

Name \_\_\_\_\_

Do not forget to write your name and fill in the bubbles with your student number, followed by a 0, and fill in test form A on the answer sheet. Write your name above as well. **You will lose points if you don't do this.** You have as much time as you need. For each question, mark the best answer. The formulas you may want are:

$$\frac{\theta}{360^\circ} = \frac{\ell}{2\pi d}$$

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

$$P^2 = a^3 \quad (M + m) P^2 = a^3$$

$$c = \lambda f$$

$$c = 3 \times 10^8 \text{ m/sec}$$

$$\frac{v_r}{c} = \frac{\lambda_1 - \lambda_0}{\lambda_0}$$

$$E = hf$$

$$T \lambda_{\text{Peak}} = 2900 \text{ K} \cdot \mu\text{m}$$

$$P = knT$$

$$d = \frac{3.26 \text{ ly}}{p}$$

$$\frac{L}{L_\odot} = \left( \frac{T}{T_\odot} \right)^4 \left( \frac{R}{R_\odot} \right)^2$$

$$L = 4\pi d^2 B$$

$$v = Hd$$

$$H = 22 \text{ km/s/Mly}$$

- By Doppler shift, a galaxy is discovered to be moving away from us at 1100 km/s. Approximately how far away is this galaxy from us?
  - 0.02 Mly
  - 0.2 Mly
  - 50 Mly
  - 5 Mly
  - 0.5 Mly
- The majority of the mass of a spiral galaxy is in the form of
  - A giant black hole in the center of the galaxy
  - Stars concentrated in the bulge of the galaxy
  - Stars spread throughout the disk of the galaxy
  - Gas that is spread throughout the disk of the galaxy
  - Dark matter, mysterious matter that is spread throughout the halo of the galaxy
- Which feature of type I supernovae makes them useful as a standard candle?
  - They are all about the same distance away
  - They are all about the same age
  - They are all about the same luminosity
  - They are all very small as viewed from Earth
  - They all have strong hydrogen spectral lines
- What type of galaxy do we probably live in?

- A) An elliptical galaxy
  - B) A lenticular galaxy
  - C) A spiral or barred spiral galaxy
  - D) An irregular galaxy
  - E) An apocryphal galaxy
5. Why is dust important to discuss when discussing galaxies?
- A) Dust obscures our views of certain places, especially in the plane of the galaxy
  - B) Because dust is the brightest part of a galaxy, it is the easiest to keep track of
  - C) Dust forms the cores of stars; without it, stars couldn't form
  - D) Dust is used to trace out the spiral arms of galaxies
  - E) Eliminating dust-bunnies is one of the unsolved problems of the Universe
6. The cause of spiral arm structure in galaxies is probably
- A) Density waves, waves of higher density that travel around the center
  - B) Winding, where straight structures get wound up over time
  - C) Pinwheel effect, caused by intergalactic winds blowing on the galaxy
  - D) Collisions, where small galaxies twist up the otherwise straight structures of the arms
  - E) Magnetic fields, which twist particles into spiral shapes
7. What do we call a collection of galaxies that are grouped together?
- A) A galaxy cluster
  - B) A galaxy supercluster
  - C) A stellar cluster
  - D) The universe
  - E) A stellar system
8. Where can the largest number of stars be found in a spiral galaxy like ours?
- A) The disk
  - B) The bulge
  - C) The nucleus
  - D) The halo
  - E) Hollywood
9. If we could see the neutrinos from a type II supernova, it would be as luminous as
- A) A 100 Watt light bulb
  - B) The Sun
  - C) A very bright star
  - D) An entire galaxy of stars
  - E) All the stars in the known universe
10. The Andromeda galaxy is believed to be the largest / most massive galaxy in the Local Group. What is the name of the second most massive galaxy in the Local Group?
- A) Dwingeloo

- B) The Milky Way
- C) The Larger Magellenic Cloud
- D) The Smaller Magellenic Cloud
- E) M33

11. What makes the galaxies become elliptical vs. spiral is mostly a question of
- A) How much hydrogen vs. helium is found in the galaxy
  - B) How much the galaxy is rotating
  - C) How large (in size) the galaxy is
  - D) How massive the galaxy is
  - E) How recently the galaxy collided with other galaxies
12. Where, in our galaxy, would be a good place to look for the oldest stars?
- A) The spiral arms
  - B) The bulge
  - C) The nucleus
  - D) The globular clusters
  - E) The disk
13. How long, roughly, does it take for the Moon to go around the Earth?
- A) About a day
  - B) About a week
  - C) About a fortnight (two weeks)
  - D) About a month
  - E) About a year
14. Which of the following best describes the cause of a type I supernova?
- A) A white dwarf accreting mass from a giant neighbor, the outer layer periodically burns in a giant explosion
  - B) A white dwarf accreting mass from a giant neighbor, it exceeds the Chandrasekhar mass, collapses, and catastrophically burns / explodes the whole star
  - C) A neutron star accreting mass from a giant neighbor
  - D) A black hole accreting mass from a giant neighbor
  - E) A pair of neutron stars or black holes coalescing to make a larger black hole
15. What is a Roche lobe?
- A) In a binary star system, it is the region controlled by one star or the other's gravity
  - B) The region in the H-R diagram where binary stars normally are found
  - C) Jets of gas that are ejected from one or the other star in a binary star system
  - D) Any of the distended spiral arms found in galaxies after they collide
  - E) The large radio emission regions found surrounding a radio galaxy
16. Which of the following objects is farther away from the Sun than the rest?
- A) Mercury
  - B) Pluto
  - C) Uranus

- D) Jupiter
- E) Mars

17. Which stage of a star's lifetime takes the longest?

- A) Asymptotic giant
- B) Main sequence
- C) Horizontal branch
- D) Planetary nebula
- E) Protostar

18. During a *lunar* eclipse, what is going on?

- A) The Earth is blocking our view of the Sun
- B) The Moon is blocking our view of the Sun
- C) The Moon is in the shadow of the Earth
- D) The Moon is in the shadow of the Sun
- E) The Earth is in the shadow of the Moon

19. Which of the following objects radiates back into the universe substantially more energy than it absorbs from the Sun?

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

20. Why is (almost) everything in the Universe expanding away from our galaxy, rather than from some other galaxy?

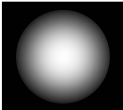
- A) Our galaxy happens to be very close to the center of the Universe, so we see everything moving away from us
- B) Though we aren't near the center of the Universe, our galaxy has a large peculiar velocity, compensating for our motion, and making it look like we're in the center
- C) Our galaxy has a very high rate of supernovas, that have pushed the other galaxies away from us
- D) Light gets red-shifted as it falls into our galaxy, making it look like everything is moving away from us, even though many things are moving towards us
- E) There is nothing special about our galaxy. You'd see the same thing from any other galaxy.

21. How did giant elliptical galaxies get to be so large?

- A) They formed from gigantic clouds of gas that coalesced all at once
- B) They began as a single massive star that fragmented to make the whole galaxy
- C) They formed from the collision/merger of many, many smaller galaxies

- D) They started as a few small stars that spewed out gas from which many more stars were formed
  - E) They form in the midst of voids from gas that is repelled from all the other galaxies around
22. In what part of our galaxy do we live?
- A) The nucleus
  - B) The globular clusters
  - C) The halo
  - D) The bulge
  - E) The disk
23. The 21 cm radio line can be used to map out
- A) H II regions, where hydrogen is completely ionized
  - B) H I regions, where there are hydrogen atoms
  - C) Molecular clouds, where hydrogen can be found in molecules
  - D) Dust, which emits a lot of the 21 cm line
  - E) Interstellar gas, which is diffuse enough to emit this line
24. How large, typically, are the lobes of radio power from a radio galaxy?
- A) As large or larger than the galaxy
  - B) About the size of the bulge of the galaxy
  - C) About the size of a cluster of stars in the galaxy
  - D) About the size of the Solar System
  - E) About the size of the Sun
25. What is the process that produces energy in the center of the Sun?
- A) Chemical burning of hydrogen to water
  - B) Nuclear burning of hydrogen to helium
  - C) Chemical burning of carbon to carbon dioxide
  - D) Nuclear burning of helium to carbon and oxygen
  - E) Nuclear burning of carbon or oxygen to heavier elements
26. Which of the following is a characteristic common of the gas giants?
- A) They are mostly made of rocks and/or metals
  - B) They have few if any moons
  - C) They have rings
  - D) They are closer than the orbit of Earth
  - E) Images of them show lots of evidence of cratering
27. Approximately how big across (diameter) is the disk of our galaxy?
- A) 100,000 km
  - B) 100 AU
  - C) 100,000 AU
  - D) 100 ly

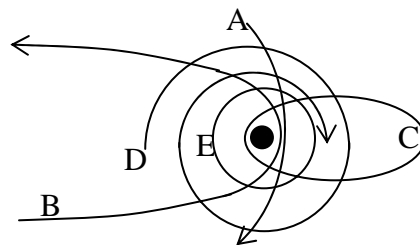
E) 100,000 ly

28. Which of the following is true about galaxy collisions?
- A) Galaxy collisions are very rare, because galaxies are so small compared to their separation
  - B) Galaxy collisions don't really have very much effect on the galaxies, since the stars miss each other
  - C) Galaxy collisions often produce irregular galaxies, at least temporarily
  - D) Galaxy collisions cause the destruction of many of the stars in the two galaxies as they collide
  - E) Galaxy collisions are probably responsible for the phenomenon called gamma ray bursters
29. In class I showed you rotation curves for some galaxies that show how fast they are rotating as a function of distance. How were these speeds measured?
- A) By taking pictures over time, and just seeing how fast they rotate
  - B) By measuring the blurring of the stars in images, which is a sign of fast motion
  - C) By knowing the mass and using Newton's version of Kepler's third law to deduce the velocity
  - D) By measuring the Doppler shift of various parts of the galaxy
  - E) I have no idea; please mark this one incorrect
30. From biggest to smallest, list the three things that contribute to the total amount of stuff in the Universe
- A) ordinary matter, dark matter, dark energy
  - B) dark energy, ordinary matter, dark matter
  - C) dark energy, dark matter, ordinary matter
  - D) dark matter, ordinary matter, dark energy
  - E) ordinary matter, dark energy, dark matter
31. The galaxy sketched at right is probably what type?
- A) E0    B) SBc    C) Sb    D) Irr    E) E5
- 
32. Which planet is the largest one that is not a gas giant?
- A) Saturn
  - B) Neptune
  - C) Mars
  - D) Mercury
  - E) Earth
33. The production of carbon dioxide on the Earth is a substantial concern because
- A) It is poisonous and kills plants, depleting oxygen
  - B) It allows large amounts of ultraviolet light to the surface of the Earth, which causes cancer
  - C) It is a greenhouse gas, warming the Earth
  - D) It affects plate tectonics, increasing the likelihood of large earthquakes

- E) It is subducted by volcanoes, making them more violent and dangerous
34. In round numbers, how long will the Sun last, from birth to death?
- A) 10 million years
  - B) 100 million years
  - C) 1 billion years
  - D) 10 billion years
  - E) 100 billion years
35. Active galactic nuclei have a power source that is not very large. The fact that it is not large helps us explain
- A) How they can change their brightness so quickly
  - B) Why they are so dim
  - C) Why the gases in the accretion disk are moving so quickly
  - D) Why they are so bright
  - E) Why our view of them is so often blocked by dust
36. What is the name of the Supercluster that our galaxy belongs to?
- A) The Coma Supercluster
  - B) The Perseus Supercluster
  - C) The Virgo Supercluster
  - D) The Milky Way Supercluster
  - E) The Andromeda Supercluster
37. Which of the following objects probably has substantial oceans of liquid water under the surface?
- A) Io
  - B) Neptune
  - C) Mars
  - D) Europa
  - E) Titan
38. Whether the universe is finite or infinite depends on the amount of stuff in the universe, denoted by  $\Omega$ . What values of  $\Omega$  would imply a finite universe?
- A) If  $\Omega > 1$ , but not if  $\Omega = 1$  or  $\Omega < 1$
  - B) If  $\Omega = 1$ , but not if  $\Omega < 1$  or  $\Omega > 1$
  - C) If  $\Omega < 1$ , but not if  $\Omega > 1$  or  $\Omega = 1$
  - D) If  $\Omega > 1$  or  $\Omega = 1$ , but not if  $\Omega < 1$
  - E) If  $\Omega < 1$  or  $\Omega = 1$ , but not if  $\Omega > 1$
39. The Hertzsprung-Russell diagram is a diagram of a star's
- A) Mass vs. temperature
  - B) Mass vs. luminosity
  - C) Mass vs. brightness
  - D) Temperature vs. brightness
  - E) Temperature vs. luminosity

40. A new asteroid has just been discovered which circles the Sun at a distance of 9 AU. How long does it take to go around the Sun?
- A) 27 years
  - B) 9 years
  - C) 3 years
  - D) 1/3 year
  - E) 1/9 year
41. On a couple of occasions, I showed you pictures of “old” or “ancient” galaxies, by which I meant pictures of galaxies as they looked long ago. How can we know what galaxies looked like long ago?
- A) There’s a really old guy with a pinhole camera who took the pictures
  - B) Light passing through H I regions leaves an impression that can be “read” billions of years later using infrared telescopes
  - C) It is simply assumed that ancient galaxies look like modern ones, so we take modern galaxies and computer anti-age them appropriately
  - D) You can deduce the ages of stars from their position on the H-R diagram. If you then replace the stars with what they WOULD have looked like long ago, you get a picture of such an old galaxy
  - E) Since light moves only one light year per year, you can simply look at very very distant galaxies, which would show you how they looked long ago
42. Observations of distant Type I supernovae suggest that
- A) The Universe is expanding, but the expansion is slowing down
  - B) The Universe is expanding at a steady rate
  - C) The Universe is expanding, and the expansion is speeding up
  - D) The Universe is neither expanding nor contracting
  - E) The Universe is contracting
43. The evil Dr. Vile, floating in space, has just activated the Doomsday Device! Professor Heroic, floating a few meters away, realizes her only chance to save the Earth is to get to Dr. Vile and type in the disable code. Thinking quickly, she draws her reaction pistol and fires directly *away* from Dr. Vile. Why?
- A) Professors are old. They don’t think clearly and they don’t see very well
  - B) The projectiles from the pistol will orbit the Earth, hitting Dr. Vile from the other side, killing him and perhaps propelling the control panel to her.

- C) It is probably a “warning shot”, fired to convince Dr. Vile to turn off the device or be killed.
- D) Whatever is propelled out of the reaction pistol is being pushed on, and therefore will push back on Prof. Heroic, propelling her *toward* Dr. Vile.
- E) The gasses from the reaction pistol will create a sound wave that will hit Dr. Vile and crush the control panel
44. Which of the following colors is *not* a single pure wavelength of light?
- A) Red  
B) Blue  
C) Green  
D) Yellow  
E) White
45. There is a relationship between the period of a Cepheid variable star and its actual luminosity. This is important because
- A) It allows astronomers to predict the period of stars, knowing only the luminosity  
B) It acts as a reliable time calibrator, allowing astronomers to determine if time passes at the same rate on distant stars that it does on Earth  
C) The period is easy to measure, and then knowing the luminosity and measuring the brightness, one can determine the distance  
D) There is a further relationship between the mass and luminosity, so by measuring the period you can determine the mass  
E) It allows one to determine the temperature, since this is related to the luminosity.
46. What aspect of a star will make it have a short lifetime?
- A) If it has a high initial helium content  
B) If it has a low initial helium content  
C) If it has a small mass  
D) If it has a large mass  
E) If it has a diet high in fat and doesn't exercise
47. Approximately how old is the universe?
- A) 14 trillion years  
B) 1.4 trillion years  
C) 140 billion years  
D) 14 billion years  
E) 1.4 billion years
48. According to Newton, which of the orbits sketched at right is impossible?

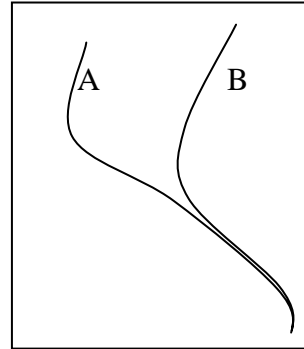


49. The basic difference between a moon and a planet is
- A) A planet goes around the Sun. A moon goes around a planet
  - B) All planets are larger than all moons
  - C) A planet always has an atmosphere; a moon never does
  - D) Planets have magnetic fields. Moons do not
  - E) Planets always face the Sun. Moons always face planets
50. When a comet is moving away from the Sun, its tail points
- A) Behind it
  - B) To one side, perpendicular to its path, but in the same plane as its orbit
  - C) Ahead of it
  - D) To one side, perpendicular to its path and perpendicular to the plane of its orbit
  - E) Towards the Earth, whichever direction that happens to be
51. On the largest scale, matter in the Universe seems to be distributed as
- A) In long strings, like a plate of spaghetti
  - B) In flat planes, like a stack of pancakes
  - C) In solid chunks with very little empty space in between, like a stack of oranges
  - D) Mostly empty space, with a thin areas of matter in between, like soap bubbles
  - E) In flat, round clusters, like a jar full of quarters
52. Why isn't parallax used to measure the distance to Andromeda, our nearest neighbor large galaxy?
- A) Parallax can only be used to measure the distances to distant objects, where the small angle approximation works
  - B) Parallax relies on main sequence stars, and there aren't any main sequence stars in Andromeda
  - C) Parallax can only be used on nearby objects, because if the objects are distant it is difficult to measure the angles accurately
  - D) Parallax requires a bright, individual star, and there are no stars bright enough in Andromeda to use this method
  - E) Parallax requires an excellent view, and Andromeda is obscured by so much dust and gas that we can't see it.
53. Which of the following is the best description of the effect known as Doppler effect?
- A) The wavelength of light changes to longer or shorter wavelength if an object is moving towards or away from us
  - B) The average wavelength of an object gets shorter or longer depending on its temperature
  - C) Dust absorbs some wavelengths of light more than others, causing the average wavelength to shift around
  - D) The position of a star on the Hertzsprung-Russell diagram shifts over time

E) Each type of atom absorbs or emits only certain wavelengths, shifted compared to other atoms

54. At right are sketched approximate HR diagrams for two different star clusters. Which star cluster is older?

- A) Cluster A
- B) Cluster B
- C) They are the same age
- D) There is insufficient information to tell



55. Hubble's Law, simply put, states that galaxies

- A) Are all moving away from us at approximately the same speed
- B) Are all moving away from us, with more distant ones moving faster
- C) Are all moving towards us at approximately the same speed
- D) Are all moving towards us, with more distant ones moving faster
- E) Are, on the average, moving neither towards us nor away from us

56. What makes an object in the sky look small (small angular size)

- A) If the object is large and nearby
- B) If the object is large and far away
- C) If the object is small and nearby
- D) If the object is small and far away
- E) If the object is dim, so it is difficult to see

57. What's a good, practical way to estimate the total mass of a galaxy cluster?

- A) Add up the masses of all the stars in the cluster
- B) Add up the mass of all the gas in the cluster, estimated from the X-rays they emit
- C) Put a satellite in orbit around the cluster and measure the period
- D) Measure the amount that light from distant sources is extinguished by all the stuff in the cluster blocking it
- E) Measure the amount that light is bent as it passes by the cluster

58. Our current view of the history of the universe is that

- A) It began in a giant explosion called the Big Bang, and will expand forever
- B) It began in a giant explosion called the Big Bang, and will end in the Big Crunch
- C) The universe is, has always been, and always will be expanding at a steady rate
- D) The universe alternates between periods of expansion and periods of contraction
- E) The universe was produced during a giant sneeze by the Creator and will end with the Coming of the Great White Hanky

59. Which of the following is probably not caused by a galaxy with a black hole that is eating stuff at the center?
- A) Quasars
  - B) Radio galaxies
  - C) Blazars
  - D) X-ray binaries
  - E) Seyfert galaxies
60. If the universe began as a giant explosion, where is the light from that explosion?
- A) It has spread far away from us, and is no longer visible here
  - B) It was absorbed by gas and dust over time, and is gone
  - C) It is all around us, but the Sun is so bright we are unable to detect it, even with satellites
  - D) It has cooled to the point where it is microwaves at a temperature of 2.72 K
  - E) It has been converted into invisible neutrinos