

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:

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

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

$$\frac{v_{\text{rad}}}{c} = \frac{\lambda_{\text{shift}} - \lambda_{\text{rest}}}{\lambda_{\text{rest}}} \quad \lambda_{\text{Peak}} T = 2900 \text{ K} \cdot \mu\text{m} \quad \frac{L}{L_{\odot}} = \left(\frac{T}{T_{\odot}} \right)^4 \left(\frac{R}{R_{\odot}} \right)^2$$

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

- What evidence is there that active galaxies are powered by something very small, as small or smaller than the Solar System?
 - The power produced is so small, it must be a small region
 - Since the power can change very quickly, it must be a small source
 - Direct observation shows they are point sources, or very small
 - Since the power comes in short wavelengths, it must be small
 - We can measure the mass of the black hole and then deduce the size
- The X-rays that come from the nucleus of our galaxy are probably coming from
 - Numerous supernovae
 - Numerous neutron star X-ray bursters
 - Very high mass stars
 - A giant black hole at the center, from the black hole itself
 - Gas streaming into the black hole at the center of the galaxy
- Which of the following is not considered a factor in the number of estimated intelligent civilizations in the galaxy (the Drake equation)?
 - The fraction of stars with planets
 - The number of planets or moons at the right temperature
 - The probability of life forming on a planet
 - The probability that a planet has carbon, which is needed for life
 - The average length of time a civilization survives

4. What is currently happening to the size of the universe?
 - A) It is expanding, but the expansion is getting slower
 - B) It is expanding, and the expansion is accelerating
 - C) It is staying the same size
 - D) It is getting smaller, and this collapse is speeding up
 - E) It is getting smaller, but this collapse is slowing down

5. Which of the following is not a type of electromagnetic wave?
 - A) Infrared
 - B) Radio
 - C) Ultraviolet
 - D) Neutrinos
 - E) Visible light

6. The amount of time it takes the Moon to go through its cycle of phases is about
 - A) 1 day
 - B) 1 week
 - C) 2 weeks
 - D) 1 month
 - E) 1 year

7. In order from most to least common, what is the nebula from which stars and planets form made of?
 - A) Hydrogen and helium, metal and rock, ices
 - B) Hydrogen and helium, ices, metal and rock
 - C) Ices, hydrogen and helium, metal and rock
 - D) Ices, metal and rock, hydrogen and helium
 - E) Metal and rock, ices, hydrogen and helium

8. Why is there no gravity aboard the International Space Station (ISS); that is, why do the astronauts float around inside it instead of falling?
 - A) It is so far from the Earth that gravity is negligible
 - B) It has rockets to counteract the gravity
 - C) The Moon's gravity cancels the Earth's
 - D) Earth's atmosphere shields it from Earth's gravity
 - E) Actually, they are falling all the time, and so is the ISS, so effectively they feel no gravity

9. The presence of dust between us and some object makes them dimmer. What other effect does it have on objects we view?
 - A) It makes them look smaller than they actually are
 - B) It makes them look larger than they actually are
 - C) It makes them look redder than they actually are
 - D) It makes them look bluer than they actually are
 - E) None of the above

10. Which of the following is true about volcanism on Mercury?
 - A) There is no evidence that there were ever volcanoes on Mercury
 - B) There is strong evidence that there were volcanoes in the distant past, but probably not any more
 - C) There are probably still active volcanoes on Mercury, though we have never seen one
 - D) Active volcanoes have been identified, but they are no more common than they are on Earth
 - E) Active volcanoes have been seen and are much more common than on Earth

11. Which source gives us samples that we can use to determine the approximate age of the Solar system?
- A) Stony meteorites
 - B) Iron meteorites
 - C) Carbon-rich primitive meteorites
 - D) Apollo moon rocks
 - E) Mars Sample Return Mission
12. If the universe started as a giant explosion, how come there isn't hot radiation from this huge explosion?
- A) Technically it isn't an explosion, so there is no radiation
 - B) All the radiation was absorbed by gas in the thick early universe
 - C) The radiation has all been converted to neutrinos, which are invisible
 - D) The radiation was converted to the matter that we see around us
 - E) It is still with us, but it has cooled so it is now microwaves
13. If I have two atoms that are both sodium atoms, what is guaranteed to be the same about both of them?
- A) The charge of their nuclei
 - B) The number of electrons
 - C) Their mass
 - D) Their chemical bonds
 - E) The number of neutrons
14. Where is the dark matter apparently in our galaxy?
- A) Halo
 - B) Nucleus
 - C) Disk
 - D) Bulge
 - E) None of these
15. What evidence indicates that spiral galaxies have dark matter in them?
- A) The fact that there are halo stars far from the galaxy
 - B) The orbital velocities of stars far from the galaxy do not fall off with distance
 - C) There are more stars forming than can be accounted for by ordinary matter
 - D) There are huge clouds of X-ray gas in a huge volume surrounding the galaxies
 - E) The number of black holes in them indicates there must be an additional source of gas
16. Which of the following are we fairly confident of the answer of?
- A) What dark matter is made of
 - B) What dark energy is made of
 - C) Where ordinary matter comes from
 - D) What caused the big bang
 - E) None of these
17. The Sun, when it is dead, will be about the size of

- A) The current Sun
- B) A city
- C) Jupiter
- D) The Earth
- E) The Earth's orbit around the Sun

18. Which one of the following distance methods helps us measure the distance to some of the most distant objects in the Universe?

- A) Radar
- B) White dwarf supernovae
- C) Parallax
- D) Cepheid variable stars
- E) Spectroscopic parallax

19. Why do we believe the dark matter is not composed of objects such as planets, white dwarfs, neutron stars, or black holes?

- A) We would be able to directly observe all of these objects in infrared
- B) It should block our views of objects behind them, but it doesn't
- C) Through gravitational lensing, it should cause stars behind them to be brightened, but we don't see enough such events
- D) Such objects should sweep through the Solar System, and we would have noticed
- E) Spacecraft leaving the Solar System would have encountered such objects

20. The reason it is warmer in the summer than in the winter is because

- A) The Earth is closer to the Sun in the summer
- B) The sunlight falls straight down on Earth in the summer
- C) The Earth is moving more slowly in the summer, so it has a longer day
- D) There are fewer clouds to block the sunlight in the summer
- E) The Sun is more luminous in the summer

21. Which of the following elements are assumed to have been mostly created in the first few minutes of the big bang?

- A) Hydrogen (only)
- B) Helium (only)
- C) Carbon (only)
- D) Hydrogen and helium, but not carbon
- E) Hydrogen, helium, and carbon

22. What classification of galaxy would appear to be a circular object?

- A) S0 B) Irr C) SBa D) E0 E) E5

23. The terrestrial planets ended up with a lot less mass than the gas giants because

- A) It was too hot for gasses to liquefy and contribute to these planets

- B) There was very little rock or metal where the terrestrial planets formed
 - C) All their material was pulled in by the proximity to the Sun
 - D) They formed inside the “frost line,” so that ices couldn’t contribute to them
 - E) There was very little hydrogen or helium where the terrestrial planets formed
24. Which of the following can escape from a black hole from inside the event horizon?
- A) Neutrinos
 - B) X-rays
 - C) Gas
 - D) Radio waves
 - E) Nothing
25. According to Copernicus, the reason that Mercury and Venus are always in the same general direction as the Sun, unlike other planets, is because
- A) The Sun’s gravitational pull pulls them close to the Sun
 - B) They orbit the Sun, while other planets orbit the Earth
 - C) They orbit the Sun in orbits closer than Earth’s, while other planets orbit farther away
 - D) They are too faint when far from the Sun to be seen
 - E) They just don’t like the cold, so they always hang out where it’s warm
26. Which event caused the universe to transform from opaque to transparent?
- A) Recombination, when electrons joined with nuclei to make atoms
 - B) Nucleosynthesis, when protons and neutrons combined to make nuclei
 - C) Neutron/proton freezeout, when the neutron/proton ratio was fixed
 - D) The grand unified scale, when strong, weak, and electromagnetic forces separated
 - E) The Planck era, when the universe began
27. Why does a planetary nebula glow?
- A) Radioactive decay of the planets that comprise it
 - B) Nuclear reactions of the gases in the nebula
 - C) Collisions with gas surrounding the dying star
 - D) Left over heat from when it was ejected from its dying star
 - E) Ultraviolet light coming from its dying star
28. According to our best measurements of the temperature of the universe, how does the temperature vary in different directions?
- A) It is exactly uniform, at the same temperature in all directions
 - B) It is uniform, except a few directions where it is slightly hotter
 - C) It is almost uniform, with very small variations in all directions
 - D) It is different temperatures in various directions
 - E) It is not even a thermal distribution, so it doesn’t have a “temperature”
29. Which of the following classification of galaxies normally has lots of star formation going on?
- A) Elliptical galaxies (only)

- B) Spiral galaxies (only)
 - C) Barred spiral galaxies (only)
 - D) Elliptical and spiral galaxies
 - E) Spiral and barred spiral galaxies
30. Why don't we use parallax to measure the distance to nearby galaxies?
- A) The objects we use for parallax are too dim to be seen at that distance
 - B) Parallax requires objects that are extremely rare, and there are none in nearby galaxies
 - C) Parallax measures angles, but the angles get too small at that distance
 - D) There is too much gas and dust between us and these galaxies
 - E) Parallax requires waiting for a radar signal to be reflected, and this would take too long
31. What fundamentally makes close binary stars different from other stars?
- A) Since they formed from a single cloud, they typically have half the mass of other stars
 - B) They heat each other up, since they are so close that each feels the radiation from the other
 - C) Since they are born at the same time, they always die at the same time
 - D) They are twice as bright and hence easier to study than ordinary stars
 - E) They can exchange gasses, producing spectacular results, particularly when one of them is dead and the other is a giant star
32. What is the approximate value of Ω , which measures the total amount of stuff in the universe?
- A) 0.05 B) 0.26 C) 0.31 D) 0.69 E) 1.00
33. Which of the following is not likely to be caused when two galaxies collide?
- A) Collision of individual stars within the two galaxies
 - B) Compression of clouds of gas in the galaxies
 - C) Feeding of gas into the cores of these galaxies
 - D) Disruption of the structure of the galaxies as a whole
 - E) Merger of the two galaxies into a single galaxy
34. Why does the power in a radio galaxy not seem to come from the galaxy itself, but instead from a much larger region coming out of the galaxy?
- A) The power is reflected from clouds that surround the galaxy
 - B) The black hole or holes that power the galaxy have actually left the galaxy
 - C) Magnetic fields produced by the galaxy magnetize space around the galaxy
 - D) Powerful jets shoot out of the nucleus and produce the radio waves
 - E) Most of the galaxy is actually invisible, but is rendered visible again by the nucleus
35. What would be an indication that a nearby star is actually a halo star?
- A) It is an especially massive star
 - B) It is not a member of a cluster
 - C) It is a white dwarf star

- D) It is moving in an orbit that would take it well out of the disk
E) It has an unusually large amount of helium
36. How is it possible that we know what ancient galaxies look like?
A) We rely on computer simulations
B) Ancient galaxies should just be young galaxies, so we look for young galaxies and assume they look like that
C) We simply look at very distant galaxies; since light has a finite speed, we are seeing them as they were long ago
D) We can see galaxies just a little younger than ours, then extrapolate backwards to figure out what they were like long ago
E) I have no idea; please mark this one wrong
37. Laniakea is the name of which structure?
A) Galaxy supercluster
B) Stellar cluster
C) Galaxy cluster
D) Galaxy
E) None of these
38. How do blazars, which can change their power apparently very quickly, differ from other types of active galaxies?
A) They have jets pointing almost directly towards us here at Earth
B) They have far more gas flowing in than other types of active galaxies
C) We have caught them right at the moment when two black holes are colliding
D) They have gas flowing into the black hole in all directions, not just from the accretion disk
E) They have more mass than other black holes
39. The gas that makes Venus' surface so hot, and is also contributing to Earth's global warming, is
A) Water B) Carbon monoxide C) Carbon dioxide D) Sulfur dioxide E) Ozone
40. In order from largest to smallest, the universe is composed of
A) Dark energy, dark matter, ordinary matter
B) Dark energy, ordinary matter, dark matter
C) Dark matter, dark energy, ordinary matter
D) Dark matter, ordinary matter, dark energy
E) Ordinary matter, dark matter, dark energy
41. The planet with the largest valleys and tallest volcanoes in the Solar System is
A) Mars B) Earth C) Jupiter D) Mercury E) Venus
42. A massive star supernova is most likely to occur in a region where
A) All the stars are very luminous

- B) All the stars are very dim
 - C) There are a lot of new stars being born
 - D) All the stars are very old
 - E) None of the above
43. For an object to make a good standard candle, it must have a consistent
- A) Brightness
 - B) Radius
 - C) Temperature
 - D) Mass
 - E) Luminosity
44. Which of the following problems is not believed to be solved by inflation?
- A) The flatness problem – why the universe is almost flat in shape
 - B) The origin of matter
 - C) The horizon problem, where opposite sides of the universe seem to be at the same temperature
 - D) The origin of structure
 - E) Actually, all of these are explained by inflation
45. As viewed from us, all galaxies are moving away, but if we were on a different galaxy, we would see
- A) Most galaxies standing still, but our galaxy would be moving away
 - B) Everything would be rushing past us in one direction
 - C) Galaxies in one direction would be moving away, in the other moving towards us
 - D) Galaxies would seem to be circling around us
 - E) Everything would be moving away from us, much as it appears from here
46. How do we get pictures of our galaxy from outside the galaxy?
- A) The Hubble space telescope
 - B) Spacecraft that have left the Solar System, such as the Voyager spacecraft
 - C) Reflections from planetary nebulae
 - D) Seeing images of our galaxy that have been gravitationally lensed by galaxy clusters
 - E) We don't have pictures of our galaxy from the outside
47. Which of the following observations helped ancient astronomers figure out the shape of the Earth?
- A) A solar eclipse
 - B) A lunar eclipse
 - C) A terrestrial eclipse
 - D) The angle of the moon at first or third quarter
 - E) None of the above; ancient astronomers were unable to deduce the shape of the Earth
48. The 21 cm line that is used to map out atomic hydrogen clouds in the galaxy are produced by what process?
- A) Collisions of high energy electrons and nuclei
 - B) Vibrations of molecules
 - C) The spin of an electron in a hydrogen atom flipping over
 - D) Chemical reactions between atoms in the interstellar medium

- E) Electrons falling down levels after being ionized by hot young stars
49. In which phase(s) of the Moon listed below would the Sun and Moon combine to cause especially large tides (spring tide)?
- A) New moon (only)
 - B) First quarter (only)
 - C) Full moon (only)
 - D) New moon and first quarter, but not full moon
 - E) New moon and full moon, but not first quarter
50. The Sun is approximately one-half degree across in the sky. What additional information about the Sun would allow you to figure out the distance to the Sun?
- A) Temperature
 - B) Mass
 - C) Actual size
 - D) Luminosity
 - E) Brightness
51. The most likely place to find new stars in our galaxy is in the
- A) Halo
 - B) Disk
 - C) Globular Clusters
 - D) Bulge
 - E) None of these
52. The position of the Sun within our galaxy is
- A) In the bulge
 - B) In the halo
 - C) In the disk, near the center
 - D) In the disk, about half way out
 - E) In the disk, near the edge
53. Which of the following represents the most immediate threat to humanity from an astronomical source?
- A) Catastrophic global warming from the Sun
 - B) Absorption of the Earth by the Sun's expansion
 - C) Collision of a large asteroid with Earth
 - D) Decay of protons and neutrons
 - E) Absorption of the Earth by a black hole
54. The cause of the spiral structure in spiral galaxies is believed to be
- A) Simple winding – straight spiral arms get wound up by the rotation
 - B) Density waves – high density regions cause self-propagating waves through their gravitational interactions
 - C) Compression waves – Sound waves circling the galaxy cause stellar formation
 - D) External perturbations – Orbiting galaxies pull the spiral structure around due to gravitational interactions

- E) Radial signaling – Bursts of power from the center propagate outwards in a spiral pattern
55. On the largest scale, how is the universe organized?
- A) It is filled approximately uniformly with galaxies
 - B) It is filled almost uniformly with galaxies except for occasional small voids
 - C) It is about half filled with planes of galaxies alternating with planes of emptiness
 - D) It is mostly huge voids of empty space with superclusters on the boundaries between them
 - E) It is almost all empty space, with small approximately spherical superclusters in between
56. The total number of moons of Saturn is
- A) One
 - B) Two
 - C) Three
 - D) Four
 - E) More than four
57. Which of the following does not convey approximately the same information as the rest?
- A) Color
 - B) Surface temperature
 - C) Spectral class
 - D) Luminosity
 - E) Actually, all of these do approximately correspond to each other
58. Comets are made primarily of
- A) Water (ice)
 - B) Hydrogen
 - C) Helium
 - D) Rock
 - E) Metal
59. Which is approximately the age of the Universe in years?
- A) 4.5 million
 - B) 13.8 million
 - C) 4.5 billion
 - D) 13.8 billion
 - E) 4.5 trillion
60. Why is the helium burning stage of a star so much shorter than the hydrogen burning stage?
- A) Because the star is more luminous and the burning produces less energy per fusion
 - B) Because the star is less luminous and the burning produces less energy per fusion
 - C) Because the star is more luminous and the burning produces more energy per fusion
 - D) Because the star is less luminous and the burning produces more energy per fusion
 - E) None of the above
61. At the center of the Sun, which nuclear process is occurring?
- A) Helium becoming carbon (only)
 - B) Hydrogen becoming helium (only)
 - C) Carbon becoming oxygen (only)
 - D) All of the above
 - E) None of the above
62. The name of our galaxy is
- A) Milky Way
 - B) Local Group
 - C) Virgo
 - D) Coma
 - E) Laniakea
63. Which is the largest planet in the Solar System?
- A) Jupiter
 - B) Earth
 - C) Saturn
 - D) Neptune
 - E) Uranus
64. The galaxy we live in, according to our best guess, is what kind?

A) Irregular B) Spiral C) Barred spiral D) Elliptical E) None of these

65. The reason that main sequence stars are the most common type of star is because
- A) These stars correspond to the mass range that is most common
 - B) This is the longest stage in the life of a star
 - C) All stars are approximately the same age, so this will be the stage they are in
 - D) The composition of these stars is mostly hydrogen, which is the most common element
 - E) Other stages are (mostly) too dim to see, so we don't notice them as much
66. Why do there tend to be giant elliptical galaxies at the centers of large galaxy clusters?
- A) They formed from the merger of many smaller galaxies
 - B) They attracted all the other galaxies with their large gravity
 - C) The other galaxies all sent gas into the center, producing the giant elliptical
 - D) They are made from the dark matter from the other galaxies
 - E) Originally there was just one giant galaxy, but it has sent out the other galaxies over time