference between electron orbits.

133. The reason a heavy weight dropped on the Earth falls at the same rate as a lighter weight is because, although the heavier object is attracted more by Earth's gravity, it

- A) attracts the Earth less than the lighter weight does.
- B) has more resistance due to friction with the air.
- C) has the same mass as the lighter object.
- D) starts out farther from the Earth.
- E) has a greater resistance to acceleration.

134. The distance between the Earth and the Sun is called:

- A) a kilometer

- B) an astronomical unit
- C) a parsec
- D) a lightyear

135. Newton's Second Law of Motion states that the acceleration

of a body when acted on by an external force is

- A) directly proportional to its mass.
- B) zero.
- C) proportional to its density.
- D) inversely proportional to its mass.
- E) independent of its mass.

136. The Hubble Deep Field is an image of the sky taken with a very long exposure using the Hubble Space Telescope. Almost all of the 5000 objects seen in that picture are:

- A) stars that are in our own Galaxy.
- B) dirt on the lens of the telescope.
- C) galaxies
- D) distant planets

137. Newton's law of gravitation states that the attractive force between any two masses in space is in proportion to

the (1)_____ of the masses and in (2)_____ proportion to the square of

- A) (1) quotient; (2) direct.
- B) (1) product; (2) inverse.
- C) (1) product; (2) direct.
- D) (1) quotient; (2) inverse.

138. Precession is the 26,000 year wobble of the Earth's axis of rotation. It was discovered by

- A) Gyro Gearloose
- B) the ancient Greeks
- C) Kepler
- D) Newton
- E) Galileo

139. A common cause of the bulging of a planet at its equator is

- A) density
- B) composition
- C) rotation
- D) revolution.

140. Ptolemy thought that the planets orbit the Earth rather than the Sun. How did he explain the retrograde motion of planets like Jupiter?

- A) The Sun roamed about among the planets and sometimes pulled them out of their circular orbits.

- B) The planets moved in very elongated ellipses, and their speed in orbit changed radically over the course of a year.
C) The planets moved on a small circle whose center in turn circled a point near Earth.
D) The planets moved along a circle centered on the Earth, sometimes in a forward direction and sometimes in a backward direction.

141. One effect of the Earth's tides is to
A) change the length of the year.
B) slowly increase the length of our day.
C) pull the Moon closer to the Earth.
D) make the Earth's axis precess with a 26,000 year period.

142. Which is the best definition of "the Universe"?
A) The system that includes our Sun and its planets.
B) All of the places we could possibly get to, disregarding light travel time.
C) The gravitationally interacting assemblage of 100 billion stars that we call the Milky Way.
D) All of the places that we can presently see with the largest telescopes.

143. Direct evidence that the Earth rotates on its axis, rather than the celestial sphere going around the earth, is provided by observations of
A) parallax of stars.
B) aberration of starlight.
C) rising and setting of the stars.
D) precession.
E) the Foucault pendulum.

144. "Occam's Razor" expresses the idea that if you have two competing theories trying to explain the same observed phenomenon, the one that is most likely to be correct is
A) the most complex theory.
B) the newest theory.
C) the most popular theory.
D) the simplest theory
E) the oldest theory.

145. Both stellar parallaxes and the aberration of starlight are a consequence of
A) the precession of the Earth's axis.
B) the presence of the Earth's atmosphere.
C) the rotation of the Earth.
D) the inclination of the ecliptic to the celestial equator.
E) the revolution of the Earth about the Sun.

146. When Kepler's 3rd law (relating periods and sizes of orbits) is derived using Newton's laws plus the law of gravity, what new quantity is introduced into the equation?

- A) the change in speed of the planet as it moves around its orbit.
B) the sum of the masses of the two bodies involved in the orbit.
C) the eccentricity of the orbit.
D) the tilt of the orbit.

147. The conditions for a solar eclipse are
A) first quarter Moon; Moon near ecliptic.
B) Moon at new phase; Moon near ecliptic.
C) full Moon; Moon near ecliptic.

148. How do we know that light behaves like a wave?
A) Because it moves at the speed of light.
B) Because it does many of the same things that water waves and sound waves do, including diffraction.
C) Because it has different colors.
D) Because it never behaves like a particle.

149. A planet will be most likely to keep its atmosphere if it is
A) cold and has a strong gravitational field.
B) hot and has a strong gravitational field.
C) hot and has a weak gravitational field.
D) None of the other answers is correct.
E) cold and has a weak gravitational field.

150. If the source of a wave is moving along the line of sight, a stationary observer sees a change in the emitted wavelength. This effect can be observed in
A) only light.
B) only water waves.
C) visible light but not in infrared light.
D) only sound waves.
E) all types of waves.

151. The greatest difference between the atmospheres of the Jovian and terrestrial planets is that Jovian atmospheres contain much more
A) water vapor
B) oxygen
C) carbon dioxide
D) hydrogen
E) nitrogen

152. Which of the following is one of the two basic postulates of Einstein's Special Theory of Relativity?

- A) The wavelength of light is shifted when the source is viewed by an observer moving at a different speed.
- B) The total energy of a system stays constant.
- C) Light is measured to move at the same speed, no matter how fast or in what direction you are moving relative to the light source when you measure it.
- D) The momentum of an object remains constant unless the object is acted upon by a force.

 153. Both Mars and Venus have atmospheres composed mainly of

- A) True
- B) False

 154. (Hint: Wien's Displacement Law). The wavelength at which the maximum energy is radiated from a black body is

- A) inversely proportional to temperature ($\lambda_{\max} = \text{const}/T$).
- B) directly proportional to temperature ($\lambda_{\max} = \text{const} * T$).
- C) directly proportional to the fourth power of temperature ($\lambda_{\max} = \text{const} * T^4$).
- D) proportional to the inverse square of temperature ($\lambda_{\max} = \text{const} / T^2$).
- E) independent of the temperature.

 155. Regarding the origin of the Moon we think that it collisional fragmentation theory.

- A) was pulled out of the Earth.
- B) was formed relatively recently, compared to Earth.
- C) condensed out of material near the Earth.
- D) was captured as it passed near the Earth.
- E) is not fully understood.

 156. Our Milky Way Galaxy consists of

- A) The Sun and its 9 planets.
- B) All of the actual stars in the Universe.
- C) A compact car formerly produced by Ford Motor Company.
- D) a system of 100 billion stars held together by their mutual gravitational attraction.
- E) A cluster of about 100,000 stars which orbits about the Galactic Center.

 157. The planet whose surface looks most like the Moon is

- A) Mars
- B) Earth
- C) Venus
- D) Mercury
- E) No planet looks even remotely like the Moon.

 158. The first person to use the telescope for astronomy was

- A) Jack Baldwin

- B) Tycho Brahe
- C) Kepler
- D) Newton
- E) Galileo

 159. The observation that the surface of Venus is significantly hotter than the Earth's can be explained

- A) by the fact that Venus rotates very slowly.
- B) completely by the fact that Venus is closer to the Sun.
- C) by the fact that Venus has no Moon to draw off heat.
- D) mostly by the greenhouse effect of Venus' atmosphere.

 160. Which of the following is NOT an example of a form of energy?

Which of the following was NOT known by the early Greeks?

- A) The Sun is at the center of the solar system.
- B) The approximate diameter of the Earth.
- C) The Earth is round.
- D) The concept of parallax.
- E) The fact that the Earth wobbles on its axis (precession).

 161. The surface of Venus has not been seen with telescopes on the Earth due to

- A) the great distance between the Earth and Venus.
- B) clouds on Venus.
- C) interplanetary dust.
- D) the glare of the nearby Sun.

 162. The term "lookback time" refers to:

- A) the time required to spin around and see what is behind you.
- B) the time at which some specific event occurred in a distant object.
- C) any point in time before the present.
- D) the time required for light to travel from a distant source to an observer on Earth.
- E) the time at which the Big Bang occurred.

 163. In general, the younger a region on the Moon, the

- A) fewer cracks or rills it has.
- B) fewer craters it has.
- C) more craters it has.
- D) farther it is from Earth.
- E) farther it is from the center of the Moon.

 164. An important difference between Kepler's 3 Laws and Newton's 3 Laws of Motion is:

- A) Kepler thought the Earth was at the center, while Newton realized the Sun was at the center.
- B) Kepler had better data and therefore worked out a more precise model.
- C) Newton did not include epicycles in his model.
- D) Kepler's laws described the orbits of the planets, Newton's laws described all known motions.
- E) Kepler could not predict solar eclipses, while Newton could.

165. The Viking landers showed that

- A) there is most likely no life on Mars.
- B) there are frequent ground quakes on Mars.
- C) Mars has super lightening bolts.
- D) the atmosphere of Mars is mostly nitrogen.

166. A) Newton did not include epicycles in his model.

- B) Kepler thought the Earth was at the center, while Newton realized the Sun was at the center.
- C) Kepler had better data and therefore worked out a more precise model.
- D) Kepler could not predict solar eclipses, while Newton could.
- E) Kepler's laws described the orbits of the planets, Newton's laws described all known motions.

167. At the north pole of Mars, the polar cap that lasts all

summer is composed primarily of

- A) water ice
- B) frozen nitrogen
- C) fine particles of sand
- D) a mixture of liquid and frozen water (slush)
- E) frozen carbon dioxide

168. ****GENE****

- A) Kepler's laws described the orbits of the planets, Newton's laws described all known motions.
- B) Newton did not include epicycles in his model.
- C) Kepler had better data and therefore worked out a more precise model.
- D) Kepler could not predict solar eclipses, while Newton could.
- E) Kepler thought the Earth was at the center, while Newton realized the Sun was at the center.

169. On which planet have features been photographed that look like erosion patterns from flowing water?

- A) Jupiter
- B) Venus
- C) Mercury
- D) Mars
- E) Uranus

170. A) Kepler had better data and therefore worked out a more precise model.

- B) Kepler thought the Earth was at the center, while Newton realized the Sun was at the center.
- C) Kepler's laws described the orbits of the planets, Newton's laws described all known motions.
- D) Kepler could not predict solar eclipses, while Newton could.
- E) Newton did not include epicycles in his model.

171. The Great Red Spot on Jupiter apparently is

- A) an illusion caused by the atmosphere acting like a lens.
- B) a hot area produced by falling matter from space.
- C) a result of a Moon pulling on the magnetic field.
- D) a long-lasting cyclonic system in the clouds.
- E) an updraft produced by winds hitting mountains.

172. On the assumption that the Earth is spherical, Eratosthenes estimated the Earth's circumference from measurements made at Alexandria and Syene that depend upon

- A) the direction of the Sun.
- B) the distance to the Sun.
- C) the brightness of the Sun.
- D) the apparent size of the Sun.

173. Io, the inner Galilean satellite of Jupiter, is apparently heated as a result of

- A) a slow compression of the satellite.
- B) friction with Jupiter's outer atmosphere.
- C) impacts of objects hitting its surface.
- D) decay of radioactive elements.
- E) friction by tides caused by Jupiter.

174. Kepler's second law states that the line joining the Sun to a planet

- A) covers an area equal to the cube of its length.
- B) moves more slowly the closer it is to the Sun.
- C) None of the choices given here is correct.
- D) covers equal distances in equal times.
- E) sweeps out equal areas in equal times.

175. The object with the greatest number of active volcanoes in the solar system is

- A) Miranda
- B) Io
- C) Mars
- D) Earth
- E) Venus

176. The rate of change of the velocity of a body is called the body's

- A) mass.

- B) kinetic energy.
- C) applied force.
- D) acceleration.
- E) momentum

177. Question deleted

178. Hydrogen, the simplest of the chemical elements, consists of

- A) a single electron revolving around a single proton.
- B) a single electron revolving around a single electron.
- C) a single proton revolving around a single electron.
- D) None of the other answers.
- E) a single electron revolving around a single neutron.

179. Saturn's Moon Titan is unusual in that it

- A) has dry ice (frozen carbon dioxide) clouds.
- B) has active volcanoes.
- C) is much larger than any other satellite.
- D) has an extensive atmosphere.
- E) is cold.

180. The particles found in the nucleus of an atom are

- A) electrons and protons.
- B) protons and neutrons.
- C) electrons and neutrons.
- D) electrons, neutrons and protons.

181. On the basis of unexplained deviations in the orbit of Uranus, Adams and Leverrier independently predicted the existence of

- A) Mars
- B) Uranus
- C) Neptune
- D) Saturn
- E) Pluto

182. If you made a movie of an atom absorbing light, and played the movie backwards, it would show an atom

- A) being ionized.
- B) violating the laws of physics.
- C) recombining.
- D) absorbing light.
- E) emitting light.

183. To the best of our present knowledge, Pluto is most similar to

- A) the Earth's Moon.
- B) the terrestrial planets.
- C) Io.
- D) the Jovian planets.
- E) typical satellites of Jovian planets such as Ganymede.

184. When an atom emits a photon in a given spectral line, the energy of the photon is determined by

- A) the speed of the atom across the line of sight.
- B) the energy lost by the electron changing orbits.
- C) the temperature of the atom.
- D) whether the electrons move to a smaller or larger orbit.
- E) the distance from the atom to the observer.

185. The planet discovered in 1930 by Clyde Tombaugh at the Lowell Observatory in Flagstaff, Arizona is

- A) Neptune
- B) Uranus
- C) Mercury
- D) Callisto
- E) Pluto

186. Compared to spectral lines of helium gas, the spectral lines of hydrogen gas

- A) are more likely to be absorption lines.
- B) appear fainter.
- C) are more likely to be emission lines.
- D) have completely different wavelengths.
- E) are shifted to shorter wavelengths.

187. The planets for which the relationship given by Bode's law fails to give the correct orbit size by more than 10% are

- A) Uranus and Pluto
- B) Mars and Neptune
- C) Pluto and Neptune
- D) Jupiter and Neptune

188. If an electron is completely detached from an atom

- A) the atom is ionized.
- B) the atom is in its ground state.
- C) the atom is at absolute zero.
- D) the atom is an isotope.

189. The largest asteroid (minor planet) has a diameter of

- A) 1 kilometer - .6 miles
- B) 1000 kilometers - 600 miles

- C) 300 kilometers - 180 miles
- D) 100 kilometers - 60 miles
- E) 20 kilometers - 12 miles

190. Ions are atoms with
A) fewer electrons than protons.
B) no electrons.
C) a different number of electrons than protons.
D) more electrons than protons.

191. The diameters of most observed asteroids are
A) 100-500 miles.
B) a mile or so.
C) several hundred miles.
D) over 1000 miles.
E) 50-100 miles.

192. What force holds an electron in orbit in the hydrogen atom?
A) The gravity of the proton.
B) A magnetic field.
C) The attraction of like electrical charges.
D) It needs no force to stay in orbit.
E) The attraction of opposite electrical charges.

193. Ceres, although originally believed to be a major planet, actually belongs to the group of objects called:
A) asteroids
B) comets
C) meteorites
D) meteoroids

194. Atoms make spectral lines because
A) electrons have only certain allowed orbits.
B) photons have only certain allowed orbits.
C) speed of light in a vacuum is a constant.
D) light consists of waves.

195. Halley's Comet had been observed several times before
A) False
B) True

196. The difference between a normal atom and its ion is the fact that the ion
A) has more static electricity in its nucleus.
B) is moving more slowly than a normal atom.
C) weighs more than the atom.
D) None of the other answers is correct.
E) doesn't have the usual number of electrons for that atom.

197. The period of Halley's Comet is (in years) about
A) 245
B) 93

- C) 145
- D) 35
- E) 76

198. A black body emits an amount of radiation from each unit area of its surface that is proportional to
A) the inverse square of its absolute temperature.
B) the cube of its temperature divided by the mass.
C) the fourth power of its absolute temperature.
D) the fourth power of the wavelength.

199. One surprise from close-up observations of Halley's comet was that the nucleus
A) was nearly spherical
B) appeared to consist of only one piece
C) was so dark
D) was covered with craters
E) was so small

200. In the particle picture of light, light particles are called $______$ and have energy associated with the $______$ in the wave picture.
A) neutrons, wavelength
B) protons, speed
C) electrons, frequency
D) photons, waveheight
E) photons, wavelength

201. Kepler's laws of motion imply that comets with highly elliptical orbits will
A) spend most of their time at great distances from the Sun.
B) travel with a uniform velocity.
C) spend most of their time near the Sun.
D) be confined to the plane of the ecliptic.

202. The primary reason that telescopes used for measuring visible light are being made larger and larger is:
A) to make sharp images (very small angular resolution).
B) to gather as much light as possible.
C) to magnify images greatly.
D) to show colors correctly.

203. Short-period comets
A) are a result of Jupiter's gravitational field.
B) spend all their time in the Oort cloud.
C) have only one tail.
D) are larger than long-period comets.

204. The primary reason that radio telescopes are made larger by spreading them out across whole continents is:

- A) to gather as much light as possible.
- B) to magnify images greatly.
- C) to make sharp images (very small angular resolution).
- D) to show colors correctly.

205. What forces a comet's tail away from the head?

- A) The tail has a larger orbit around the Sun.
- B) Lighter particles naturally go slower.
- C) Both radiation pressure and solar wind.
- D) Heavier particles naturally go slower.
- E) Gravitational pull from the Sun and planets.

206. What sort of light does the Chandra telescope measure?

- A) Seismic waves.
- B) Red light.
- C) Ultraviolet light.
- D) Infrared light
- E) X-rays.

207. A "new" comet, making its first pass by the Sun, approaches

the Sun on an orbit which is

- A) usually in the plane of the ecliptic.
- B) somewhat eccentric, reaching the orbit of Neptune.
- C) about as circular as an asteroid's orbit.
- D) a spiral, continually circling and approaching the Sun.
- E) very eccentric, reaching the limit of the solar system.

208. An advantage of a large reflecting telescope over a refractor of the same size is that the objective of a reflector

- A) does not make the image appear upside down.
- B) has considerably more light-gathering power.
- C) has better resolving power.
- D) can be mechanically supported across its back surface.
- E) has a greater magnifying power.

209. The nucleus of a comet is about _____ in radius.

- A) 160 km - 100 miles
- B) 16 km - 10 miles
- C) 1600 km - 1000 miles

210. The largest telescopes used for observation in the visible (optical) region of the spectrum

- A) are refracting telescopes.
- B) suffer from chromatic aberration.
- C) are reflecting telescopes.
- D) are radio telescopes.

211. A vast cloud or reservoir of comets has been proposed by

H. Oort to be revolving around the Sun in a region

- A) 50,000 to 150,000 A.U. from the Sun.
- B) occupied by the nearest stars.
- C) 50 to 100 A.U. from the Sun.
- D) just outside the orbit of Pluto.

212. If galaxy A has a velocity of recession that is 3 times larger than that of galaxy B, what is the ratio of the distances of the two galaxies?

- A) Galaxy A is 9 times closer than galaxy B.
- B) Both galaxies are at the same distance.
- C) Galaxy A is 3 times closer than galaxy B.
- D) Galaxy A is 9 times farther away than galaxy B.
- E) Galaxy A is 3 times farther away than galaxy B.

213. Meteors are usually best observed between

- A) sunrise and noon.
- B) midnight and sunrise.
- C) sunset and midnight.
- D) noon and sunset.

214. How does the General Theory of Relativity describe gravity?

- A) As a force that acts from a distance.
- B) As a particle that travels between objects.
- C) As a law passed by the Michigan state legislature.
- D) As a stretching and bending of the geometry of space.
- E) by the fact that light moves at a constant speed.

215. Which of the following is only visible for a few seconds?

- A) lunar eclipse
- B) meteor
- C) comets

216. What is the approximate diameter of our own Galaxy (the Milky Way)?

- A) 100,000 light years
- B) 10 light years
- C) 1,000,000,000 light years
- D) 1,000,000 miles
- E) 1000 light years

217. The Perseid meteor shower results from

- A) small minor planets
- B) fireballs
- C) solar wind
- D) carbon dioxide
- E) comet debris

218. When were most of the hydrogen and helium found on Earth formed?

- A) By the radioactive decay of uranium and iron.

- B) When the collision of the earth with an asteroid killed the dinosaurs.
C) When the Earth captured the Moon.
D) When the universe was only a few minutes old..
E) In the center of the Sun after it started to have thermonuclear reactions.

219. Which type of meteorite is most common to see in museums and why?

- A) stony; they have an unusual low density for stones.
B) stony; most meteorites hitting Earth are stony.
C) stony; they look unusual hitting Earth.
D) iron; most meteorites hitting Earth are iron.
E) iron; they look unusual and don't crumble.

220. How do we know that the universe is expanding from a very much smaller size?

- A) Because it has a flat geometry.
B) Because we see Cosmic Microwave Background radiation coming from all directions.
C) Because the velocity of recession of distant galaxies is proportional to their distance.
D) From the combination of two of the other answers.
E) None of the other answers are correct.

221. A meteor radiant is the

- A) point in the sky from which a meteorite is seen to fall.
B) radiation we receive from meteors.
C) brightest meteor of a shower of meteors.
D) luminous trail of a bolide.
E) point in the sky from which shower meteor trails diverge.

222. Which best describes the orbit of the Sun through our Galaxy?

- A) A circular orbit tipped at a large angle relative to the plane of the disk.
B) An elongated orbit tipped at a large angle relative to the plane of the disk.
C) It sits stationary at a great distance from the center of the Galaxy.
D) None of the other answers is correct.
E) A circular orbit in the plane of the disk.

223. The Barringer meteor crater is a mile wide. The asteroid

- A) 1 mile
B) 10 yards
C) 1 millionth of an inch
D) 0.1 inch
E) 10 miles

224. Which best describes the orbit of a typical star that is part of our Galaxy's halo?

- A) A circular orbit tipped at a large angle relative to the plane of the disk.
B) A circular orbit in the plane of the disk.
C) None of the other answers is correct.
D) An elongated orbit tipped at a large angle relative to the plane of the disk.
E) It sits stationary at a great distance from the center of the Galaxy.

225. What effect of a meteor impact may have killed the dinosaurs?

- A) increased ocean tides
B) shock wave
C) dust blocking sunlight
D) being hit by small fragments
E) a change in the Earth's orbit

226. The basic source of energy of quasars is:

- A) Matter-antimatter reactions.
B) Nuclear reactions inside the black hole.
C) Nuclear reactions in stars.
D) The release of gravitational potential energy as gas falls onto a disk around the central black hole.
E) High-energy particles escaping from the central black hole.

227. Meteorites are best seen

- A) shortly before sunrise.
B) in museums.
C) in November.
D) shortly after sundown.

228. The main classifications of galaxies are:

- A) OBAFGKM
B) Elliptical, Spiral and Prime.
C) Convex, Concave and Square
D) Spherical, Elliptical and Spiral
E) Elliptical, Spiral and Irregular

229. Which of the following is now visible as a well-formed crater?

- A) Serpent Mound, Ohio
B) Tunguska event
C) Barringer meteor crater
D) Sudbury igneous complex

230. Through which fundamental force does Dark Matter interact with normal matter?

- A) the centripital force.
B) the electromagnetic force.
C) dark matter and normal matter do not interact through any force.

- D) light
- E) the gravitational force

 231. A faint glow, concentrated along the ecliptic and sometimes seen in the west as darkness falls or in the east just before it gets light, is known as the
 A) asteroidal glow
 B) Zodiacal light
 C) ecliptic light
 D) Milky Way
 E) ecliptic glow

 232. The inflation model predicts that the geometry of the universe should be
 A) it does not make any prediction about the geometry
 B) open (negative curvature; 4D version of a potato chip)
 C) obtuse
 D) flat
 E) closed (positive curvature; 4D version of a ball)

 233. The wavelength of red light is
 A) shorter than the wavelength of blue light.
 B) longer than the wavelength of blue light.
 C) stronger than white light.
 D) of a higher frequency than that of blue light.

 234. What force currently works to SLOW DOWN the expansion of the universe?
 A) Electrostatic attraction between atomic nuclei.
 B) The cosmological constant.
 C) The kinetic energy contained in the motion of the galaxies.
 D) Gravitational attraction of all matter for all other matter.
 E) Reluctance of small investors to buy stocks even at today's depressed prices.

 235. If a radar astronomer sends a radio pulse toward the sun, before being able to observe the reflected pulse coming back from the sun, he would just have time to
 A) blink his eyes.
 B) read Tolstoy's
 C) have a cup of coffee and a doughnut.
 D) serve a term as a U.S. senator.

 236. The carbon and oxygen in our bodies was formed in
 A) stars.
 B) the big-bang explosion of the universe.
 C) the epoch during which the universe inflated in size by a huge factor.

- D) the hot gas that preceded the decoupling of the Cosmic Microwave Background.
- E) plant life on Earth.

 237. Since blue photons have more energy than red photons, they
 A) True
 B) False

 238. How would astronomers measure the mass that our Galaxy contains inside the orbit of the Sun?
 A) Measure the average total luminosity of nearby galaxies similar to our Galaxy, and use that to estimate the number of stars and hence the total mass.
 B) Add up all of the emission coming from hydrogen clouds in our Galaxy, since gas clouds comprise most of the mass.
 C) Measure the distance to the center of the Galaxy and the Sun's orbital period about the center, then use Kepler's third law.
 D) Count the number of stars in some typical unit volume of space, and then multiply by the total volume inside the Sun's orbit.
 E) There is no known way to measure this quantity.

 239. The speed of light in a vacuum is
 A) 300,000 km/sec
 B) 18,600,000,000 cm/sec
 C) 18,600,000,000 km/sec
 D) 0.00003 km/sec
 E) 30,000,000,000 km/sec

 240. Which of the following best describes the density wave theory of how spiral arms are formed and maintained?
 A) Spiral arms are strings of globular clusters, like pearls on a necklace.
 B) Spiral arms are paths where friction due to higher gas density is causing material to spiral down into the center of the galaxy.
 C) Spiral arms are caused by jets shot out of the center of the galaxy being wound up due to differential rotation.
 D) Spiral arms are regions of higher density; the extra gravitational attraction causes passing stars to slow down as they pass through the arm, thus perpetuating the traffic jam.
 E) Spiral arms are caused by stars being ejected from the nucleus of a galaxy and pinwheeling out into space.

 241. Letting light pass through two or more closely-spaced slits is important because it demonstrates that waves from each slit
 A) cause atoms to absorb the light.
 B) produce the photoelectric effect.

- C) travel at the same speed as waves from other slits.
- D) interfere with waves from other slits.
- E) can produce absorption lines.

 242. Which of the following statements about the implications of Hubble's Law is FALSE?

- A) The law requires us to be at the center of an expanding universe.
- B) The constant H_0 that relates velocity to distance has been recalibrated by factor of several since Hubble's original work.
- C) If you were observing the universe from some distant galaxy, you would still see the same effect (all of the galaxies moving away from you).
- D) The law can be used to measure distances to remote galaxies for which we can measure a Doppler shift.
- E) The whole universe must be expanding.

 243. When comparing water waves and light waves, we find that

- A) only light waves can reflect off barriers.
- B) only water waves interfere with each other.
- C) only light waves interfere with each other.
- D) only light waves display Doppler shifts.
- E) both spread out after passing through a narrow opening.

 244. Which component of our Galaxy contains the largest amount of mass?

- A) Population I stars.
- B) Halo.
- C) Dark matter.
- D) Disk.
- E) Nuclear bulge.

 245. The wave nature of light is demonstrated by

- A) the photoelectric effect.
- B) diffraction and interference of light.
- C) the fact light can have different colors.
- D) reflection of light.
- E) spectral lines.

 246. The Principle of Equivalence as used in General Relativity says that that an observer cannot tell the difference between acceleration and

- A) gravity.
- B) time.
- C) deceleration.
- D) a falling elevator.
- E) being inside a black hole.

 247. Upon passing through a prism, blue light is refracted

- (bent) more than red light because in the prism
- A) red light has a longer wavelength than blue light.

- B) blue light is slowed more than red light.
- C) red light is slowed more than blue light.
- D) blue light has greater energy than red light.

 248. Oops! You take the wrong exit on I96 and find yourself trapped inside the Schwarzschild radius (event horizon) of a black hole. You use your cell phone to try to send a radio SOS message back to the AAA (who prudently have located their office outside the Schwarzschild radius). What will be the fate of that message?

- A) The message will make it to the AAA in fine shape with all information intact (but your call will be put on hold).
- B) The radio waves will emerge from the Schwarzschild radius with a huge gravitational redshift.
- C) The message will never emerge from the Schwarzschild radius.
- D) The message will make it to AAA but all of its information will be randomly garbled.
- E) The radio waves will emerge from the Schwarzschild radius as gamma rays.

 249. A simple convex lens forms the image of a distant point source at a place called the

- A) focal length
- B) focal point
- C) object point
- D) objective

 250. Why do we think that quasars are extremely luminous?

- A) We cannot measure any parallax for them, so they must be far away and therefore very luminous.
- B) They are powered by black holes, which always are very luminous objects.
- C) We can see that they are much larger in diameter than any normal galaxy, so they must be much more luminous as well.
- D) Their position on the H-R diagram indicates that they must be more luminous than any stars.
- E) Their large redshifts plus Hubble's Law indicate very large distances, so they must be very luminous to produce the observed flux.

 251. Which combination of lens parameters will give the brightest image of a faint comet?

- A) large diameter, short focal length
- B) small diameter, short focal length
- C) small diameter, long focal length
- D) large diameter, long focal length

252. Based on the variability of the light, which is the best size estimate for the central light source in a typical quasar?

- A) 1000 light years.
- B) Similar in size to our Solar System
- C) Larger than our Galaxy
- D) Smaller than a breadbox.
- E) 100 light years.

253. For a given wavelength of light, the theoretical resolving

power of a telescope depends on the

- A) magnification of the telescope.
- B) brightness of the object under observation.
- C) distance to the object under observation.
- D) focal length of the objective.
- E) diameter of the objective.

254. If we watch from afar as an astronaut falls into a black hole, which of the following effects would we

- A) The astronaut never quite reaching the Schwarzschild radius.
- B) The astronaut getting older at an ever-slowing rate.
- C) The astronaut being horribly stretched out by tidal forces near the Schwarzschild radius.
- D) The way in which the astronaut is mashed up into the infinitely dense material at the center.
- E) We could see all of these things happen.

255. The bigger the primary lens or mirror in a telescope,

- A) the redder objects seen through it appear.
- B) the farther away objects seen through it would appear.
- C) None of the other answers is correct.
- D) the bigger the area of the sky one can see at one time.
- E) the more light the telescope collects.

256. If the universe has a closed geometry (positive curvature, described by the surface of a sphere in our 2D analogy), which of the following would be true?

- A) It would have infinite volume.
- B) It could not be expanding.
- C) Two lines which are parallel at a given point would never cross each other at any other point.
- D) Hubble's Law could not occur.
- E) It would be possible to construct triangles in which each angle is 90° .

257. Spherical mirrors are not normally used in a telescope due to the fact

- A) they cause coma.
- B) they cause spherical aberration.

- C) they are hard to make.
- D) they cause chromatic aberration.

258. What is the source of the Cosmic Microwave Background radiation?

- A) It is emitted by stars in distant galaxies.
- B) It is photons left over from a time when the Universe was denser, and was filled by hot, opaque gas.
- C) It is emitted by supernovae in galaxies in the Local Supercluster.
- D) It comes from the disk of the Milky Way.
- E) It comes from cold gas (3°K) at the edge of the universe.

259. The largest fully operating optical telescope in the U.S.

- A) Palomar
- B) Yerkes
- C) Lowell
- D) Lick
- E) Keck

260. The expansion of the Universe, according to astronomers, is:

- A) a prediction of Λ CDM theory of cosmology for which the evidence is very controversial.
- B) a piece of established observational evidence which any theory of cosmology must include.
- C) making all of the planets in our solar system harder to reach, driving up NASA budgets.
- D) the opposite of what Hubble's law describes.
- E) a theory for which there is no observational evidence.

261. When looking at Mars through a telescope, one sees the image shimmering as a result of

- A) convection currents in the atmosphere of Mars.
- B) defects in the eyepiece lens.
- C) Martians.
- D) dust storms on Mars.
- E) turbulence in the Earth's atmosphere.

262. Which of the following statements about dark matter is FALSE?

- A) It is observed to be a major part of the Milky Way.
- B) We can detect its gravity, even though we can't see it.
- C) It is observed to be present in other groups of galaxies.
- D) Astronomers have a pretty good idea what the dark matter is made of.
- E) It appears to make up most of the matter in the universe.

263. The most important reason for placing telescopes in orbit around the Earth is to

- A) avoid interference of clouds.
- B) detect wavelengths that don't penetrate our atmosphere.
- C) avoid rotating telescopes to follow stars across the sky.
- D) avoid problems of light emitted by our atmosphere.
- E) observe during the daytime.

264. A) It appears to make up most of the matter in the universe.

- B) Astronomers have a pretty good idea what the dark matter is made of.
- C) It is observed to be a major part of the Milky Way.
- D) We can detect its gravity, even though we can't see it.
- E) It is observed to be present in other groups of galaxies.

265. Ceres, the largest asteroid, has a diameter of about

- A) 1 kilometer - .6 miles
- B) 300 kilometers - 180 miles
- C) 20 kilometers - 12 miles
- D) 1000 kilometers - 600 miles
- E) 100 kilometers - 60 miles

266. Which of the following best describes the inflation model of the universe?

- A) The scale factor increased by a huge amount in a very short period of time early in the life of the universe, then continued to increase at a much slower rate.
- B) The universe expanded to a large size very early on, and now is steadily collapsing back to a single point.
- C) The universe first swelled up to an enormous size, then collapsed back down to the approximate size we see today.
- D) The universe has always been expanding at a roughly constant rate.
- E) The amount that money can buy steadily decreases with time.

267. Most meteors are caused by material from

- A) comets.
- B) Earth's Moon.
- C) Jupiter.
- D) large moons of Jupiter.
- E) asteroids.

268. The Doppler shift, measured from the change in wavelength of emission or absorption lines in the spectrum of a galaxy, tells us

- A) the speed of light in the direction of that galaxy.
- B) the velocity of that galaxy perpendicular to the line of sight.
- C) the velocity of that galaxy along the line of sight.
- D) the chemical composition of that galaxy.
- E) the temperature of that galaxy.

269. Which of the following killed over 15,000 reindeer, and produced a shock measured around the world?

- A) Tunguska event in Siberia in 1908.
- B) Barringer meteor crater.
- C) Sudbury igneous complex.
- D) meteor of 63 million years ago.

270. The correct interpretation of Hubble's law is that

- A) the universe is unchanging... it has always been like it is now.
- B) our own Galaxy is at the exact center of an exploding universe.
- C) the universe is spherical in shape.
- D) the universe is really just a big loaf of bread.
- E) the whole universe is uniformly expanding.

271. Periodic meteor showers are probably caused through

- A) Saturn's rings.
- B) asteroids.
- C) the Sun.
- D) meteorite.
- E) comets.

272. Newton described gravity as

- A) the incorporation of time as a 4th dimension, in addition to the 3 space dimensions.
- B) a force acting between any two objects with masses.
- C) objects moving in ellipses with $P^2 = a^3$.
- D) the curvature of space-time into an extra space dimension.

273. The largest number of meteors are seen

- A) at midnight.
- B) before midnight.
- C) after midnight.

274. The theory of Special Relativity shows that observers moving at different constant velocities will see time pass at different rates. This is due to

- A) daylight-savings time.
- B) the fact that each observer measures light to move at a different speed.

- C) the fact that clocks cannot operate properly at high speeds.
 - D) the interconnection between time coordinates and space coordinates.
 - E) the clock is moving faster than the speed of light, as seen by one of the observers.
-

275. The best current models for a comet consider them to be made mostly of
- A) loose, sandy grains.
 - B) rock.
 - C) dirt mixed with snow and ice.
 - D) pure hydrogen.
-

276. The Principle of Equivalence states that
- A) an ISP205 final is equivalent to 5 years in the county jail.
 - B) the speed of light is the same as seen from any moving coordinate system.
 - C) you cannot tell the difference between gravity and acceleration.
 - D) gravity and time are equivalent.
 - E) nothing can move faster than the speed of light.
-

277. If a comet has two tails, one rather featureless and the other showing much structure,
- A) only one tail would follow the comet through space.
 - B) both would probably have bright spectral lines.
 - C) both tails must follow the comet through space.
 - D) one would probably be dust and the other gas.
 - E) both would probably have dark spectral lines.
-

278. Which of the following is NOT a proof of the theory of General Relativity?
- A) The precession of Mercury's orbit is more rapid than is predicted by Newton's laws.
 - B) The two stars in a binary system each orbit about the center of mass of the system.
 - C) The strong gravitational field of white dwarfs redshifts the light emitted from their surfaces.
 - D) Time is observed to run more slowly in clocks when they are flown to high altitudes above the Earth.
 - E) The path of light from distant stars is bent by the Sun's gravitational field.
-

279. The quickest way to tell which way a comet is moving in
- A) True
 - B) False
-

280. The Cosmic Microwave Background is
- A) the gravitational attraction from the most distant matter in the universe.

- B) none of the other answers are correct.
 - C) light that is emitted by nearby galaxies.
 - D) relic black-body radiation from an earlier, hotter stage of the universe.
 - E) radiation from the dark matter that is all around us.
-

281. The objects composed mostly of rock are the
- A) Jovian planets.
 - B) comets.
 - C) asteroids.
 - D) iron meteorites.
-

282. Astronauts falling into a black hole would not notice anything special happening as they fell through the Schwarzschild radius. Watching from the outside, we would see the astronauts
- A) age very rapidly and disappear.
 - B) bounce off the Schwarzschild radius.
 - C) disappear from sight as they crossed the Schwarzschild radius.
 - D) appear to get closer and closer to the Schwarzschild radius, but never arrive there.
 - E) pass right through the black hole and out the other side.
-

283. The largest asteroid
- A) is in orbit about Jupiter.
 - B) is not much larger than a city block in size.
 - C) is equal in size to one of the Galilean satellites.
 - D) was discovered in 1961.
 - E) is about 1,000 km (600 miles) in diameter.
-

284. A fairly massive black hole appears to reside at the center of our own Galaxy. The evidence for this is:
- A) We see gigantic radio jets shooting out from the center of our Galaxy.
 - B) We see from the orbits of stars very close to the Galactic center that there must be a very massive object in there.
 - C) Astronauts have been seen to fall into the black hole.
 - D) We see periodic bursts of intense x-ray energy coming from the Galactic center.
 - E) When we look at infra-red and radio wavelengths, we see a full-fledged quasar shining away in the center of our own Galaxy.
-

285. The asteroids mostly lie between Mars and
- A) Mercury
 - B) Uranus
 - C) Pluto
 - D) Jupiter
 - E) Earth
-

286. What is currently believed to be the approximate age of the universe?

- A) 300,000 years.
- B) It has been here forever.
- C) 14 million years.
- D) 14 billion years.
- E) 1 billion years.

 287. Halley was the first to see Halley's comet.

- A) False
- B) True

 288. When we look over very large size scales in space, what is the distribution of galaxies and clusters of galaxies?

- A) They are smoothly distributed throughout space.
- B) The density of these objects in space gets to be less the farther you go away from Earth in any direction.
- C) They form the centers of large spheres of completely empty space.
- D) They lie on the surfaces of gigantic, intersecting bubbles.
- E) They all lie along one long line that connects back to the center of the universe.

 289. Halley's Comet returns to the Sun about once every

- A) 76 years
- B) 93 years
- C) 159 years
- D) 256 years
- E) 35 years

 290. The Cosmic Microwave Background radiation is systematically slightly brighter in one direction and slightly fainter in the opposite direction. What is this due to?

- A) Because we are located near the edge of the universe, there is more material in one direction than in the other direction.
- B) Dust has absorbed the CMB radiation from one direction.
- C) The Cosmic Microwave Background comes from stars within our Galaxy.
- D) The universe is systematically hotter in one direction and cooler in the opposite direction.
- E) Doppler shifting due to the motion of our galaxy in an orbit about the Virgo cluster of galaxies.

 291. The distance between the image that a distant object forms and the lens (mirror) of a telescope is the _____ of the

- A) magnifying power
- B) refractor
- C) secondary
- D) focal length
- E) objective

 292. What sort of matter makes up 90% of all matter?

- A) Stars.
- B) Dark matter.
- C) Income tax forms.
- D) Hydrogen gas between the galaxies.
- E) X-Ray emitting gas in galaxy clusters.

 293. The main reason for using a parabolic mirror in a telescope

- instead of a spherical one is
- A) coma can be avoided.
- B) they are cheaper.
- C) spherical aberration can be avoided.
- D) they reflect more light.

 294. Gravitational lensing shows that

- A) giant black holes exist at the centers of quasars.
- B) the Sun is located near the edge of our Galaxy.
- C) luminous matter makes up only 10% of the total mass of giant galaxy clusters.
- D) the universe has a flat geometry.
- E) none of the other answers is correct.

 295. Twinkling of starlight is caused by

- A) turbulence in the Earth's atmosphere.
- B) the solar wind.
- C) clouds in the ionosphere.
- D) signals from intelligent beings on other planets.

 296. Our current understanding of how structures formed in the Universe in the presence of dark matter shows that structures of different sizes should have formed in what order?

- A) Largest first, smallest last (top down).
- B) Smallest first, largest last (bottom up).
- C) All size scales formed at the same time (simultaneous).
- D) The models make no prediction about this.

 297. The world's largest telescope with a lens for an objective is located at which observatory?

- A) Kitt Peak
- B) Palomar
- C) Lick
- D) Cerro Tololo
- E) Yerkes

 298. The recent balloon measurements of the Cosmic Microwave Background show that the geometry of the universe is

- A) closed
- B) open
- C) perfectly smooth
- D) contracting

E) flat

299. To find the total mass of a visual binary, we need to first find its

- A) Doppler shift and proper motion.
- B) apparent magnitude and distance from Earth.
- C) space velocity and apparent orbit.
- D) true orbit and proper motion.
- E) distance from Earth and the apparent orbit.

300. Recent measurements of supernovae let us accurately measure the relation between the redshifts of distant objects of known luminosity and the flux (expressed in magnitude units) that we receive from them. What is the surprising conclusion from these observations?

- A) The universe is not expanding; rather it is contracting.
- B) The expansion rate of the universe is slowing down, rather than speeding up as expected.
- C) The universe is neither expanding nor contracting.
- D) The expansion rate of the universe is speeding up, rather than slowing down as expected.

301. The primary reason for making telescopes very large is

- A) to magnify greatly.
- B) to reduce the seeing effects of the atmosphere.
- C) to make sharp images.
- D) to gather as much light as possible.
- E) show colors correctly.

302. The term "cosmological constant" refers to

- A) the force of attraction that pulls together any two objects having mass.
- B) the average density of matter in the universe.
- C) the constant average temperature of the Cosmic Microwave Background.
- D) a mysterious repulsive force that pushes apart everything in the universe.
- E) the constant that appears in Hubble's Law.

303. Which of the following lists orders the regions of the electromagnetic spectrum from longest wavelength to shortest wavelength?

- A) gamma-ray, x-ray, ultraviolet, visible, infrared, radio.
- B) gamma-ray, x-ray, radio, ultraviolet, visible, infrared.
- C) infrared, visible, radio, ultraviolet, x-ray, gamma-ray.
- D) radio, infrared, visible, ultraviolet, x-ray, gamma-ray.

E) x-ray, radio, infrared, visible, ultraviolet, gamma-ray.

304. Saturn's rings are believed to be composed of

- A) frozen hydrogen.
- B) a liquid disk.
- C) recycled Coca Cola cans... that's what they do with them.
- D) a solid disk of frozen methane.
- E) small bodies of rock and ice.

305. Roemer was able to estimate the velocity of light by

- A) timing eclipses of Jupiter's satellites.
- B) timing eclipses of the Sun.
- C) timing eclipses of the Moon.

306. Which has never had volcanic activity?

- A) Io
- B) Venus
- C) The Moon
- D) They have all had volcanic activity.
- E) Mars

307. It takes light roughly _____ to go from the Sun to the

- A) 2 hours
- B) 1 second
- C) 8 minutes
- D) 1 year
- E) 30 seconds

308. Which has the highest surface temperature?

- A) Mercury
- B) The Moon
- C) Earth
- D) Mars
- E) Venus

309. When a wave passes through a narrow opening, the wave

- This is called
- A) interference.
 - B) reflection.
 - C) diffraction.
 - D) refraction.
 - E) dispersion.

310. One side of the Moon always faces the Earth because the

- A) revolution rate about the Earth equals the rotation rate.
- B) rotation rate about the Sun equals the revolution rate.
- C) Earth always has the same side facing the Moon.
- D) Moon does not spin on its axis.

311. The phenomenon of refraction is the ____ of a light beam as it passes slantwise from a medium of one density into a

- A) weakening
- B) bending
- C) reflecting
- D) dispersion

312. Which planet is known to have rings around it?

- A) Pluto
- B) Uranus
- C) Mars
- D) Mercury
- E) Venus

313. The higher the frequency of light

- A) the shorter its wavelength.
- B) the greater its velocity in a vacuum.
- C) the redder it will be.
- D) the longer its wavelength.

314. Which has the smallest diameter?

- A) Venus
- B) Mars
- C) Mercury
- D) The Earth's Moon
- E) Earth

315. The meteoroid which gives rise to an average naked-eye meteor is about the size of

- A) Shaquille O'Neal
- B) a grain of salt.
- C) a molecule.
- D) a basketball.

316. What is one thing wrong with the theory that the Moon was formed far away in the Solar System and then captured into its orbit around the Earth?

- A) This does not explain the craters on the Moon..
- B) The Moon goes around in its orbit in the opposite direction of the earth's spin (retrograde orbit).
- C) We don't know how the Moon could have slowed down to get into orbit.
- D) The Moon's composition is entirely unrelated to the composition of the Earth.
- E) This is actually the accepted theory... there is nothing wrong with it.

317. One advantage of a reflecting telescope compared to a

- refracting telescope is that the reflecting telescope
- A) more easily focuses all wavelengths at the same place.
 - B) can see the far side of the Moon in daytime.

- C) can be used only at prime focus.
- D) doesn't need cleaning as often.

318. Which of the following is a true statement?

- A) Mercury has a lower average density than Uranus.
- B) Saturn is the most massive planet.
- C) 50% of the mass of the solar system is contained in the planets.
- D) None of the other statements are true.
- E) Four of the planets have rings.

319. Isaac Newton discovered that sunlight

- A) behaves like waves.
- B) is only a dream at MSU.
- C) causes skin cancer.
- D) is made up of all the colors of the rainbow.
- E) causes interference.

320. The inner and outer Galilean moons differ, in that

- A) the inner moons have more ice.
- B) the inner moons have more geological activity.
- C) the inner moons have more impact craters.
- D) the inner moons have fewer volcanoes.

321. Isaac Newton invented

- A) the prism.
- B) fig-filled cookies.
- C) the reflecting telescope.
- D) the refracting telescope.

322. Which of the following is false? The atmosphere of Jupiter

- A) circulates at different speeds at different latitudes.
- B) contains a storm larger than the Earth.
- C) has had a space probe parachuted into it.
- D) is made up primarily of hydrogen and helium.
- E) is strikingly similar to the Earth's atmosphere .

323. The electrical charges on the proton and electron are

- A) of equal strength but opposite sign.
- B) respectively, negative and positive.
- C) both positive.
- D) of unequal strength but same sign.

324. How big is Mars compared to other planets?

- A) Half the diameter of Earth.
- B) Nearly as large as Saturn.
- C) Mars is the smallest planet.
- D) Four times larger diameter than Earth.
- E) Twice the diameter of Venus.

325. Molecules are formed when two or more atoms

- A) share electrons.
- B) share nuclei.
- C) exchange nuclei.

-
326. Which is the 2nd planet out from the sun?
A) Jupiter
B) Saturn
C) Earth
D) Venus
E) Mars
-
327. The particles found in the nucleus of an atom are
A) protons and neutrons.
B) electrons and neutrons.
C) electrons and protons.
D) electrons, neutrons and protons.
-
328. What is the largest moon in the solar system?
A) Titan
B) Phobos (the larger moon of Mars)
C) Earth's Moon
D) Ganymede
E) Charon
-
329. Which force holds people together?
A) weak nuclear
B) strong nuclear
C) electromagnetic
D) gravity
-
330. What is a basic distinction between most asteroids and most comets?
A) The oldest comets are older than the oldest asteroids.
B) Only comets collide with the Earth.
C) The oldest asteroids are older than the oldest comets.
D) Only asteroids collide with the Earth.
E) They come from different parts of the Solar System.
-
331. An atom can absorb light if the energy of the light
A) is less than that of a proton.
B) equals the energy difference between electron orbits.
C) moves an electron to a lower orbit.
D) exceeds the energy difference between electron orbits.
E) is less than that of an electron.
-
332. Kepler's laws of motion imply that comets with highly elliptical orbits will
A) spend most of their time at great distances from the Sun.
B) be confined to the plane of the ecliptic.
C) travel with a uniform velocity.
D) spend most of their time near the Sun.
-

333. If you made a movie of an atom absorbing light, and played the movie backwards, it would show an atom
A) violating the laws of physics.
B) emitting light.
C) recombining.
D) absorbing light.
E) being ionized.
-
334. If two planets have the same diameters, but different mean densities, what does that tell us?
A) They are made up of different mixes of the chemical elements.
B) That the one with higher mean density must have a larger core.
C) Their overall composition may be the same, but the elements have settled out (differentiated) differently inside.
D) They must have different core temperatures.
E) That they must have different surface temperatures.
-
335. When an atom emits a photon in a given spectral line, the energy of the photon is determined by
A) whether the electrons move to a smaller or larger orbit.
B) the energy lost by the electron changing orbits.
C) the speed of the atom across the line of sight.
D) the distance from the atom to the observer.
E) the temperature of the atom.
-
336. Which has the highest level of oxygen in its atmosphere?
A) Venus
B) Earth
C) Mars
D) Titan
E) Earth's Moon
-
337. The positions of the spectrum lines emitted by an element are primarily influenced by
A) the number of neutrons in the nucleus.
B) the number of isotopes present.
C) the mass of the nucleus.
D) the number of electrons orbiting the atom.
-
338. Which planet's moons are currently being explored by the Galileo probe?
A) Venus
B) Saturn
C) Jupiter
D) Neptune
E) Pluto
-

339. If an electron is completely detached from an atom

- A) the atom is ionized.
- B) the atom is an isotope.
- C) the atom is at absolute zero.
- D) the atom is in its ground state.

340. An important cause of the slowing down of the Earth's rotation is the

- A) pull of the Moon on the Earth's equatorial bulge.
- B) pull of the Earth's equatorial bulge on the Moon.
- C) pull of the Moon on the Earth's magnetic field.
- D) gravitational increase in the size of the Earth's orbit.
- E) tides caused by the gravity of the Moon.

341. Ions are atoms with

- A) more electrons than protons.
- B) fewer electrons than protons.
- C) no electrons.
- D) a different number of electrons than protons.

342. To the best of our present knowledge, the composition of Pluto is most similar to

- A) Io.
- B) Mars.
- C) the Earth's Moon.
- D) Triton.
- E) Neptune.

343. Radial velocity is the speed

- A) away from the center of a circle.
- B) of radio waves.
- C) toward or away from the observer.
- D) None of the other answers are correct.
- E) of the rim of a wheel.

344. The observation that the surface of Venus is significantly hotter than the Earth's can be explained

- A) completely by the fact that Venus is closer to the Sun.
- B) by the fact that Venus has no Moon to draw off heat.
- C) by the fact that Venus rotates very slowly.
- D) mostly by the greenhouse effect of Venus' atmosphere.

345. The spectral lines of a star are observed to be shifted

Therefore

- A) the star is very hot.
- B) the star is approaching us.
- C) the star is receding from us.
- D) the star is rather cool.

346. There are large straight cracks in the icy covering of the moon Europa. These are thought to be due to

- A) the slow expansion of Europa due to its hot interior.
- B) the fact that the ice sits over an underlying ocean of water.
- C) none of the other answers is correct.
- D) the gradual contraction of Europa due to differentiation in its interior.
- E) long cracks spreading out from the many impact craters on the surface.

347. An absorption-line spectrum is formed by

- A) a hot gas in front of a cool dense source of radiation.
- B) a glowing metal.
- C) None of the other answers.
- D) a cool gas between the observer and a hot dense body.
- E) a glowing gas at constant temperature.

348. Which of the following was NOT accomplished by the Apollo astronauts?

- A) Brought back material from which chemical composition of lunar surface could be determined.
- B) Set up seismographs which studied the lunar interior.
- C) Brought back rock samples for which ages could be measured.
- D) Landed in several different locations on Moon.
- E) Found evidence of ancient life forms.

349. Temperature is related to the _____ of atoms.

- A) speed
- B) mass
- C) atomic weight
- D) densities
- E) size

350. We cannot see the entire surface of the Moon from Earth because

- A) the Moon does not rotate.
- B) the Moon's axis always points toward the Earth.
- C) one side of the Moon is dark.
- D) the Moon rotates once for every orbit around the Earth.
- E) there is nothing behind the Moon.

351. Stefans' law states that the amount of energy radiated by

each square centimeter of a body is

- A) proportional to the fourth power of its temperature.
- B) proportional to the cube of the temperature.
- C) proportional to its temperature.
- D) proportional to the cube of the wavelength.

E) proportional to its distance.

352. Which planet does ~~not~~ have rings around it?

- A) Venus
- B) Saturn
- C) Neptune
- D) Uranus
- E) Jupiter

353. As a glowing black body gets hotter, what happens to its color and what happens to the brightness of the red light it emits?

- A) color gets more red; all colors get stronger.
- B) color gets more blue; all colors don't change.
- C) color gets more red; all colors get weaker.
- D) color gets more blue; all colors get weaker.
- E) color gets more blue; all colors get stronger.

354. Which has the largest diameter?

- A) Mercury
- B) Mars
- C) The Earth's Moon
- D) Pluto
- E) Venus

355. The luminosity of a star

- A) depends upon the distance to the star.
- B) usually is greater for stars with large proper motion.
- C) is the rate at which it radiates energy.
- D) was first introduced by Hipparchus.
- E) can be measured only if the star is ten parsecs away.

356. What is wrong with the theory that the Moon was born as a sister planet right next to the Earth?

- A) The Moon goes around in its orbit in the opposite direction of the earth's spin (retrograde orbit).
- B) The Moon should have fallen into the Earth.
- C) The Moon does not have the exact same composition as the Earth.
- D) This is actually the accepted theory... there is nothing wrong with it.
- E) There was not enough primordial material in our part of the Solar System to form more than just the Earth.

357. The most important reason for measuring distances to stars

is to

- A) see how many stars could influence the Oort comet cloud.
- B) convert radial velocity to space velocity.
- C) find spectral types for stars.

D) determine how luminous they are.

E) find out what direction clusters of stars are moving in.

358. Which of the following is a true statement?

- A) 50% of the mass of the solar system is contained in the planets.
- B) None of the other statements are true.
- C) Uranus is the most massive planet.
- D) Neptune is sometimes the 9th planet out from the Sun.
- E) Neptune has a higher average density than Venus.

359. If two stars have the same luminosity, the cooler star will have a

- A) larger diameter.
- B) fainter apparent magnitude.
- C) greater distance.
- D) larger Doppler shift.
- E) bluer color.

360. The inner and outer Galilean moons differ, in that

- A) the outer moons have more ice.
- B) the outer moons have more volcanoes.
- C) the outer moons have more geological activity.
- D) the outer moons have fewer impact craters.

361. The redder a star is,

- A) the lower its surface temperature.
- B) the larger it must be.
- C) the denser it is.
- D) the smaller it must be.
- E) the younger it is.

362. Which of the following is false? The atmosphere of Jupiter

- A) has had a space probe parachuted into it.
- B) is made up primarily of hydrogen and helium.
- C) contains a storm that is as big as Earth.
- D) sits on top of a solid rocky surface.
- E) circulates at different speeds at different latitudes.

363. The main reason the pattern of stellar spectral lines

changes from one spectral type to the next is the

- A) composition changes.
- B) absolute magnitude changes.
- C) temperature changes.
- D) diameter changes.

364. How big is Mercury compared to other planets?

- A) Nearly as large as Saturn..
- B) Twice the diameter of Venus.
- C) Four times larger diameter than Earth.
- D) Smaller than Mars.

E) Mercury is the smallest planet.

365. The letters classifying the spectral sequence of stars from blue to red (high temperature to low temperature) is

- A) B A F K G M O.
- B) M K G F A B O.
- C) O B A F K M G.
- D) O B A F G K M.
- E) M G K F A O B.

366. Which is the 4th planet out from the Sun?

- A) Venus
- B) Earth
- C) Saturn
- D) Mars
- E) Jupiter

367. The most abundant chemical elements in a star's photosphere will almost always give the strongest spectral lines in the

- A) False
- B) True

368. Which is smallest in diameter?

- A) Earth's Moon
- B) Titan
- C) Ganymede
- D) Mercury
- E) Pluto

369. As we look at the stars hotter than spectral class A, the higher the temperature, the weaker the hydrogen spectral

- Why?
- A) Strong helium lines cover the hydrogen lines.
 - B) The hydrogen is used to form molecules.
 - C) Very hot stars have converted hydrogen to helium.
 - D) Too much of the hydrogen is ionized.
 - E) All hydrogen atoms have electrons in the first orbit.

370. What is a basic distinction between asteroids and comets?

- A) Only asteroids collide with the Earth.
- B) Their compositions are very different.
- C) The oldest comets are older than the oldest asteroids.
- D) The oldest asteroids are older than the oldest comets.
- E) Only comets collide with the Earth.

371. If a star has very weak hydrogen lines but strong lines of

molecules in its spectrum, it should be a

- A) fairly cool star.
- B) be farther away.
- C) be larger.
- D) have bluer color.
- E) have fainter absolute magnitude.

372. Which statement best describes a typical comet during the vast MAJORITY of its lifetime?

- A) It has two huge tails, one made of dust and the other of ions.
- B) It is in an orbit roughly like the orbits of the terrestrial planets.
- C) It has an expanded shell of hydrogen gas, in some cases larger than the sun.
- D) It is a small ball of icy materials, a few km across.
- E) It is closer to the Sun than the orbit of Mars.

373. If we compare the spectra of two stars of the same temperature but much different luminosities, the star with

- the higher luminosity is likely to have
- A) spectral lines that are easier to see.
 - B) stronger lines from molecules.
 - C) more splitting of its lines by its magnetic field.
 - D) lines more broadened by its rotation.
 - E) narrower (less fuzzy) lines.

374. Comets like Halley's Comet have periods of just a few 10's of years, while another type of comets has periods of several thousand years. What does this immediately tell us?

- A) The short period comets like Halley's come from the Oort Cloud.
- B) The two groups of comets have very different ages.
- C) The two groups of comets have very different compositions.
- D) One type of comet travels very much farther out in the solar system than does the other type.
- E) The periods of comets gets longer and longer as they repeatedly pass through the inner solar system.

375. The nearest star other than the Sun is roughly _____ light

- A) 1
- B) 60
- C) 100,000
- D) 4
- E) 2,000,000

376. The difference in density between the giant planets and the terrestrial planets tells us that

- A) they were formed in different parts of the solar system

- B) their ages are different.
- C) the giant planets have gaseous atmospheres.
- D) the giant planets are bigger.
- E) their compositions are different.

 377. The greater the distance of a star, the smaller is its

- A) rotation.
- B) temperature.
- C) period.
- D) luminosity.
- E) parallax.

 378. The spacecraft that have visited the outer planets have all flown close to inner planets (Venus, for example), often more than once, as part of their journeys. What was the primary reason for this?

- A) The outer planets happened to have been on the far side of the Sun, so the shortest route passes the inner planets.
- B) To chalk up lots of extra frequent flyer miles.
- C) To study the nature of the inner planets.
- D) To pick up extra energy through their gravitational encounter with the inner planet.
- E) To refuel from the material in the atmosphere of Venus.

 379. Parallax can be used to measure distances as large as _____

- A) 60
- B) 200
- C) 100,000
- D) 1
- E) 4

 380. What is the main reason that we know so much less about Pluto than about any of the other planets?

- A) It has not been visited by a space probe.
- B) It is smaller.
- C) It is less interesting.
- D) It is always on the far side of the Sun from the Earth.
- E) It was discovered more recently than the other planets.

 381. The apparent change in position of the foreground star against the background stars in photographs taken at times

separated by one year would include or show only

- A) parallax and proper motion
- B) proper motion
- C) parallax
- D) secular motion

382. Gravitational resonances are thought to cause the gaps in the rings of Saturn, the gaps in the asteroid belt, and the fact that Mercury's rotation period is 2/3 of its orbital period. What is a basic feature of this process?

- A) Two bodies must physically collide with each other.
- B) Quantum mechanics says that certain orbits are forbidden.
- C) A body with with a strong gravitational field is able to pull repeatedly on a smaller body at the same point in its orbit with the same force, time after time.
- D) The strength of the force of gravity between two stationary objects continuously resonates like a big spring.

 383. The most simply constructed atom, consisting of a single proton plus one orbiting electron, is

- A) neutral helium
- B) doubly ionized helium
- C) ionized hydrogen
- D) neutral hydrogen

 384. What has caused the gaps in the rings of Saturn?

- A) The material at those locations formed into the large moons of Saturn.
- B) Large moons have crashed through the rings at those positions, and the resulting holes have smeared out into rings.
- C) The material at these positions is very dark and absorbing, as compared to the highly reflective material elsewhere in the rings.
- D) Roche's law says that material cannot exist at the positions of the gaps.
- E) Gravitational encounters between the ring material and small moons in orbit around Saturn.

 385. The factor which distinguishes one element from another is

- A) the number of neutrons
- B) the size
- C) the number of ions
- D) the number of protons

 386. In the context of the formation of planets, what is meant by "Differentiation"?

- A) It is a hateful mathematical technique invented by Isaac Newton.
- B) Chemical reactions within the forming planet change the composition of some parts of its interior.
- C) Centrifugal force causes the denser material to move to the outer parts of the planet.
- D) When the planet is molten, the heavier material sinks to the center.

E) The giant planets can easily be differentiated from the terrestrial planets because of their larger sizes.

387. The nucleus of atoms other than hydrogen are composed of

- A) protons and neutrinos
- B) electrons and neutrons
- C) protons, neutrons and electrons
- D) protons and electrons
- E) protons and neutrons

388. What is the general distribution of the planets in their orbits about the Sun?

- A) All of the planets are always on the same side of the Sun.
- B) The orbits go off in all directions (inclinations).
- C) The larger planets are closer to the Sun.
- D) All orbits except one lie in a thin disk.
- E) The larger planets move faster in their orbits.

389. What is necessary for the strong nuclear force to hold together two protons?

- A) The protons must have a low temperature.
- B) The protons must be very close together.
- C) The protons must become neutrons.
- D) The protons must have opposite charge.
- E) The protons must be moving slowly.

390. Roughly what percentage of the mass of the Solar System is contained in the Sun?

- A) exactly all of it; i.e. 100%
- B) 4-5%
- C) 45-50%
- D) 99.8-99.9%
- E) 9.8-9.9%

391. The greatest proportion of the mass of the atom is found

- A) in the protons.
- B) in the nucleus.
- C) in the electrons.
- D) in the neutrons.

392. What is the approximate measured age of the solar system and of the Earth?

- A) 4.5 million years (4,500,000 years)
- B) 4.5 trillion years (4,500,000,000,000 years)
- C) 2002 years
- D) 4.5 billion years (4,500,000,000 years)
- E) 4.5 thousand years (4,500 years)

393. If we compare two stars of different temperature, the hotter star

- A) always looks brighter as seen from Earth.

B) always has higher luminosity.

C) always emits more energy from each unit area

D) always will be larger.

394. The process of 'Differentiation' explains

A) why Jupiter is composed mostly of gas while Earth is composed mostly of rock.

B) why the Earth is not at the center of the Solar System.

C) why Earth's density is constant at all depths.

D) why the material at the cores of the planets is denser than the material in their outer layers.

E) why most of the Solar System's material is in the Sun.

395. We don't see spectral lines from an ordinary incandescent

light bulb because the glowing filament

A) would only give bright (emission) lines.

B) None of the other answers listed here is correct.

C) would only give dark (absorption) lines.

D) has its atoms so close together their structures are

E) is made from atoms which never give spectral lines.

396. What does the number of impact craters per unit area tell us about the surface of a planet or moon?

A) The size of the moon or planet.

B) The numbers of years that have passed since the last resurfacing by a lava flow.

C) The density of the material that makes up the surface.

D) Whether the planet is located near plane of the solar system.

E) Whether the surface is in the shadow of a planet or receives the full force of the impacts.

397. A black body emits an amount of radiation from each unit

area of its surface that is proportional to

A) the inverse square of its absolute temperature.

B) the fourth power of the wavelength.

C) the fourth power of its absolute temperature.

D) the cube of its temperature divided by the mass.

398. Radioactive decay allows us to determine

A) how long it has been since a given impact crater was formed.

B) how long ago the Earth's atmosphere formed.

C) whether or not a rock originally contained Uranium

Uranium

D) how long ago certain rock samples were first formed.

E) the masses of the planets

399. If we compare several objects at the same temperature, all glowing because they are hot, the one that emits the most

light from each unit area of surface will also

- A) appear reddest.
- B) absorb light hitting it most efficiently.
- C) appear faintest.
- D) appear bluest.

400. The planets all go around the Sun in the same direction, and most also spin on their axis in that same sense. This is due to

- A) the conservation of energy.
- B) the fact that light always travels at the same speed.
- C) no special reason... the planets just happen to do that.
- D) Kepler's 3rd law ($P^2 = a^3$).
- E) the conservation of angular momentum.

401. Matter has a dual wave/particle nature just as light does.

- A) True
- B) False

402. What is the history of the rate of crater formation (i.e the rate of bombardment by asteroids, meteorites, etc) in our part of the solar system?

- A) Intense bombardment during the first half billion years, followed by bombardment at a low, steady rate.
- B) Initially a very low rate of bombardment, but then a steady increase up through the present time.
- C) Occasional periods of intense bombardment, with long lulls in between.
- D) All of the bombardment happened right at the start, after which all of the asteroids, meteorites, etc had been swept up on planetary surfaces.
- E) Bombardment at a steady rate ever since the solar system formed, which enables us to calculate the ages of cratered surfaces.

403. An electron occupies only certain orbits in an atom because of its

- A) snobbery
- B) age
- C) negative charge
- D) particle nature
- E) wave nature

404. What theory is the current favorite for the origin of the Moon?

- A) It was formed in an orbit much closer to the Sun, and then captured by the Earth's gravitational field.

B) It was expelled from the Earth by centrifugal force, at a time when the Earth was molten and rotating very rapidly.

C) It and the Earth formed side-by-side at the same time.

D) It formed from the remnants of a collision between Earth and another large body.

E) It was formed far out in the solar system, and then captured by Earth's gravitational field.

405. To find the total mass of a visual binary, we need to first find its

- A) apparent magnitude and distance from Earth.
- B) true orbit and proper motion.
- C) space velocity and apparent orbit.
- D) Doppler shift and proper motion.
- E) distance from Earth and the angular size and period of

406. Why are meteorites so important?

- A) They can be analyzed to tell us about the initial chemical composition of the solar system.
- B) They come in on elongated orbits reaching to the edge of the Sun's sphere of gravitational influence.
- C) They may have been responsible for depositing much of the atmosphere onto the Earth..
- D) They tell us the age of the solar system.
- E) Two of the other answers are correct.

407. While observing the spectrum of a distant star, an astronomer notices that every few hours each spectral line

It can be concluded

- A) the astronomer has periodic fuzzy vision.
- B) the star is moving toward the Earth.
- C) the star is pulsating in size.
- D) there are really two stars that orbit each other.

408. Which is the best description of the process of formation of the planets?

- A) Condensed as very large bodies in the first step, which subsequent meteor impacts then broke up into today's planets.
- B) Condensed in nearly their finished form directly from the solar nebula, in one step.
- C) Nothing is known about how the planets formed.
- D) Venus emerged fully formed from a seashell.
- E) The initial gas condensed into small bodies called planetesimals, which then coalesced into larger and larger bodies.

409. If a stellar spectrum has strong hydrogen lines and strong

molecular lines, then probably the star

- A) is really a double star.

- B) is seen behind a dust cloud.
- C) has an unusual chemical composition.
- D) is hotter than the Sun, but not extremely hot.
- E) is quite cool.

 410. What difference in the formation process caused the giant planets to be so different from the terrestrial planets?

- A) Ices survived in the outer solar nebula, enabling larger protoplanets to be built up, which had enough gravity to then capture the surrounding gas.
- B) The terrestrial planets are moons which have escaped from the giant planets.
- C) The heavy material sank to the center of the solar system, forming the terrestrial planets, while only gas was left in the outer solar system.
- D) The Sun's tidal forces are less in the outer solar system, so larger bodies could survive.

 411. The study of binary stars is important because it allows us to measure

- A) absolute magnitude of stars.
- B) distances of stars.
- C) temperature of stars.
- D) parallaxes and proper motions of stars.
- E) masses of stars.

 412. Why doesn't the material in Saturn's inner rings eventually clump together into just a few large moons?

- A) Because the Great Red Spot is a storm larger than the diameter of the Earth.
- B) It will eventually happen, but it is a very slow process and there hasn't been enough time yet since Saturn was formed.
- C) Because the difference in the orbital velocities at different distances from Saturn tears apart any bodies that try to form.
- D) Because the rings are so thin... only one km thick by our best estimate.

 413. The mass-luminosity law for main sequence stars is based on

- A) less than one hundred
- B) about ten
- C) several thousand

 414. In the Runaway Greenhouse Effect, why is it that light from the Sun can heat a planet, but the planet cannot cool off by re-radiating that energy back out to space?

- A) The planet acts as a black body that only absorbs light; it does not emit light.
- B) The sunlight directly heats the cloud layer, which then conducts the heat to the surface.
- C) The surface heats up from volcanic activity.

D) Visible light from the Sun can pass through the CO₂ in the atmosphere and heat the surface, but the infrared light re-radiated by the planet is trapped by the CO₂.

 415. The most massive stars observed are about

- A) 8000 times the mass of the Sun.
- B) 8 times the mass of the Sun.
- C) 800 times the mass of the Sun.
- D) 80 times the mass of the Sun.
- E) 80,000 times the mass of the Sun.

 416. Which best describes the interior structure of the giant planets?

- A) Jupiter and Saturn have rocky cores, but Uranus and Neptune don't.
- B) A thick methane atmosphere over a central core of metallic hydrogen.
- C) Nothing is known about the interior structure of these planets.
- D) A layer of hydrogen and helium over a core made of ice and rock.
- E) Hydrogen and helium gas that gets denser and denser all the way to the center.

 417. In an H-R diagram, one plots a star's mass against its

- A) False
- B) True

 418. Why are there are two high tides per day on Earth?

- A) Because the Earth goes around the Moon twice per day.
- B) Because the Moon goes around the Earth twice per day.
- C) Because the Moon's gravitational pull sets up a wave that is sometimes on one side of the Earth and sometimes on the other side.
- D) The Moon's gravity pulls most strongly on water on the near side of Earth, least strongly on water on the far side, and a medium amount on the solid bulk of the Earth.
- E) Trick question... there is only one high tide per day, and it occurs on the side nearest the Moon.

 419. The main sequence is a sequence of surface temperature.

What other physical property of a star varies continuously along the main sequence?

- A) age
- B) rotational velocity
- C) chemical composition
- D) mass
- E) extent of the corona

420. The Moon has more maria on its near side than on its far side. This is because:

- A) The volcanic activity on the far side occurred earlier in the Moon's history and has subsequently been covered by more craters than on the near side.
- B) Greater volcanic activity on the far side has deposited a thicker layer of material.
- C) The Earth's gravitational pull causes more large bodies to strike the near side of the Moon than the far side.
- D) The Earth's tidal pull has caused the Moon to have a thinner crust on the near side.
- E) It's a random coincidence.

421. The most luminous stars on the main sequence are the

- A) most massive.
- B) least dense of all stars
- C) longest lived.
- D) coolest.
- E) oldest.

422. What is the source of the best evidence favoring the past existence of life on Mars?

- A) Analysis of samples of ice from Antarctica.
- B) Observations from Earth of canal-like structures.
- C) The careful chemical analysis made by the Viking landers.
- D) Rocks blown off the Martian surface by meteorite impacts.
- E) Rocks brought back by the Apollo astronauts.

423. The largest stars are found in which corner of the H-R diagram?

- A) lower right
- B) lower left
- C) upper left
- D) center
- E) upper right

424. How do the four largest moons of Jupiter compare to Earth's Moon?

- A) They all have compositions similar to that of Earth's Moon.
- B) They are all made of ice, unlike Earth's Moon.
- C) They are all geologically dead, like Earth's Moon.
- D) They all have sizes similar to that of Earth's Moon.
- E) They are all far less massive than Earth's Moon.

425. Where would you look on an H-R diagram to find a very small star with very high density?

- A) below the main sequence
- B) near the lower end of the main sequence

- C) near the center of the main sequence
- D) near the upper end of the main sequence
- E) above the main sequence

426. Which has clouds made of sulfuric acid?

- A) Earth's Moon
- B) Venus
- C) Los Angeles
- D) Mercury
- E) Mars

427. We can obtain the distance to a cluster of stars by comparing an H-R diagram for nearby stars with the cluster's

- A) luminosity-proper motion diagram
- B) spectral type-color diagram
- C) proper motion-tangential velocity diagram
- D) color-luminosity diagram
- E) color-brightness diagram

428. Where in the Solar System do we find most of the asteroids?

- A) Crossing the orbit of Earth.
- B) On highly elliptical orbits reaching out to the very edge of the Solar System.
- C) Slightly beyond the orbit of Pluto
- D) Between the orbits of Mars and Jupiter
- E) Inside the orbit of Mercury.

429. The stars which lie closest to the Sun in space are mostly

- A) hotter than the Sun.
- B) younger than the Sun.
- C) larger than the Sun.
- D) much more luminous than the Sun.
- E) less luminous and cooler than the Sun.

430. The material which is most dominant in Jupiter and Saturn is

- A) ammonia
- B) hydrogen
- C) helium
- D) oxygen
- E) carbon

431. The most abundant element in the Sun is

- A) carbon
- B) hydrogen
- C) helium
- D) oxygen

432. Which part of the Moon is oldest?

- A) the rilles.
- B) the maria and the highlands are the same age.
- C) the lowlands.
- D) the maria.

E) the highlands.

433. Studying the spectrum of the Sun can give no information about its

- A) None of the other answers is correct.
- B) chemical composition.
- C) magnetic fields.
- D) speed toward or away from the Earth.
- E) distance.

434. Mars has

- A) ice caps of frozen carbon dioxide and water.
- B) a very high surface temperature.
- C) rivers carrying water from the poles.
- D) abundant vegetation.
- E) a dense atmosphere.

435. With knowledge of a star's brightness and luminosity, one can compute its

- A) radius
- B) larger Doppler shift
- C) cooler surface temperature
- D) temperature
- E) distance

436. Jupiter's atmosphere is mostly hydrogen and

- A) helium
- B) sulfuric acid
- C) neon
- D) ammonia
- E) water

437. We see absorption lines from different atomic elements in the spectra of stars with different surface temperatures because

- A) excitation and ionization depends on temperature.
- B) a star's color depends on temperature.
- C) composition of stellar surfaces depends on temperature.
- D) potential energy is converted to kinetic energy.

438. The largest volcano in the solar system is found on

- A) Mars
- B) Phobos
- C) Earth
- D) Mercury
- E) Venus

439. The letters classifying the spectral sequence of stars from blue to red (low temperature to high temperature) is

- A) M G K F A O B

B) O B A F G K M

C) M K G F A B O

D) B A F K G M O

E) O B A F K M G

440. Comets like Halley's Comet have periods of just a few 10's of years, while another type of comets has periods of several thousand years. What does this immediately tell us?

- A) One type of comet travels very much farther out in the solar system than does the other type.
- B) The two groups of comets have very different ages.
- C) The short period comets like Halley's come from the Oort Cloud.
- D) The periods of comets gets longer and longer as they repeatedly pass through the inner solar system.
- E) The two groups of comets have very different compositions.

441. The relative strengths of absorption lines in stellar

spectra, considered from cool type to hot (late) type, would show maxima in which of the following sequences?

- A) molecules, hydroge, ionized helium.
- B) hydrogen, neutral helium, ionized helium.
- C) ionized helium, hydrogen, molecules.
- D) neutral metals, hydrogen, helium.
- E) metals, molecules, helium.

442. There is a progressive increase in the level of geological activity in Jupiter's four largest moons:

- A) as you move from the moons closest to Jupiter to the ones farther out, because the tidal forces from Jupiter become stronger at larger distances.
- B) as you move from the moons farther from Jupiter to the ones closer to Jupiter, because of the differences in composition of the moons.
- C) as you move from the smallest of these moons to the largest, because larger moons have greater interior pressures.
- D) as you move from the moons farther from Jupiter to the ones closer to Jupiter, because of the increasingly stronger tidal effects from Jupiter.
- E) as you move from the moons closer to Jupiter to the ones farther out, because of the differences in composition of the moons.

443. If one star has strong lines of molecules and the second

star has no molecular lines but strong hydrogen lines, then

the first star must

- A) be cooler.
- B) have a fainter absolute magnitude.

- C) have a bluer color.
- D) be farther away.
- E) be larger.

 444. Which giant planet does not have much helium in its atmosphere, probably because it has fallen toward the center of the planet?

- A) Saturn
- B) Neptune
- C) Uranus
- D) Jupiter
- E) None of the otehr answers is correct.

 445. Compared to a giant star of the same spectral class, a main sequence star will have

- A) higher luminosity.
- B) broader (or fuzzier) spectral lines.
- C) brighter apparent magnitude.
- D) lower density.
- E) cooler temperature.

 446. A planet is more likely to keep an atmosphere from escaping into space if its upper atmosphere is

- A) hot and the gravitational field is strong.
- B) hot and the atmosphere is made of hydrogen.
- C) cold and the gravitational field is weak.
- D) hot and the gravitational field is weak.
- E) cold and the gravitational field is strong.

 447. If a star has a parallax of one-eighth of a second of arc,

it is at a distance of

- A) 206,265 astronomical units.
- B) eight light years.
- C) one-eighth parsec.
- D) eight parsecs.
- E) one-eighth light years.

 448. Most of the craters on the Moon

A) are seen most easily at full Moon.
 B) were formed in the Moon's first billion years of existence

- C) occur in the younger parts of the Moon's surface.
- D) were predicted to exist by Aristotle.
- E) were created by volcanoes.

 449. The greater the parallax of a star, the smaller its

- A) space velocity
- B) absolute magnitude
- C) temperature
- D) distance
- E) radial velocity

 450. The surface of Mercury most closely resembles

- A) the surface of Venus.

- B) the surface of Jupiter.
- C) the Earth's surface.
- D) the Moon's surface.
- E) the surface of Europa.

 451. To find the total mass of a binary star, we must know the size of the orbit which we get from the angular size of the orbit and the binary star's

- A) Doppler shift
- B) distance
- C) proper motion
- D) brightness

 452. Which of the following has little or no atmosphere?

- A) Earth
- B) Venus
- C) Jupiter
- D) Mars
- E) Mercury

 453. The type of binary star for which information about the

diameters of the components is derived is a(n)

- A) spectroscopic binary
- B) astrometric binary
- C) multiple star
- D) visual binary
- E) eclipsing binary

 454. The Great Red Spot on Jupiter is

- A) the top of a gigantic volcano.
- B) sulfurous clouds over the vertex of a solid obstacle.
- C) a violent cyclonic storm.
- D) reddish dust.
- E) an island floating in a sea of molecular gases.

 455. If we observe a periodic change in the wavelengths in a star's spectrum, probably the star is

- A) actually a planet.
- B) very hot.
- C) a member of a binary system.
- D) among the closest stars to the Sun.
- E) rotating rapidly.

 456. One satellite known to possess a thick atmosphere is

- A) Callisto
- B) Ganymede
- C) Charon
- D) The Earth's Moon
- E) Titan

- 457. Reliable masses have been measured for
A) all of the nearer stars.
B) all stars which are in binary systems.
C) most faint stars.
D) only about 100 stars.
E) most bright stars.

- 458. A) The Earth's Moon
B) Ganymede
C) Callisto
D) Titan
E) Charon

- 459. The Hertzsprung-Russell diagram shows the relation between
A) temperature and color
B) size
C) luminosity
D) apparent brightness and diameter

- 460. The two planets whose orbits cross (i.e. one planet periodically gets closer to the Sun than the other planet) are
A) Mercury and Venus
B) Neptune and Pluto
C) Venus and Earth
D) Mars and Jupiter
E) Uranus and Neptune

- 461. In an H-R diagram, a star's H is plotted against its R.
A) False
B) True

- 462. In general, the younger a region on the Moon, the
A) farther it is from Earth.
B) more craters it has.
C) fewer craters it has.
D) farther it is from the center of the Moon.
E) fewer cracks or rills it has.

- 463. In following the main sequence on the H-R diagram in the direction of increasing temperature, one is also following
a sequence of
A) increasing percentage of hydrogen
B) decreasing mass
C) increasing age
D) increasing mass

- 464. The locations of mountains and valleys on Venus are best found by
A) X-rays emitted by the surface.
B) the strength of radio waves given off.

- C) landing vehicles on the surface to drive around.
D) simple photographs from orbit around Venus.
E) radar measurements.

- 465. A relationship between _____ and _____ holds for main
A) period, radius
B) period, luminosity
C) mass, period
D) temperature, period
E) mass, luminosity

- 466. On which planet have features been photographed that look like erosion patterns from flowing water?
A) Uranus
B) Mercury
C) Venus
D) Mars
E) Jupiter

- 467. Which of the following stars would be the largest?
A) luminosity of 1 unit, temperature of 3000 degrees
B) luminosity of .1 units, temperature of 3000 degrees
C) luminosity of 10 units, temperature of 6000 degrees
D) luminosity of 10 units, temperature of 3000 degrees
E) luminosity of 1 unit, temperature of 6000 degrees

- 468. At the north pole of Mars, the polar cap that lasts all summer is composed primarily of
A) water ice
B) fine particles of sand
C) frozen carbon dioxide
D) frozen nitrogen
E) a mixture of liquid and frozen water (slush)

- 469. The distances of the stars can be inferred from a study of their
A) richness of spectrum.
B) apparent brightness.
C) velocities in the line of sight.
D) None of the other answers is correct.
E) spectrum and apparent brightness.

- 470. A) a mixture of liquid and frozen water (slush)
B) frozen nitrogen
C) fine particles of sand
D) frozen carbon dioxide
E) water ice

471. If a color-brightness diagram of a cluster of stars is compared to an H-R diagram of stars around us, we can use

the comparison to find the cluster's

- A) metal content.
- B) size.
- C) mass.
- D) distance.
- E) space velocity.

472. Io, the inner Galilean satellite of Jupiter, is apparently heated as a result of

- A) decay of radioactive elements.
- B) friction by tides caused by Jupiter.
- C) impacts of objects hitting its surface.
- D) a slow compression of the satellite.
- E) friction with Jupiter's outer atmosphere.

473. If we take a census of the 37 nearest stars, we find that the Sun is

- A) about average with regard to luminosity.
- B) one of the most luminous.
- C) one of the least luminous.

474. An asteroid consists mostly of

- A) dust
- B) frozen gases
- C) ice
- D) hydrogen and helium
- E) rock

475. The locations of all but a few of the stars in the solar

"neighborhood" on the H-R diagram are

- A) in the Supergiant Region.
- B) in the White Dwarf Region.
- C) on the main sequence.
- D) in the H-R Block.

476. The tail of a comet generally

- A) precedes the comet.
- B) points away from the Sun.
- C) follows the comet.
- D) points toward the Earth.
- E) points toward the Sun.

477. Cecilia Payne-Gaposhkin studied spectra of stars of various colors and concluded not only that star spectra depended

primarily on temperature but that the compositions of the stars

- A) are virtually the same.

B) vary greatly with temperature.

C) are primarily of iron when cool and hydrogen when hot.

D) cannot be measured.

478. If you were an astronaut on the dark side of the Moon and your task was to count meteors, how many would you expect to see in one hour?

- A) none
- B) about a dozen
- C) about 100
- D) about the same as on Earth
- E) many more than on Earth

479. The age of the Sun is about

- A) five million years.
- B) five thousand years.
- C) five billion years.
- D) five trillion years.

480. At present, the most abundant gas in the Earth's atmosphere is

- A) ozone
- B) CO₂
- C) oxygen
- D) nitrogen
- E) water vapor

481. The estimated age of the Sun leads one to believe that the

solar energy source is

- A) gravitational contraction.
- B) uranium fission.
- C) hydrogen fusion.
- D) burning of coal.

482. Which has the highest surface temperature?

- A) Mercury
- B) Mars
- C) The Moon
- D) Venus
- E) Earth

483. Northern Lights result from

- A) sunlight shining on the Earth's north polar cap.
- B) light from flares hitting the Earth's upper atmosphere.
- C) charged particles from the solar wind hitting the upper
- D) lightning discharges high in our atmosphere.
- E) the burning of hydrogen high in our atmosphere.

484. Most of the Earth's volcanoes are found in what sorts of places?

- A) above isolated hot spots in the middle of the plates, such as the Hawaiian island chain.

- B) national parks.
- C) at places where meteors have just hit.
- D) under water.
- E) zones where the tectonic plates are either crashing together or spreading apart.

 485. The following energy sources occur in the core of the Sun during its pre-main sequence, main sequence, and red giant stages respectively:

- A) hydrogen fusion, helium fusion, carbon fusion.
- B) cosmic rays, gravitational contraction, hydrogen fusion.
- C) gravitational contraction, hydrogen fusion, helium
- D) helium fusion, hydrogen fusion, carbon fusion.
- E) hydrogen fusion, gravitational contraction, helium

 486. What is thought to be a major cause of the present global warming?

- A) the release of CO₂ as a result of human activity.
- B) the natural long-term increase in the energy output of the sun.
- C) the slow release of radioactive energy from the Earth's crust.
- D) the gradual heating of the Earth due to the slow contraction of its core
- E) the destruction of ozone over Antarctica, due to human pollution of the atmosphere.

 487. Which type of light is used to observe young stars being born?

- A) visible
- B) ultraviolet
- C) gamma-ray
- D) infrared
- E) radio

 488. Which has an atmosphere consisting mostly of CO₂?

- A) Earth
- B) Mercury
- C) None of the other answers is correct.
- D) Mars
- E) The Moon

 489. Stars are probably being born in regions rich in

- A) dust and gas.
- B) red giants.
- C) globular clusters.
- D) heavy elements.
- E) planetary nebulae.

 490. Which has retrograde rotation?

- A) Mars
- B) The Moon
- C) Earth
- D) Venus
- E) Mercury

 491. The order of the stages of evolution a star like our Sun goes through is

- A) red giant, white dwarf, main sequence, proto-star.
- B) proto-star, white dwarf, main sequence, red giant.
- C) red giant, main sequence, proto-star, white dwarf.
- D) proto-star, red giant, main sequence, white dwarf.
- E) proto-star, main sequence, red giant, white dwarf.

 492. Why does Mars have such a thin (low-density) atmosphere.?

- A) Because Mars' low mass means that much of the atmosphere had escape velocity from the planet.
- B) Because of the extremely high surface temperature of Mars.
- C) Because Mars' atmosphere is composed of nitrogen and oxygen.
- D) Because Mars' atmosphere is composed mostly of CO₂.
- E) Because it started out that way.

 493. The lower end of the main sequence is set by the point where

- A) hydrogen stays in a liquid form.
- B) gravity could make the star contract.
- C) stars are too faint for us to see.
- D) a star's core can just barely have hydrogen fusion.
- E) internal pressure would blow the star up.

 494. About half of the heating of Jupiter's atmosphere is due to energy coming up from lower depths. What is the source of this energy?

- A) It is caused by the rapid rotation of the planet, which causes intense heating through friction between the atmosphere and the ground.
- B) It is sunlight which is reflected from low-lying cloud layers.
- C) Jupiter is actually like a small star, with nuclear energy being generated deep in its core.
- D) It is due to the greenhouse effect.
- E) It is due to heat in the interior, left over from the release of gravitational energy when Jupiter formed.

 495. The cluster turn-off point is

- A) hotter for older star clusters.
- B) located at the cluster's apex in the sky.
- C) used to find the ages of stars in a cluster.
- D) located near the Milky Way in the sky.
- E) located at the cluster's antapex in the sky.

496. The volcanic activity on the moon Io is due to
A) continuing contraction of Io's interior.
B) heating of Io's interior by tidal forces due to the gravitational effects of Jupiter.
C) radioactive heating in its rocky interior.
D) the slow release of heat energy left over from Io's original formation.
E) constant impacts by large bodies captured by Jupiter's strong gravitational field.

497. Different stars appear at different places on the main

What fundamental physical quantity causes these stars to be different?

- A) temperature at the surface
- B) age
- C) color
- D) mass
- E) brightness

498. The Cassini/Huygens space probe will attempt to land on the surface of Titan. Why are we so interested in this moon of Saturn?

- A) Because after Earth's Moon, it is the next closest moon to which we can travel.
- B) To obtain rock samples for age dating.
- C) Because the surface of Titan appears to have oceans of water interspersed with rocky continents, just like on Earth.
- D) We wish to study the intense volcanic activity on its surface.
- E) It has an atmosphere with many similarities to Earth's.

499. The Sun's location on an H-R diagram is not on the zero-age main sequence because the Sun has A) too much pressure in its core to balance.

- B) converted the helium in its core to carbon.
- C) the same composition in the core as in the photosphere.
- D) not yet reached the zero-age main sequence.
- E) converted some of the hydrogen in its core to helium.

500. Which of the following statements about Pluto is NOT true? A) It always shows the same face to its moon.

- B) It is similar to some moons of the giant planets.
- C) It is in a very unusual orbit about the sun (as compared to the other planets).
- D) Its surface was mapped in great detail by a space probe.
- E) It has a moon half as big as the parent planet.

501. Unlike a main sequence star, a red giant at its center may be fusing

- A) hydrogen into helium.
- B) iron into uranium.
- C) carbon into lead.
- D) helium into carbon.
- E) nothing. All fusion will have stopped.

502. What is a major reason for the high level of interest in near-Earth asteroids?

- A) This is the most numerous type of asteroid in the solar system.
- B) We want to know if any of them will hit the Earth anytime soon.
- C) These are thought to be fragments of the cataclysm that originally formed our Moon.
- D) These are thought to be far older than any other asteroids.
- E) We are searching for life-forms on these particular asteroids.

503. A star cluster whose H-R diagram has a main sequence which has only very cool stars must be

- A) very old.
- B) very young.
- C) very far away.
- D) in a spiral arm.

504. Why is a comet's dust tail curved while its ion tail is straight?

- A) The particles in the dust tail were ejected from the comet's nucleus many orbits ago and are just trailing along behind in the comet's orbit, while the ion tail is the material which is currently being ejected.
- B) The dust tail consists of particles that streamed off the comet's nucleus in the ion tail, but are now falling back on to it.
- C) Because the particles in the dust tail are shot out of the comet's nucleus by geyser-like activity.
- D) The particles in the ion tail are accelerated outwards much more strongly than those in the dust tail, relative to the gravitational forces that try to keep the particles in orbit about the Sun.
- E) Because the ion tail is the shadow of the comet in the light of the sun, while the dust tail consists of actual particles.

505. A star cluster whose H-R diagram has a main sequence which includes very hot stars must be

- A) a globular cluster.
- B) very young.
- C) very old.
- D) very far away.

506. The Moon has more maria on its near side than on its far side. This is because:

- A) The Earth's gravitational pull causes more large bodies to strike the near side of the Moon than the far side.
- B) The Earth's tidal pull has caused the Moon to have a thinner crust on the near side.
- C) The volcanic activity on the far side occurred earlier in the Moon's history and has subsequently been covered by more craters than on the near side.
- D) Greater volcanic activity on the far side has deposited a thicker layer of material.

507. As our galaxy ages the abundance of heavy elements in the interstellar medium will

- A) decrease.
- B) remain the same.
- C) increase.

508. Valles Marineris is a wide, deep canyon stretching some 2500 miles across the surface of Mars. How was it originally formed?

- A) It was caused by tectonic pressures from deep within the planet.
- B) It was produced suddenly by immense floods of water some 4 billion years ago.
- C) It was slowly cut by a river.
- D) It was scoured out of the Martian sands by the action of regular dust storms.

509. Listed in the order of their increasing density we would find as follows the degenerate or collapsed configurations of material which are equivalent in mass to stars along the main sequence:

- A) white dwarfs, neutron stars, black holes.
- B) neutron stars, black holes, white dwarfs.
- C) black holes, white dwarfs, neutron stars.
- D) black holes, neutron stars, white dwarfs.

510. The surface of Venus has not been seen with telescopes on the Earth due to

- A) interplanetary dust.
- B) the glare of the nearby Sun.
- C) the great distance between the Earth and Venus.
- D) clouds on Venus.

511. A neutron star is typically the size of

- A) the Sun.
- B) Mercury's orbit.
- C) the Earth's orbit.

- D) the Earth.
- E) a large city.

512. Impact craters are produced

- A) only on the Moon and on Mercury.
- B) only during the initial formation of the Solar System.
- C) by volcanic activity on the geologically active planets.
- D) at a (currently) steady rate on all exposed solid surfaces in the Solar System.
- E) only following lava flows.

513. After a supernova event, the remaining core of the star may become a

- A) white dwarf
- B) planet
- C) quasar
- D) black dwarf
- E) neutron star

514. What is the explanation of tidal locking (the tendency of a smaller body to always point the same face towards a larger body about which it is orbiting)?

- A) Friction between the larger bodies and the tides on its surface drag the smaller body more rapidly around in its orbit.
- B) Conservation of angular momentum.
- C) Circulating electrical charges in the core cause a magnetic field.
- D) If the smaller body has an elongated mass distribution, the gravitational force of the larger body is strongest (potential energy is lowest) when the elongation is pointed towards the larger body.
- E) The outer surface of the smaller body is dragged around on top of the mantle, similar to the tides on Earth.

515. Which of the following behaves most like degenerate matter?

- A) liquid water
- B) ionized iron gas
- C) hydrogen gas
- D) solid metal
- E) carbon gas

516. A) Friction between the larger bodies and the tides on its surface drag the smaller body more rapidly around in its orbit.

- B) Conservation of angular momentum.
- C) If the smaller body has an elongated mass distribution, the gravitational force of the larger body is strongest (potential energy is lowest) when the elongation is pointed towards the larger body.

D) The outer surface of the smaller body is dragged around on top of the mantle, similar to the tides on Earth.

E) Circulating electrical charges in the core cause a magnetic field.

517. The Chandrasekhar limit implies that stars ending up more

25 solar masses cannot become

- A) neutron stars
- B) black holes
- C) supernovae
- D) giant stars
- E) white dwarfs

518. Which of the following does NOT need to be described by an equation when computing a model of the Sun's interior?

- A) The Sun formed from the solar nebula.
- B) The Sun is neither contracting nor expanding.
- C) The Sun is neither heating up nor cooling down.
- D) The way in which energy is transported through the Sun's interior.
- E) The Sun is made out of gas.

519. Suspected black holes are detected as _____ in a binary

- A) X-ray objects
- B) novae
- C) observed singularities
- D) dark objects
- E) Black holes cannot be detected by any known means.

520. What is the most important factor that tells us that the Sun's interior structure must change and evolve?

- A) Matter is steadily being accreted onto the Sun through collisions with asteroids and comets.
- B) Mass is being lost in huge quantities through the solar wind.
- C) Differentiation (the downward settling of heavier elements) is bringing helium into the central core.
- D) The composition is being changed by the nuclear reactions.

521. The light variation of a Cepheid variable is best explained

by the theory that Cepheids are

- A) pulsating
- B) exploding
- C) black holes
- D) rapidly rotating
- E) binary stars

522. What is currently the major source of the Sun's energy?

- A) Conversion of helium to iron through the proton-proton reaction.
- B) Gravitational contraction.
- C) Angular momentum.
- D) Conversion of hydrogen to helium through the proton-proton reaction.
- E) Conversion of helium to iron through the CNO cycle.

523. Miss Leavitt arrived at a period-luminosity relation for

Cepheid variables from her studies of

- A) binary stars
- B) the Magellanic Clouds
- C) globular clusters
- D) galaxies

524. Where in the Sun is most of its energy produced?

- A) Only in the layer where there is a lot of convection going on.
- B) Pretty much throughout the Sun.
- C) Only near the photosphere.
- D) In the central core.
- E) Nowhere.

525. Mass flowing onto the surface of a white dwarf star can

cause the star to become a

- A) red giant star
- B) Cepheid variable star
- C) red dwarf star
- D) black hole
- E) nova

526. When you look up at the Sun in the sky, NOT during an eclipse, the glowing part which you can directly see is called

- A) the photosphere.
- B) the bathysphere.
- C) the chromosphere.
- D) the corona.
- E) the reflection of Detroit.

527. Where does the Crab Nebula ultimately get the energy which

is observed as radiation being emitted by the nebula?

- A) from a slowdown in the spin of a neutron star
- B) from the original supernova explosion
- C) from a pulsating white dwarf
- D) from fusion of hydrogen to helium
- E) from very fast vibrations of a neutron star

528. Which part of the Sun's atmosphere (i.e. its outer layers) is the hottest?

- A) all parts have the same temperature (5800 degrees K).
- B) the photosphere.
- C) the corona.
- D) the sunspots.
- E) the transition region.

 529. The Crab Nebula is the result of a supernova explosion

At the present time the nebula

- A) is contracting as matter falls back onto the star.
- B) is still expanding from the original explosion.
- C) appears to be expanding because it is getting closer.
- D) has become static and quite featureless.

 530. When "prominences" of hot gas are ejected from the sun's surface, what force causes them to often form huge arcs?

- A) Gravity.
- B) The electrostatic force.
- C) Jedi warriors.
- D) Conservation of angular momentum.
- E) Magnetic fields.

 531. The heavy elements we see in the universe probably were created mainly in

- A) planetary nebulae.
- B) nova explosions.
- C) red giant stars.
- D) supernova explosions.
- E) Bethlehem Steel.

 532. If you measure the flux from a star and want to know its luminosity, what other parameter do you need to measure?

- A) its temperature.
- B) its age
- C) its distance
- D) its color
- E) its diameter

 533. A planetary nebula represents the transition between what two stages of a star?

- A) red giants and white dwarf
- B) proto-star and main sequence
- C) proto-star and red giant
- D) main sequence and Cepheid variable
- E) red giant and supernova

 534. Which of the following is a method for measuring the surface temperature of a star?

- A) Using a spectrograph to see what absorption lines are present in its spectrum.
- B) Measuring its color, using colored filters and a photocell.
- C) None of the other answers are correct.
- D) Measuring its flux and distance.
- E) Two of the other answers are correct.

 535. The three fundamental forces are

- A) faith, hope and charity
- B) electrical, magnetic and nuclear
- C) gravity, nature and repulsion
- D) earth, wind and fire
- E) gravitational, electromagnetic, and nuclear

 536. If hydrogen is the most common element in the universe, why do we not see the lines of hydrogen in the spectra of the hottest stars?

- A) Because the hottest stars emit all of their light as x-rays and are invisible from Earth.
- B) In the hottest stars, hydrogen atoms are ionized, so there are no electrons to produce hydrogen lines in the spectrum.
- C) In the hottest stars, hydrogen can quickly combine with oxygen to make H₂O, whose spectrum consists of completely different lines.
- D) In the hottest stars, all hydrogen in the star has quickly fused into helium.
- E) In the hottest stars, hydrogen nuclei are forced to break apart into smaller nuclei.

 537. Even though they have average densities roughly equal to that of water, main sequence stars are gaseous because their interior temperatures are so high that they are completely ionized and the average particle size is therefore not the size of the atom, but the size of the nucleus of the atom

- A) False
- B) True

 538. If you compare the spectra of two stars which have the same chemical composition, and see that in star A the absorption lines of hydrogen come from more highly excited states than in star B, then you know that

- A) star A has a larger radius than star B.
- B) star A is cooler than star B.
- C) star A has a smaller radius than star B.
- D) that both stars are made of pure hydrogen (no other elements present).
- E) star A is hotter than star B.

 539. The temperature in the center of the Sun is about

- A) 15, unclar fishing

- B) 15 million, hydrogen fusion
- C) 15 hundred, nuclear fission
- D) 15 thousand, hydrogen fusion
- E) 15 billion, helium fusion

 540. What causes the 11 and 22-year Solar Cycle in which the numbers of sunspots change in a periodic way?

- A) The Sun's rate of spin changes on an 11 year cycle.
- B) The Sun's magnetic field winds up, disappears, and then is regenerated.
- C) The sunspots are caused by the Sun's gravitational interaction with Jupiter, which has an 11-year orbital period.
- D) The sunspots are due to asteroids crashing into the sun, the rate of which varies on an 11 year cycle.
- E) The rate at which the Sun generates energy changes on an 11 year cycle.

 541. The "Northern Lights" are caused by

- A) nuclear fission.
- B) gravitational contraction.
- C) the solar wind.
- D) nuclear fusion.

 542. What important fact can you learn by measuring the shifts of the absorption lines in the spectra of the stars in a spectroscopic binary system?

- A) The relative luminosities of the two stars.
- B) The relative ages of the two stars.
- C) The sum of the masses of the two stars.
- D) That it is no longer possible to learn what chemical elements are in the star.
- E) The distance to the pair of stars.

 543. The equivalence between mass and energy was first stated by

- A) Capriotti, $E=M$
- B) Einstein, $E=MC^2$
- C) Kirchhoff, $E=MC$
- D) Fraunhofer, $E=MC^4$
- E) Newton, $E=MC^3$

 544. Ninety percent of all stars, if plotted on the H-R diagram, would fall into a region astronomers call:

- A) the pits.
- B) the white dwarf region.
- C) the main sequence.
- D) the visual region.
- E) the supergiant region.

 545. The following energy sources occur in the core of the Sun

during its pre-main sequence, main sequence, and red giant

stages respectively:

- A) hydrogen fusion, gravitational contraction, helium fusion.
- B) cosmic rays, gravitational contraction, hydrogen fusion.
- C) helium fusion, hydrogen fusion, carbon fusion.
- D) gravitational contraction, hydrogen fusion, helium fusion.
- E) hydrogen fusion, helium fusion, carbon fusion.

 546. A giant star, compared to a main sequence star with the same surface temperature, would always be

- A) farther away from Earth.
- B) redder.
- C) smaller in diameter.
- D) more luminous.
- E) bluer.

 547. Young stars being born are best seen in the _____ part of

- A) radio
- B) visible
- C) gamma-ray
- D) infrared
- E) ultraviolet

 548. The Orion Nebula is

- A) a small disk of gas the size of our solar system, from which planets are forming.
- B) a bubble of hot gas illuminated by the light of several newly-formed stars within it.
- C) the reflection off a molecular cloud of continuum light from distant stars.
- D) a region heated by the collision between two massive stars.
- E) the remnant of a star which exploded several thousand years ago.

 549. A newly-formed star with the Sun's mass slowly contracts toward the main sequence, radiating at the expense of

_____ until the onset of _____ stops the contraction and supports

- A) gravitational energy, hydrogen fusion
- B) electromagnetic energy, hydrogen fusion
- C) hydrogen fusion, helium fusion
- D) gravitational energy, helium fusion

 550. The main sequence is a sequence of surface temperature. What other physical property of a star varies continuously along the main sequence?

- A) rotational velocity
- B) chemical composition
- C) mass

- D) extent of the corona
- E) age

551. The order of the stages of evolution a star like our Sun goes through is

- A) red giant, white dwarf, main sequence, proto-star.
- B) proto-star, white dwarf, main sequence, red giant.
- C) proto-star, main sequence, red giant, white dwarf.
- D) red giant, main sequence, proto-star, white dwarf.
- E) proto-star, red giant, main sequence, white dwarf.

552. Which technique has led to the discovery of most of the currently-known planets outside the solar system?

- A) directly taking pictures of the planet.
- B) measuring periodic dimming of the star about which the planet orbits.
- C) measuring periodic changes in the radial velocity of the star about which the planet orbits.
- D) the discovery that many political figures seem to live on distant planets.

553. A cluster of stars contains, O, B, and A main sequence stars but it also contains G and K stars lying above the main sequence. It can be concluded that

- A) I have gotten some incorrect data from my observations.
- B) the cluster is extremely young.
- C) the cluster is about the age of the Sun.
- D) I have found a halo population object.

554. The big surprise about most of the extra-solar planets discovered to date is:

- A) they do not yet have McDonald's hamburger stands.
- B) they have masses similar to Jupiter, but orbits smaller than Earth's.
- C) they are found only around the most massive stars.
- D) they not only have small orbits, but short orbital periods.
- E) only Jupiter-sized planets have been found.

555. Those main-sequence stars which go through their evolution most rapidly are the

- A) stars like the Sun.
- B) All main sequence stars evolve at the same rate.
- C) red stars of low mass.
- D) very massive stars.

556. What causes the center of a proto-star to heat up during the time that it is contracting towards the main sequence on the H-R diagram?

- A) Nuclear fusion.

- B) Nuclear fission.
- C) It is absorbing radiation from nearby stars.
- D) It is converting H into He.
- E) Release of gravitational potential energy.

557. T Tauri stars are apparently

- A) stars that have not yet quite reached the main sequence.
- B) left over from a nova outburst.
- C) faint main sequence stars.
- D) found mostly in old star clusters.
- E) stars that just left the main sequence.

558. What is the most likely cause of the "Pillars of Creation" in M16?

- A) They are molecular gas that has not evaporated because it is in the shadow of particularly dense globules.
- B) They are material being squirted out from the site of a collision between two giant molecular clouds.
- C) The force of gravity causes the molecular gas to collapse into long, narrow streamers.
- D) The molecular gas has condensed in the wake of rapidly moving stars.
- E) They are just chance patterns in a complex jumble of cloud shapes.

559. If we compare two main sequence stars of the same mass, one formed recently and the other formed 10 billion years ago, we find that the older star

- A) has much stronger spectral lines of hydrogen.
- B) is considerably larger.
- C) has a much higher luminosity.
- D) has a much lower abundance of heavy elements.
- E) probably has much smaller space velocity.

560. What is the energy source of stars on the main sequence of the H-R diagram?

- A) Release of gravitational energy.
- B) Burning helium into carbon in the core of the star.
- C) The breakup of uranium into lighter elements.
- D) Burning hydrogen into helium in the core of the star.
- E) Burning hydrogen into helium in a shell outside the core of the star.

561. The elements more massive than iron were produced in

- A) main sequence stars
- B) proto-stars
- C) the planets
- D) supernova explosions
- E) white dwarf stars

562. Which type of star spends the longest time on the main sequence?

- A) A red giant.
- B) A white dwarf.
- C) A star like the Sun.
- D) A low-mass M star.
- E) A high-mass O star.

563. Which choice has the objects ranked by size, largest to smallest?

- A) black hole, red giant, sun, neutron star, white dwarf
- B) sun, red giant, black hole, neutron star
- C) red giant, sun, white dwarf, neutron star, black hole
- D) red giant, white dwarf, sun, neutron star, black hole

564. What determines how long different types of stars last on the main sequence?

- A) Whether they transport energy to their surface by convection or by radiation.
- B) The rate at which they burn their fuel relative to the amount of fuel they start with.
- C) Their eventual diameters when they have run out of nuclear fuel.
- D) The rate at which they can contract due to the force of gravity.
- E) Whether they are made out of pure hydrogen or pure helium.

565. A white dwarf is typically the size of ____ and _____ in

- A) the Sun, gaseous
- B) the Earth's orbit, gaseous
- C) the Earth, metallic
- D) Mercury's orbit, liquid
- E) a large city, metallic

566. As a star becomes a giant, its outer layers are expanding. Where does the energy for expanding these layers come from?

- A) from the fusion of helium into carbon in the core.
- B) from the gravitational collapse of the core.
- C) from the fusion of hydrogen into helium in the core.
- D) from an explosion which disintegrates the core
- E) from the fusion of hydrogen into helium in a shell around the core.

567. The Chandrasekhar limit implies that stars ending up more

- A) black holes
- B) neutron stars

- C) supernovae
- D) giant stars
- E) white dwarfs

568. How can we tell the age of a cluster of stars?

- A) The lowest mass star on the cluster's H-R diagram tells you the age of the cluster.
- B) The hottest star on the cluster's main sequence is just finishing its life on the main-sequence.
- C) The flux coming from a main-sequence M star is proportional to its age.
- D) The luminosity of a main-sequence M star is proportional to its age.

569. Black holes are

- A) very cold stars.
- B) always extremely massive objects.
- C) places where gravity prevents light from escaping.
- D) places where no matter can exist.

570. When the core of a star is not burning nuclear fuel, what is it doing (up until it becomes a white dwarf)?

- A) Contracting and heating.
- B) Expanding and heating.
- C) Expanding and cooling.
- D) It just sits there hoping for something to happen.
- E) Contracting and cooling.

571. The second time the Sun moves into the red giant stage it

will become a _____ that will eject its envelope forming a

- A) eclipsing variable, black hole, Cepheid variable
- B) supernova remnant, neutron star, black hole
- C) Mira variable, planetary nebula, white dwarf
- D) planetary nebula, white dwarf, neutron star

572. If the Sun suddenly became twice as large in diameter as it is now, but maintained the same surface temperature, which way would it move on the H-R diagram?

- A) directly to the right.
- B) straight down.
- C) diagonally to the upper right.
- D) diagonally to the upper left.
- E) straight up.

573. In 1912 Miss Leavitt discovered that the Cepheid variables in the Small Magellanic Cloud

- A) obeyed a period-mass relation.
- B) obeyed a period-luminosity relation.
- C) were all the same brightness.
- D) all had the same period.

574. Why are the less massive stars NOT able to produce elements heavier than carbon and oxygen?

- A) because the star's center cannot get hot enough for the fusion of heavier nuclei.
- B) because the cores of such stars get too hot for further types of fusion to be able to happen.
- C) because all such elements become radioactive and their nuclei break apart rather quickly.
- D) because all such stars explode before they can produce heavier elements.
- E) because those are the two most stable nuclei; production of heavier nuclei requires the input of energy.

575. Most, and maybe all, novae apparently are _____ that involve

- A) pulsating stars, rotating white dwarf
- B) members of close binary stars, white dwarf
- C) main sequence stars, mira variable
- D) rotating neutron stars, pulsating star
- E) red giants, neutron star

576. What is the source of pressure that holds up a white dwarf?

- A) Nuclear reactions.
- B) The electrostatic repulsion between the neutrons in its core.
- C) The expansion of hot gas.
- D) Its electrons cannot be squeezed any closer together.
- E) Sound waves.

577. The Crab Nebula was caused by a

- A) nova
- B) supernova

578. Why do neutron stars emit periodic pulses of light?

- A) They are in short-period orbits around larger stars which periodically block our view of the pulsar.
- B) They are powered by wildly unstable nuclear reactions.
- C) They emit narrow beams of light that rapidly rotate through our field of view.
- D) They suffer frequent power outages due to winter storms.

579. The heaviest (most complex) atomic nuclei found on Earth were made in

- A) the outer layers of a pulsating M star.
- B) the explosion of a supernova.
- C) a planetary nebula.
- D) the interior of the Sun.

580. Which of the following chemical elements has the simplest structure in its nucleus?

- A) carbon
- B) oxygen
- C) iron
- D) hydrogen
- E) uranium

581. The variability of the light from Cepheid variable star is

- A) caused by a pulsation.
- B) caused by an eclipsing companion.
- C) undetectable.
- D) non-repeating.

582. Which of the following is NOT a possible end point in stellar evolution?

- A) White dwarf.
- B) Black hole.
- C) All of these are possible end points.
- D) Neutron star.
- E) Main sequence star.

583. The "Kapteyn universe" was an early model for the

- A) universe, with the Sun at the center.
- B) universe, with the Sun displaced from the center.
- C) universe, similar to the
- D) universe, similar to the

584. Stars are born in regions rich in

- A) red giants.
- B) heavy elements.
- C) dust and gas.
- D) planetary nebulae.
- E) globular clusters.

585. The main reason Herschel thought the Milky Way galaxy was considerably smaller than it really is was because he did

not include the effects of

- A) H II regions.
- B) bright blue stars.
- C) radio and spectral lines.
- D) interstellar dust.
- E) the lack of heavy elements in nearby stars.

586. The most massive stars

- A) are the coolest stars.
- B) have the shortest lives.
- C) have the smallest diameters.
- D) live the longest.
- E) are the least luminous.

587. Roughly how long does it take for the Sun to go around the Galaxy one time?

- A) 6,000 years
- B) 250 billion years
- C) 100,000 years
- D) 250 million years
- E) 1 billion years

588. When we apply the famous equation $E=mc^2$ to the Sun's energy source, what does this tell us?

- A) That the total kinetic energy contained in the Sun is its mass multiplied by the speed of light squared.
- B) That the total gravitational energy of the Sun is its mass multiplied by c squared.
- C) That protons must be moving at nearly the speed of light in order to have enough energy to react.
- D) That some of the Sun's initial mass of hydrogen can be converted to energy through the conversion of hydrogen to helium.
- E) That nuclear fusion reactions cannot be the source of the Sun's power.

589. The 21 cm radio line, seen in many interstellar clouds, is produced by the spin-flip of an electron in

- A) neutral hydrogen.
- B) neutral iron.
- C) neutral helium.
- D) interstellar molecules.
- E) ionized hydrogen.

590. The Drake Equation tries to calculate the number of intelligent civilizations that might be trying to communicate with us at any time. The problem with this equation is:

- A) it is irrelevant because nobody is looking for signals from other civilizations.
- B) it ignores the effect of dust between the stars.
- C) it is a string of probabilities, many of which have unknown values.
- D) it does not take the speed of light into account.
- E) no planets have ever been found around other stars.

591. The spiral arms of our Galaxy can be located by the use of

- A) double stars.
- B) red giants.
- C) hydrogen 21 cm lines.
- D) supernovae.
- E) white dwarfs.

592. Which part of the Sun has the greatest density?

- A) The photosphere.

- B) Since the sun is made of gas, all parts must have the same density.
- C) The corona.
- D) The central core.
- E) The convection region.

593. The mass of our Galaxy is best found by measuring

- A) how much interstellar hydrogen is emitting radio waves.
- B) the number of stars in the galaxy.
- C) the number of hot main sequence stars.
- D) the masses of binary stars.
- E) the rotation of the galaxy.

594. Where in the Sun is most of its energy produced?

- A) In the central core.
- B) Nowhere.
- C) Only near the photosphere.
- D) Only in the layer where there is a lot of convection going on.
- E) Pretty much throughout the Sun.

595. Populations I and II can be distinguished by means of differences in

- A) All of these answers are correct.
- B) motions and positions in the galaxy.
- C) chemical composition.
- D) position in the H-R diagram.

596. How is energy transported through the interior of the sun?

- A) Hot bubbles of gas are formed at the very center and then float to the surface, while cool gas flows downward clear to the center.
- B) By conduction in the central, solid core, then by convection further out.
- C) By the random walk of radiation, all the way from the center to the surface.
- D) By radiation in the inner part, and then by convection in the outer part.
- E) By photons which are emitted in the center and then escape in one shot all the way out through the surface.

597. O and B associations and their H II regions are usually found in what part of the galaxy?

- A) spiral arms
- B) globular clusters
- C) halo
- D) None of the other answers.
- E) nucleus

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

- A) nitrogen
- B) helium
- C) kryptonite
- D) oxygen
- E) hydrogen

599. Shapley determined the direction of and the distance to the center of the galaxy by correctly assuming the frame of the galaxy is represented by the distribution of

- A) binary stars
- B) Cepheid variables
- C) globular clusters
- D) O type stars

600. On Earth, a period of low sunspot activity such as the Maunder minimum, means:

- A) less volcanic activity.
- B) a climate with cooler temperatures.
- C) very little; there is no connection between the Sun's activity and what happens on Earth.
- D) partial melting of the polar icecaps.

601. The globular clusters

- A) are concentrated near the edge of the galaxy.
- B) are present only in our galaxy.
- C) are concentrated in spiral arms.
- D) are concentrated in the galactic nucleus.
- E) are spherically distributed about the galactic center.

602. According to the inverse square law, the flux received from a star 3 times farther away than another identical star will be

- A) 9 times larger than the flux from the nearer star.
- B) 3 times larger than the flux from the nearer star.
- C) the same as the flux from the nearer star.
- D) 9 times smaller than the flux from the nearer star.
- E) 3 times smaller than the flux from the nearer star.

603. If we located clouds of gas and dust on a chart of the sky,

where are the clouds generally located?

- A) Scattered fairly uniformly over the whole sky.
- B) In regions away from the Milky Way.
- C) Along the ecliptic.
- D) Along the Milky Way.
- E) In the same region where globular clusters are.

604. If stars A and B both radiate like black bodies, and star A is hotter than star B but both stars have the same diameters, then

- A) star A will emit less total energy than does star B.

B) the atoms in the atmosphere of star A will be less ionized than those in star B.

C) Trick question. All stars have the same surface temperature.

D) star A will emit its maximum amount of light at a smaller wavelength than does star B.

E) star A will appear red while star B will appear blue.

605. Complex molecules such as alcohol are found mostly in

- A) the atmospheres of hot stars.
- B) supernovae.
- C) emission nebulae.
- D) dark dust clouds.
- E) sunspots.

606. Which color star is likely to be the hottest?

- A) Red
- B) Yellow
- C) Green
- D) Blue-violet
- E) Orange

607. A good example of a dark nebula is the

- A) Veil Nebula in Cygnus.
- B) Trapezium in Orion.
- C) Ring Nebula in Lyra.
- D) Horsehead Nebula in Orion.
- E) Crab Nebula in Taurus.

608. How are emission lines formed?

A) They are formed when an atom is cooled down to absolute 0 (0° K).

B) They are formed in the process of an atom being ionized.

C) An electron jumps to a higher orbit (farther from the nucleus).

D) An electron falls to a lower orbit (closer to the nucleus).

E) They are paid for by soft campaign funds.

609. If several luminous hot stars are seen embedded in a cloud

of glowing gas in the sky, we are probably seeing an area

- A) where a supernova recently exploded.
- B) where stars are dying out.
- C) where a new galaxy is forming.
- D) where several planetary nebulae are close together.
- E) of recent star formation.

610. Which type of star has the coolest surface temperature?

- A) A stars

- B) F stars
- C) G stars
- D) M stars
- E) O stars

 611. What color is a typical reflection nebula, and why?

- A) Blue; the illuminating star is blue.
- B) Blue; blue light reflects better off dust particles.
- C) Red; it radiates like a red-hot black body.
- D) Red; hydrogen has a strong red spectral line.
- E) Red; red light reflects better of dust particles.

 612. If you look at the spectrum of a cool gas superimposed in front of a bright background black-body source, you will see

- A) emission lines on top of continuum radiation.
- B) only emission lines.
- C) absorption lines cutting into continuum radiation.
- D) no light at all.
- E) only continuum radiation.

 613. The Galaxy is at present thought to be about

- A) 1,000,000 light years in diameter.
- B) 100 light years in diameter.
- C) None of the choices given here is correct.
- D) 100 parsecs in diameter.
- E) 100,000 light years in diameter.

 614. What is the basic idea behind the parallax method of measuring distances to stars?

- A) You measure the shift in wavelength of an emission or absorption line.
- B) You measure the difference in time for light to travel to one side of Earth's orbit or to the other side.
- C) You measure the flux and luminosity of a star, and then solve for its distance.
- D) You measure the change in direction to the star as the Earth moves from one side of its orbit to the other.
- E) The speed of the arriving photons depends on the distance to the star which emitted them.

 615. The best estimate of the mass of the milky way galaxy is the equivalent of about

- A) 200 suns.
- B) 200,000,000 suns.
- C) 200,000 suns.
- D) 200 billion suns.
- E) 200 trillion suns.

 616. You are measuring the spectrum of the stars in a spectroscopic binary system. When one of the stars is moving toward the Earth in its orbit, you observe

- A) that the lines in its spectrum move towards shorter wavelengths.

- B) none of the other answers is correct.
- C) that it is no longer possible to learn what chemical elements are in the star.
- D) that the lines in its spectrum merge with the lines of the other star.
- E) that the lines in its spectrum get brighter.

 617. The three main types of galaxies are

- A) spiral, globular, erratic
- B) globular, irregular, open
- C) small, medium and large
- D) spiral, elliptical, irregular

 618. Which has the smallest mass?

- A) the Sun
- B) a brown dwarf.
- C) an M star.
- D) the Universe.
- E) a planet.

 619. The distance to nearby galaxies can be obtained from

- A) trigonometric parallax.
- B) spectroscopic parallax.
- C) Hubble's law.
- D) red giant stars.
- E) Cepheid variables.

 620. Which of the following sets of parameters determines the position of a star on the HR diagram?

- A) Its luminosity and temperature.
- B) Its flux, distance, and spectral type.
- C) Its temperature and diameter.
- D) All of these do.
- E) Its luminosity and spectral type.

 621. The galaxies near us (out to about 1 million parsecs) are called

- A) M33
- B) the near ones
- C) the nearby crowd
- D) the local group
- E) None of these.

 622. Ninety percent of all stars (if plotted on the H-R diagram) would fall into a region astronomers call:

- A) the pits.
- B) the white dwarf region.
- C) the visual region.
- D) the supergiant region.
- E) the main sequence.

 623. Distances to individual galaxies can be estimated by using

- A) supernovae in galaxies.

- B) Cepheid variables in galaxies.
- C) the globular clusters in the galaxies.
- D) all of the other answers.
- E) H II regions.

 624. A giant star (compared to a main sequence star with the same surface temperature) would always be

- A) farther away from Earth.
- B) redder.
- C) larger in diameter.
- D) less luminous.
- E) bluer.

 625. The most massive galaxies belong to the type of galaxies known as

- A) ellipticals
- B) globular
- C) irregular
- D) barred spirals
- E) normal spirals

 626. When a star settles down to a stable existence as a main-sequence star, what characteristic determines where on the main sequence in an H-R diagram the star will fall?

- A) its mass.
- B) whether it is located in the outer regions or the central regions of the molecular cloud that gave it birth.
- C) the temperature of the molecular cloud from which it formed.
- D) the size of the disk around it.
- E) the fraction of its atmosphere that consists of hydrogen.

 627. Which type has no interstellar medium or young stars?

- A) spiral
- B) elliptical
- C) Seyfert

 628. Why do young stars often have long, narrow streams of material sticking out from them in two opposite directions?

- A) The rapidly-moving protostar has carved a long tunnel through the interstellar dust, and is able to excite and ionize the gas in this tunnel.
- B) They are losing mass, which is being channeled by a disk surrounding the star.
- C) In all cases these are actually just disks seen edge-on.
- D) Material falls onto the proto-star just at its poles, because of the star's strong magnetic field.
- E) Newton's law of action-reaction requires this.

629. Ring galaxies and galaxies with long "tails" are thought to be created by

- A) two galaxies colliding.
- B) supernova explosion.
- C) rapid rotation of a spiral galaxy.
- D) spiral arms that became unusually massive.
- E) hot intergalactic gas.

 630. The average kinetic energy of the individual atoms in a gas cloud is measured by

- A) chemical composition.
- B) their temperature.
- C) density.
- D) pressure.
- E) mass.

 631. A galaxy that has no bright blue stars would be expected to have

- A) a relatively low mass.
- B) a rapid rotation.
- C) bright emission nebulae.
- D) relatively frequent supernova explosions.
- E) little interstellar gas and dust.

 632. The luminosity of a star

- A) was first introduced by Hipparchus.
- B) can be measured only if the star is ten parsecs away.
- C) is the rate at which it radiates energy.
- D) usually is greater for stars with large proper motion.
- E) depends upon the distance to the star.

 633. Hubble's law states that the velocity of recession of a

- A) galaxy is inversely proportional to its distance.
- B) galaxy is independent of its distance.
- C) star is inversely proportional to its distance.
- D) galaxy is proportional to its distance.
- E) star is proportional to its distance.

 634. From a star's distance and flux, one can find the star's

- A) proper motion.
- B) space velocity.
- C) tangential velocity.
- D) luminosity.
- E) spectral type.

 635. Hubble's study of the distribution of galaxies indicated that

- A) the galaxies are distributed uniformly in the sky.

- B) few galaxies are seen near the plane of the Milky Way.
C) more galaxies are counted towards the globular clusters.
D) tend to occur near H II regions.

- 636. If two stars have the same luminosity, the cooler star must have a
A) larger diameter.
B) bluer color.
C) larger Doppler shift.
D) smaller radius
E) greater mass.

- 637. Which is used to measure the mass of a galaxy?
A) period-luminosity relation
B) inverse square law
C) Kepler's third law
D) total luminosity of galaxy
E) principle of relativity

- 638. There are three stars which are all at the same distance and are the same size. Star A is 5000 degrees, star B is 8000 degrees and star C is 10,000 degrees. Which is brightest?
A) star C
B) star A
C) They are all equally bright.
D) star B

- 639. The concept of the "Expanding Universe" is based on the interpretation of the observed red shifts of the galaxies as due to
A) Doppler effect.
B) continuous creation of matter.
C)
D) Communist infiltration.
E)

- 640. The redder a star is,
A) the larger it must be.
B) the lower its surface temperature.
C) the denser it is.
D) the younger it is.
E) the smaller it must be.

- 641. The arms of spiral galaxies
A) trail behind the galactic rotation.
B) pull the galaxy around behind them.
C) are jet propelled.
D) expel population II stars into the corona.

- 642. The main reason the pattern of stellar spectral lines changes from one spectral type to the next is the
A) temperature changes.

- B) composition changes.
C) absolute magnitude changes.
D) diameter changes.

- 643. The properties which collectively characterize Population I (disk population) stars are
A) higher metal abundances, younger ages, circular orbits.
B) low metal abundances, old ages, elongated orbits.
C) low metal abundances, young ages, no massive stars.
D) found only in black holes, old ages.

- 644. The letters classifying the spectral sequence of stars from blue to red (high temperature to low temperature) is
A) O B A F G K M
B) A B C D E F G
C) M K G A F B O
D) B A L D W I N
E) M A Y B E M E

- 645. Light has a dual nature; sometimes behaving like waves,
A) False
B) True

- 646. Knowing only the color of a star, one can often estimate the star's
A) luminosity
B) apparent magnitude
C) radial velocity
D) temperature
E) mass

- 647. The rotation curve of our galaxy indicates that objects in the galaxy orbit the galactic center primarily under the gravitational influence of:
A) neighboring galaxies.
B) a massive black hole at the center of the galaxy.
C) a massive dark matter halo.
D) the material in the spiral arms.
E) main sequence 0-type stars.

- 648. The most abundant chemical elements in a star's photosphere will almost always give the strongest spectral lines in the star's visible spectrum.
A) False
B) True
C) Disregard this choice
D) Disregard this choice

- 649. Herschel and later Kapteyn concluded that the Milky Way

consists of a disk with the Sun near the center, based on

his observations of

- A) distances and directions of globular clusters.
- B) O and B stars.
- C) the 21-cm emission line.
- D) the number of stars he saw in different directions.
- E) H II regions.

650. As we look at the stars hotter than spectral class A, the higher the temperature, the weaker the hydrogen spectral lines. Why?

- A) The hydrogen is used to form molecules.
- B) All hydrogen atoms have electrons in the first orbit.
- C) Strong helium lines cover the hydrogen lines.
- D) Too much of the hydrogen is ionized.
- E) Very hot stars have converted hydrogen to helium.

651. Stars in the neighborhood of the Sun revolve once around the center of the galaxy in about

- A) 200 billion years.
- B) 250 million years.
- C) 2 million years.
- D) 2 billion years.

652. With knowledge of a star's flux and luminosity, one can compute its

- A) mass
- B) radius
- C) distance
- D) temperature
- E) surface gravity

653. The gas and dust in the Galaxy is strongly confined to the

- A) reflection nebulae.
- B) diffuse nebulae.
- C) galactic halo.
- D) H II regions.
- E) spiral arms.

654. If we compare two stars of different temperature, the hotter star

- A) always looks brighter as seen from Earth.
- B) always will be larger.
- C) always emits more energy from each unit area
- D) always has higher luminosity.

655. The general structure of spiral arms in distant parts of

our galaxy can be mapped using

- A) visible light.
- B) the 10-Mhz frequency of WWV.
- C) the 21-cm radiation of hydrogen.

D) visible light and 21-cm radiation of H I.

656. The difference between a normal atom and its ion is the fact that the ion

- A) None of the other answers is correct.
- B) is moving more slowly than a normal atom.
- C) doesn't have the usual number of electrons for that atom.
- D) has more static electricity in its nucleus.
- E) weighs more than the atom.

657. To map very distant spiral arms in our galaxy, we must use

21-centimeter radiation rather than young hot stars because

- A) young hot stars are obscured by 21-cm radiation.
- B) hot stars get slightly reddened and look like cool stars.
- C) distant stars show large Doppler shifts.
- D) radio waves penetrate dust clouds.
- E) radio waves penetrate interstellar gas.

658. While observing the spectrum of a distant star, an astronomer notices that every few hours each spectral line splits and becomes two. It can be concluded

- A) the astronomer has periodic fuzzy vision.
- B) the star is moving toward the Earth.
- C) there are really two stars that orbit each other.
- D) the star is pulsating in size.

659. Generally, as a star orbits in our galaxy, the closer it

stays to the galactic plane the

- A) less metals it has.
- B) older it is.
- C) more eccentric its orbit around the galaxy.
- D) less massive it is.
- E) younger it is.

660. The study of binary stars is important because it allows us to measure

- A) masses of stars.
- B) temperature of stars.
- C) distances of stars.
- D) parallaxes and proper motions of stars.
- E) absolute magnitude of stars.

661. Shapley estimated the distance to the center of our galaxy

from the locations of

- A) galactic clusters.
- B) 21-centimeter radio emission from hydrogen.
- C) young massive main sequence stars.
- D) Cepheid variables.
- E) globular clusters.

662. The stars in the diagonal band running from the upper left to the lower right in the H-R Diagram are known as

- A) supergiants.
- B) giants.
- C) All of the other answers are correct.
- D) white dwarfs.
- E) main sequence stars.

663. Comparing globular clusters and open clusters, which of the following is true?

- A) Globulars are found closer to the Milky Way in the sky.
- B) Open clusters are more massive (have more stars).
- C) Stars in globulars have strong spectral lines of metals.
- D) There are more red stars in open clusters.
- E) Open clusters have hotter and bluer bright stars.

664. The most luminous stars on the main sequence are the

- A) coolest.
- B) least dense of all stars
- C) longest lived.
- D) most massive.
- E) oldest.

665. If one region of the sky shows nearby stars but no distant

stars or galaxies, our view is probably

- A) being blocked by cold interstellar gas.
- B) directed toward a particularly empty region of space.
- C) being blocked by many cool stars.
- D) being blocked by an interstellar dust cloud.
- E) being blocked by an emission nebula.

666. By a star's position on an H-R diagram, we can determine its

- A) color, distance, and chemical composition.
- B) distance, apparent brightness, and mass.
- C) luminosity, surface temperature, and size.
- D) age, chemical composition, and luminosity.
- E) age, luminosity, and distance.

667. Clouds rich in dust silhouetted against a bright background

- A) reflection
- B) planetary
- C) dark
- D) emission
- E) bright

668. The largest stars are found in which corner of the H-R diagram?

- A) center
- B) upper left
- C) upper right
- D) lower right
- E) lower left

669. The gas in H II regions is radiating under the influence of

- A) stars which have formed out of the nebulae.
- B) stars in the central region of the galaxy.
- C) cosmic rays.
- D) energy derived from magnetic fields.

670. Where would you look on an H-R diagram to find a very small star with very high density?

- A) near the center of the main sequence
- B) near the upper end of the main sequence
- C) near the lower end of the main sequence
- D) above the main sequence
- E) below the main sequence

671. What is the principal difference between an emission and a reflection nebula?

- A) The temperatures of the nearby stars differ.
- B) The reflection nebula contains more hydrogen.
- C) The luminosity of the nearby stars differ.
- D) Only the reflection nebula contains dust.

672. The Sun is a

- A) supergiant star
- B) giant star
- C) blue star
- D) white dwarf star
- E) main sequence star

673. The properties which collectively characterize Population I

(disk population) stars are

- A) low metal abundances, old ages, elongated orbits.
- B) higher metal abundances, younger ages, circular orbits.
- C) found only in black holes, old ages.
- D) low metal abundances, young ages, no massive stars.

674. The spectral lines of a star are observed to be shifted to longer wavelengths than those measured for a source at rest. Therefore,

- A) the star is approaching us.
- B) the star is moving away from us.
- C) the star is rather cool.
- D) the star is very hot.

675. The diameter of our Galaxy is closest to

- A) 100 light years

- B) 100,000 light years
- C) 1,000,000 light years
- D) 10,000 light years
- E) 1000 light years

676. The basic cause of the different spectral classes is

- A) age
- B) pressure
- C) composition
- D) luminosity
- E) surface temperature

677. Galactic cannibalism is a

- A) significant factor only away from galaxy clusters.
- B) confirmed origin of dwarf elliptical galaxies.
- C) confirmed cause of supernova explosions.
- D) reason why S0 galaxies contain much gas and dust.
- E) possible origin of giant elliptical galaxies.

678. In an H-R diagram, a star's H is plotted against its R.

- A) False
- B) Disregard this choice
- C) True
- D) Disregard this choice

679. Elliptical galaxies comprise about _____ percent of all

- A) 3
- B) 25
- C) 15
- D) 50
- E) 70

680. Most of the stars on the H-R diagram belong to which group?

- A) red giant
- B) super giants
- C) main sequence
- D) white dwarf

681. The local group refers to

- A) the white dwarfs in the vicinity of the Sun.
- B) all stars within 100 light years of the Sun.
- C) the Andromeda galaxy and its two companion galaxies.
- D) the small cluster of galaxies, to which our own belongs.

682. In following the main sequence on the H-R diagram in the direction of increasing temperature, one is also following a sequence of

- A) decreasing mass
- B) increasing mass

- C) increasing percentage of hydrogen
- D) increasing age

683. The Magellanic Clouds are

- A) cirrus clouds seen only in the southern hemisphere.
- B) small irregular galaxies and companions of the Milky Way.
- C) the super-aggregate of which our own galaxy is a part.
- D) nearby elliptical galaxies.

684. The chemical composition of the Sun, by weight, is about

- A) 50 percent metals, 50 percent hydrogen.
- B) 73 percent hydrogen, 25 percent helium, 2 percent others.
- C) 75 percent helium, 20 percent hydrogen, 5 percent others.
- D) 75 percent carbon, 25 percent helium.
- E) 50 percent metals, 50 percent helium.

685. A galaxy consisting primarily of old stars with very little cool gas and dust will be a(n)

- A) spiral
- B) elliptical
- C) peculiar
- D) quasar
- E) irregular

686. The very high pressure inside the Sun does not blow the Sun apart because of the

- A) Sun's neutrino emission.
- B) inward force of gravity.
- C) nuclear reactions going on there.
- D) Sun's magnetic field.
- E) Sun's rotation.

687. A galaxy that has long "tails" reaching out into space is

- A) several supernovae going off near the nucleus.
- B) the effects of magnetic fields.
- C) a galaxy which lacks a halo.
- D) the collision of two galaxies.
- E) a strong galactic wind.

688. Why does the conversion of helium to carbon require a higher temperature than the conversion of hydrogen to helium?

- A) Helium doesn't ionize as easily as hydrogen.
- B) The repulsion of like charges is stronger for helium.
- C) Carbon more easily forms a black body.
- D) Helium gas is more dense than hydrogen.

E) Helium gas is less dense than hydrogen.

689. We would expect a galaxy with many bright blue stars

- A) to contain no life.
- B) to have little or no dust and gas.
- C) to have much dust and gas.
- D) to have no old stars.
- E) to contain no stars like the Sun.

690. The order of the stages of evolution a star like our Sun goes through is

- A) red giant, white dwarf, main sequence, proto-star.
- B) proto-star, white dwarf, main sequence, red giant.
- C) red giant, main sequence, proto-star, white dwarf.
- D) proto-star, red giant, main sequence, white dwarf.
- E) proto-star, main sequence, red giant, white dwarf.

691. According to the Hubble law, clusters of galaxies twice as

- A) away from, 2 x
- B) away from, 4 x
- C) towards, 2 x
- D) towards, 4 x

692. The highest mass that a star has on the main sequence is set by the point where the

- A) central temperature causes helium to form carbon.
- B) age of the star is older than the age of the universe.
- C) radiation is so strong it converts helium to hydrogen.
- D) central temperature barely can cause hydrogen to fuse.
- E) luminosity prevents more mass from collecting.

693. If the sky is photographed to locate other galaxies on a

- A) star chart, the galaxies that are seen are clustered in the same part of the sky as globulars.
- B) occur more frequently near the Milky Way.
- C) tend to occur near H II regions in the Milky Way.
- D) uniformly across the entire sky.
- E) tend to be seen only rarely in the Milky Way.

694. The lower end of the main sequence is set by the point where

- A) hydrogen stays in a liquid form.
- B) stars are too faint for us to see.
- C) a star's core just barely gets hot enough for hydrogen fusion.
- D) internal pressure would blow the star up.
- E) gravity could make the star contract.

695. The masses of spiral galaxies are calculated from their

rotation curves by application of

- A) Hubble's law.
- B) Kirchhoff's law.
- C) Newton's second law.
- D) Kepler's third law.
- E) Newton's third law.

696. A star cluster whose H-R diagram has a main sequence which has only very cool stars must be

- A) very old.
- B) very young.
- C) very far away.
- D) in a spiral arm.

697. The particle nature of light is demonstrated by

- A) refraction.
- B) short wavelength of x-rays.
- C) the photoelectric effect.
- D) the interference effect.

698. A star cluster whose H-R diagram has a main sequence which includes very hot stars must be

- A) a globular cluster.
- B) very young.
- C) very far away.
- D) very old.

699. The distances to stars more luminous and hotter than the

Sun are usually found from

- A) parallax
- B) the
- C) brightness
- D) angular size

700. A neutron star is typically the size of

- A) the Earth's orbit.
- B) Mercury's orbit.
- C) the Sun.
- D) the Earth.
- E) a large city.

701. The mass-luminosity law for main sequence stars is based on

- A) about ten
- B) several thousand
- C) about one hundred

702. A white dwarf is typically the size of

- A) the Sun.
- B) Mercury's orbit.
- C) a large city.
- D) the Earth's orbit.
- E) the Earth.

703. Which of the following has essentially no atmosphere?

- A) Earth
- B) Mercury
- C) Jupiter
- D) Mars
- E) Venus

704. An object whose gravitational field is so strong that light cannot escape is called a

- A) dark nebulae
- B) neutron star
- C) black hole
- D) black dwarf
- E) pulsar

705. The outer Galilean moons of Jupiter are thought to consist primarily of

- A) hydrogen, methane, and ammonia.
- B) carbon dioxide and nitrogen.
- C) metals and rock.
- D) ice, water, and rock.

706. The central stars of planetary nebulae

- A) are cool stars.
- B) ejected the matter found in the nebulae
- C) have condensed out of the material of the nebulae.
- D) captured the matter of the nebulae.

707. Since distant galaxies all seem to be moving away from us, we are very close to the point of origin of the explosion

- A) True.
- B) False.

708. The temperature in the center of the Sun is about _____ degrees K which is hot enough for _____ to occur.

- A) 15 million, hydrogen fusion
- B) 15, unclear fusion
- C) 15 hundred, nuclear fission
- D) 15 thousand, hydrogen fusion
- E) 15 billion, helium fusion

709. For which theory might we expect to see differences between the nearest and the most remote galaxies?

- A) Steady State
- B) Big Bang

710. Regions rich in _____ are the birthplaces of stars.

- A) dust and gas
- B) planetary nebulae
- C) globular clusters

- D) heavy elements
- E) red giants

711. The cosmological principle states that all observers,

everywhere in space, would

- A) believe themselves to be at the center of space.
- B) see total confusion.
- C) view the same large scale picture of the universe.
- D) be members of civilizations of the same maturity.

712. A newly-formed star with the Sun's mass slowly contracts toward the main sequence, radiating at the expense of _____ until the onset of _____ stops the contraction and supports the star for its main sequence lifetime.

- A) electromagnetic energy, hydrogen fusion
- B) gravitational potential energy, hydrogen fusion
- C) gravitational potential energy, helium fusion
- D) hydrogen fusion, helium fusion

713. If the quasars are indeed the very most distant objects in

- A) True.
- B) False.

714. Those main-sequence stars which go through their evolution most rapidly are the

- A) stars like the Sun.
- B) red stars of low mass.
- C) All main sequence stars evolve at the same rate.
- D) very massive stars.

715. One method of keeping the universe in a Steady State is to postulate

- A) the steady expansion of the universe.
- B) the spontaneous creation of matter.
- C) the production of supernovae.
- D) the rotation of galaxies.

716. The energy emitted by a white dwarf comes from

- A) contraction, releasing potential energy.
- B) core helium burning.
- C) the heat stored in the star.
- D) hydrogen burning.

717. Quasars

A) should be more common in the future than in the past.

B) were more common when the universe was younger.

C) probably have less than a thousand solar masses.

D) have the same luminosity as giant elliptical galaxies.

E) have absorption lines but rarely have emission lines.

718. Sunspots are

- A) hotter regions on the surface of the sun.
- B) places where magnetic field lines leave or enter the Sun's surface.
- C) related to the Sun's electric field.
- D) cyclonic storms similar to Jupiter's great red spot.
- E) a hot, rarified gas surrounding the Sun.

719. In the outline of the Big Bang cosmology, all of the matter and radiation in the universe was occupying a tiny volume

- A) one hundred billion
- B) one billion
- C) one hundred million
- D) fifteen billion

720. The chromosphere of the Sun lies

- A) above the photosphere.
- B) next to the core.
- C) outside of the corona.
- D) in the region where the Sun's gas is hottest.
- E) below the photosphere.

721. The primeval atom contained how much mass?

- A) all the mass in the universe
- B) 1 billion solar masses
- C) 6 protons and 6 neutrons
- D) 1 million solar masses
- E) 4 solar masses

722. A solar flare is

- A) a burst of energy that shows up as a sudden brightening of the Sun.
- B) a sudden increase in the rate of nuclear reactions at the Sun's center.
- C) the place where the majority of absorption lines form.
- D) a dark region on the photosphere.
- E) the bright visible surface of the Sun.

723. Which elements were present when the universe was 500 seconds old?

- A) hydrogen
- B) hydrogen and helium
- C) all the elements now present
- D) only elements heavier than iron

724. Which of the following statements is false?

- A) The sun is one of the hottest known stars.
- B) White dwarf stars are much denser than main sequence stars.

C) The greater a star's mass, the faster it converts its fuel to energy.

D) On the main sequence, more massive stars are brighter.

725. Which one of these is a name for the source of 3 radio and

microwave emission coming from the entire sky?

- A) primeval fireball
- B) giant elliptical
- C) galaxy
- D) quasar

726. What has to happen inside a star before it is possible to initiate each new nuclear reaction in the chain leading to heavier and heavier atoms?

- A) The star must become a white dwarf.
- B) The star's outer layers must expand.
- C) The star must lose some of its mass.
- D) The gas temperature has to increase.
- E) The gas pressure has to increase.
