1. The Hubble classification for a spiral galaxy with a moderate-sized nuclear region and moderately well-defined spiral arms is
   A. *Sb
   B. E3
   C. SBa
   D. Sa

2. What assignment is given to a galaxy with a large nuclear bulge and tightly wound arms starting from a bar through the central part of the galaxy?
   A. *SBa
   B. SBc
   C. Sb
   D. SBb

3. What is an E3 galaxy?
   A. *a galaxy with a smooth light distribution and a moderately elongated elliptical shape, without a disk or central bulge
B. a galaxy with a smooth light distribution and a very elongated elliptical shape, without a disk or central bulge
C. a galaxy with a smooth light distribution and a moderately elongated elliptical shape, having a pronounced disk and central bulge
D. a galaxy with an irregular light distribution and a very elongated shape

4. Which of the following galaxy types contain little or no interstellar dust or gas?
A. *ellipticals
B. barred spirals
C. spirals
D. irregular galaxies

5. The observational fact about a Cepheid variable star that leads to a measurement of its distance from the Earth is that its period of variation is directly related to its
A. *absolute magnitude or luminosity
B. apparent magnitude
C. speed away from us, using the relativistic effect upon pulsation period
D. surface temperature

6. In which of the following types of galaxies is star formation no longer occurring?
A. irregular galaxies
B. spirals
C. barred spirals
D. *ellipticals

7. The largest range of sizes of galaxies is found in which class of galaxies?
A. barred spirals
B. *elliptical
C. irregular
D. spiral

8. Which of the following objects are NOT used as “standard candles” for distance measurements to distant galaxies?
A. supernova explosions
B. RR Lyrae stars
C. *hot white dwarf stars
D. Cepheid variable stars

9. What is the brightest standard candle found so far, and therefore the one that can be seen to the greatest distance?
A. Cepheid variables
B. *Type Ia supernovae
C. RR Lyrae stars
D. Type II supernovae
10. The Tully-Fischer Relationship can be used to measure the luminosity of (and this the distance to)
A. elliptical galaxies
B. *spiral galaxies
C. globular clusters
D. Type II supernovae

11. The Hubble relation links which two characteristics of distant objects in the universe?
A. *distance and velocity of recession
B. the state of organization of stars in clusters and the age of clusters
C. stellar mass and luminosity
D. distance and brightness

12. Galaxies are distributed through the universe in
A. *clusters, which are grouped into linked superclusters around huge voids (like soap bubbles)
B. isolated clusters containing anywhere from a few dozen galaxies to thousands of galaxies
C. isolated superclusters, each of which contain dozens of clusters of galaxies
D. a random scattering of small clusters of galaxies similar to the Local Group

13. What is a starburst galaxy?
A. a galaxy with streams of stars arching out from one region, as if from an explosion
B. *a galaxy with an unusually large number of newborn and young stars
C. a galaxy that is still in the process of formation from the intergalactic medium and is undergoing its first episode of star formation
D. a galaxy with stars moving radially outward in all directions from the explosion of the accretion disk of its central supermassive black hole

14. The rotation curve of a galaxy is a graph showing the galaxy’s speed of rotation at different distances from the center. The observed rotation curve in the OUTER PARTS of a typical large spiral galaxy
A. decreases suddenly to zero at the outer edges of the visible galaxy
B. decreases smoothly with increasing distance from the center, following a Keplerian curve
C. *is quite flat (roughly the same speed at all distances)
D. increases drastically with increasing distance from the center, as shown by the spiral arms

15. What is a rich cluster of galaxies?
A. a cluster with a high metal content
B. a cluster with more spiral galaxies than ellipticals
C. a cluster (like our local group) that contains at least two large galaxies
D. *a cluster containing thousands of galaxies

16. In which of the following type of galaxy is star formation no longer occurring?
A. *E0 elliptical galaxy
B. Irregular I-type galaxy
C. Sc spiral galaxy
D. SBb barred spiral galaxy

17. Quasars appear to be
A. *very distant, intrinsically bright objects, moving away from Earth at very high speeds*
B. very distant, intrinsically faint objects, moving toward Earth very rapidly
C. relatively close, very bright objects moving away from Earth
D. very distant and intrinsically bright objects moving in random directions at high speeds

18. The specific characteristics that identify most quasars are
A. *starlike appearance, very high redshifts, and hence very large distances, indicating very energetic sources.*
B. that they look like elliptical galaxies, but with high spectral redshifts.
C. spiral galaxy appearance, and very high spectral blueshift, indicating that they are coming toward the Sun at high speed.
D. starlike appearance, and very high spectral blueshift, indicating that they are approaching the Sun very fast.

19. The most likely mechanism for the many double radio lobes that are now detected in distant space is
A. *two oppositely directed jets of matter, ejected from a small source in the center of a galaxy.*
B. two pulsars on opposite sides of a quasar.
C. two black holes on either side of a small galactic nucleus.
D. two radio stars in the spiral arms of a galaxy, symmetrically placed around the galactic nucleus.

20. If the red shifts of quasars really do indicate their distance then
A. a quasar must be very small.
B. a quasar must be within the Local Group.
C. a quasar must be a single star with an extremely large mass.
D. *a quasar must be very luminous.*

21. Synchrotron radiation is produced whenever
A. *electrons move in spirals in a magnetic field*
B. atoms in a molecule vibrate back and forth
C. electrons jump from level to level in an atom
D. light passes into a transparent medium, such as glass

22. The mechanism that appears to generate two extensive regions of radio emission near active galaxies is
A. the double image of a single source behind the galaxy, produced by gravitational lensing by the galaxy
B. two small black holes orbiting around the center of the galaxy
C. *two oppositely directed jets of energetic particles*
D. two very hot gas clouds, emitting 21-cm radio waves
23. To what does the phrase “superluminal motion” refer?
   A. the motion of relativistic electrons in magnetic fields
   B. *the apparent motion of jets of gas at speeds faster than light
   C. the apparent motion of arcs of light caused by gravitational lensing
   D. the motion of galaxies at redshifts $z > 1$

24. In the “unified model” of active galaxies, the main difference between quasars, blazars, and radio galaxies appears to be that
   A. the mass of the central black hole is different in each case-largest in quasars, less in blazers, and least in radio galaxies
   B. the rate at which matter is falling into the central black hole is different in each case-highest in quasars, less in blazers, and lowest in radio galaxies
   C. the galaxy type is different in each case-spiral for blazers, elliptical for quasars, and irregular for radio galaxies
   D. *we see the accretion disk around the central black hole from a different angle in each case-face-on for blazers, edge-on for radio galaxies, and in between for quasars.

25. Many astronomers believe that quasars are
   A. Wormholes that can lead us to another dimension.
   B. Signals from extraterrestrial intelligent beings.
   C. *Active galactic nuclei in distant galaxies.
   D. Explosions of stars in distance galaxies.

26. The "central engine" of an active galaxy appears to be
   A. stars falling into a supermassive black hole, their remnants being thrown out in all directions.
   B. supernova explosions in an extremely dense star cluster at the center of the galaxy.
   C. the violent merger of two galaxies, in which the collision throws out jets of matter along the rotation axis of the larger galaxy.
   D. *a supermassive black hole at the center of an accretion disk, with jets of material being ejected perpendicular to the disk.

27. Why are there no nearby (and thus “young”) quasars?
   A. *Eventually, most of the accretion disk falls into the black hole and the “central engine” runs out of fuel.
   B. The central black hole eventually consumes the entire galaxy, and with no more matter in the vicinity, it becomes dormant until another galaxy happens to pass nearby.
   C. The continual infall of material causes the mass of the black hole to grow until it explodes, resulting in a supernova.
   D. The immense radiation output from the quasar carries away energy. The mass of the black hole gets smaller until it evaporates.

28. Observations indicate that blazars are
   A. quasars that have absorbed or merged with a smaller galaxy within a cluster
   B. distant spiral galaxies undergoing an intense burst of star formation
   C. *radio galaxies whose jets and radio lobes point almost directly at the Earth
D. black holes in binary stars systems, where matter pulled from the companion star forms a hot accretion disk around the black hole

29. In the expansion of the universe, the expansion takes place
A. only between objects separated by a vacuum; as a result, our bodies do not expand but the Earth-Moon system does.
B. primarily in the huge voids between clusters of galaxies: "small" objects like galaxies or the Earth do not expand.
C. only over distances about the size of a galaxy or larger; consequently, our galaxy expands but the solar system does not.
D. *between all objects, even between the atoms in our bodies, although the expansion of a person is too small to be measured reliably.

30. I thought that the Big Bang was hot! If the cosmic microwave background radiation is the radiation left over from the Big Bang, why then is it only 3 K?
A. *The Big Bang itself was hot, but the temperature decreased as the universe expanded, and the temperature now is 3 K.
B. It is not from the Big Bang itself—it is from cold, intergalactic hydrogen clouds that are left over from the Big Bang.
C. The Big Bang itself was hot, but by the time the universe became transparent the temperature had already decreased to 3 K.
D. The Big Bang was not hot—its temperature was the same as we observe it now from the cosmic background radiation.

31. At an age of 380,000 years, the temperature of the universe had fallen to 3000 K, and electrons could then combine with protons to produce hydrogen gas instead of roaming freely through space. What major transition occurred as a consequence of this change in the universe at this time?
A. The universe would have lost its electrical charge suddenly to become electrically neutral.
B. The present laws of physics were applicable to the properties of the universe for the first time.
C. *The universe became transparent to light for the first time.
D. Nuclear fusion no longer occurs below this temperature, and so, general fusion throughout the universe would have ceased.

32. The cosmic background radiation comes from a time in the evolution of the universe
A. when protons and neutrons were first formed.
B. when the big bang first began to expand.
C. when gamma rays had enough energy to destroy nuclei.
D. *when electrons began to recombine with nuclei to form atoms.

33. What causes cosmological redshift of photons that reach us from distant galaxies?
A. The photons have moved from high gravitational field regions toward lower fields, thereby becoming reddened.
B. The photons were emitted from the galaxies much earlier in time when the overall temperature of matter was much lower. Hence, the observed photons are redder, the farther away from Earth that they were produced.
C. *The photons have traveled across space that has been expanding and their wavelengths have expanded with it, becoming redder.
D. The photons were emitted by objects that were moving rapidly away from us, and thereby have been reddened by the Doppler effect.

34. Whether the universe is open, closed or flat depends on the ______ in the universe.
A. luminosity of the matter
B. *density of matter
C. temperature of matter
D. radius of the big bang

35. Consider the above geometric representations, within which geometry(ies) will two parallel beams of light never meet?
A. Closed Geometry
B. Flat Geometry
C. Both Open and Closed Geometries
D. *Both Flat and Open Geometries

36. What is “dark energy”?
A. the energy associated with the matter that has fallen into a black hole
B. *the matter-energy needed to bridge the gap between the energy we see or infer and the energy needed to make the universe flat
C. the energy associated with “dark matter”
D. the unseen matter-energy needed to make the universe closed

37. Why is the universe expanding?
A. It is not expanding—it is not local space that is getting smaller as we fall into a supermassive black hole, making the universe seem bigger and bigger
B. *because space itself is expanding, carrying the galaxies (or superclusters of galaxies) with it
C. because an infinitely small but infinitely dense clump of matter exploded, sending the galaxies (or superclusters of galaxies) hurtling out through space
D. because the energy from all the stars is heating the universe, making it expand like a gas that is heated
38. In cosmology, the phrase “critical density” refers to
A. the smallest density that will produce inflation of the universe
B. the density below which stars will never form
C. the density above which the universe is opaque to radiation
D. *the density needed to produce precisely flat space on average throughout the universe

39. Recent results from very bright supernovae in very distant galaxies seem to indicate that the expansion of the universe
A. is continuing at a constant rate and has done so since just after the Big Bang
B. has now stopped and the universe will shortly begin to contract again toward a Big Crunch
C. *is accelerating (speeding up)
D. is decelerating (slowing down)

40. The resolution of Olbers’ paradox suggests that it gets dark at night because
A. *the universe is not infinite.
B. the universe is not static.
C. the universe is open
D. the universe is uniform