Astronomy – Final Exam  Test form A

Name ______________________

Do not forget to write your name on your answer sheet and above as well, and fill in your student ID bubbles and test form bubble A on your answer sheet. You have 120 minutes. For each question, mark the best answer. The formulas you may want are:

\[ F = \frac{GMm}{d^2} \quad F = ma \quad P^2 = a^3 \quad (M + m)P^2 = a^3 \]

\[ c = \frac{\lambda f}{c} = 3 \times 10^8 \text{ m/sec} \quad E = hf \quad P = knT \]

\[ \frac{v_{\text{rad}}}{\lambda_{\text{rest}}} = \frac{\lambda_{\text{shift}}}{\lambda_{\text{rest}}} \quad \lambda_{\text{Peak}}T = 2900 \text{ K} \cdot \text{m} \]

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

\[ d = \frac{3.26 \text{ ly}}{p} \quad L = 4\pi d^2B \quad v = H_0d \quad H_0 = 21 \text{ km/s/Mly} \]

1. Why do there tend to be giant elliptical galaxies (central dominant galaxies) near the centers of large clusters of galaxies?
   A) Gravitational lensing simply makes the central galaxies look larger, they aren’t really
   B) Initially, these were isolated giant galaxies, but their enormous gravity gathered clusters around them
   C) The many collisions of galaxies in such clusters caused many galaxies to merge, creating these super galaxies
   D) The gravitational attraction of all the other galaxies caused gas to accumulate in the center of the cluster, creating the galaxy
   E) It’s just a statistical artifact – if you have a lot of galaxies, there’s bound to be one that’s particularly large

2. What makes it particularly hard to study our own galaxy?
   A) Our galaxy is exceptionally dim
   B) We live in the disk, where there is a lot of gas and dust obstructing our view
   C) Our galaxy is so bright that it overwhelms most ordinary telescopes
   D) The black hole at the center of our galaxy obscures our view of much of it
   E) Most of the galaxy is only visible from the southern hemisphere; most telescopes are in the northern hemisphere
3. At present, the universe is expanding. In the long run, we think it will
   A) Continue expanding; in fact, it will speed up
   B) Continue expanding, ultimately going at a constant rate
   C) Continue expanding, but eventually it will slow down
   D) Expand for a while, then coast to a stop
   E) Expand for a while, then stop and finally recontract

4. Radio waves with a wavelength of 21 cm is produced from
   A) Collisions between charged particles in very hot, think plasma
   B) Thermal radiation from the surface of stars
   C) Vibrations of molecules in molecular clouds
   D) Dust that is scattered throughout the galaxy
   E) Atomic hydrogen, atoms where the electron spin flips over

5. How are the temperature of the universe $T$ and the time $t$ related?
   A) The temperature has remained the same as time progresses
   B) Temperature has steadily increased over time
   C) Temperature has steadily decreased over time
   D) Temperature has sometimes increased and sometimes decreased over time
   E) We don’t have a good understanding/theory telling us how these relate

6. The Triangulum Galaxy is about 3 million light years away. When we take pictures of it, we are seeing it
   A) Exactly as it currently is
   B) As it was about 3 million years ago, which is probably not that different than it is now
   C) As it was about 3 million years ago, when the universe was very different
   D) Several billion years ago, when it was very different
   E) It is impossible to know how long ago we are seeing it unless we also know how long it took the light to get here

7. The Milky Way is the name of our
   A) Galaxy group
   B) Galaxy cluster
   C) Galaxy
   D) Supercluster
   E) Stellar cluster

8. When we see a large irregular galaxy, our best guess about what makes the galaxy irregular is
   A) There is insufficient rotation to flatten it out
   B) The galaxy is or recently was an active galaxy, disrupting the galaxy
   C) The galaxy recently underwent a collision with another galaxy, disrupting it
   D) The galaxy has low mass, so gravity hasn’t had time to organize it yet
   E) The galaxy has an especially large black hole, which is ripping it to shreds

9. The Andromeda Galaxy, also known as M31, is the name of
A) Our galaxy
B) Another galaxy in our group of galaxies
C) Another galaxy in our supercluster, but not in our group
D) A galaxy that is not a member of our supercluster
E) Not technically a galaxy at all, rather a nearby galaxy cluster

10. Which of the following is true about Blazars, a type of active galaxy?
   A) They can be extremely bright, brighter than an ordinary galaxy (only)
   B) They can change their brightness in a relatively short time frame (only)
   C) They are probably powered by a massive black hole at their center (only)
   D) A and B are true, but not C
   E) A, B, and C are all true

11. What stage of its life is the Sun currently in?
   A) Protostar
   B) Planetary nebula
   C) Core helium burning
   D) Double shell burning
   E) Main sequence

12. How big across, approximately, is the disk of our galaxy?
   A) 100 AU  B) 100,000 AU  C) 100 ly  D) 100,000 ly  E) 1 billion ly

13. By studying the rotation rate of the stars and clouds of gas in our galaxy and similar galaxies, we have determined that the majority of the mass is in the form of
   A) Stars in the disk
   B) Stars in the halo
   C) Stars in the bulge
   D) A black hole in the center of the galaxy
   E) Dark matter spread throughout the halo

14. One way we can reliably conclude that most of the dark matter in our galaxy is NOT white dwarfs, black holes, brown dwarfs, or planets, collectively known as MACHOS, is by
   A) Searching for incidents where a MACHO passes in front of a distant star, blocking it out
   B) Searching for incidents where a MACHO passes in front of a distant star, gravitationally lensing it and making it brighter
   C) Looking for gravitational disturbances in our own Solar System, caused by a passing MACHO
   D) Looking for these object by direct searches using visible light
   E) Looking for radio waves emitted by these objects

15. Venus’ surface temperature is higher than Mercury. This is probably because
   A) Venus is closer to the Sun than Mercury
B) Venus rotates more slowly than Mercury
C) Venus doesn’t have Mercury’s large metal core to absorb the heat
D) Venus has a lot of carbon dioxide in its atmosphere, which is a greenhouse gas
E) Venus has heavy volcanism, unlike Mercury

16. When I discussed the possibility of there being multiple universes, I mentioned “spontaneous creation of the universe” as one reason that there might be multiple universes. Which of the following summarizes this viewpoint?
A) Whatever process might have created our universe out of nothing could have happened more than once; hence, multiple universes
B) The creation of our universe requires the simultaneous creation of an anti-universe at the same time; hence, two universes
C) Once you created one universe (ours), it will naturally spontaneously create more (other universes)
D) Since time must be continuous, the creation of our universe going forward in time must be matched by a second universe going backwards in time
E) Since the Flying Spaghetti Monster (Google it later) “after drinking heavily” created our universe, and He probably gets drunk a lot, odds are He created more than one universe, even if He doesn’t remember it

17. One of the best early arguments for the Earth being round was
A) Since it was made by the gods, it would be perfect, and the only perfect shape is a sphere
B) During solar eclipses, you could see the shadow of the Earth on the Sun was round
C) During lunar eclipses, you could see the shadow of the Earth on the Moon was round
D) The phases of the Moon could not be explained unless the Earth is round
E) All the oceans of the Earth would flow off the edge if it weren’t round

18. Most active galaxies have a bright source of electromagnetic radiation right at their center, but some have energy coming from giant lobes that stick well out of the galaxy. What sort of energy do we typically get from these giant lobes?
A) Radio  B) X-rays  C) Ultraviolet  D) Infrared  E) Gamma rays

19. How can we tell a star is a disk star vs. a halo star?
A) Disk stars tend to go in flat, circular orbits; halo stars tend to go in orbits that stick out of the disk
B) Halo stars tend to go in flat, circular orbits; disk stars tend to go in orbits that stick out of the disk
C) Disk stars are made mostly of hydrogen; halo stars are made mostly of helium
D) Disk stars are made mostly of helium; halo stars are made mostly of hydrogen
E) Halo stars tend to be younger; disk stars tend to be older

20. Which of the following distinguishes typical elliptical galaxies from spiral galaxies?
A) Ellipticals don’t have disks (only)
B) Ellipticals have few young stars (only)
C) Ellipticals have very little cool gas (only)
D) All of the above are generally true
E) None of the above are generally true

21. Why is it that when we look at galaxies as they were long ago, they were generally much smaller than typical galaxies today?
A) Galaxies have been gradually expanding because of heating by stars in their center
B) Galaxies have been gradually expanding because of the general Hubble expansion of the universe
C) Galaxies contain stars that spit out new stars, making them get bigger
D) Modern galaxies are generally the product of mergers of many smaller galaxies
E) They aren’t actually smaller, they just look smaller because they are farther away

22. If, as the Moon orbits the Earth, gravity suddenly stopped working, how would the Moon move afterwards?
A) The Moon would suddenly stop moving at the same moment
B) The Moon would continue moving in the same direction for a while, then it would slowly slow down and stop
C) The Moon would continue moving in a straight line at a steady speed, leaving the Earth
D) The Moon would follow a curved path, curving away from the Earth
E) The Moon would move in a straight line directly away from the Earth

23. Which of the following is a common consequence of observations of objects when we look at them through dust?
A) They tend to be significantly dimmed by the dust (only)
B) They tend to get more blue by the light passing through the dust (only)
C) They tend to get more red by the light passing through the dust (only)
D) A and B are true, but not C
E) A and C are true, but not B

24. If we look at the universe $10^{12}$ years from now, it is likely we will see only our galaxy, but no other galaxies. Why?
A) Protons in all the other galaxies will have decayed, but they are longer lived in our galaxy
B) Stars will have stopped forming in other galaxies, but ours will still keep creating new ones
C) The black holes in other galaxies will have swallowed all their stars, rendering them effectively invisible
D) The expansion of the universe will have taken the other galaxies so far away that they will be invisible
E) There will be so much dust from dead stars that we won’t be able to see out of our galaxy

25. In which part of our galaxy is one most likely to find young stars?
   A) The disk
   B) Isolated halo stars
   C) Globular clusters
   D) The bulge
   E) There are no or very few young stars in our galaxy

26. The galaxy imaged at right is approximately galaxy class
   A) Sa    B) SBd    C) E0    D) E7    E) Irr

27. If we find a meteorite that consists almost exclusively of metal, its most likely history is
   A) It formed in the extreme inner solar system, where only metals could condense
   B) It formed near Jupiter, where massive magnetic fields attract metal
   C) It formed during the earliest part of the solar system, when there were more metals, and has remained pristine ever since
   D) It was ejected from the core of one of the current planets
   E) It was once part of some object, like a protoplanet, so large that it differentiated, but then got broken up by collisions

28. It is common that we will see a pair (or more) extremely similar galaxies apparently behind a nearby cluster. What is causing this phenomenon?
A) The mass of the cluster causes distant galaxies behind them to physically split in two, creating matched twin galaxies
B) The apparently distant galaxies are really a galaxy in the cluster, distorted by the black hole in the cluster to look like two
C) With so many galaxies in the cluster, it is hardly surprising that one of these galaxies is almost a perfect match for the more distant galaxy
D) The gas in the cluster acts as a lens, much as a piece of glass can bend light, to create two images
E) The galaxy cluster acts as a gravitational lens, so we are seeing two images of the same cluster

29. Our best measurements of our galaxy indicate that it is probably
A) An S0 galaxy, with a disk but no spiral structure
B) An SBb or SBc galaxy, with a disk, a barred central component, and spiral arms
C) An E0 or E1 galaxy – elliptical and nearly perfectly spherical
D) An E6 or E7 galaxy – elliptical, but quite flattened
E) An Irr galaxy with no discernible shape

30. The biggest contribution to the composition of the universe is
A) Dark matter  B) Dark energy  C) Ordinary matter  D) Radiation  E) Neutrinos

31. The most common source of energy for stars is
A) Fusing hydrogen to carbon
B) Fusing hydrogen to helium
C) Fusing helium to carbon
D) Gravitational contraction to produce heat
E) Chemical burning of hydrogen to water

32. Why is it that the inner large moons of Jupiter have so little ice, while the outer ones have more?
A) Ice has low density compared to rock, so it gravitationally migrated to the more distant moons
B) Early Jupiter was so hot that it evaporated most of the ice from the inner moons, while leaving the outer moons intact
C) Collisions in the inner moons knocked most of the ice off, while the outer moons were less affected
D) The gravity from Jupiter drew off most of the ice from the inner moons
E) The magnetic field from Jupiter drew in metals, leaving the ice at greater distances

33. How does the background radiation temperature vary as we look in different directions?
A) The temperature, as far as can be measured, is perfectly uniform
B) Though we see very small fluctuations in temperature, these are likely just experimental error.
C) The temperature is almost uniform in all directions, but there are small but important variations in different directions.
D) There are large variations, with a much higher temperature in the plane of the galaxy, and cooler near the poles.
E) There are large variations, with no obvious pattern to them or correlation with the galaxy.

34. When two galaxies collide, which of the following would not normally occur?
A) Clouds of gas in each galaxy would collide, compressing them and causing star formation.
B) The gravity from each galaxy would disrupt the other galaxy.
C) The galaxies merge to make a larger galaxy.
D) Individual stars from each galaxy collide with those in the other galaxy.
E) Actually, all of these do occur.

35. The reason it is hotter in the summer than in the winter is because
A) The Earth is closer to the Sun in the summer.
B) The Earth moves more quickly around the Sun in the summer.
C) The Sun changes its luminosity, and is brighter in the summer.
D) The Earth tilts so that sunlight shines down on us more directly in the summer.
E) Greenhouse gases have a greater effect in the summer.

36. How can we generally figure out which part of a planet or moon is very old?
A) Craters: The more it has, the older it is.
B) Craters: The fewer it has, the older it is.
C) Radioactivity: The more it has, the older it is.
D) Radioactivity: The less it has, the older it is.
E) Solar fading: The more faded it is, the older it is.

37. Where in our galaxy can be found a giant black hole, with a mass millions of times that of our Sun?
A) In the exact center, or very close to the center.
B) In the disk, but away from the center.
C) In the bulge, but away from the center.
D) In the halo, very far from the center.
E) Our galaxy has no giant black hole.

38. What is the approximate current temperature of the microwave background radiation of the universe?
A) $10^{31}$ K  
B) $10^9$ K  
C) 4000 K  
D) 2.7 K  
E) -270 K

39. Collections of clusters of galaxies are called
A) Superclusters
B) Hyperclusters
C) Uberclusters  
D) Metaclusters  
E) There are no structures in the universe larger than clusters

40. The moon with the most substantial atmosphere in the Solar System is  
A) Iapetus  
B) Io  
C) Titan  
D) Triton  
E) Europa

41. When we use white dwarf supernovae to measure the distance to the most distant objects in the Universe, they don’t seem to satisfy the relation $v = H_0 d$. Why?  
A) Peculiar velocities, velocities in addition to the general Hubble flow, add errors to this formula  
B) The universe is not really undergoing uniform expansion: distant objects may be expanding differently  
C) The distances are calculated to these supernovae using parallax, which is unreliable at these distances  
D) We are looking so far away that we are looking back to very early in the universe, when the expansion may well have been at a different rate  
E) At the early times when we were looking, objects were much hotter, which introduces errors

42. Which of the following can only occur in binary star systems?  
A) White dwarf supernova  
B) Massive star supernova  
C) Formation of a black hole  
D) Formation of a neutron star  
E) Planetary nebula

43. Every calcium atom, whether neutral or not, must have exactly the same  
A) Nuclear charge (only)  
B) Number of electrons (only)  
C) Nuclear charge AND number of electrons  
D) Number of neutrons  
E) Energy

44. One huge advantage Galileo had over his predecessors, like Tycho Brahe or Kepler, was  
A) He had the telescope  
B) He was mathematically trained, unlike Kepler  
C) He was a careful experimenter, unlike Tycho Brahe  
D) He was able to travel the world, and realized it was actually round  
E) He had learned calculus from Newton, which he applied to astronomy

45. Star A is spectral class A5 and star B is spectral class B5. They have the same brightness. They are both main sequence stars. Which star is farther away?  
A) Star A  
B) Star B
C) They are equal distance away
D) You can’t tell unless you also know the luminosity
E) You can’t tell, even if you know the luminosity

46. At right is sketched a Hertzsprung-Russell diagram for four clusters. Which cluster is probably the oldest?
   A) A
   B) B
   C) C
   D) D
   E) Insufficient information

47. How old is the universe compared to the current age of the Earth?
   A) Only a little older
   B) About twice as old
   C) About three times as old
   D) About ten to twenty times as old
   E) About a hundred to two-hundred times as old

48. Which of the following is probably the best current estimate for $\Omega$, the density parameter of the universe?
   A) 0.05
   B) 0.30
   C) 0.70
   D) 1.00
   E) 1.70

49. Saturn’s rings are made primarily of
   A) Hydrogen gas
   B) Helium gas
   C) Ice
   D) Metal
   E) Methane

50. Alpha Centauri, the nearest star to our own, is 4.3 light years away. How did we measure this?
   A) Parallax
   B) Hubble’s Law
   C) White dwarf supernovae
   D) Cepheid variable stars
   E) Radar distancing

51. Moving away from the Sun, which planet comes after Mars?
   A) Mercury
   B) Earth
   C) Saturn
   D) Jupiter
   E) Venus

52. The Sun will end its life as a
   A) Black hole
   B) Neutron star
   C) Molecular cloud
   D) Brown dwarf
E) White dwarf

53. A standard candle is any astronomical object that is consistently the same
   A) Distance  B) Temperature  C) Brightness  D) Mass  E) Luminosity

54. Which of the following is not a type of electromagnetic radiation?
   A) Visible light  B) Infrared  C) Microwaves  D) Neutrinos  E) Gamma rays

55. Galaxy G1 is moving away from us at ten thousand kilometers per second. Galaxy
    G2 is moving away from us at twenty thousand kilometers per second. What can we
    conclude about their relative distances, assuming Hubble’s law works?
   A) G1 is twice as far away as G2  
   B) G2 is twice as far away as G1
   C) G1 is four times as far away as G2
   D) G2 is four times as far away as G1
   E) We can’t conclude anything about their relative distances

56. Which elements are believed to have been created during the first few minutes of the
    big bang?
   A) None
   B) Hydrogen but not helium
   C) Helium but not hydrogen
   D) Hydrogen and helium, but not carbon
   E) Hydrogen, helium, and carbon

57. If a star gets hotter but stays the same luminosity, which direction would it move on
    the Hertzsprung-Russell diagram?
   A) Up  B) Down  C) Right  D) Left  E) None of the above

58. What technique is commonly used with the largest visible light telescopes based on
    the Earth to minimize blurring?
   A) Selective imaging – Only pick pointlike objects to image, like stars
   B) Vacuum penetration – A small, brief hole is drilled through the atmosphere,
      eliminating the distortion
   C) Adaptive optics – the primary mirror’s shape is constantly adjusted to compensate
      for the atmospheric distortion
   D) Pinhole optics – a mask with a tiny hole is placed over the telescope, so only light
      that is going perfectly straight can make it to the imaging system
   E) Tranquil optics – images are only taken when the atmosphere is perfectly still, so
      there is no distortion

59. To find the distance to a Cepheid Variable star, I need to measure what two things?
   A) Temperature and period
   B) Spectral class and period
   C) Brightness and period
   D) Brightness and temperature
   E) Brightness and spectral class
60. Which of the following is true about high mass stars, compared to low mass stars?  
   A) They live much longer (only)  
   B) They are more common (only)  
   C) They tend to be more luminous (only)  
   D) All of the above  
   E) None of the above

61. Most of the comets in the Solar System come from where?  
   A) Inside Mercury’s orbit  
   B) Between Mercury’s and Venus’s orbit  
   C) The same region where asteroids come from  
   D) Between Uranus’ and Neptune’s orbit  
   E) Beyond Neptune’s orbit

62. Just before the core of a massive star begins to collapse to make a supernova, the core of the star is made of  
   A) Carbon  
   B) Silicon  
   C) Iron  
   D) Helium  
   E) Neutrons

63. The most common way that serious scientists look for evidence of extraterrestrial intelligence is  
   A) Investigating claims of lights in the sky and other UFO reports  
   B) Searching for radio signals sent by alien civilizations  
   C) Searching for evidence of giant construction projects  
   D) Building spacecraft to go visit distant stars  
   E) No serious scientists are involved in looking for alien civilizations

64. When we observe planets like Mars, compared to the background stars, it usually moves west to east (prograde) but occasionally east to west (retrograde). What is the correct explanation for retrograde motion?  
   A) Since we are measuring its position from the also moving Earth, it seems to move backwards whenever we pass it
B) Mars’ speed is complex, following a formula which actually lets it move backwards along its orbit some of the time
C) Mars follows an epicycle, going on a circle which itself is circling on a bigger circle called the deferent, and the combined motion causes the backwards motion
D) The crystalline sphere on which the stars are mounted sometimes rotates, and when it speeds up it makes Mars go backwards compared to it
E) The motion relative to the stars is an illusion caused by the Earth rotating on its axis

65. A comet orbits the Sun following the ellipse sketched at right, going clockwise. At which point will the comet be moving fastest?
A) A  B) B  C) C  D) D  E) The speed is constant

66. Which of the gas giant planets have very few (less than three) known moons?
A) Saturn
B) Uranus
C) Neptune
D) Jupiter
E) All of these planets have three or more known moons