***The Essential Cosmic Perspective, 8e* (Bennett et al.)**
Chapter 2 Discovering the Universe for Yourself

2.1 Multiple Choice Questions

1) Which of the following statements about the celestial equator is true at *all* latitudes?
A) It lies along the band of light we call the Milky Way.
B) It represents an extension of Earth's equator onto the celestial sphere.
C) It cuts the dome of your local sky exactly in half.
D) It extends from your horizon due east, through your zenith, to your horizon due west.
E) It extends from your horizon due north, through your zenith, to your horizon due south.
Answer: B

2) At midnight, on a clear and moonless night, the number of stars that are distinctly visible to the eye is in the range
A) 2000-5000.
B) 20,000-50,000.
C) 200,000-500,000.
D) 2 million-5 million.
Answer: A

3) The number of official constellations is
A) 56.
B) 88.
C) 123.
D) 205.
Answer: B

4) How many arcseconds are in one degree?
A) 60
B) 360
C) 3,600
D) 100
E) 10,000
Answer: C

5) What is a *circumpolar* star?
A) a star that is close to the north celestial pole
B) a star that is close to the south celestial pole
C) a star that always remains above your horizon
D) a star that makes a daily circle around the celestial sphere
E) a star that is visible from the Arctic or Antarctic circles
Answer: C

6) Which of the following statements about circumpolar stars is true at *all* latitudes?
A) They are the stars close to the north celestial pole.
B) They always remain above your horizon.
C) They make relatively small circles, traveling clockwise around the north celestial pole.
D) Like all other stars, they rise in the east and set in the west.
E) You cannot see them from the Southern Hemisphere.
Answer: B

7) What makes the North Star, Polaris, special?
A) It is the brightest star in the sky.
B) It is the star straight overhead.
C) It appears very near the north celestial pole.
D) It is the star directly on your northern horizon.
E) It can be used to determine your longitude on Earth.
Answer: C

8) You are standing on Earth's equator. Which way is Polaris, the North star?
A) 30 degrees up, due West
B) on the northern horizon
C) directly overhead
D) The answer depends on whether it's winter or summer.
E) The answer depends on what time of day (or night) it is.
Answer: B

9) By locating the north celestial pole (NCP) in the sky, how can you determine your latitude?
A) The altitude of the NCP is the same as your latitude.
B) The altitude of the NCP is your angular distance from the North Pole.
C) The direction of the NCP is the same as your latitude.
D) The direction of the NCP is the angular distance from the North Pole.
E) The altitude of the NCP is the same as your distance from the North Pole.
Answer: A

10) The constellation Orion, located on the celestial equator, is visible on winter evenings but not on summer evenings because of
A) blockage by the full moon.
B) the tilt of Earth's rotation axis.
C) the location of Earth in its orbit around the Sun.
D) the precession of Earth's rotation axis.
Answer: C

11) Why is it summer in the Northern Hemisphere when it is winter in the Southern Hemisphere?
A) Due to Earth's tilt, the Northern Hemisphere is closer to the Sun than the Southern Hemisphere.
B) The Northern Hemisphere is tilted toward the Sun and receives more direct sunlight.
C) The Northern Hemisphere is tilted away from the Sun and receives more indirect sunlight.
D) It isn't; both hemispheres have the same seasons at the same time. Summer comes when Earth is nearest the Sun.
Answer: B

12) Which of the following statements is *true*?
A) Both the Northern and Southern hemispheres receive the same amount of sunlight on the equinoxes.
B) Both the Northern and Southern hemispheres receive the same amount of sunlight on the solstices.
C) The Northern Hemisphere receives the most direct sunlight on the June solstice.
D) The Southern Hemisphere receives the most direct sunlight on the June solstice.
E) Both A and C are true.
Answer: E

13) Which of the following statements about constellations is *false*?
A) There are only 88 official constellations.
B) Some constellations can be seen from both the Northern and Southern hemispheres.
C) Some constellations can be seen in both the winter and summer.
D) It is possible to see all the constellations from Earth's equator.
E) Most constellations will be unrecognizable hundreds of years from now.
Answer: E

14) Which of the following statements about lunar phases is *true*?
A) The time between new moons is two weeks.
B) Only one quarter of the first-quarter moon is illuminated by the Sun.
C) The full moon sometimes rises around midnight.
D) It is possible to have two full moons during January, but not during February.
E) It is possible to have two full moons during November, but not during December.
Answer: D

15) While the historical definition of a *constellation* is "a pattern or figure of stars in the sky," the modern definition used by astronomers is
A) a group of stars in the sky that are all very close to each other.
B) a specifically named and bordered region of the celestial sphere.
C) any grouping of very bright stars in our galaxy, often hosting a star cluster.
D) no definition. Astronomers no longer use the term *constellation*, just numerical coordinates.
Answer: B

16) The *celestial sphere is*
A) the central spherical region of the Milky Way Galaxy, dense with stars.
B) a spherical galaxy, centered on the Sun.
C) a useful illusion used to map the stars and other objects in the sky.
D) the star-sphere discovered by the Greeks and other ancient civilizations which shows the physical location in space of the nearby stars.
E) the orb of the Sun; a normal star.
Answer: C

17) If the Moon is setting at 6 A.M., the phase of the Moon must be
A) first quarter.
B) third quarter.
C) full.
D) new.
E) waning crescent.
Answer: C

18) The *celestial equator*
A) is another name for the ecliptic.
B) defines the path of the Sun through the stars, and it also defines the plane of the solar system.
C) is a projection into space of Earth's equator onto the celestial sphere.
D) is the technical name of the Sun's equator.
Answer: C

19) The Sun
A) seems to move around the celestial sphere daily to the East.
B) is a fixed point on the celestial sphere at its distance from Earth.
C) circles around the celestial equator once each year.
D) is the fixed point at the north celestial pole.
Answer: A

20) At approximately what time would a full moon be on your meridian?
A) 6 A.M.
B) 9 A.M.
C) noon
D) 6 P.M.
E) midnight
Answer: E

21) Consider three circles that may be imaginatively "drawn" across the night sky (note that we see only parts of each circle at any time): the *Milky Way*; the *ecliptic*; and the *celestial equator*. Which statement about these circles is true?
A) The celestial equator is unique, since it traces the *path* of an object, namely, the Sun.
B) The ecliptic circle is unique as it traces a broad band of stars.
C) The Milky Way and the ecliptic are the only two circles that are tilted relative to each other.
D) Only the ecliptic circle passes through all the zodiacal constellations.
E) All three circles cross at the same two points: the *equinoxes*.
Answer: D

22) The stars stay in "fixed" positions on the celestial sphere because
A) the stars on the sphere are all chosen to be approximately the same distance from Earth.
B) while they actually move through space, they are too far away for their motion to be seen.
C) the sphere to which they are attached moves with them through space.
D) they are all expanding away, so they have no transverse (sideways) motions.
Answer: B

23) In which direction on the horizon does a crescent moon rise?
A) north
B) south
C) east
D) west
E) The Moon can become a crescent moon only after it has risen and changed its phase.
Answer: C

24) Which of the following statements about the Moon is true?
A) The Moon goes through its cycle of four phases in a month (30 or 31 days).
B) If you see a full moon from North America, someone in South America will be seeing a new moon.
C) The Moon's distance from Earth varies during its orbit.
D) The Moon is visible only at night.
E) The side of the Moon facing away from Earth is in perpetual darkness.
Answer: C

25) What effect or effects would be most significant if the Moon's orbital plane were exactly the same as the ecliptic plane?
A) Solar eclipses would be much rarer.
B) Solar eclipses would be much more frequent.
C) Total solar eclipses would last much longer.
D) Both A and C
E) Both B and C
Answer: B

26) What conditions are required for a solar eclipse?
A) The phase of the Moon must be new, and the nodes of the Moon's orbit must be nearly aligned with Earth and the Sun.
B) The phase of the Moon must be full, and the nodes of the Moon's orbit must be nearly aligned with Earth and the Sun.
C) The phase of the Moon can be new or full, and the nodes of the Moon's orbit must be nearly aligned with Earth and the Sun.
D) The phase of the Moon must be new, and the Moon's orbital plane must lie in the ecliptic.
E) The phase of the Moon must be full, and the Moon's orbital plane must lie in the ecliptic.
Answer: A

27) What conditions are required for a lunar eclipse?
A) The phase of the Moon must be new, and the nodes of the Moon's orbit must be nearly aligned with Earth and the Sun.
B) The phase of the Moon must be full, and the nodes of the Moon's orbit must be nearly aligned with Earth and the Sun.
C) The phase of the Moon can be new or full, and the nodes of the Moon's orbit must be nearly aligned with Earth and the Sun.
D) The phase of the Moon must be new, and the Moon's orbital plane must lie in the ecliptic.
Answer: B

28) In addition to the conditions required for any solar eclipse, what must also be true in order for you to observe a *total* solar eclipse?
A) Earth must lie completely within the Moon's umbra.
B) Earth must lie completely within the Moon's penumbra.
C) Earth must be near aphelion in its orbit of the Sun.
D) The Moon's umbra must touch the area where you are located.
E) The Moon's penumbra must touch the area where you are located.
Answer: D

29) If part of the full moon passes through Earth's umbra, we will see a(n)
A) total lunar eclipse.
B) penumbral lunar eclipse.
C) partial lunar eclipse.
D) partial solar eclipse.
E) annular eclipse.
Answer: C

30) The Milky Way shows itself as a blurry circle of light in the sky because
A) we are looking along the plane of our galaxy that is filled with stars. When we look in other directions, we see fewer stars because we are looking through (at a steep angle to) the plane of our galaxy. We actually see only a small fraction of the stars of the Milky Way Galaxy.
B) the Sun is at the center of the Milky Way Galaxy. The galaxy is a flat disk of stars appearing as a blurry band or ring of stars and dust in the sky, all seen at great distances.
C) it is a ring-like structure of stars and dust located hundreds of thousands of light-years from Earth. It is blurry because it is so far away.
D) the spinning Earth blurs the stars above its equator onto this faint circle of blurry starlight and dust.
Answer: A

31) When we look toward the constellation Sagitarius, we are looking
A) at the galaxy's central bulge.
B) toward Polaris, the "Pole Star."
C) toward the Winter Triangle.
D) out towards the outer Milky Way.
Answer: A

32) What is represented by the figure-eight *analemma*?
A) a positional map of Earth's wandering north celestial pole projected into the sky over the course of the next 10,000 years
B) the time-lapse photograph of a planet (e.g., Mars) as it undergoes retrograde motion
C) an eight-fold intermediate analytical theorem (lemma) pertaining to all astronomical motions
D) a composite snapshot of the Sun taken from the same location at the same time of day over one year
Answer: D

33) Ancient people who knew the saros cycle could
A) completely predict every lunar eclipse.
B) completely predict every solar eclipse.
C) predict what type of eclipse would occur.
D) predict when they'd see the next total solar eclipse in their area.
E) predict when an eclipse would happen, but not necessarily what type and where it would be visible.
Answer: E

34) What happens during the apparent retrograde motion of a planet?
A) The planet rises in the west and sets in the east. This is an illusion completely due to Earth's motion.
B) The planet appears to turn around in its eastward path through the stars and backs up for many nights traveling westwardly.
C) The planet, under strong gravitational influences, travels backwards, westward in its orbit around the Sun.
D) The planet's orbit decays and it retrogressively returns to its former orbit.
Answer: B

35) What causes the apparent retrograde motion of the planets?
A) As Earth passes another planet, its gravitational pull slows that planet and causes it to travel backwards for a short period.
B) Planets, when further from the Sun, move more slowly than when nearer the Sun. It is during this slower period that they appear to move backwards, in retrograde.
C) The other planets never really appear to move backward; the background stars shift due to Earth's revolution around the Sun.
D) As Earth passes another planet, the planet appears to move backward with respect to the background stars. This is an apparent effect; the planet's true motion has not changed.
E) Planets have slowed in their orbits since their formation, leading to retrograde motions.
Answer: D

36) Which of the following never goes in retrograde motion?
A) the Sun
B) Venus
C) Mars
D) Jupiter
E) Saturn
Answer: A

37) Which of the following statements about parallax is *not* true?
A) You can demonstrate parallax simply by holding up a finger and looking at it alternately from your left and right eyes.
B) The existence of stellar parallax is direct proof that Earth orbits the Sun.
C) Measurement of stellar parallax allows us to determine distances to nearby stars.
D) The technique of stellar parallax was used by Hubble to determine that the Andromeda Galaxy (M 31) is about 2 million light-years away.
E) Ancient astronomers were unable to measure parallax and used the absence of any changes in the stars' separations as an argument in favor of an Earth-centered universe.
Answer: D

38) Which of the following statements about stellar parallax is *true*?
A) We observe all stars to exhibit at least a slight amount of parallax.
B) Stellar parallax was first observed by ancient Greek astronomers.
C) The amount of parallax we see depends on how fast a star is moving relative to us.
D) It takes at least 10 years of observation to measure a stars parallax.
E) The closer a star is to us, the more parallax it exhibits.
Answer: E

39) We can't detect stellar parallax with naked-eye observations. Which of the following would make parallax easier to observe?
A) increasing the size of Earth's orbit
B) speeding up Earth's orbital motion
C) slowing down Earth's orbital motion
D) speeding up the precession of Earth's axis
Answer: A

40) Why were ancient peoples unable to detect stellar parallax?
A) They did not look for it.
B) They could not see distant stars.
C) They did not have the ability to measure very small angles.
D) They did not observe for long enough periods of time.
E) They did detect it, but they rejected the observations.
Answer: C

41) How many arcseconds are in one arcminute?
A) 60
B) 360
C) 3600
D) 100
E) 10,000
Answer: A

42) How many arcminutes are in one degree?
A) 60
B) 360
C) 3600
D) 100
E) 10,000
Answer: A

43) Has Polaris always been the "North Star", also known as the "Pole Star"?
A) Yes, because stars position change little over many centuries.
B) No, because it is a young star which formed only a few hundred years ago.
C) No, because the Earth's axis slowly changes the direction it points.
D) No, because the Milky Way blocked our line of site to it for a long time.
Answer: C

44) If you see Polaris directly overhead at midnight, you must be at
A) the equator.
B) the South Pole.
C) the Tropic of Cancer.
D) the North Pole.
Answer: D

45) You experience night-time when
A) the Moon blocks the Sun's light.
B) the Earth revolves 90 degrees in its orbit.
C) the side of the Earth you occupy is facing away from the Sun.
D) the Earth's axis precesses.
Answer: C

46) If the Moon is setting at noon, then it rose at
A) 6 A.M.
B) 9 A.M.
C) noon.
D) 6 P.M.
E) midnight.
Answer: E

2.2 True/False Questions

1) In South Africa, it's usually quite warm around the time of the December solstice and quite cool around the time of the June solstice.
Answer: TRUE

2) You can find the tilt of Earth's axis by measuring the angle between your horizon and the North Star.
Answer: FALSE

3) 23-1/2 degrees is the angle between Earth's rotation axis and the celestial equator.
Answer: FALSE

4) We have been able to view farther through the Milky Way Galaxy by viewing it with telescopes sensitive to X-ray radiation, infrared light, and radio waves than with telescopes sensitive to optical light.
Answer: TRUE

5) When the Sun sets exactly in the West, it is at an azimuth of 90 degrees.
Answer: FALSE

6) In the Northern Hemisphere, the day that the Sun is up the longest in the sky is on the June solstice.
Answer: TRUE

7) Planets are normally seen to pass through the stars going westward, except during periods of retrograde motion when they are seen to turn around and travel eastward.
Answer: FALSE

8) If you lived on the Moon, you'd see full Earth when we see new moon.
Answer: TRUE

9) More extreme seasons occur at locations of higher latitude on Earth because the number of daylight hours varies greatly during the year.
Answer: TRUE

10) The Moon and the Sun are approximately the same angular size.
Answer: TRUE

11) A solar eclipse occurs only when the Moon is full.
Answer: FALSE

12) When an object 's angular size is $\frac{360^\circ}{2\pi}$ (about 57°), its distance from you is equal to its physical size.
Answer: TRUE

13) Earth spins once on its axis in 23 hours and 56 minutes, not 24 hours.
Answer: TRUE

14) If you hold your hand out at arm's length, you can block the entire disk of the Sun with your little finger.
Answer: TRUE

15) The stars are present in the local sky during the daytime. We just can't see them.
Answer: TRUE

16) At the North Pole, on the June equinox, the Sun sets and six months of night begins.
Answer: TRUE

17) The North Star (Polaris) is always located at the zenith.
Answer: FALSE

18) During a total eclipse the Moon shadow travels across at 170 km/hour.
Answer: FALSE

19) During a total eclipse of the Sun the Moon's shadow (the dark umbra) is about 270 km (170 miles) wide.
Answer: TRUE

2.3 Process of Science Questions

1) *Models in Science*: Models play a central role in astronomy and science in general. Two models used extensively are the celestial sphere and the heliocentric (Sun-centered) model for the solar system. Astronomers clearly believe that the celestial sphere model is *false* and the heliocentric model is *true*. Given this, why do you think astronomers persist in using the celestial sphere model to describe the night sky?
Answer: While answers will vary, a key point is that due to the great distance to all of the stars beyond the Sun, the celestial sphere is an excellent approximation of the apparent fixed positions of the stars in two dimensions. Since we cannot perceive the third (radial) dimension, the approximation is a very useful and accurate way to predict the observed behavior of the sky, while the motion of the Sun adds some complexity to this model.

2) *Cognitive Dissonance*? You are talking to a friend who insists that the seasons are caused by a varying Earth-Sun distance over the course of a year. What other fact does your friend likely know that completely contradicts this view of how the seasons are caused? Can you think of other examples of two beliefs that many people feel are both true but which completely contradict each other? How does science view this situation?
Answer: Will vary.

3) *The Sidereal Day*: Using your wristwatch and observations of the night sky over the course of a few weeks, how can you demonstrate to a friend that 24 hours cannot be the true rotation period of the Earth (often called the sidereal day)? What assumptions do you make in this argument?
Answer: Will vary, but one may observe that the same constellation rises 4 minutes earlier each night.

4) *Scientific Reasoning*: The scientific method requires that we put any hypothesis about how the universe works to the test by conducting observations of the natural world. Consider the Greek reaction to the idea of a heliocentric (Sun-centered) solar system. Why did most Greeks reject this hypothesis in favor of the geocentric (Earth-centered) model? Do you think that the Greeks were following a scientific form of reasoning to reach this conclusion? Does the fact that the Greeks reached the *wrong* conclusion affect your answer?
Answer: Will vary. The inability to measure stellar separations to a few arcseconds was not helpful to test hypotheses fully.

5) *Scientific Reasoning:* The temperature at any location on Earth depends on the Sun angle, the number of daylight hours, and the history of the season. Extreme examples include: the high angles of the Sun (sometimes overhead) at tropical latitudes, and the extremely low angles at high arctic latitudes. Extreme daylight examples include: 12 hours of daylight always at the equator with longer summer days as one goes north or south, to a long six months of constant daylight at the poles. These two heating effects work against each at both high and low latitudes. Given these facts, why are the hottest places on Earth found not on the equator where the Sun can be directly overhead, but at latitudes of 30° degrees North and South? (Hint: at 30° degrees latitude, the summer Sun can reach 81° in altitude, and summer daylight can be 14 hours long.)
Answer: The 30° latitude provides the optimal combination of high Sun altitude and summer day length, producing the most severe deserts of the world. This solution is implied in the last sentence of the question.

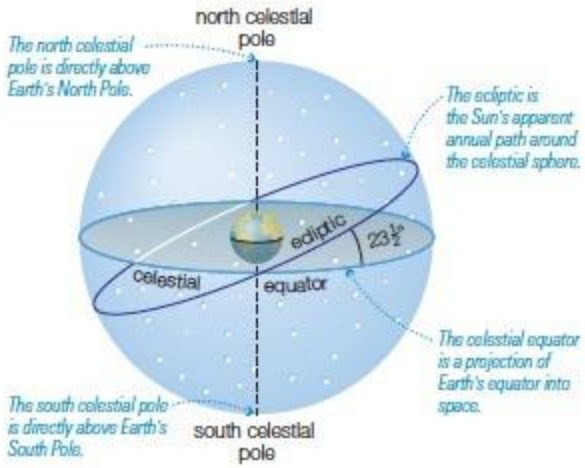
6) *Scientific Reasoning:* Earth sees Mars exhibiting retrograde motion each time Earth overtakes Mars as Earth orbits around the Sun. Earth goes around the Sun in 365 days while Mars goes around the Sun in 687 days. How often does Earth pass Mars?
Suggested approach: having a shorter year, Earth must go around more than one full orbit to catch up with Mars again. After t days, where t is more than 365 days, Mars will have gone around the Sun ($\frac{t}{687}$ 360°) degrees, while Earth has gone more than a circle: ($\frac{t}{365}$ 360° - 360°) degrees. To solve the problem, equate these two angles and find t, the number of days between passings.
Answer: Earth passes Mars approximately every 2 years (about 778 days). Having a shorter year, Earth must go around more than one full orbit to catch up with Mars. After t days, Mars will have gone around the Sun ($\frac{t}{687}$ 360°) degrees, while Earth has gone more than a circle:

($\frac{t}{365}$ 360° - 360°) degrees. Equating these two angles gives:

t = 1/ ($\frac{1}{365}$ - $\frac{1}{687}$) = 778 days.

(There are about 10 days of inaccuracy in the result due to the changing orbit speeds of each planet).

7) *Scientific Reasoning*: By considering the ecliptic and the celestial equator on the celestial sphere pictured below, can you explain why the North Pole experiences six continuous months of daylight each year? Can you explain why all locations on the Earth's equator experience exactly 12 hours of daylight every day?



Answer: The pole has six months of daylight each year because the Sun, in its yearly path around the ecliptic, spends six months North of the celestial equator. The celestial equator *is* the horizon at the pole, so the Sun never sets for these six months.
On the equinoxes exactly half of Earth is illuminated. On the equinox, the two halves (light, dark) are separated by a circle that runs through the poles. Thus, as Earth spins, all locations pass through 12 hours of night and 12 hours of day.

8) *Scientific Reasoning:* The *northern* analemma, below, shows the Sun photographed at the same time each day producing a lopsided figure-eight. Is the lower, larger lobe taken in winter or in summer? If the time intervals between snapshots are equal, is Earth moving faster or slower in the lower lobe? Would an analemma photographed from the southern hemisphere look differently?

Answer: Since the Sun is lower in the sky, the lower lobe is taken in the northern winter. The Sun points are farther apart, so Earth is traveling faster (as it is closer to the Sun). The southern hemisphere analemma looks the same, but is inverted to the horizon due to the inverted perspective of the southern hemisphere, and oriented to the north.

2.4 Short Answer Questions

The choices below are for the following questions. For each question, choose the letter for the real motion that is responsible for the apparent motion as seen from Earth.

A. Earth rotates once each day.
B. Earth revolves around the Sun once each year.
C. The direction of Earth's axis in space precesses with a period of 26,000 years.
D. The universe is expanding.

1) Polaris will no longer be the North Star 1,000 years from now.
Answer: C

2) In the year A.D. 15,000, Vega will be a better "north star" than Polaris.
Answer: C

3) When the Moon casts its shadow on the Earth during a total solar eclipse, the shadow moves across the face of Earth very rapidly.
Answer: A

4) The Moon rises in the east and sets in the west.
Answer: A

5) The stars of Orion's belt rise in the east and set in the west.
Answer: A

6) No one on Earth can see the constellation Orion in June.
Answer: B

7) Planets show retrograde motion.
Answer: B

8) The stars visible just after sunset are different from those visible just before sunrise.
Answer: A

9) If Earth's axis had no tilt, would we still have seasons? Why or why not?
Answer: We would no longer have seasons because the Sun's light would be received from the same range angles each day from any latitude throughout the year, and with exactly 12 hours of sunlight each day.

10) Do all the planets exhibit retrograde motion as seen from Earth?
Answer: Yes. As Earth overtakes outer planets or is overtaken by an inner planets, retrograde motion is seen.

11) What are the names of the two angles used to describe the location of an object in your local sky, where, for example, an object on your north horizon would be described by the angles (0°, 0°)?
Answer: This is the local "azimuth, altitude" coordinate system.

12) Why does the Milky Way appear as a *band* of light in the sky?
Answer: The solar system lies midway out in the disk of stars making the Milky Way. When we look along the plane of the disk, along the Milky Way, we see huge numbers of stars at once, which, to the naked eye, merge into a diffuse band of light. When we look out of the plane of the disk, we see fewer stars, and these are typically individually discernable.

13) Consider the following statement, and explain whether or not it is sensible: Although all the known stars appear to rise in the east and set in the west, we might someday discover a star that will appear to rise in the west and set in the east.
Answer: This statement does not make sense. The stars aren't really rising and setting, they only appear to rise in the east and set in the west because Earth rotates.

14) At what altitude and in what direction in your sky does the north or south celestial pole appear?
Answer: Answers will vary with your latitude; latitude = altitude of NCP (or SCP in Southern Hemisphere).

15) During an annular solar eclipse, is the Moon nearer or farther from Earth compared to its average distance?
Answer: The Moon is farther and presents a smaller angular size than the Sun.

16) The ancient Greeks, in attempting to test a Sun-centered model of the solar system, would *not* have expected to see parallax, because they believed that the stars were all affixed to the celestial sphere. But they did look (unsuccessfully) for another change affecting closely separated stars. What was that?
Answer: They looked to see if stars became separated by wider angles when Earth was closest to them in its orbit around the Sun. The stars are too far away for this effect to be seen.

17) Answer each of the following questions for our local sky.
A. Where is the north celestial pole in our sky?
B. Is Polaris a circumpolar star in our sky? Explain.
C. Describe the meridian in our sky.
D. Describe the celestial equator in our sky.
Answer:
A. Answers will vary with latitude; here is a sample for 40° N: The north celestial pole appears at an altitude of 40°, in the direction due north.
B. Yes, for any location in the Northern Hemisphere; no, for any location in the Southern Hemisphere. Polaris is circumpolar because it never rises or sets in our sky. It makes a daily circle, less than 1° in radius, around the north celestial pole.
C. The meridian is a half-circle that stretches from the due south point on the horizon, through the zenith, to the due north point on the horizon.
D. Answers will vary with latitude; here is a sample answer for 40° N: The celestial equator is a half-circle that stretches from the due east point on the horizon, through an altitude of 50° due south, to the due west point on the horizon.

18) Consider the following statement, and explain whether or not it is sensible: If you lived on the Moon, you'd see full Earth when we see new moon.
Answer: This is true, because at full moon Earth lies between the Sun and the Moon. Thus, an observer on the Moon would be looking at the night side of Earth.

19) Suppose you lived on the Moon near the center of the face that we see from Earth. During the phase of full moon, what phase would you see for Earth? Would it be day or night at your home?
Answer: During the full moon, it would be daytime and you would see the phase of new Earth.

20) What is the azimuth of the zenith?
Answer: The azimuth of the zenith is undefined.

21) If your computer screen had a width of 20° and you moved it ten times further away, what would be its new angular width?
Answer: The screen would have a width of 2°.

22) Given that the Moon and Sun are about the same angular width in the sky, what can you say about their relative physical widths and distances?
Answer: The Sun's physical width (diameter) is proportionally greater in the same way its distance is greater. (The Sun is 400 times wider than the Moon and is 400 times more distant than the Moon).

23) What would you see if you were on the near side of the Moon during a lunar eclipse?
Answer: During a lunar eclipse, you would see Earth pass in front of the Sun. It would be completely dark where you were.

24) Why is the Moon *not* completely invisible (it appears as a very deep red color) to the naked eye during a total lunar eclipse?
Answer: The Moon shines through reflected light from the Sun and thus it becomes very dark during a lunar eclipse since the Moon lies within Earth's shadow at this time. However, some sunlight still gets through because it is bent (similar to the way a lens works) by Earth's atmosphere. We see the reflection of this faint light and thus the Moon is not completely invisible. (The bending of light is called *refraction* and the effect is strongest at long wavelengths. Thus it is most pronounced for red light and the eclipsed Moon appears dark red.)

25) What would you see on Earth if you were on the near side of the Moon during a solar eclipse?
Answer: During a solar eclipse, you would see a small circular shadow traveling across a portion of Earth's surface.

26) Suppose the distance to the Moon were twice its actual value. Could we still have solar eclipses? If so, what type(s)?
Answer: If the Moon were twice its actual distance from us, we would no longer be able to see total solar eclipses because the Moon would not be able to completely cover the surface of the Sun; however, we would still see partial and annular eclipses, although the Moon would not block as much of the Sun during these times.

27) Consider the following statement, and explain whether or not it is sensible: Last night I saw Mars move eastward through the sky in its apparent retrograde motion.
Answer: Retrograde motion occurs when a planet begins to move through the stars westwardly, not eastwardly. Furthermore, Mars's motion through the stars would become apparent only after many nights of observation, not during a single night.

2.5 Mastering Astronomy Reading Quiz

1) About how many stars are visible to the naked eye on a clear, dark night away from city lights?
A) a few dozen
B) approximately two thousand
C) several million
D) a few hundred billion
Answer: B

2) What do astronomers mean by a *constellation*?
A) A constellation is a region in the sky as seen from Earth.
B) A constellation is a group of stars related through an ancient story.
C) A constellation is any random grouping of stars in the sky.
D) A constellation is a group of stars that are all located in about the same place in space.
Answer: A

3) What is the *ecliptic*?
A) the path the Sun appears to trace around the celestial sphere each year
B) the Sun's daily path from east to west in our sky
C) the path traced by the Moon's shadow on Earth during a solar eclipse
D) a half-circle extending from your horizon due north, through your zenith, to your horizon due south
Answer: A

4) What is the *celestial sphere*?
A) The celestial sphere is a representation of how the entire sky looks as seen from Earth.
B) The celestial sphere is a model that shows the true locations in space of the Sun and a few thousand of the nearest stars.
C) The celestial sphere is a model of how the stars are arranged in the sky relative to our Sun, which is in the middle of the sphere.
D) It represents a belief in an Earth-centered universe, and hence is no longer considered to have any use.
Answer: A

5) As Earth goes around the Sun each year, Earth's rotation axis in the North points
A) tipped toward the Sun, 23-1/2 degrees.
B) in a direction that traces a cone of radius 23-1/2 degrees, crossing through Polaris and Vega.
C) tipped toward the galactic center, 23-1/2 degrees.
D) in the direction of the celestial pole, near Polaris, throughout the year.
Answer: D

6) Which of the following statements does *not* use the term *angular size* or *angular distance* correctly?
A) The angular distance between those two houses in the distance is 30 degrees.
B) The angular distance between those two bright stars in the sky is about 2 meters.
C) The angular size of the Sun is about the same as that of the Moon.
D) You can use your outstretched hand against the sky to estimate angular sizes and angular distances.
Answer: B

7) Which of the following correctly describes the *meridian* in your local sky?
A) a half-circle extending from your horizon due east, through your zenith, to your horizon due west
B) a half-circle extending from your horizon due east, through the north celestial pole, to your horizon due west
C) a half-circle extending from your horizon due north, through your zenith, to your horizon due south
D) the point directly over your head
Answer: C

8) The point directly over your head is called _____.
A) the meridian
B) the zenith
C) the north celestial pole
D) the North Star
Answer: B

9) Stars in the local sky that never cross below the horizon during the year are called _____.
A) bright
B) seasonal
C) circumpolar
D) celestial
Answer: C

10) We describe a location on *Earth's surface* by stating its _____.
A) altitude and direction (or azimuth)
B) meridian and longitude
C) latitude and direction
D) latitude and longitude
Answer: D

11) If you are located in the Northern Hemisphere, how can you learn how far you are from the North Pole?
A) The altitude of the north celestial pole equals your latitude.
B) The altitude of the celestial equator equals your latitude.
C) The altitude of the north celestial pole equals your longitude.
D) The longitude of the north celestial pole is circumpolar, and therefore crosses your zenith at the meridian.
Answer: A

12) Which of the following best describes why we have seasons on Earth?
A) The tilt of Earth's axis causes different portions of the Earth to receive more direct sunlight and more hours of sunlight at different times of year.
B) Earth's elliptical orbit means we are closer to the Sun and therefore receive more intense sunlight at some times of year than at others.
C) The tilt of Earth's axis causes the northern hemisphere to be closer to the Sun than the southern hemisphere in summer, and vice versa in winter.
D) The varying speed of Earth in its orbit around the Sun gives us summer when we are moving fastest and winter when we are moving slowest.
Answer: A

13) Each choice below describes how a few astronomical phenomena are related to time periods. Which list is entirely correct? (Careful: some lists are partially correct.)
A) Earth's rotation defines a day.
The cycle of the Moon's phases takes about a month.
Earth's orbit defines a year.
Earth's cycle of axis precession takes 26,000 years.
B) Earth's rotation defines a day.
The cycle of the Moon's phases takes about a week.
Earth's orbit defines a year.
Earth's cycle of axis precession defines a month.
C) Earth's rotation defines a day.
The Sun's rotation defines a week.
The Moon's rotation defines a month.
Earth's orbit defines a year.
D) Earth's rotation defines a day.
The saros cycle of eclipses defines a month.
Earth's orbit defines a year.
Earth's cycle of axis precession takes 26,000 years.
Answer: A

14) If we have a new moon today, when will we have the next full moon?
A) in about two weeks
B) in about 1 week
C) in about 1 month
D) in about 6 months
Answer: A

15) The Moon's angular width is
A) 1/2 degree.
B) 1/2 arcminute.
C) 1/2 arcsecond.
D) it changes, growing larger at the horizon.
Answer: A

16) Lunar eclipses can occur only during a _____.
A) new moon
B) first quarter moon
C) full moon
D) third quarter moon
Answer: C

17) What is the *saros cycle*?
A) the 26,000-year cycle of the Earth's precession
B) the roughly 18-year cycle over which the pattern of eclipses repeats
C) the roughly one-month cycle of lunar phases in the sky
D) the annual cycle of the seasons
Answer: B

18) During the time that a planet is in its period of *apparent retrograde motion*, _____.
A) the planet moves backwards (clockwise as viewed from above Earth's north pole) in its orbit of the Sun
B) the planet appears to rise in the west and set in the east, rather than the usual rising in the east and setting in the west
C) over many days or weeks, the planet moves westward relative to the stars, rather than the usual eastward relative to the stars
D) the planet is getting closer to the Sun in its orbit
Answer: C

19) What is *stellar parallax*?
A) It is the daily rise and set of the stars.
B) It describes the fact that stars are actually moving relative to one another, even though to our eyes the stars appear fixed in the constellations.
C) It is the slight back-and-forth shifting of star positions that occurs as we view the stars from different positions in Earth's orbit of the Sun.
D) It is the change in the set of constellations that we see at different times of year in the evening sky.
Answer: C

20) The ecliptic crosses the celestial equator on the celestial sphere at points called
A) the equinoxes.
B) the solstices.
C) the nodes.
D) aphelion and perihelion.
Answer: A

2.6 Mastering Astronomy Concept Quiz

1) Which of the following statements about the celestial sphere is *not* true?
A) The Earth is placed at the center of the celestial sphere.
B) When we look in the sky, the stars all appear to be located on the celestial sphere.
C) The "celestial sphere" is another name for our universe.
D) The celestial sphere does not exist physically.
Answer: C

2) If the Earth's rotation axis were tilted by 45 degrees instead of 23.5 degrees, what are some of the implications, and why?
A) The seasons would be more extreme, because the Sun's rays would be more direct in summer, and less direct in winter.
B) The seasons would be less extreme, because the Sun's rays would be less direct in summer, and more direct in winter.
C) The seasons would be less extreme, because the surface of the Earth would be farther from the Sun in the summer, and closer to the Sun in the winter.
D) The seasons would be more extreme, because the surface of the Earth would be closer to the Sun in the summer, and farther from the Sun in the winter.
Answer: A

3) Tonight, your telescope shows you RXJ1800, a galaxy, very near in the sky to the bright star Vega. What can you conclude from this observation?
A) RXJ1800 and Vega will drift apart from each other on the sky, over a matter of nights.
B) Vega and RXJ1800 must be very close to each other, less than a few light-years.
C) Vega orbits the center of mass of RXJ1800.
D) RXJ1800 and Vega will set in the west, at very similar times.
Answer: D

4) When traveling north from the United States into Canada, you'll see the North Star (Polaris) getting _____.
A) brighter
B) dimmer
C) higher in the sky
D) lower in the sky
Answer: C

5) Suppose you use the Southern Cross to determine that the south celestial pole appears 40 degrees above your horizon. Then you must be located at _____.
A) latitude 40 degrees north
B) latitude 50 degrees south
C) latitude 40 degrees south
D) longitude 40 degrees
Answer: C

6) Suppose you are facing north and you see the Big Dipper close to your northern horizon, with Polaris (and the Little Dipper) above it. Where will you see the Big Dipper in six hours?
A) to the right of Polaris; that is, 90 degrees counterclockwise from its current position
B) to the left of Polaris; that is, 90 degrees clockwise from its current position
C) directly above Polaris
D) still in the same place, below Polaris
Answer: A

7) In any particular place on Earth, certain constellations are visible in the evening only at certain times of the year because _____.
A) our evening view of space depends on where Earth is located in its orbit around the Sun
B) during some times of year, some constellations drop below the southern horizon
C) some constellations are circumpolar
D) on any particular night, we can only see stars that are directly opposite (180 degrees away from) the Sun in the sky
Answer: A

8) The Greeks rejected the notion that the Earth orbits the Sun. Why?
A) They could not measure how big the Earth was.
B) They could not measure a change in stars' positions on the sky.
C) They were not as smart as we are.
D) They believed that the Sun is a God.
Answer: B

9) Your friend tells you that last night, they saw Mars high in the sky at midnight. You conclude that
A) Mars must be in retrograde.
B) your friend must be mistaken: Mars can never be seen at midnight.
C) Mars must be at its farthest distance from the Earth.
D) Mars must be at its closest distance from the Sun.
Answer: A

10) If our year were twice as long (that is, if Earth took twice as many days to complete each orbit around the Sun), but Earth's rotation period and axis tilt were unchanged, then _____.
A) stars would take twice as long to rise and set
B) the cycle of precession would take 13,000 years instead of 26,000 years
C) the four seasons would each be twice as long as they are now
D) the Earth would not have seasons
Answer: C

11) How does Earth's varying distance from the Sun affect our seasons?
A) It doesn't. Earth's orbital distance plays no significant role in the seasons.
B) It makes summer warmer in the Northern Hemisphere than in the Southern Hemisphere.
C) It is responsible for the fact that the seasons are opposite in the Northern and Southern hemispheres.
D) It causes the seasons to be more extreme than they would be if the Earth's distance from the Sun were always the same.
Answer: A

12) Suppose you live in the United States and you see a crescent moon in your evening sky tonight. What will a friend in South America see tonight?
A) Your friend will see a gibbous moon.
B) Your friend will also see a crescent moon.
C) Your friend will see a first quarter moon.
D) Your friend won't see the Moon tonight, because it is up only in the morning.
Answer: B

13) During a lunar eclipse the Moon's phase must be
A) full.
B) new.
C) 1st quarter.
D) 3rd quarter.
Answer: A

14) If the Moon is 3rd quarter phase, what shape does it have in the sky?
A) a quarter circle
B) a full circle
C) a half circle
D) nothing (It is impossible to view a 3rd quarter moon.)
Answer: C

15) Earth's distance from the Sun varies during the year
A) not at all.
B) by 3%.
C) by 10%.
D) by 30%.
Answer: B

16) Which of these (hypothetical) modifications would cause lunar eclipses to happen once per month?
A) Make the Moon orbit the Earth twice as fast.
B) Relocate the Moon to twice its current distance from the Earth.
C) Change the Moon's orbital plane so it tilts the opposite way.
D) Change the orbital plane of the Moon so it lies in the same plane as Earth's orbit around the Sun.
Answer: D

17) The Moon is nearly tidally locked to the Earth, which means the Moon's rotation period is almost the same as its orbital period. If you were camped at the equator of the Moon, you would experience (approximately)
A) 14 hours of darkness followed by 14 hours of sunshine.
B) sunshine all the time, except when the Earth blocks the Sun.
C) (14 × 24) hours of darkness followed by (14 × 24) hours of sunshine.
D) sunshine (day) all the time.
Answer: C

18) During the period each year when we see Mars undergoing apparent retrograde motion in our sky, what is really going on in space?
A) Mars is moving around the Sun in the opposite direction from which Earth is moving around the Sun.
B) Earth and Mars are getting closer together.
C) Earth is catching up with and passing by Mars in their respective orbits.
D) Earth and Mars are on opposite sides of the Sun.
Answer: C

19) Which of the following conditions must exist for a solar eclipse to occur?
A) The only condition is that the phase of the Moon must be new.
B) The only condition is that the phase of the Moon must be full.
C) Moon phase is new, and the Moon is passing through the Earth's orbital plane.
D) Moon phase is full, and the Moon is passing through the Earth's orbital plane.
Answer: C

20) RXJ1800, a galaxy, lies very near in the sky to the bright star Vega. What is the best explanation for them appearing close together?
A) Their random motions have caused RXJ1800 and Vega to drift to within a few light-years of each other.
B) They coincidentally lie along the same line of sight.
C) Vega orbits the center of mass of RXJ1800.
D) Vega must have recently formed in RXJ1800 and been ejected.
Answer: B

21) You are standing on Earth's equator. In which direction is Polaris, the North star?
A) The answer depends on what time of day (or night) it is.
B) The answer depends on whether it is winter or summer.
C) It is on the northern horizon.
D) It is directly overhead.
Answer: C

22) You observe a full moon rising at sunset. What will you see 6 hours later?
A) a full moon on or near your meridian
B) a waning gibbous moon
C) a first quarter moon
D) a third quarter moon
Answer: A

23) Why is it summer in the Northern Hemisphere when it is winter in the Southern Hemisphere?
A) The Northern Hemisphere is "on top" of Earth and therefore receives more sunlight.
B) The Northern Hemisphere is tilted away from the Sun and receives more indirect sunlight.
C) The Northern Hemisphere is tilted toward the Sun and receives more direct sunlight.
D) It isn't: both hemispheres have the same seasons at the same time.
E) The Northern Hemisphere is closer to the Sun than the Southern Hemisphere.
Answer: C

24) Today the Sun is in the middle of the constellation Virgo. Therefore, tomorrow the Sun will be in the constellation
A) Libra.
B) Virgo.
C) Leo.
D) Sagittarius.
Answer: B

25) If Earth's rotation axis was tilted by 45 degrees instead of 23.5 degrees, what are some of the implications, and why?
A) The seasons would be more extreme, because the Sun's rays would be more direct in summer, and less direct in winter.
B) The seasons would be more extreme, because the surface of the Earth would be closer to the Sun in the summer, and farther from the Sun in the winter.
C) The seasons would be less extreme, because the Sun's rays would be less direct in summer, and more direct in winter.
D) The seasons would be less extreme, because the surface of the Earth would be farther from the Sun in the summer, and closer to the Sun in the winter.
Answer: A

26) The phenomenon where Earth's rotation axis slowly makes a circle in the celestial sphere over 26,000 years is called
A) spin-coupling.
B) osculation.
C) contortion.
D) precession.
Answer: D

27) If Earth rotated once every 48 hours, and everything else was the same, which of the following statements would *not* be true?
A) There would still be summer and winter in the temperature zones.
B) The length of the year would be longer.
C) The daytime temperatures would be higher on average.
D) High tide would happen less frequently.
E) The length of a day would be longer.
Answer: B

28) Polaris is 10 degrees above your horizon. Where are you?
A) Latitude 10 degrees north
B) Latitude 10 degrees south
C) Latitude 80 degrees north
D) Latitude 80 degrees south
Answer: A

29) We see two stars separated by one degree on the celestial sphere. What can we infer about these stars?
A) They are very close together in space.
B) They have similar luminosities.
C) They rise and set at about the same time.
D) They were born about the same time.
Answer: C

30) The parallax angle of two stars is reported in a star catalog. Which star is farther?
A) The one with the larger parallax angle
B) You can't tell, since parallax angle has nothing to do with distance.
C) The one with the smaller parallax angle
Answer: C

31) If Earth's rotation slowed down so that it completed exactly one rotation about its axis in 100 hours, what would be the typical time interval between sunrise and sunset?
A) 24 hours
B) 25 hours
C) 50 hours
D) 100 hours
Answer: C

32) When the Moon's phase is a first quarter moon, it rises
A) just before sunset.
B) just after sunset.
C) around noon.
D) close to sunrise.
Answer: C