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

1. In the setup at the left, the observer will see
   a. a blackbody spectrum
   **b. an emission line spectrum**
   c. an absorption line spectrum
   d. a continuous spectrum
   e. it could be any of the four options above

2. The most basic building blocks of matter that we know about are
   a. photons
   **b. quarks**
   c. antiprotons and antineutrons
   d. neutrinos
   e. protons, neutrons, and electrons

3. North of the equator, the stars rise in the east and set in the west and revolve in a counter-clockwise direction around the north celestial pole. South of the equator, they
   a. rise in the west, set in the east, and revolve clockwise around the south celestial pole
   **b. rise in the east, set in the west, and revolve clockwise around the south celestial pole**
   c. rise in the west, set in the east, and revolve counter-clockwise around the south celestial pole
   d. rise in the east, set in the west, and revolve counter-clockwise around the south celestial pole

4. Two identical planets are orbiting a star very similar to the Sun. The one planet has a mass and orbital radius identical to the Earth’s. The other planet is 2 times more distant. How different is the force of gravity on this second planet than on the Earth-like planet?
   a. the force is about 2 times weaker
   b. the force is about 9 times weaker
   **c. the force is about 4 times weaker**
   d. the force is the same
   e. the force is stronger

5. You obtain spectra of two stars you think are identical (see below). One is nearby (the upper one, labeled “unshifted”). What is most likely to be different about the second star (lower spectrum)?
   a. it is cooler, causing its spectrum to peak further into the red
   b. the electric force is a bit weaker, shifting the electrons to different orbits in its gas
   c. it has very high surface gravity that causes the photons to lose energy as they leave it
   d. it is moving rapidly toward us
   **e. it is moving rapidly away from us**

6. If you know the wavelength of a photon, you can compute
   a. its position
   b. its frequency
   c. its energy
   d. its position, frequency, and wavelength
   **e. its frequency and energy**
7. Galileo's greatest contribution to science was
   a. he showed that science was superior to religion
   b. he wrote his results up in books and had them published for general circulation
   c. he built telescopes and made important observations with them
   d. he did experiments
   e. he proved that the Copernican system was correct

8. The seasons are primarily due to
   a. the earth getting closer to and farther away from the sun as it goes around its orbit
   b. the tilt of the axis of the earth relative to the axis of its orbit around the sun
   c. greenhouse effects
   d. changes in the output of the sun
   e. large scale movements of air

9. Aristarchus' ideas about the solar system
   a. were accepted by the other Greek scientists
   b. were rejected because they were wrong
   c. were rejected because he was judged not to be qualified
   d. were rejected because they contradicted theories about how planets should move
   e. both c. and d.

10. $5.83 =
    a. $5.83 \times 10^0$
    b. $5.83 \times 10^{-2}$
    c. $5.83 \times 10^{-5}$
    d. $5.83 \times 10^{-4}$
    e. $5.83 \times 10^{-3}$

11. Compared with the Greeks, the Babylonian and Mayan astronomers:
   a. did not make very accurate measurements
   b. did not connect their results over long periods to discover patterns in them and in the motions of the sun, moon, and planets
   c. did not make accurate predictions about the positions of the moon and planets
   d. did not get the attention of powerful rulers and other people for their work
   e. did not try to develop physical ideas of how and why the planets moved

12. Jupiter is 5 AU from the Sun. Using the graph at right, how long does it take Jupiter to orbit the Sun?
   a. 1.9 years
   b. 1.25 years
   c. 11 years
   d. 4 years
   e. More information is needed

13. Two stars are identical in all respects but one: Star B is two times further away from us than Star A. What are the relative brightnesses of these two stars?
   a. Star A is two times fainter than Star B
   b. Star B is two times fainter than Star A
   c. Star A is four times fainter than Star B
   d. Star B is four times fainter than Star A
   e. The stars appear equally bright

14. An astronomer is designing a new telescope to use in space. The Hubble Space Telescope operates at wavelengths close to 500nm (1nm = $10^{-9}$ meter). The new telescope is to be used at 5000nm (in the infrared).
   a. such a telescope is not needed because nothing emits at 5000nm
   b. such a telescope will need to be 10 times larger in diameter to see the same level of detail
   c. such a telescope would be better built at sea level
   d. such a telescope should be a refractor
   e. such a telescope could be smaller than the Hubble Telescope to enable use of a cheaper rocket, while still returning pictures with similar detail
15. A solar eclipse occurs
   a. some place on earth every time there is a new moon
   b. when the moon enters the shadow of the earth
   c. **when the orbit of the moon lines up and it is new moon so the moon is exactly in front of the sun**
   d. only at full moon and when the orbits of the earth and moon line up correctly
   e. at times and places that we cannot predict – that is what makes eclipses to awe-inspiring

16. Kepler's great breakthrough in explaining the motions of the planets came because
   a. for the first time, he put the sun at the center of the system
   b. he developed a new understanding of the underlying causes for the relative sizes of the planet orbits
   c. he realized that gravity could hold the planets in their orbits
   d. he was the first to use mathematics to calculate planet orbits
   e. **he realized that the planet orbits are ellipses, not combinations of circles**

17. Gravity is an important force in shaping the Universe because
   a. it is the strongest force
   b. actually, it does not play much of a role off the surface of the earth
   c. it is described by Newton’s Laws that were designed to explain how the Universe works
   d. **there is no antigravity, or opposite-sign gravity**
   e. it is the only inverse r squared force

18. "Conservation of Energy" means that
   a. Laws should be passed to preserve energy for future generations
   b. Energy must be supplied to conserve the motions of the planets in their orbits
   c. **The sum of the energy associated with motion (kinetic) and that associated with the ability to do work (potential) stays the same in a system**
   d. Energy can be converted into matter and matter to energy according to E=mc²
   e. An object in motion tends to retain the motion in the same direction and at the same speed.

19. Kepler's "music of the spheres" theory
   a. was a good start toward a physical theory for the motions of the planets
   b. was an good fit to the Tycho’s measurements of the motions of the planets but has been shown to be wrong by modern observations
   c. was an impressively good fit to the planetary orbital periods
   d. **was an impressively good fit to the eccentricity of the orbits of the planets**
   e. related the day to the month and year

20. People often refer to the side of the moon away from the earth as the "dark side". Is this term correct?
   a. Yes, that side hardly ever gets any light
   b. Partly, since there is less light on that side than on the one toward the earth
   c. **No, all sides of the moon get about the same amount of light**
   d. That side only gets lit by earth shine (reflected from the earth) and so it is not completely dark, but almost
   e. We can’t know for sure without sending a spacecraft there to make measurements

21. Galileo’s discovery of the phases of Venus indicated that
   a. Venus orbits the earth, like the moon
   b. Tycho's model for the solar system was wrong
   c. Venus orbits the sun
   d. **Venus comes between the earth and sun on its orbit**
   e. Venus undergoes eclipses

22. Scientists
   a. work only to apply old theories to new observations
   b. **use observations to test their theories**
   c. derive new theories without reference to observations
   d. use observations to make predictions that can be tested by future theories
   e. do not accept observations that disagree with theory
23. The most persuasive reason ancient astronomers thought the earth was fixed in space and did not orbit the sun was:
   a. the earth is different from bodies in space, which are just bright points of light
   b. space is unchanging while the earth changes all the time
   c. the directions toward the stars did not change over the year (there was no parallax)
   d. their gods placed the earth at the center of the solar system
   e. observations of eclipses of the moon showed that the earth stood still

24. Progress in astronomy was particularly difficult during Medieval times because
   a. a long period of cloudy weather made observations difficult
   b. the Greek theories were particularly advanced on astronomy, making improvements difficult
   c. Aristotle’s views were adopted widely and even codified as part of the Catholic religion
   d. Ptolemy’s writings had been lost
   e. the differences between Ptolemy’s theory and the motions of the planets were very small and hard to measure

25. Einstein is not given credit for solving the problem of planetary motions because
   a. Einstein’s theory of relatively is not as good a theory as Newton’s laws of motion
   b. Newton was a better scientist than Einstein
   c. Newton’s laws provided an accurate explanation without Einstein’s additions
   d. It’s just politics – Newton was English and Einstein was German
   e. Einstein’s theories are still under test

26. A box with no leaks contains a collection of molecules (for example, the box might be full of air). We have a gauge that records how much force is exerted on the walls of the box by molecules. We take data for awhile and then notice that the force increased. What probably happened?
   a. this just happens sometimes
   b. the temperature decreased
   c. the molecules joined together to form more complex ones
   d. the temperature increased
   e. some molecules escaped from the box

27. Copernicus’ theory for the solar system
   a. made much more accurate predictions than previous theories
   b. was much simpler than previous theories
   c. was obviously a big improvement over previous theories
   d. was attractive initially for aesthetic reasons only
   e. introduced new physical principles to understand the motions of the planets

28. Newton’s explanation of Kepler's Laws is accepted as a full scientific theory because
   a. it was more easily understood than Kepler’s work
   b. it provided a more sophisticated version of Kepler's "music of the spheres"
   c. it explained them in terms of simple laws that applied in many other situations also
   d. it used calculus and other sophisticated arguments
   e. it cut the connections with religion and astrology

29. Telescopes are put in space to:
   a. Get them closer to the stars
   b. Get away from city lights
   c. Let astronomers observe day and night
   d. Avoid the absorption by the atmosphere
   e. Let them point more accurately

30. had an immense influence on the calendar
   a. Julius Caesar, emperor of Rome
   b. Kepler
   c. Ptolemy
   d. Hipparchus, great Greek astronomer
   e. Aristarchus, Greek astronomer who proposed a correct model of the solar system
31. When the sun is highest in the sky at noon for people in Sydney Australia, what seasonal event is occurring in Tucson?
   a. summer solstice       b. autumnal (fall) equinox
   c. winter solstice       d. vernal (spring) equinox
   e. summer

32. Examine the figure below. When was it taken?
   a. at dawn  b. at dusk  c. either a.) or b.)  d. could have been any time at night
   e. close to midnight

33. Ptolemy's work was preserved by
   a. finding where it had been buried in dry desert sands
   b. it was discovered in the ruins of the ancient library of Alexandria
   c. Islamic scholars
   d. Aristotle
   e. The Islamic army had brought it to Spain when they invaded

34. Galileo's dispute with the Church
   a. was purely a case of a hard-working scientist being persecuted for his views
   b. was primarily due to Galileo not giving credit to Jesuit priest scientists for their work
   c. reflected deep and fundamental philosophical differences about science and what it could do
   d. was trumped up by the Church with no provocation from Galileo
   e. should never have occurred because Galileo had proof of all of his claims

35. Ptolemy's solar system model
   a. was not scientific
   b. used mathematical calculations to provide a reasonably good fit to the observations
   c. made no reference to observations - was just a theoretical construct
   d. was not quantitative - it just gave a general description of the planetary motions
   e. had obvious flaws that worried ancient astronomers and caused them to reject it

36. Which of the following moves the fastest?
   a. visible light  b. blue photons  c. x-rays  d. radio waves  e. all move at the same speed
37. Which controls accelerate a car, according to Newton's Laws?
   a. the accelerator  b. the brake
   c. the clutch  d. the steering wheel
   e. all but the clutch

38. If you are at the Equator and observe the sky for an entire year, you will be able to see
   a. virtually all the bright stars in the sky
   b. half the bright stars in the sky
   c. the fraction of stars visible will depend on which year you observe
   d. only the stars between the Tropics of Cancer and Capricorn
   e. just the same stars you could see from Tucson

39. An object that emits light with a peak wavelength at 100nm has a temperature ______ that of an object whose emission peaks at 500nm. (1nm = 10⁻⁹ meters)
   a. the same as  b. 5 times  c. 2 times  d. one half
   e. Cannot be computed from the information given.

40. These days, astronomers usually use ______ for obtaining observations of visible photons from stars
   a. their eyes, looking through eyepieces on big telescopes
   b. refracting telescopes
   c. photographic film
   d. electronic detectors
   e. observing assistants

41. An ad claiming that a product is light-years ahead of its time does not make sense because
   a. a light-year is so large that a product could not possibly be so advanced.
   b. light-years only apply to light.
   c. it doesn’t say the number of light-years.
   d. it uses light-years to talk about time, but a light-year is a unit of distance.
   e. it gives no comparison with similar products

42. At what temperature does an object emit electromagnetic radiation?
   a. just above -100° C
   b. just at temperatures above freezing
   c. just around 5500° K, where visible light is emitted
   d. at no particular temperature
   e. at any temperature above absolute zero

43. When we look at a star that is 10 million light years away, the light we see
   a. will be spread over the next 10 million years
   b. looks the same as it would have 10 million years ago
   c. was created 10 million years ago, before human-like beings existed on Earth
   d. is as it was 10 million light-years ago
   e. has dimmed by 10 million times in reaching us

44. Ancient civilizations that had a strong interest in astronomy
   a. were more advanced than any others
   b. tended to develop sophisticated number systems and mathematics as part of their astronomy
   c. lived in desert areas where the sky was clear
   d. also developed excellent science in other areas
   e. had enlightened rulers who were interested in scientific discoveries

45. Because of their wave character, electrons
   a. have the same mass as positrons
   b. are not particles
   c. come and go periodically
   d. can only be found only outside atoms
   e. can only exist in selected orbits within atoms
46. Galileo’s arguments for the Copernican system
   a. were based on solid proof that it was correct
   b. were well founded because his work improved the ability of this system to make accurate predictions
   c. were backed only by some good circumstantial evidence (phases of Venus, Galilean Satellites)
   d. built on the Greek work recorded by Aristotle
   e. were so obviously correct that anyone should have accepted them

47. When mass is annihilated
   a. It disappears into another universe
   b. It just disappears
   c. It is converted into energy, as shown by $E = mc^2$
   d. It is converted into anti-mass
   e. We don't know what happens, since we have never annihilated mass

48. Observing at wavelengths away from visible light
   a. gives astronomers new perspectives about celestial bodies
   b. is so experimental we do not know what it will show
   c. has been tried but not found to be useful
   d. is the main impetus behind our building larger telescopes
   e. can only be done by astronomers with exceptional eyesight

49. Astronomy played a big role in the early development of science in general because
   a. the sky was so awesome it inspired young scientists
   b. the motions of the moon and planets posed a precise, but difficult intellectual challenge
   c. astronomy was useful to predict when to take major steps, such as going to war
   d. astronomy was at the foundation of many important myths
   e. the best minds worked on astronomy

50. People like the Celts and Maya built huge monuments to illustrate astronomy (like Stonehenge or the snake shadow on Chichen Itza)
   a. so their astronomer/priests could live luxuriously in the monuments when they were not being used for astronomy
   b. to provide the people with something to do
   c. to awe the populace with their skill and power
   d. to educate more of the people in astronomical theory
   e. to improve the accuracy of their observations