Solution Manual for Discovering the Essential Universe 6th Edition by Comins ISBN 1464181705 9781464181702

Answers to the End of Chapter Questions
Discovering the Essential Universe, Sixth Edition
Chapter 2

1. Who wrote down the equation for the law of gravitation? a. Copernicus b. Tycho c. Newton d. Galileo e. Kepler

    c. Newton proposed and developed the law of gravitation.

2. Which of the following most accurately describes the shape of Earth's orbit around the Sun? a. circle b. ellipse c. parabola d. hyperbola e. square

    b. Earth orbits the Sun in an elliptical orbit with a small eccentricity. It is very nearly circular.

3. Of the following planets, which takes the longest time to orbit the Sun? a. Earth b. Uranus c. Mercury d. Jupiter e. Venus

    b. Uranus takes the longest because it is farthest from the Sun.

4. What is a Sun-centered model of the solar system called?

    A Sun-centered model is a heliocentric model.

5. How long does it take Earth to complete a sidereal orbit of the Sun?

    A sidereal period is measured with respect to the distant stars. The sidereal period of Earth is 365.26 days.

6. How did Copernicus explain the retrograde motions of the planets?

    The planets move with different orbital speeds by Kepler's third law, faster or shorter period at distances closer to the Sun and slower or longer farther away. By placing the Sun at the center of the solar system, the retrograde motion of the superior planets can be explained by visualizing Earth on an inside track overtaking and passing the superior planet on the outer track. The apparent retrograde motion is when the slower planet seems to stop and change direction as the faster planet passes it. The same applies for Mercury and Venus as they pass Earth in their orbits around the Sun.

7. Which planets can never be seen at opposition? Which planets never pass through inferior conjunction?

Inferior planets, Mercury and Venus, can never go through opposition, which is when the planets are on the opposite side of Earth from the Sun. Superior planets can never be seen at inferior conjunction, which is when the planet is between Earth and Sun.

8. At what configuration (superior conjunction, greatest eastern elongation, etc.) would it be best to observe Mercury or Venus with an Earth-based telescope? At what configuration would it be best to observe Mars, Jupiter, or Saturn? Explain your answers.

In either case, the best time to observe a planet is when it appears farthest in angle from the Sun. Mercury or Venus can therefore be seen best at greatest eastern or western elongation. Mars, Jupiter, and Saturn are best seen at opposition.

9. What are the synodic and sidereal periods of a planet?

The sidereal periods are the true orbital periods. They are measured with reference to the position of a planet or other body compared with the background stars. The synodic period express the time taken to cycle through the configurations, such as superior conjunction to superior conjunction. There is a difference between these periods because Earth is also moving relative to the Sun and the other planet.

10. What are Kepler's three laws? Why are they important?

Kepler deduced three laws of planetary motion from Tycho Brahe's observational data. The first law states that the planets orbit around the Sun in elliptical paths with the Sun at one focus. His second law says that a line joining the planet and the Sun sweeps out equal areas in equal times. The consequence of this second law is that planets move faster the closer they are to the Sun, while slowing down the farther they are away from it. The third law states that the square of a planet's sidereal period around the Sun is directly proportional to the cube of the length of the semimajor axis of its orbit. This law implies that for any pair of planets, the one that has the greater average distance has the longer year. The three laws are important because they summarize how planets orbit the Sun and how moons orbit planets. They are empirical fits to observational data rather than philosophical speculation, and they represent one of the first statements that celestial objects do not travel at uniform rates around perfectly circular orbit as claimed by Plato. They provide the foundation for the explanation of gravity and the measurement of mass of the Sun and planets.

11. In what ways did the astronomical observations of Galileo support a heliocentric cosmology?

The phases of Venus and the brightness of Venus at its various phases are only possible if Venus orbits the Sun. The motion of Jupiter's satellites provided evidence for objects orbiting an object other than Earth, and is easily shown to follow Kepler's laws.

12. How did Newton's approach to understanding planetary motions differ from that of his predecessors?

Whereas his predecessors, like Kepler, approached planetary motion from astronomical observations, Newton approached it from a theoretical, mathematical description of gravity. His equations described the orbits of the planets, as well as the motion of other objects, but he derived them first from principles using gravitational theory, in which any object with mass attracts any other object with mass by means of a noncontact or field force that depends on the masses and separation distance. Comparison of the predictions of Newton's equations with the predictions of Kepler's laws (deduced from observed motion) served to test the validity of the equations. Newton also added the “universal” aspect to the law of gravity, indicating that the smaller object pulls on the larger object with an equal force as the larger object exerts on it.

13. What is the difference between mass and weight?

Weight is the force of attraction on a mass due to the strength of the gravitational field near the surface of Earth or any other body. Mass is a measure of the number of particles an object has, regardless of its location.

14. Why was the discovery of Neptune a major confirmation of Newton’s universal law of gravitation?

Neptune cannot be directly observed without the use of a telescope, and even then can be difficult to distinguish from background stars. The existence and location of Neptune were correctly predicted from Newton’s law of universal gravitation in advance of Neptune’s discovery instead of the usual method of trying to apply a theory to explain an observation. Its presence was inferred by its gravitational effect at a regular period, or perturbation, on the orbit of Uranus.

15. Why does an astronaut have to exert a force on a weightless object to move it?

An astronaut has to exert a force on a weightless object to move it because the object has inertia. Inertia is the resistance any object has to changing its direction of motion or speed, and it is represented physically by the mass of the object.

16. A comet coming inward from the Kuiper belt, a region of Sun-orbiting debris out beyond the orbit of Neptune, experiences a gravitational force from the Sun. Does the presence of the planets affect the comet’s orbit? Explain your reasoning.

Yes. All objects exert gravitational attraction on all other objects at all times. The strength of the attraction depends on the mass and distance from the object. The presence of planets can certainly have a noticeable effect to deflect, capture, or even collide with the comet if it passes close enough to a planet, most notably Jupiter. Some evidence for this includes the Jupiter family of short period comets, as well as the destruction of Comet Shoemaker-Levy 9. This further suggests that previous comets may have encountered similar fates.

17. How would the weight of an astronaut on the Moon compare with her weight on Earth?

The weight of an astronaut depends on the mass and the strength of the gravitational field at the surface. She would be lighter on the Moon. While the astronaut’s mass would remain the same, she would weigh one-sixth as much as she does on Earth as a result of the weaker gravity field.

18. How would the mass of an astronaut on the Moon compare with his mass on Earth?

His mass would be the same on the Moon as on Earth.

19. An astronomer observes a new comet and calculates that it will exit the solar system and not return. Which of the following best describes the path of the comet?
a. a nearly straight line
b. a circle
c. an ellipse d.
a hyperbola
e. some other shape

d. The interpretation of this shape is that the speed of the comet is greater than the escape speed needed to overcome the force of gravity at its closest passage to the Sun.

20. From the definition $KE = 1/2\ mv^2$, derive the equation $KE = p^2/2m$, as discussed in Appendix P.

Use the definitions of kinetic energy and momentum: $KE = ½\ mv^2$, $p=mv$; $p^2=m^2v^2$, $p^2/2m = ½\ mv^2 = KE$

21. Is it possible for an object in the solar system to have a synodic period of exactly one year? Explain your answer.

No, it is not possible for any object other than Earth in the solar system to have a synodic period of exactly one year. Kepler's laws show that all objects at different distances from the Sun have different orbital periods. If an object were farther from the Sun than Earth, that object would have to move faster than its normal orbital speed for it to have a synodic period of one year and thus be aligned with Earth at the same time each year. One that was closer would have to move more slowly than normal to have the same synodic period as Earth. It would be very difficult to change the orbit of an object to exactly that of Earth's. If the object were in the same orbit as Earth, it would never change position with respect to us and so it would not have a synodic period.

22. Describe why there is a systematic decrease in the synodic periods of the planets from Mars outward, as shown in Table 2-1.

The time from one opposition to the next is a superior planet's synodic period. The farther a planet is from the Sun, the slower that planet orbits the Sun. Therefore, the farther the planet is away from the Sun, the more quickly Earth can return to being directly between it and the Sun—that is, the shorter the time from opposition to opposition compared with the same intervals for superior planets closer to Earth.

23. Make diagrams of Jupiter's phases as seen from Earth and as seen from Saturn.

Jupiter is almost full all the time as seen from Earth. From Saturn, Jupiter's phases would resemble those of Venus or Mercury as seen from Earth, where almost all phases except full would appear. See Figure 2-10.

24. In what direction (left or right, eastward or westward) across the celestial sphere do the planets normally appear to move as seen from Australia? In what direction is retrograde motion as seen from there?

> The planets would seem to move eastward normally, but westward during retrograde as seen from Australia, just as in the northern hemisphere.

25. The dictionary defines astrology as "the study that assumes and attempts to interpret the influence of the heavenly bodies on human affairs." Based on what you know about scientific theory, is astrology a science? Why or why not? Feel free to further explore astrology, if you wish, before answering this question.

> Astrology is not a science. Astrology does not make readily testable, quantifiable, or falsifiable hypotheses. If you were to objectively test the predictions of astrology, you would find them either to be invalid or so general that they can neither be proved nor disproved. Astrology fails the scientific method.

26. Which planet would you expect to exhibit the greatest variation in apparent brightness as seen from Earth? Explain your answer.

> As a superior planet, Mars will not show much phase variation, but will always appear full or nearly full. Mars shows a great variation in brightness due to the difference between its closest distance (~.5 AU) and greatest distance (~2.5 AU) and appears brightly every other year. There are is a subtle but noticeable difference between different oppositions if the oppositions occur at perihelion or aphelion. As an inferior planet, Venus shows a broader phase variation. Venus has a larger change in distance but its brightness is low at inferior conjunction as it is around new phase.

27. Use two thumbtacks (or pieces of tape), a loop of string, and a pencil to draw several ellipses. Describe how the shapes of the ellipses vary as you change the distance between the thumbtacks.

> See Figure 2-8. The thumbtacks (or pieces of tape) represent the positions of the foci. One tack will produce a circle with the same radius around the path. Two tacks will produce an ellipse. The figure will appear more elliptical, elongated, or eccentric for larger tack separation, as the difference between major axis (line connecting the foci) and minor axis (perpendicular line crossing between the two foci at an equal distance from each) becomes more apparent. The limiting case for an ellipse is eccentricity approaches 1, in which the foci are located at the ends of the major axis.

Answers to the End of Chapter Questions
Discovering the Essential Universe, Sixth Edition
Chapter 3

1. Describe reflection and refraction. How do these processes enable astronomers to build telescopes?

Refraction is the change of direction, or bending, of travel as light (or any other form of wave energy) passes from one transparent medium into another of a different density. Reflection is the change of direction of travel as light bounces off a surface. For reflecting surfaces, the angle of incidence always equals the angle of reflection. The changes of direction caused by both refraction and reflection can be controlled by shaping the lens or mirror appropriately. The collected beam of light by such a curved lens or mirror is sent to a point or a plane, or focused. Taking the light emerging from this focal point or focal plane through another lens straightens the beam, which is now brighter, and can be viewed or cast onto a screen or film as an image. The objects are magnified and seen in higher resolution than they were before their light was transmitted through the telescope.

2. Give everyday examples of refraction and reflection.

Example of refraction: A straw in a glass of water appears bent. Example of reflection: You look at yourself in a mirror.

3. Which side of the secondary mirror in Figure 3-9 is coated with aluminum? Justify your answer.

The side of the flat secondary mirror that faces more toward the primary mirror at the bottom of the tube and the eyepiece must be the shiny, reflective side. The incoming light is reflected from the primary mirror, to the secondary, and then to the eyepiece. If only the other side was shiny, the incoming radiation would just be reflected back into space and no image would be formed.

4. Explain some of the advantages of reflecting telescopes over refracting telescopes. See

Figure 3-11. Using a reflecting telescope, an astronomer can choose to access the light at several foci: the prime focus, the Newtonian focus, the Cassegrain focus, or the coudé focus. Reflecting telescopes require only one large glass surface to be ground, the light does not pass through the glass, and the mirrors of these telescopes do not cause chromatic aberration. A telescope mirror is more easily supported and kept rigid than a lens. The shape of a telescope mirror is easier to manufacture than that of a telescope lens. Mirrors can also be constructed from small segmented pieces rather than one continuous piece of glass. Mirror segments are easier and less expensive to replace if damaged, and it is easier to manipulate the shape of such a mirror.

5. What are the three major functions of a telescope?

A telescope increases the amount of gathered light (making objects brighter and making dimmer objects visible), it shows increased angular resolution of the objects it is used to view, and it enlarges the image compared with what could be seen with the naked eye. The latter two functions can enhance the visible detail of the image.

6. What is meant by the angular resolution of a telescope?

When you observe an object on the celestial sphere, you are observing its angular size, for instance, approximately 0.5^{o} for the Moon. Angular resolution measures the clarity of images or the details of each object that are discernible. It is not possible to see individual Moon craters with the naked eye because the angular size is too small compared with what could be perceived by a typical eye. The telescope improves angular resolution by allowing the observer to see a smaller angular size, and Moon craters can be seen with almost any telescope.

7. Why will many of the very large telescopes of the future make use of multiple mirrors?

The best way to improve the performance of a telescope is to use the largest primary aperture possible. Very large telescopes of the future will use multiple mirrors or ultra-thin mirrors because thick monolithic mirrors of that size are much more difficult and, hence, more expensive to construct. A single large mirror will also flex when moved into different positions, which will decrease the quality of the resulting images. Segmented mirrors are easier and less expensive to construct, manipulate, repair, and can possible expand the size of the telescope.

8. What is meant by adaptive optics? What problem does adaptive optics overcome?

Adaptive optics refers to the automated reshaping of a telescope mirror based on the amount of twinkling caused by atmospheric turbulence. Adaptive optics reduces the problem of atmospheric distortion, thereby increasing the resolution that the telescope can deliver.

9. Compare an optical reflecting telescope with a radio telescope. What do they have in common? How are they different?

An optical reflecting telescope and a radio telescope both use a curved reflecting surface to focus the incoming radiation. The radio telescope uses a metal dish as the reflecting surface instead of a thin reflective coating on glass. The metal dish does not have to appear shiny or even be continuously solid, while the optical mirror must appear shiny. Because radio wavelengths are longer than visible light wavelengths, radio telescopes must have larger diameters than those of visible light telescopes.

10. Why can radio astronomers observe at any time of the day or night, whereas optical astronomers are mostly limited to observing at night?

Day and night refer to the ambient visible light in the sky. Daylight does not interfere with radio waves passing through Earth’s atmosphere, while visible light from stars and other astronomical objects are too dim to be seen during the day, and to some extent in regions that experience light pollution. Some human-made radio signals emitted at any time of the day or night do interfere with radio astronomy.

11. Why must astronomers use satellites and Earth-orbiting observatories to study the heavens at X-ray wavelengths?

The atmosphere is not transparent to X rays (nor to gamma rays). Therefore, these forms of radiation must be studied from orbits outside Earth's atmosphere.

12. What are NASA's four Great Observatories, and in what parts of the electromagnetic spectrum do (or did) they observe?

All four are observatories in space. The Hubble Space Telescope observes infrared light, visible light, and ultraviolet light; the Chandra X-ray Observatory observes X rays; the Compton Gamma Ray Observatory observed gamma rays; and the Spitzer Space Telescope observes the infrared portion of the electromagnetic spectrum. Of the four, Hubble, Spitzer, and Chandra are operating at extended times beyond their planned lifetimes. Only Compton is no longer observing, and has been replaced by GLAST. The James Webb Space Telescope and SOFIA are expected to serve as replacements for Hubble and Spitzer.

13. Why did Rømer's observations of the eclipses of Jupiter's moons support the heliocentric, but not the geocentric, cosmology?

Had Jupiter orbited around Earth as the geocentric cosmogony claimed, then the eclipses of Jupiter's moons would have all occurred at the predicted times. In that scenario, the light from all the eclipses would have taken the same length of time to reach Earth. What Rømer observed was that some eclipses were delayed (when Jupiter was farther from Earth than average) or advanced (when Jupiter was closer to Earth than average).

14. A blackbody glowing with which of the following colors is coolest? a. yellow b. red c. orange d. violet e. blue

b. Red is the coolest.

15. Of the following photons, which has the highest energy? a. infrared b. radio waves c. visible light d. X ray e. ultraviolet

d. X ray has the highest energy.

16. The spectrum of which of the following objects will show a redshift?

a. an object moving just eastward on the celestial sphere
b. an object moving just northward on the celestial
sphere c. an object moving directly toward Earth
d. an object moving directly away from Earth
e. an object that is not moving relative to Earth

d. An object moving directly away from Earth will show a redshift. The object moving toward Earth would show a blueshift. The others will not show any Doppler shift.

17. What is a blackbody? What does it mean to say that a star appears almost like a blackbody? If stars appear to be like blackbodies, why are they not black?

A blackbody is a perfect emitter, or a hypothetical object whose continuous radiated spectrum, or the statistical distribution of emitted energies, depends only on its temperature. A star is described as almost like a blackbody when the continuous part of that star's spectrum follows the shape of a blackbody spectrum. Stars are not black because they are hot and emit large amounts of electromagnetic radiation. A blackbody does not necessarily appear black, but emits a distribution of radiation with a peak wavelength or apparent tint and intensity that depend on the temperature. They would be black only if they gave off no electromagnetic radiation.

18. What is Wien's law? How could you use it to determine the temperature of a star's surface?

Wien's law is the mathematical relationship between the peak wavelength and the temperature of a blackbody. It says that the hotter an object is, the shorter the wavelength of the peak of its blackbody curve. This peak is the wavelength that the body emits most intensely. Since all blackbodies with the same temperature have the same blackbody curves, finding the wavelength at the peak of the continuous spectrum enables you to calculate the object's surface temperature.

19. What is the Stefan-Boltzmann law? How do astronomers use it?

The Stefan-Boltzmann law is the mathematical relationship between the intensity of radiation and the surface temperature of an object. It says that an object emits energy at a rate that is proportional to the fourth power of its temperature in degrees Kelvin. In other words, the hotter something is, the brighter each part of its surface appears compared to the same area of a cooler object. Astronomers use this law to determine the luminosity or brightness of stars from their temperatures.

20. Using Wien's law and the Stefan-Boltzmann law, state the changes in color and intensity that are observed as the temperature of a hot, glowing object increases.

Wien's law indicates that as an object becomes hotter, the peak wavelength of its blackbody spectrum shifts from radio to infrared radiation to red, to the visible light, to violet, to ultraviolet, and to even shorter wavelengths. The Stefan-Boltzmann law proposes that hotter objects have higher intensities of radiation, assuming that they all have the same visual diameter. Larger, cooler objects can appear brighter than smaller, hotter ones depending on how much of your field of view they occupy.

21. What is an element? List the names of five different elements, and briefly explain what makes them different from one another.

An element is an atom with one or more protons in its nucleus. The number of protons dictates what element the atom is, and the number of electrons in a neutral atom. Further, this defines the physical properties and chemical reactivity of the element. Examples include hydrogen, a highly reactive gas; helium, an inert gas;

iron, a heavy and reactive metal; aluminum, a lighter and less reactive metal; and carbon, which can readily forms bond with other carbon atoms.

22. How are the three isotopes of hydrogen different from one another?

These isotopes all have the same numbers of protons—one—but they have different masses due to differing numbers of neutrons in their nuclei. Having the same number of protons means the nuclei of these isotopes all have the same electrical charge, or that a neutral atom includes one electron. The hydrogen isotope deuterium has one proton and one neutron, and is approximately twice as massive as the regular hydrogen, which does not have any neutrons, but has one proton. Tritium has two neutrons, and is unstable and radioactive.

23. Why do different elements have different patterns of lines in their spectra? Different elements have different numbers of electrons orbiting with different allowed, discrete energy levels. The electrons can only transition or "jump" between the specific energy levels. The photons emitted or absorbed by an element (its spectrum) is determined by the differences in the energies of these orbits. Since they all emit or absorb photons with unique sets of wavelengths, all elements have unique spectra.

24. What is the Doppler shift, and why is it important to astronomers?

The Doppler shift is the change in frequency that occurs when a source and an observer are moving toward or away from each other. Astronomers use this effect to measure the speeds of bodies in space as they move toward or away from Earth. The Doppler shift can be used to determine the rotation rates of planets and the Sun, the presence of planets around other stars, the masses of stars in binary systems, and the motions of galaxies in a galaxy cluster, to name a few.

25. Explain why the Doppler shift tells us only about the motion directly along the line of sight between a light source and an observer but not about motion across the celestial sphere.

Doppler shift is a measure of the change of frequency from an object because of its motion toward or away from an observer. For a moving source (or observer), the speed of a travelling wave will not change as the source moves, but the wavefronts are emitted at increasingly closer or more distant locations. The spacing between emitted wavefronts will change, effectively changing the frequency. Motion across the line of sight does not change the distance between a light source and an observer, or the spacing of wavefronts. Therefore, the wavelength or frequency is not altered by this motion.

26. Why do stars twinkle?

As seen from space, they don't. As seen from Earth, they twinkle because the light rays from them pass through Earth's atmosphere, which continually changes density and thereby changes the direction, or distorts, of the starlight passing through it. These changes, which happen typically every one-half second, are what we see as twinkling.

27. Why do all research telescopes use primary mirrors rather than objective lenses?

A large primary lens or mirror is desirable for a research telescope. Lenses do not refract all colors equally, thereby creating chromatic aberration, while mirrors do not have this problem. Lenses also cannot be prevented from sagging (and hence distorting images) is their telescopes change direction, while mirrors can be prevented from sagging because it is easier to support a mirror. It is also very hard to grind a lens to the right shape to focus light, but easier to make mirrors of the right shape, because only one side of the mirror must be shaped and polished. Lenses often have air bubbles, which distort light, but mirrors don't have this problem since light never enters them. It is possible to form images with Cassegrain mirrors, or those with central holes.

28. For the purpose of observing very faint objects, which of the following features of a telescope is most important? Explain your answer.
a. its maximum magnification
b. its ability to resolve colors
c. the size of its objective lens or primary mirror
d. the type of mount it has
e. its weight

c. The larger the diameter of the primary or objective, the more photons the telescope can collect, hence the brighter dim objects appear.

29. Of the following types of electromagnetic radiation, which is most dangerous to life? a. radio waves
b. X rays
c. ultraviolet (UV) radiation
d. infrared radiation
e. visible light

b. Of all the types listed, X rays have the shortest wavelength and hence each X-ray photo carries the most energy. This is followed by UV, the next highest energy. Some frequencies of UV and all frequencies of X rays are forms of ionizing radiation, and are capable of breaking chemical bonds and damaging cells.

30. What color does the Sun emit most intensely?

Blue-green, as you can see on a blackbody diagram. However, the Sun appears white or yellow because the radiation is nearly evenly distributed in more energetic (blue) and less energetic (red) regions of the spectrum.

31. A star of which of the following colors is
hottest? a. blue b. red c. orange
d. yellow e. white

a. A blue star is hottest as explained by blackbody emission.

32. If a yellow star cools off, what color will it become next?

A yellow star will appear more orange, then red, as it cools off.

33. Advertisements for home telescopes frequently give a magnification for the instrument. Is this a good criterion for evaluating such telescopes? Explain your answer.

The major advantages to using a telescope are improvements in light gathering power, or limiting magnitude, and angular resolution or detail of objects. Magnifying ability is not a good criterion for evaluating telescopes because the magnification is easily changed by changing eyepieces. In addition, if the telescope does not collect sufficient light, no amount of magnification will produce a good image.

34. Show by means of a diagram why the image formed by a simple refracting telescope is “upside down.”

See Figures 3-17 and 3-18. A lens forms an image by bending rays of light, and an extended object emits many rays from every part. The rays emitted from the top and bottom of the Moon in Figure 3-17 cross each other as they pass through the first lens, forming an inverted image. In Figure 3-18, parallel rays are focused to a point by the first lens as before, but the eyepiece makes these rays parallel but does not invert them a second time.

35. Why does no major observatory have a Newtonian reflector as its primary instrument, whereas Newtonian reflectors are popular among amateur astronomers?

The fact that the observer would have to be positioned on the side and near the top of the telescope makes the Newtonian focus inconvenient for a major observatory. For example, these telescopes often place heavy detectors at the focal point, which would unbalance the telescope. In contrast, the low cost and convenient location of the eyepiece for a standing observer make the Newtonian focus popular among amateurs. The Schmidt-Cassegrain telescopes are also popular for amateurs because their short length makes them easily portable, and the observer looks in the same direction as the telescope points, making it easier for observers to locate objects in the night sky through the telescope.

36. Why will many of the very large telescopes of the future have ultrathin primary mirrors?

It is desirable to use the largest possible mirror to build a telescope. Thin mirrors weigh less; traditional thick mirrors are very difficult and more costly to construct. Thin mirrors can be easier to manipulate for the purposes of the adaptive optics system

37. What color will an interstellar gas cloud composed of hydrogen glow, and why?

A cloud of hydrogen gas will most likely glow red, as it will absorb and re-emit red H-alpha photons from stars. This photon corresponds to the transition between the second and third orbits of the electron in the H atom, which is the most probable visible transition to occur.

38. Explain how the spectrum of hydrogen is related to the structure of the hydrogen atom.

The spectrum of atomic hydrogen is the pattern of lines corresponding to the frequencies or energy values of photons absorbed or emitted from the gas. The single electron orbits the proton only with certain discrete values of energy. The electron may transition or "jump" between the energy states, and these jumps correspond to the emission or absorption of a photon equal to the difference in energy between levels. Different photons are associated with transitions between the different levels. Transitions to or from the ground state involve UV photons (Lyman series). The visible Balmer series involves transitions to or from the first excited state.

39. Do we see all the colors from each star? Why or why not?

Stars generally behave as blackbody emitters, meaning that they emit a continuous spectrum with a peak wavelength and intensity depending on the surface temperature. Ideally, all frequencies of light are present in a continuous blackbody spectrum. The probability of seeing higher energy photons such as violet or ultraviolet may be smaller for stars with a lower temperature than for hotter stars.

40. Discuss the advantages and disadvantages of using a relatively small visible-light telescope in Earth's orbit (for example, the 2.4-m Hubble Space Telescope) versus a large visible-light telescope on a mountaintop (for example, the 8.3-m Subaru Telescope on Mauna Kea, Hawaii).

The larger telescope is ideally advantageous to the smaller telescope because of improved light gathering power and angular resolution. A small telescope in Earth orbit can continually observe objects in space (except when the object is behind a body like the Sun or Earth), whereas even the largest visible-light telescopes on Earth can only be used at night. Telescopes in space, beyond Earth's atmosphere, are unaffected by atmospheric motion (twinkling), air pollution, light pollution, or weather conditions which all affect the light gathering power and resolution of telescopes on Earth, although the mountaintop location may reduce these effects significantly. However, if a telescope in space fails, it is much harder and more expensive to repair it than if it were on Earth. Both telescopes are likely to be in high demand.

41. If you were in charge of selecting a site for a new observatory, what factors would you consider?

Ideally, you would put an observatory in space to avoid atmospheric effects. If it were placed on the ground, you would want to put it as high up a mountain as possible. Placing it at high altitude would help minimize the effects of twinkling and the absorption of electromagnetic radiation by water in the atmosphere. Also, you would want to place the observatory as far away from the light pollution of cities as possible. Finally, you would want to survey the location to see if the weather is good year round. For example, a large mountain in a rainforest (such as in British Columbia) would be unsuitable because it would have very few clear nights. Another point of consideration is that many mountaintops such as Kitt Peak or Mauna Kea are considered sacred to indigenous people, and there may be restrictions to the use of the land.

42. Consider two identical Cassegrain telescope mirrors. One is set up as a prime focus telescope, whereas the other is used in a Cassegrain telescope.
a. Sketch both telescopes.
b. What are the differences between the two that make each useful in different observing situations?

See Figures 3-11b and 3-11d. The Cassegrain focus is below the base of the telescope because of a relatively small central hole in the primary mirror. The primary focus is located near the top center of the tube. If the telescopes are the same size, the prime focus telescope will produce a brighter image, since the light undergoes fewer reflections and it will have a wider field of view. The Cassegrain telescope has a longer focal length and allows easy access to changing instruments without having to climb into the telescope itself.

43. Compare the technique of identifying chemicals by their spectral line patterns with that of identifying people by their fingerprints.

Each chemical element has a unique set of spectral lines, as a result of different electron energy level spacing in different elements, just as each person has a unique set of fingerprints.

44. Suppose you look up at the night sky and observe some of the brightest stars with your naked eye or binoculars. Is there any way of telling which stars are hotter and which are cooler? Explain your answer.

You can determine the temperature from the color of the star. The hottest stars will look blue-white. In order of decreasing temperature, cooler ones will appear white, yellow, orange, or red.

45. How could we exclude Earth’s atmosphere as the source of the iron absorption lines in Figure 3-46?

A gas is the source of an absorption spectrum, and iron is not in gaseous form in Earth’s atmosphere.