MULTIPLE CHOICE: Choose the one best answer from among the five choices for each of the following 20 questions. Each correct answer is worth one point.

1. Eratosthenes lived in Egypt around 200 B.C., and he...
   (A) determined the size of the Earth
   (B) determined the angle of the tilt of the Earth's axis with respect to the plane of the Solar System, with an accuracy of better than 0.01 degree.
   (C) determined the length of the year, with an accuracy of several minutes
   (D) believed that the daily rising and setting of the Sun and stars is due to the rotation of the Earth
   (E) developed a method for predicting Lunar eclipses

2. Around 500 A.D., Chinese astronomers...
   (A) determined the size of the Earth
   (B) determined the angle of the tilt of the Earth's axis with respect to the plane of the Solar System, with an accuracy of better than 0.01 degree.
   (C) determined the length of the year, with an accuracy of several minutes
   (D) believed that the daily rising and setting of the Sun and stars is due to the rotation of the Earth
   (E) developed a method for predicting Lunar eclipses

3. In India, around 500 A.D., the Aryabhata school of astronomy...
   (A) determined the size of the Earth
   (B) determined the angle of the tilt of the Earth's axis with respect to the plane of the Solar System, with an accuracy of better than 0.01 degree.
   (C) determined the length of the year, with an accuracy of several minutes
   (D) believed that the daily rising and setting of the Sun and stars is due to the rotation of the Earth
   (E) developed a method for predicting Lunar eclipses

4. Around 500 B.C., the Babylonians...
   (A) determined the size of the Earth
   (B) determined the angle of the tilt of the Earth's axis with respect to the plane of the Solar System, with an accuracy of better than 0.01 degree.
   (C) determined the length of the year, with an accuracy of several minutes
   (D) argued that the daily rising and setting of the Sun and stars is due to the rotation of the Earth
   (E) developed a method for predicting Lunar eclipses
5. Around 900 A.D., the Arab astronomer Al Battani...
(A) determined the size of the Earth
(B) determined the angle of the tilt of the Earth's axis with respect to the plane of the Solar System, with an accuracy of better than 0.01 degree.
(C) determined the length of the year, with an accuracy of several minutes
(D) believed that the daily rising and setting of the Sun and stars is due to the rotation of the Earth
(E) developed a method for predicting Lunar eclipses

6. A third quarter Moon rises...
(A) at noon  (B) during the afternoon
(C) at sunset  (D) at midnight  (E) at dawn

7. The desire to explain Kepler's Laws was an important stimulus for the development of which branch of physics:
(A) classical mechanics  (B) classical theory of electromagnetism
(C) quantum mechanics  (D) Einstein's Theory of Relativity
(E) none of the above

8. The desire to understand the spectrum of light emitted by a very hot tenuous gas (e.g. the mercury vapor lamp that I showed in class) was an important stimulus for the development of which branch of physics:
(A) classical mechanics  (B) classical theory of electromagnetism
(C) quantum mechanics  (D) Einstein’s Theory of Relativity
(E) none of the above

9. The spectrum of the light emitted by a very hot tenuous gas, like the mercury vapor lamp that I showed you in class, is...
(A) a continuous spectrum  (B) an emission line spectrum
(C) an absorption line spectrum  (D) a clothes line spectrum
(E) all of the above

10. The spectrum of sunlight is...
(A) a continuous spectrum  (B) an emission line spectrum
(C) an absorption line spectrum  (D) a foul line spectrum
(E) all of the above

11. Typically, a new extra-solar planet will be discovered by:
(A) measuring the redshift of the starlight reflected by the planet
(B) measuring the side-to-side motion of the star that the planet orbits
(C) detecting the dimming of the star when the planet blocks its light
(D) measuring the Doppler shift of absorption lines in the spectrum of the star that the planet orbits
(E) communicating directly with life forms residing on the planet
12. The mass of a planet can be directly determined by studying...
(A) the properties (size, shape, period) of its orbit around the Sun
(B) the properties of the orbits of any one of its moons (if it has any)
(C) its composition   (D) A and B   (E) A and C

13. The angular resolution of the unaided human eye is about how many times worse that that of a telescope of 6 inches diameter:
(A) 6          (B) 60          (C) 600
(D) 6,000      (E) 60,000

14. We believe that the Helium in our Universe was created:
(A) in white dwarf stars
(B) in the cores of main sequence stars
(C) during Big Bang nucleosynthesis
(D) A and B   (E) B and C

15. A certain kind of particle is created in the Sun's core and then travels through the Sun almost completely unimpeded. Such particles can be detected when they reach the Earth, using sophisticated (and huge) underground detectors. What are these particles called ?
(A) photons   (E) MACHOs   (C) WIMPs
(D) neutrons   (E) neutrinos

16. The distances to the nearest stars are measured by observing how the apparent position of a star in the sky changes...
(A) as the Galaxy slowly rotates   (B) as the star's planets orbit around it
(C) as the Earth orbits the Sun   (D) all of the above
(E) none of the above

17. The most luminous main sequence stars...
(A) are blue in color   (B) live short lives, compared to the Sun
(C) have surfaces that are hotter than that of the Sun
(D) B and C   (E) A, B, and C

18. From the luminosity and surface temperature of a star, we can directly determine its...
(A) mass   (B) distance   (C) radius
(D) all of the above   (E) none of the above

19. A white dwarf star is in a state of pressure equilibrium. The very large gravitational forces tending to compress it are balanced by a pressure that can be best explained using ideas from which branch of physics:
(A) classical mechanics   (B) classical theory of electromagnetism
(C) quantum mechanics   (D) Einstein's Theory of Relativity
(E) none of the above
20. The main sequence lifetime of the Sun is approximately...
(A) a million years        (B) ten million years
(C) 100 million years       (D) 1 billion years
(E) 10 billion years

21. A common unit of distance used by astronomers is the parsec. One parsec (also written 1 pc) equals about...
(A) 1 light-year      (B) 3 light-years
(C) 10 light-years    (D) 30 light-years    (E) 100 light-years

22. The distance to the nearest star (not counting the Sun) is about...
(A) 0.01 pc      (B) 0.1 pc
(C) 1 pc        (D) 10 pc   (E) 100 pc

23. One megaparsec (1 Mpc) equals one million parsecs. The distance to the nearest significant galaxy (not counting the one we live in!) is about...
(A) 0.01 Mpc      (B) 0.1 Mpc
(C) 1 Mpc        (D) 10 Mpc    (E) 100 Mpc

24. The distance to the “edge of the observable universe” is about...
(A) 5 Mpc      (B) 50 Mpc
(C) 500 Mpc    (D) 5,000 Mpc    (E) 50,000 Mpc

FILL IN THE BLANK(S): For each of the following 14 statements, insert the most appropriate word or phrase in the space provided. Each correct answer is worth two points.

25. The explanation for why we have seasons is related to the fact that the __________ is not exactly perpendicular to the ________________ .
   (NOTE: Give the true explanation, not the explanation according to the “useful fiction” of the celestial sphere.)

26. In New Zealand, the longest day of the year is ____________ . (insert approximate date)

27. In Chicago, the Sun sets North of West during the following dates each year: all dates between ____________ and ____________ .
28. In the 19th century, mathematicians using Newton's theory of classical mechanics predicted the existence of a seventh planet, and even told astronomers where to point their telescopes to look for it. It was discovered within a degree of where the mathematicians predicted it would be. This planet is called ________________.

29. An electron is orbiting the nucleus of a Hydrogen atom, and is occupying the lowest energy level (n = 1). It can make a transition to the n=3 energy level if it _________ a photon.

30. The telescope was invented by __________________________.

31. Wein's Law states that, for an ideal blackbody, the wavelength corresponding to the peak in the spectrum of the electromagnetic radiation is inversely proportional to the ________________.

32. Basically, there are two general types of planets in our Solar System. These are the terrestrial planets and the _____________ planets.

33. When a spinning ballerina pulls her arms and legs in closer to her body (closer to her axis of rotation), she spins faster. This is due to the Law of ____________________ ____________________.

34. Two stars have the same luminosity but one has an apparent brightness that is 64 times greater than that of the other. The brighter star is located at a distance of 200 parsecs from the Solar System. We can infer from the method of “standard candles” that the distance to the fainter star is _________________________.

35. All stars will eventually run out of fuel. Their cores will eventually become ________________, or ________________, or ________________.

36. During the old age and death of a star, there occurs some ejection of matter back into the interstellar medium. For our Sun, this will be in the form of a ____________________________, but for a high-mass star, there can occur a much more violent explosion called a ____________________________.

37. The very latest discoveries in cosmology suggest that all the baryonic matter and dark matter together form only about one third of all of the mass-energy in our Universe. According to this currently popular hypothesis, the other two thirds is something mysterious that we call ____________________.

38. Once you slip past a black hole's __________________, you can never come out again.
SHORT ANSWER QUESTIONS: For each of the following eight questions, provide a brief answer in the space provided. The point value of each question is noted below.

Questions 39 through 43 refer to a far-away star that has its own Earth-like planet. This imaginary planet is called “Krypton”. Krypton orbits its sun once per “Krypton-year”. Like Earth, Krypton has just one moon. When Krypton's moon and sun are viewed from the surface of Krypton, the moon subtends an angle of 1.2 degrees, and the sun subtends an angle of 1.5 degrees. The picture below shows Krypton (K) and Krypton's moon (KM), at eight positions along the orbit of Krypton about Krypton's sun (KS).

39. On the diagram above, write “LE” next to the time(s) for which it is possible that a lunar eclipse might be visible from Krypton. [NOTE: For this question you don't need to explain your reasoning – just write “LE” in the appropriate place(s).] (3 pts.)

40. On the diagram above, write “SE” next to the time(s) for which it is possible that a solar eclipse might be visible from Krypton. [Again, for this question you don't need to explain your reasoning.] (3 pts.)

41. Can the residents of Krypton ever witness a total solar eclipse? Why or why not? (4 pts.)
42. How many “Krypton synodic months” are there in a “Krypton year”? Explain your reasoning. (4 pts.)

43. How many “Krypton sidereal months” are there in a “Krypton year”? Explain your reasoning. (4 pts.)

44. By applying modern physics including Einstein’s Theory of General Relativity to develop models for the evolution of the Universe, we have learned that space-time could be curved on the largest spatial scales. One way to find out if there is such large-scale curvature in space-time is to define a very large triangle in our Universe, and then measure some of the sides and angles of this triangle. Recently, cosmologists have defined such triangles and obtained such measurements. What did they use as the three corners of their triangles, and what did they learn from their measurements? (10 pts.)
45. In the 1920's, Edwin Hubble made some measurements that led him to the discovery of what is now called Hubble's Law. What measurements were these? State Hubble's Law. (10 pts.)

46. The most luminous objects that we see in our Universe are called quasars. We think that we have a good explanation for what these quasars are, and for what accounts for their incredibly high luminosity. What is this explanation? How is the luminosity produced? (10 pts.)