Be sure to write your name and student ID number on the first blank at the bottom of the form. Please mark the version (C) in the “Key ID” space at the top of the Scantron, and enter your name in the appropriate box. If you need to erase an answer, please do so carefully and remove all of the old mark.

1. A black hole can glow in an active nucleus when
   a. a jet of light escapes from within the event horizon
   b. it lenses the light from objects behind it
   c. friction heats matter falling into it to very high temperature
   d. a pulsation in its gravitational field lets light out
   e. it draws many stars into a tight knot around it

2. The Galactic Center was hidden from astronomers for many years because
   a. it only emits in the radio and infrared
   b. it is a very diffuse region that is hard to pinpoint
   c. they were looking in the wrong places
   d. the Milky Way has a peculiar, atypical structure that made it hard to find
   e. it is hidden in the visible by clouds of interstellar dust

3. An active nucleus can be identified by
   a. bright and broad emission lines
   b. radio jets emerging from the nucleus
   c. a luminoust source that varies rapidly
   d. strong X-ray emission
   e. all of the above

4. Which physical force dominates the process of star formation?
   a. strong nuclear
   b. weak nuclear
   c. electrical
   d. gravitational
   e. reactional

5. The best place to look for stars just beginning to form is
   a. in empty space
   b. in a molecular cloud
   c. in a reflection nebula
   d. in a supernova remnant
   e. in an HI cloud

6. Ring-shaped galaxies and galaxies with tails of stars are evidence for
   a. galaxies forming from intergalactic matter
   b. nuclear activity in galaxies
   c. explosions across the face of previously normal galaxies
   d. galaxies taking part in the expansion of the Universe
   e. galaxy collisions

7. Galaxies undergoing starbursts
   a. are full of bursting stars
   b. are breaking up stars as they fall into active nuclei
   c. were identified through clusters of stars bursting out from them
   d. are forming massive stars rapidly and in exceptionally large numbers
   e. have less dark matter than other galaxies

8. We see where the young stars are in a galaxy most easily when we look in
   a. the visible and near infrared
   b. the ultraviolet and far infrared
   c. the X-ray and ultraviolet
   d. the radio and gamma ray
   e. the visible and X-ray

9. Distance measurements to the galaxies around us show that
   a. the Milky Way is isolated in space
   b. the Milky Way is the biggest galaxy by far compared to other members of the Local Group
   c. the Milky Way is surrounded by many small galaxies
   d. we are moving rapidly toward a certain point in space, leaving the nearby galaxies behind
   e. the Milky Way is stripping gas and stars from the large, nearby galaxy M31 (the Andromeda galaxy)

10. Interstellar dust makes the things behind it look
    a. redder
    b. brighter
    c. more diffuse
    d. it blots them out completely
    e. bluer
11. Galaxy distances are determined
   a. just by using Cepheid variables
   b. by measuring supernovae
   c. with parallax
   d. using the cosmic redshift
   e. by a large variety of techniques that have to be used together, depending on the circumstances

12. Henrietta Leavitt's period luminosity relation for RR Lyrae stars proved important because:
   a. it allowed the astronomers of her time to test their models for the interiors of these stars, to see if they were made of hydrogen
   b. it was the first significant astronomical discovery by a woman
   c. it explained why some star fields looked different in pictures taken at different times
   d. it allowed the luminosity of these stars to be determined based on intrinsic properties, and thus their distances from their apparent brightnesses
   e. it showed that they moved on the HR diagram

13. A "standard candle" for an astronomer is
   a. a special candle of constant brightness maintained at the Bureau of Standards
   b. an astronomical object whose luminosity can be determined without knowing its distance
   c. a barred spiral galaxy
   d. a votive candle of the usual size and wax content
   e. a variable red supergiant star

14. The Shapley-Curtis debate
   a. was important philosophically because it touched on our place in the Universe
   b. was decisively won by Shapley
   c. was decisively won by Curtis
   d. was an argument about the role of star formation in affecting our view of the cosmos
   e. showed the superiority of Harvard College Observatory

15. Why did astronomers in the 19th century believe that the solar system was close to the center of the Milky Way?
   a. we are close to the center
   b. their telescopes were too small to see the whole system
   c. they did not realize how interstellar dust cut off their view
   d. they needed infrared detectors
   e. they did not have photographic plates to detect very faint stars

16. A newly formed massive, hot star changes the surrounding interstellar gas into
   a. a molecular cloud
   b. an HII (ionized hydrogen) region
   c. a dark globule seen as a shadow against the background light
   d. an absorption line nebula
   e. an HI (neutral hydrogen) region

17. Gravitational lensing
   a. is being built into the next generation of digital cameras
   b. produces arc-like images of galaxies at behind massive galaxy clusters
   c. is useful for studying planets that pass in front of the sun
   d. was a surprise discovery not predicted by Einstein's theories of relativity
   e. changes the color of the objects lensed

18. The mass of a cluster of galaxies
   a. is entirely from its galaxy members
   b. includes a significant part from very hot gas and even more from dark matter
   c. results in broadening the spectral lines from active nuclei in the cluster
   d. causes the cluster to glow all over as things fall into it
   e. makes the emission lines of the galaxies in the cluster shift wavelength significantly due to relativity

19. Galaxies are distributed
   a. uniformly through space
   b. in vast sheets and filaments that make a structure a little like soap bubbles
   c. in clusters and groups
   d. in rings centered around the Milky Way
   e. both b. and c.
20. The Milky Way is a
   a. barred spiral galaxy    b. elliptical galaxy    c. irregular galaxy    d. Sa galaxy
   e. we do not have much idea of what type it is

21. We think that the most likely explanation for observations indicating dark matter is:
   a. Newton's Law of gravitation is wrong
   b. the Universe is filled with an undetected type of nuclear particle
   c. the galaxy rotation curves are distorted
   d. we are overestimating the accuracy of the velocity measurements in galaxies
   e. the spectral lines suffer gravitational redshift due to Einstein's law of relativity

22. What is the evidence there is dark matter beyond the disks of spiral galaxies?
   a. inner disk stars orbit faster than the mass due to stars and gas can explain
   b. infrared telescopes detect mass beyond the galaxy disks
   c. the stellar mass distribution does not account for the rotation curve of the galaxies
   d. disk stars orbit faster than stars in the galactic centers
   e. regions outside the disks obscure the light of galaxies behind them

23. The rapid variability in the outputs of quasars and other active nuclei shows that
   a. they are exploding
   b. they are moving very fast
   c. the nuclear sources are very small
   d. stars are blowing up in these regions
   e. the apparent variability is an effect of gravitational lensing

24. Jets emerging from an active nucleus contain particles moving nearly at the speed of light because
   a. that is the only way to account for their apparent superluminal motions
   b. that is how they can get so far from the galaxy
   c. we measure extreme Doppler shifts in their emission lines
   d. it lets them punch their way through the stars
   e. both a. and d.

25. Superluminal - faster than light - motions result when
   a. the geometry of motions sets up an optical illusion
   b. matter falls into a black hole
   c. there is such a violent explosion that pieces are expelled faster than light
   d. Einstein's laws are broken
   e. neutrinos are accelerated to a very high speed

26. We know about the black hole in the Galactic Center because
   a. It glows brightly
   b. it makes an active nucleus
   c. from Newton's and Kepler's laws
   d. because we see a dark spot where it bends the light away
   e. because we have seen stars get sucked into it

27. Dark energy is causing
   a. galaxies to collide and merge more quickly
   b. the Universe to expand faster
   c. photons to move faster
   d. gravity to be weaker
   e. magnetic fields

28. The period-luminosity relationships for RR Lyrae and Cephid stars were easier to establish for stars in the Magellanic Clouds (nearby external galaxies) because
   a. there are more of these stars in the Magellanic Clouds than in the Milky Way
   b. they were easier to see in the Magellanic Clouds than in the Milky Way
   c. the ones in the Magellanic Clouds are all at about the same distance
   d. because the Magellanic Clouds are only visible south of the equator, they had been observed particularly well
   e. their proper motions are smaller, making comparisons over time with other stars more accurate
29. Spiral arms
   A.                B.                  C.             D.
30. Globular cluster
   A.                B.                  C.             D.
31. Bulge
   A.                B.                  C.             D.
32. The masses of black holes in the galaxy centers
   a. are higher for more massive galaxies
   b. are higher for younger galaxies
   c. are higher for more distant galaxies
   d. are similar to each other
   e. can’t be measured

33. When gas clumps first collapse into young stars,
   a. they cannot burn hydrogen because it has not settled into their cores yet
   b. they cannot burn hydrogen until a spark ignites it
   c. their activity level needs to rise before they can burn hydrogen
   d. their cores must shrink and heat up to burn hydrogen
   e. the hydrogen must be converted from molecular to atomic form to burn

34. A spiral galaxy differs from an elliptical galaxy
   a. in shape
   b. by having more interstellar material
   c. by rotating more rapidly
   d. by having more young stars
   e. all of these

35. A starburst in a galaxy may be triggered by
   a. collision with another galaxy
   b. a lack of interstellar material
   c. a magnetic field
   d. old stars
   e. none of these

36. Spiral arms are the result of
   a. stars closer to the center of the galaxy orbiting faster than more distant ones
   b. magnetic fields
   c. convection stirring the gas in the galaxy
   d. waves in the distribution of stars that can compress molecular clouds
   e. galaxies colliding

37. You are asked to find a giant elliptical galaxy. Which of these locations would be the best place to look?
   a. a rich cluster of galaxies
   b. the Local Group
   c. orbiting the Milky Way
   d. extremely far away
   e. all locations are equally good

38. Interstellar dust was discovered by
   a. sending a rocket into space and scooping some up
   b. comparing the colors of stars with their spectral types
   c. counting nearby stars
   d. measuring the mass of the Milky Way which showed something extra
   e. a theoretical calculation

39. The sun is roughly ___ from the center of the Milky Way
   a. 100,000 Astronomical Units
   b. 25,000 Light Years
   c. 1000 Light Years
   d. 500 Parsecs
   e. 10 million miles
40. What type of galaxy is shown in the picture at the right?  
   a. spiral  
   b. elliptical  
   c. irregular  
   d. merging  
   e. ring

41. If we wait a long time, the Local Group of galaxies will look  
   a. basically the same as now  
   b. different because the large galaxies will have "eaten" some of the smaller ones  
   c. different because all the galaxies will have turned to spirals  
   d. like it has vanished because it will have dissipated into intergalactic space  
   e. full of small galaxies because collisions will break up the large ones

42. The age sequence of the parts of spiral galaxies is (from young to old):  
   a. spiral arms, disk, bulge, halo  
   b. disk, bulge, spiral arms, halo  
   c. halo, disk, bulge, spiral arms  
   d. halo, bulge, disk, spiral arms  
   e. bulge, halo, spiral arms, disk

43. Molecular clouds are mostly composed of  
   a. ammonia and methane  
   b. dust  
   c. atomic hydrogen  
   d. molecular helium  
   e. molecular hydrogen

44. The primary way Shapley figured out where we are in the Milky Way was he  
   a. found the cluster of massive stars at the Galactic Center  
   b. used a special kind of variable star and the inverse r squared law to estimate the distances of star clusters  
   c. counted stars in various directions to judge where the galaxy extended  
   d. argued that the Milky Way was similar to the spiral nebulae  
   e. mapped the system in HI

45. The question of whether the spiral nebulae were galaxies like the Milky Way was settled  
   a. when Heber Curtis decisively defeated Harlow Shapley in this part of their debate  
   b. when Shapley showed how big the Milky Way is, using globular clusters  
   c. when Edwin Hubble used the new 100-Inch Telescope to photograph stars in nearby galaxies  
   d. by Herschel when he cataloged other galaxies in the process of mapping the sky  
   e. when Henrietta Leavitt discovered the period-luminosity relation

46. The various types of galaxy  
   a. show a sequence that evolves with age from one to the other  
   b. include spirals, ellipticals, and irregulars  
   c. are a result of different distances to them and the resulting limits to the amount of detail we can see  
   d. are only apparent in the visible spectral range  
   e. show they are made of different types of matter

47. The biggest change in our view of our place in the Universe compared with the view 100 years ago is  
   a. then, we thought that the "Universe" was just the Milky Way  
   b. then, we believed the earth was at center of the solar system  
   c. then, we believed we were off at one edge of the Milky Way  
   d. then, we believed that Milky Way was less than 10,000 years old, from the accounts of years in the Bible  
   e. then, we thought stars made their energy by chemical burning

48. An HII region can be identified from  
   a. its absorption lines  
   b. its molecular lines  
   c. from the reddening it imposes on objects behind it  
   d. from its emission lines  
   e. from its X-ray emission
49. In very deep images that let us detect very distant and hence young galaxies, we find them to be
   a. very similar to nearby ones
   b. generally to be smaller and with less regular structure compared with nearby ones
   c. mostly to be ellipticals since bulges formed first
   d. all very obscured by the dust in their interstellar matter
   e. we cannot get a good enough sense of their nature to describe them well

50. Most of the mass of the Milky Way is
   a. in its stars
   b. in the supermassive black hole in its center
   c. in the interstellar gas
   d. in a.) through c.)
   e. in the form of dark matter