Correct answers shown in boldface. Be sure to write your name and student ID number on the first blank at the bottom of the form, the exam number on the second (subject) one, and your section number (7 for 11:00, 8 for 12:00) in the "period" one. If you need to erase an answer, please do so carefully and remove all of the old mark.

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

2. To form a real star, an object must be massive enough to
   a. have enough gravity to hold planets in orbit
   b. make an HII region
   c. explode as a supernova
   d. create enough pressure and heat in its core for hydrogen fusion
   e. burn hydrogen and helium into heavier elements

3. The outer planets are mostly large and gaseous because
   a. beyond the frost line, hydrogen froze to form the jovian planets
   b. the Sun's gravity caused the denser rock and metals to settle towards the center of the solar system, leaving lighter materials in the outer system
   c. beyond the frost line, the gravity of large, ice-rich planetesimals captured the abundant light gases
   d. the disk's spin flung lighter materials farther from the Sun
   e. the protoplanetary disk was gas on the outside, solids on the inside

4. 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. they did not have photographic plates to detect very faint stars
   c. their telescopes were too small to see the whole system
   d. they needed infrared detectors
   e. they did not realize how interstellar dust cut off their view

5. When clumps of gas first collapse into young stars, their arrival on the main sequence is delayed because
   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

6. 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

7. 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

8. We study galaxies at very high redshift to
   a. see how far away we can see
   b. determine how galaxies form and evolve to ones like ours
   c. look for active nuclei
   d. to see them smash into each other
   e. to probe the earliest stages in the Big Bang

9. 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. there 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

10. 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

11. 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. 1000 Parsecs
   e. 10 million miles

12. Spiral arms are prominent in some galaxies because
   a. they mark where the dust is thin and we can see the stars better
   b. they show where young and bright stars have formed
   c. they represent bright blobs that have been wound into the spiral shape by the galaxy rotation
   d. Population III stars make them bright
   e. they mark where material has been ejected by the nucleus

13. 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

14. 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

15. In the early 1900's it became possible to measure large numbers of RR Lyrae and Cepheid variables in the nearest galaxies because
   a. telescopes were built larger than ever before
   b. telescopes were put at high mountain sites for the first time
   c. the first observatories were built in the southern hemisphere
   d. photographic plates were used, letting thousands of stars be measured to very faint levels all together
   e. the first electronic detectors were introduced

16. The central galaxies of dense clusters are
    a. similar to the other cluster members
    b. massive spirals that attracted the rest of the cluster galaxies around them
    c. virtually always with active nuclei because gas from the cluster is falling in
    d. massive ellipticals that result from many mergers with smaller cluster members
    e. galaxies with immense tidal tails and other indications of interactions

17. Galaxies come
    a. in a chaotic, bewildering variety of shapes
    b. always in the same shape - but they look different to us because we view them at different angles
    c. in a limited number of shapes that we can describe in systematic ways
    d. in different shapes depending on what kind of material makes them up
    e. in different shapes depending on whether they have an active nucleus

18. 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

19. In comparison with the black holes in some other galaxies, the one in the Galactic Center is curious because
    a. it is far less massive
    b. it is harder to study in any detail
    c. it seems to be making very little energy
    d. it occasionally has a huge outburst
    e. it is spinning rapidly

20. Why does the rotation curve of a galaxy increase with increasing distance near the galaxy's center?
    a. the encircled mass increases so fast that gravity increases with radius
    b. the stars are exploding outwards from the center, thus showing the high speeds
    c. most of a galaxy's mass is in the center
    d. because the center rotates like a rigid wheel or Merry-Go-Round
    e. because of the effects of the nuclear massive black hole

21. We know about the black hole in the Galactic Center because
    a. It glows brightly
    b. Shapley found it
    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 things get sucked into it

22. The nature of quasars was initially confusing primarily because
    a. their emission lines were at peculiar wavelengths
    b. they were radio sources
    c. they varied rapidly
    d. they were very luminous
    e. they looked like stars

23. Galaxies undergoing starbursts
    a. are full of bursting stars
    b. are usually ellipticals
    c. were identified through clusters of stars bursting out from them
    d. are forming massive stars rapidly
    e. have less dark matter than other galaxies

24. When matter falls into a black hole
a. it quickly disappears from sight
b. it often gets very hot and glows in X-rays
c. it passes out into another Universe
d. it takes an unfamiliar form
e. its light shifts to the blue

25. Superluminal - faster than light - motions result when
a. the geometry of very rapid motions sets up an optical illusion
b. matter falls into a black hole and is then expelled rapidly
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. The outer part of the rotation curve of a galaxy is flat; this fact indicates that
a. where the curve is flat, the mass is still increasing with increasing distance from the center
b. Newton's law of gravity is wrong
c. there is a supermassive black hole at the center of the galaxy
d. the galaxy is still in the process of forming and gas is falling in where we measured the rotation
e. practically all the mass of the galaxy is within the radius where the curve flattens out

27. To get reliable information, you should
a. only use books, since publishers always check their content carefully
b. rely on the web, because it is where the most up-to-date material can be found
c. see if a number – at least three - of apparently reliable sources agree
d. consult magazines, since they have to include good facts to keep their circulation up
e. ask around to see what others think is reliable

28. SABIO is
a. the University Library computerized book finding system
b. a new brand of cell phone
c. the Southern Arizona BIOgraphical society
d. a super-secret anti-terrorist branch of the CIA
e. none of the above

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

30. A newly formed massive, hot star changes the surrounding interstellar gas into
a. a molecular cloud
b. a glowing cloud of excited gas called an HII region
c. a dark globule seen as a shadow against the background light
d. an HI region
e. interstellar dust

31. It is important to study the center of the Milky Way because
a. it gives infrared and radio astronomers something to do
b. it helps us locate the position of the solar system within the galaxy
c. there is a unique type of star there
d. it gives a unique perspective on how a galaxy nucleus works
e. actually, there is nothing of much interest there

32. The mass of a cluster of galaxies
a. results in broadening the spectral lines from active nuclei in the cluster
b. causes the cluster to glow all over as things fall into it
c. makes the emission lines of the galaxies in the cluster shift wavelength significantly due to relativity
d. is almost all concentrated in its giant central galaxies
e. is mostly in the form of very hot gas and dark matter

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

34. The large-scale distribution of the galaxies in space is a result of
a. the gravitational attraction of great black holes that attract galaxies to their vicinity
b. that galaxies tend to slow each other down when they pass closely, making them tend to concentrate together
c. galaxies are fairly uniformly distributed, but intergalactic dust clouds hide some of them and make the distribution look clumpy
d. the structure of the early Universe
e. galaxies of similar types tending to clump together

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

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

37. Disks form around young stars
a. if the cloud from which the star forms is too massive for all of it to fall into the star
b. when the new star passes through a dense cloud and it is attracted to the star
c. from material that was spinning around the protostellar core too fast to fall into the star
d. when a second star that formed in orbit breaks up
e. because once a star is on the main sequence, matter has to stop falling into it and ends up in a disk

38. What kind of experiment has proven most useful for finding planets around other stars?
a. using a very large telescope to take pictures sensitive enough to capture their light
b. listening for radio emissions from civilizations on them
c. measuring the positions of the stars very accurately to detect the effects of the planets' gravity on their motions
d. measuring accurate Doppler shifts in the stellar spectra to detect the effects of the planets gravitational tugs on the stars' motions
e. using spectrographs to measure absorption features associated with planetary atmospheres

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

40. When galaxies collide
a. they explode
b. they pass right through each other with no other consequences
c. they tend to merge into a single galaxy
d. there is a loud noise
e. this happens so seldom we do not have a good idea of what happens

41. Active galaxy nuclei are powered by
a. galaxy mergers
b. matter falling into very massive black holes
c. lots of star formation in the centers of galaxies
d. energy left over from when the galaxy formed
e. star collisions in the dense environment of galaxy nuclei

42. The Milky Way is a
a. elliptical galaxy
b. irregular galaxy
c. barred spiral galaxy
d. Sa galaxy
e. we do not have much idea of what type it is

43. The distance to nearby galaxies like the one in Andromeda was determined from
a. determining its gravitational effects on the Milky Way
b. measuring its parallax
c. using Cepheid variables as standard candles
d. comparing its apparent size with that of the Milky Way
e. observing HII regions in it

44. 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

45. Star formation is often aided by
a. heating of an interstellar cloud by a star ejecting a planetary nebula
b. thermal instability in interstellar gas
c. a nearby supernova explosion compressing a molecular cloud
d. planets passing through a molecular cloud and upsetting its equilibrium
e. centrifugal forces caused by spinning cloud fragments

46. A "standard candle" for an astronomer is
a. a candle used as a source of light to calibrate their measurements
b. a variable red supergiant star
c. an astronomical object whose luminosity can be determined independent of knowing its distance
d. a barred spiral galaxy
e. a special candle of constant brightness maintained at the Bureau of Standards

47. Galaxy distances are important because
    a. they let us calibrate parallax measurements
    b. they tell us where to look to find stars with planetary systems
    c. they help address the philosophical questions about our place in the Universe and how it is built
    d. they show us which galaxies are coming toward us
    e. they identify which galaxies are colliding with each other

48. Distance measurements to the galaxies around us show that
    a. the Milky Way is isolated in space
    b. the Milky Way belongs to a group of only three galaxies, including M31 and M33
    c. the Milky Way is part of a galaxy group in which it and M31 are 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 orbiting M31, and we see its projected position move relative to background galaxies

49. Gravitational lenses in galaxy clusters are used
    a. to confirm that the clusters have huge amounts of dark matter
    b. to get a better view of the Big Bang
    c. to search for distant planets
    d. to study the theory of relativity
    e. to improve our determination of Hubble's Law

50. Interstellar dust makes the things behind it look
    a. bluer and fainter
    b. greener and brighter
    c. redder and fainter
    d. it blots them out completely
    e. redder and more diffuse