Exam 01: Chapters 00-03

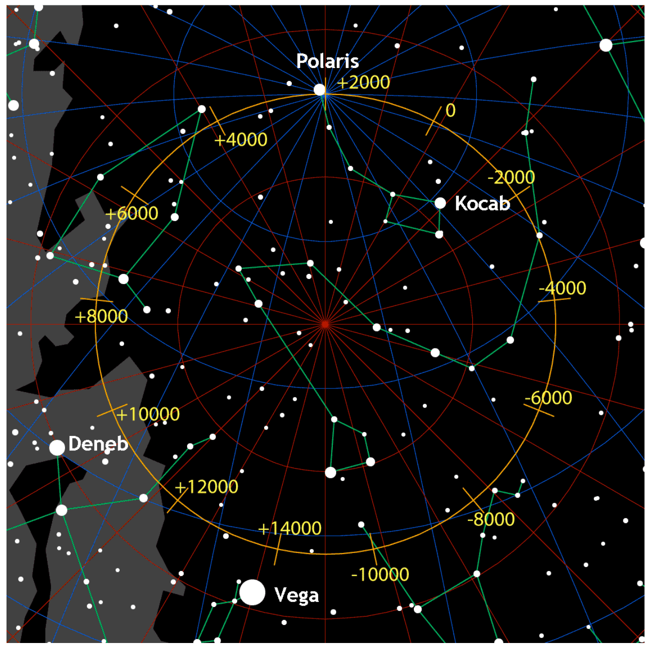
The very bright bluish star Rigel (βOri) is located in the constellation Orion. The **right ascensio**n of Rigel is **RA = 5h 14m 32s**, and the declination is **DE = –8°12'06"**. Answer Questions 1–3 below using this information

1. The bright star Betelgeuse (αOri) is also located in the constellation Orion. How are these stars related?
   A) All of the stars in any specific constellation are part of a related cluster. That's why they appear in patterns: because they are actually located close to one another.
   B) The patterns have no genuine astronomical significance, because the stars in a constellation are unrelated to each other. They may have cultural significance to the people viewing them, however.
   C) The shapes of the constellations tell you about the orbits of the planets. Without understanding why Orion looks like a hunter, or Scorpio looks like a scorpion, you cannot determine why planets have elliptical orbits.
   D) The constellations are significant because of the gravitational effect they have on every person. Where those constellations are at your moment of birth determines your personality traits and your fate.
   E) We need to know the pattern of the constellations of the zodiac, because until we find the planet with those particular patterns in the night sky, we will never find the fabled thirteenth colony—Earth!
2. What does the **right ascensio**n of Rigel signify?
   A) Rigel always rises 5h 14m 32s after the sun rises.
   B) Rigel always rises 5h 14m 32s after the sun sets!
   C) Rigel is visible in the sky above the horizon for exactly 5h 14m 32s each night.
   D) The RA of any celestial object is measured in hours with respect to the vernal equinox.
   E) The RA of any celestial object is measured in hours north (+) or south (–) of the celestial equator.
3. What does the **declination** of Rigel tell you about its location in the night sky? Rigel will be found
   A) 8°12'06" north of the celestial equator.
   B) 8°12'06" south of the celestial equator.
   C) 8°12'06" east of the vernal equinox.
   D) 8°12'06" west of the vernal equinox.
   E) 8°12' above the horizon as viewed from Conway, AR.

The bright reddish star Antares (αSco) is located in the constellation Scorpio. The **right ascensio**n of Antares is **16h 29m 24s**, and the **declination** is **–26°27'25"**. Answer Questions 1–3 below using this information.

4. The bright star Shaula (βSco) is also located in the constellation Scorpio. How are these stars related?
   A) All of the stars in any specific constellation are part of a related cluster. That's why they appear in patterns: because they are actually located close to one another.
   B) The patterns have no genuine astronomical significance, because the stars in a constellation are unrelated to each other. They may have cultural significance to the people viewing them, however.
   C) The shapes of the constellations tell you about the orbits of the planets. Without understanding why Scorpio looks like a scorpion, or Orion looks like a hunter, you cannot determine why planets have elliptical orbits.
   D) The constellations are significant because of the gravitational effect they have on every person. Where those constellations are at your moment of birth determines your personality traits and your fate.
   E) We need to know the pattern of the constellations of the zodiac, because until we find the planet with those particular patterns in the night sky, we will never find the fabled thirteenth colony—Earth!
5. What does the **right ascensio**n of Antares signify?
   A) Antares always rises 16h29m after the sun rises.
   B) Antares always rises 16h29m after the sun sets!
   C) Antares is visible in the sky for exactly 16h29m each night.
   D) The RA of any celestial object is measured in hours with respect to the vernal equinox.
   E) The RA of any celestial object is measured in hours north (+) or south (–) of the celestial equator.
6. What does the **declination** of Antares tell you about its location in the night sky?
   A) 26° north of the celestial equator.
   B) 26° south of the celestial equator.
   C) 26° east of the vernal equinox.
   D) 26° west of the vernal equinox.
   E) 26° above the horizon as viewed from Conway, AR.
7. What are constellations?
   A) The planets of our solar system, when viewed at different times of the year, seem to make pictures in the sky.
   B) Groups of extra-solar planets orbiting nearby stars that appear to form patterns.
   C) Groups of stars gravitationally bound to each other, appearing close together in the sky.
   D) Groups of stars making an apparent pattern on the celestial sphere.
   E) Groups of galaxies gravitationally bound and close together in the sky.
8. How are constellations scientifically significant?
   A) All of the stars in any specific constellation are part of a related cluster. That's why they appear in patterns: because they are actually located close to one another.
   B) The patterns have no genuine astronomical significance, because the stars in a constellation are unrelated to each other. They may have cultural significance to the people viewing them, however.
   C) The shapes of the constellations tell you about the orbits of the planets. Without understanding why Leo looks like a lion, or Orion looks like a hunter, you cannot determine why planets have elliptical orbits.
   D) The constellations are significant because of the gravitational effect they have on every person. Where those constellations are at your moment of birth determines your personality traits and your fate.
   E) We need to know the pattern of the constellations of the zodiac, because until we find the planet with those particular patterns in the night sky, we will never find the fabled thirteenth colony—Earth!
9. The declination of the bright star Vega is +38°47'2". This star is located
   A) 38° north of the celestial equator.
   B) 38° south of the celestial equator.
   C) 38° east of the vernal equinox.
   D) 38° west of the vernal equinox.
   E) 38° above the horizon as viewed from Conway, AR.

10. The declination of the bright star Antares is –26°27'25".
This star is located
    A) 26° east of the vernal equinox.
    B) 26° west of the vernal equinox.
    C) 26° north of the celestial equator.
    D) 26° south of the celestial equator.
    E) 26° above the horizon as viewed from Conway, AR.
11. Compare a solar and sidereal day.
    A) Both solar and sidereal days are precisely 24 hours in length. There is no difference.
    B) A solar day is how long it takes the sun to rotate once on its axis. A sidereal day is how long it takes the Earth to rotate once on its axis.
    C) A solar day measures the rotation of the Earth with respect to the sun. Sidereal measures the rotation of the Earth with respect to the moon.
    D) Sidereal days are slightly longer than solar days.
    E) Sidereal days are slightly shorter than solar days.
12. What is the ecliptic?
    A) The projection of the Earth's equator out onto a celestial sphere.
    B) The projection of the Earth's axis of rotation out onto a celestial sphere.
    C) The line drawn from the Earth to the moon when there is an eclipse occurring.
    D) The apparent path of the sun across the sky.
    E) The apparent change in the position of a star when observed six months apart.
13. Compare the orientation of the ecliptic to the celestial equator (CE).
    A) The ecliptic is perpendicular to the CE.
    B) The ecliptic coincides with the CE, so they are the same thing.
    C) It varies. They are the same on the equinoxes, but 90° apart on the solstices.
    D) It varies, and it is random. You cannot know or predict where the ecliptic will be.
    E) The ecliptic is at 23.5° to the CE, because of the tilt of the Earth's axis.
14. What is the declination of the Sun on the day of the spring equinox?
    A) –90°.
    B) –23.5°.
    C) 0°.
    D) +23.5°.
    E) +90°.
15. What is the declination of the Sun on the day of the autumnal equinox?
    A) –90°.
    B) –23.5°.
    C) 0°.
    D) +23.5°.
    E) +90°.
16. Where will the sun set today (09/28/12)?
    A) Due east, azimuth = 90°.
    B) A bit south of east, azimuth > 90°.
    C) A bit south of west, azimuth < 270°.
    D) Due west, azimuth = 270°.
    E) A bit north of west, azimuth > 270°.
17. What is the declination of the sun on the day of the winter solstice?
    A) -90°.
    B) -23.5°.
    C) 0°.
    D) +23.5°.
    E) +90°.
18. What does this imply for people living in the Southern Hemisphere (i.e., in Australia)?
    A) Nothing. The declination of the sun does not *mean* anything, it's just a number.
    B) The sun is at its lowest in the sky, for the shortest day of the year.
    C) The sun is at its highest in the sky, for the longest day of the year.
    D) There are equal hours of daylight and darkness on the day of the winter solstice.
    E) The sun never actually rises above the horizon on this day. Australians are in total darkness for the winter solstice



19. Ten thousand years from now, none of us will be here. But when whoever is here looks at the sky, they will see the stars appear to
    A) circle Polaris.
    B) circle Kocab.
    C) circle Vega.
    D) circle Deneb.
    E) move, but there will be no Pole Star which appears stationary.
20. If you traveled backwards through time, when was the last time there was a star aligned with the Earth's North Pole?
    A) About 2000 years ago, or t = 0 on the figure.
    B) About 3000 years ago, or t = –1000.
    C) About 4000 years ago, or t - –2000.
    D) About 5000 years ago, or t = –3000.
    E) About 6000 years ago, or t = –4000.
21. Why would an observer in the far future (or far in the past) perceive a different Pole Star than we do?
    A) They wouldn't. Polaris is our Pole Star now, and always has been. And always will be.
    B) The star which appears stationary in the sky is aligned with the Earth's equator. As the earth spins, different stars come into alignment.
    C) As the Earth spins, its axis wobbles slightly. That precession means the axis gradually move to point in a different direction over time.
    D) What we call a "Pole Star" is really just the sun, which, as we all know, appears in a different part of

the sky over the course of a year as the Earth completes a revolution.

22. On Friday, 09/18/09, the moon was new. At about what time did the moon rise on that day?
    A) About 6AM, or sunrise.
    B) About 12PM, or noon.
    C) About 6PM, or sunset.
    D) About 12AM, or midnight.
    E) It did not rise at all. That's why you cannot see a new moon.

23. Today (Friday, 10/01/10), the Moon phase is third quarter. At about what time will the Moon rise today?
    A) About 6AM, or sunrise.
    B) About 12PM, or noon.
    C) About 6PM, or sunset.
    D) About 12AM, or midnight.
    E) It did not rise at all. That's why you cannot see a new Moon.

24. Today (Friday, 02/17/12), the Moon phase is three days past the third quarter. At *about* what time will the Moon rise today?
    A) About halfway between sunrise and noon.
    B) About halfway between noon and sunset.
    C) About halfway between sunset and midnight.
    D) About halfway between midnight and sunrise.
    E) It will not rise at all.

25. Today (Friday, 09/28/12), the Moon is about two days before full. At *about* what time will the Moon rise today?
    A) About an hour before noon.
    B) About an hour before sunset.
    C) About an hour past sunset.
    D) About an hour past midnight.
    E) Trick question! It will not rise at all.

26. Why was there no eclipse last Friday?
    A) The orbit of the moon is slightly tilted. Last Friday, the moon was not on the ecliptic.
    B) When the moon is new, there can never be an eclipse. An eclipse can only occur when the moon is at 1st or 3rd quarter phases.
    C) The moon can only eclipse the sun when it is new and the sun crosses the celestial equator. Because the sun only crosses the CE on the vernal equinox, solar eclipses can only happen on March 21.

27. The star Wolf 1061 has a parallax of 2.34 arcsec, while the star Ross 652 has a parallax of 1.70 arcsec. What can you correctly conclude?
    A) Wolf 1061 is closer to Earth than Ross 652.
    B) Ross 652 is closer to Earth than Wolf 1061.
    C) Wolf 1061 is brighter, hotter than Ross 652.
    D) Ross 652 is brighter, hotter than Wolf 1061.
    E) Both stars are outside the Milky Way galaxy.

28. A planet in prograde motion appears to move across the sky
    A) from north to south.
    B) from south to north.
    C) from east to west.
    D) from west to east.
    E) from up to down.

29. How does the Ptolemaic geocentric model of the solar system explain retrograde motion?
    A) Retrograde motion is the result of a planet stopping its forward motion, reversing direction, traveling backwards along its orbit, then resuming its forward progress.
    B) Retrograde motion is naturally observed as a planet moves along its epicycle.
    C) Retrograde motion does not exist, it is simply a visual aberration due to making observations without the use of a telescope.
    D) Ptolemy's model had no explanation for this, and as a result, Aristotle's model was preferred for literally a thousand years.

30. What finally and completely killed the credibility of the Ptolemaic model?
    A) Copernicus published *de Revolutionibus*, a book declaring the sun at the center of the solar system. There was much rejoicing.
    B) Aristotle pointed out that Ptolemy's model was unable to adequately explain the retrograde motion of the planets.
    C) Kepler developed the idea that planets closer to the sun moved faster, which was not predicted by Ptolemy.
    D) Galileo observed a full cycle of phases for the planet Venus, which is impossible under the Ptolemaic system.
    E) Nothing. Ptolemy's model is correct, and is the basis for the entire science of modern astronomy that we study today.

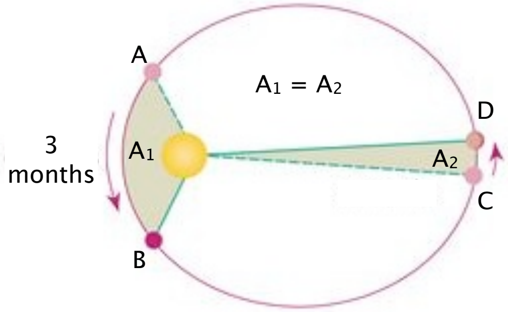
31. How did Kepler come up with elliptical orbits?
    A) He didn't. That was Copernicus, who was the first person to suggest that planets orbited the sun rather than the earth.
    B) He was well acquainted with Galileo, and was able to use the observations that Galileo made with his new telescope to prove that planetary orbits were ellipses.
    C) He had an enormous quantity of very precise data inherited from Tycho Brahe. By painstakingly plotting orbits, he was able to demonstrate that they were not circular.
    D) He guessed and got lucky. He had no observational data to reference, but his intuition told him that elliptical orbits just made more sense than any other shape.

32. If the orbit of a hypothetical planet has an eccentricity e = 0, what does the orbit look like?
    A) Eccentricity e =0 is a perfect circle.
    B) Eccentricity e = 0 is not a perfect circle, but just a little bit elongated on its major axis.
    C) Eccentricity e = 0 is a *very* elongated ellipse.
    D) Eccentricity e = 0 is actually a straight line!
    E) Eccentricity e = 0 means that the orbit is not a closed loop, but rather an open curve like a parabola.

On 03/21/1931 the planet Mars was 1.65AU from the sun. On 08/13/1941, Mars was 1.35AU from the sun. Use this information to answer the following questions 16—18.

33. On which day was Mars *closest* to aphelion?
    A) March 21, 1931
    B) August 13, 1941
    C) Neither. The aphelion date would be halfway between those dates, or about the middle of May, 1936.

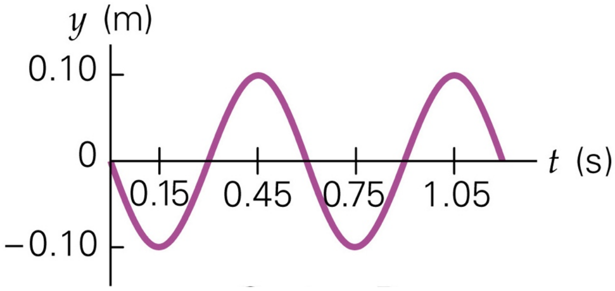
34. According to Kepler's Second Law, on which date was Mars traveling faster along its orbit?
    A) March 21, 1931
    B) August 13, 1941
    C) Neither. It would be moving fastest on the date halfway between those dates, or about the middle of May, 1936.



35. Kepler's Second Law of Planetary Motion is summarized by the figure above. If, as shown, the area A_1 is exactly equal to the area A_2, then
   A) the distance traveled by the planet from point A to point B is exactly the same as the distance traveled from C to D, sine the speed is constant.
   B) the planet is moving slower as it travels from A to B, and faster as it moves from C to D. The closer the planet is, the slower it goes.
   C) the planet is moving faster as it moves form A to B and slower as it moves from C to D, since it takes 3 months to do either.
   D) the picture is wrong. It is very clear that A_1 is much bigger than A_2, so it takes much more time to travel from A to B and less time from C to D. If A to B is 3 months, then C to D is more like one month.
   E) the picture is wrong. The sun is way too far off to the left, and should be right in the middle of the oval. Except the oval is wrong, too: it should be a perfect circle instead.
36. According to Kepler's Third Law, it takes Mars
   A) less than 365 days (1 Earth year) to complete one revolution around the sun.
   B) exactly 365 days to complete one revolution.
   C) more than 365 days to complete one revolution around the sun.
   D) a variable amount of time to revolve around the sun. Some Martian years are longer than 365 days, but some Martian years are shorter than 365 days.
37. Use Kepler's Third Law to predict the orbital period in years of a hypothetical planet located at **5AU** from the Sun. (Think for a minute before you grab your calculator!) The period is *closest* to
   A) 1 year
   B) 2.9 years
   C) 5 years
   D) 11 years
   E) 125 years
38. Use Kepler's Third Law to predict the orbital period of a hypothetical planet located at a distance of 4AU from the Sun.
   A) 1 year
   B) 4 years
   C) 8 years
   D) 32 years
   E) 64 years
39. Newton's Second Law of Motion can be stated mathematically as $F = ma$. You apply a 10N force to a 5kg mass. How much force must you apply to a 10kg mass to achieve the same acceleration?
   A) 0 N.
   B) 5 N.
   C) 10 N.
   D) 15 N.
   E) 20 N.
40. The gravitational force between two masses
   A) may be either attractive or repulsive.
   B) is neither attractive nor repulsive.
   C) is exclusively repulsive.
   D) is exclusively attractive.
   E) is always precisely zero.
41. Which of the following is a characteristic of the force of gravity between two masses?
   A) Force is directly proportional to mass: the larger the mass, the bigger the force. Doubling the mass doubles the force.
   B) Force is directly proportional to distance: the larger the separation between masses, the greater the force between them.
   C) Force is inversely proportional to distance: the larger the separation between masses, the smaller the force between them.
   D) Answers A and B are both accurate.
   E) Answers A and C are both correct.
42. The gravitational pull of the Sun on on an object at 1 AU (Earth distance) is F_E. The gravitational force on the same object at 10 AU (Saturn distance) due to the Sun is F_S. Compare these forces.
   A) $F_E = (1/100)F_S$
   B) $F_E = (1/10)F_S$
   C) $F_E = F_S$
   D) $F_E = (10)F_S$
   E) $F_E = (100)F_S$
43. The Earth's Moon is, for all practical purposes, the same distance away from the sun as the Earth. The Moon, however, is much less massive than the Earth. The gravitational force on the Moon due to the sun
   A) the same as the gravitational force on the Earth due to the sun.
   B) less than the gravitational force on the Earth due to the sun.
   C) greater than the gravitational force on the Earth due to the sun.
   D) zero. The sun exerts no pull on the Moon.
44. As a planet travels around the sun, the force of gravity keeps it on its orbit. Compare the direction of the force on the planet due to the sun with the direction of the velocity of the planet as it moves along its orbit.
   A) They are parallel: Both the force and velocity point directly inwards towards the sun.
   B) They are parallel but opposite: The force points directly towards the sun, but the velocity points directly away from the sun.
   C) They are perpendicular: The force always points inwards towards the sun, and the velocity is always at 90° to the force (pointing in the direction of travel).
   D) They are skew, neither parallel nor perpendicular. The relationship depends on the planet: The farther the distance, the bigger the angle.
   E) When the planet is near perihelion, the force and velocity are parallel. When the planet is at aphelion, the fore an velocity are perpendicular.
45. Compare the units of astronomical distances: parsec (pc), astronomical unit (AU), and light year(ly).
   A) In order of increasing size, the units are: pc, AU, ly.
   B) An AU is the smallest unit, and the pc is the largest.
   C) They are multiples of 100: a parsec = 100 AU, and a light year = 100 pc.
   D) It is customary to use AU to measure distances in our own galaxy, but pc to measure distances in other

galaxies. Sort of like how we use miles here in the US, but we would use kilometers in Europe.
E) Parsecs and light years are not actually units of distance at all, they are units of time. The AU is the only distance unit listed.

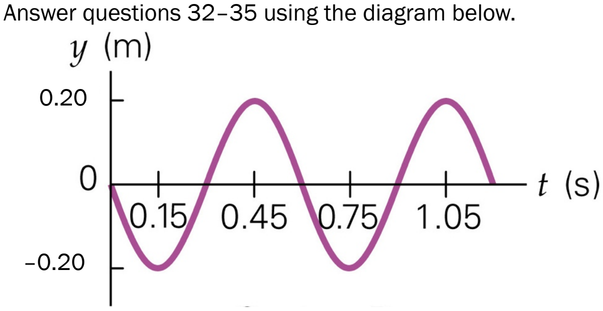
Answer questions 25 and 26 using the diagram below.



46. What is the amplitude of this wave? Answer numerically, with two decimal places.
A = 0.10m

47. What is the period of this wave? Answer numerically with two decimal places (X.xx).
P = 0.60s

Answer questions 32–35 using the diagram below.



48. What is the **amplitude** of this wave?
A) 0.20 m
B) 0.30 m
C) 0.40 m
D) 0.50 m
E) 0.60 m

49. What is the **period** of this wave?
A) 0.20 s
B) 0.30 s
C) 0.40 s
D) 0.50 s
E) 0.60 s

50. What is the **frequency** of this wave?
A) 1.67 Hz
B) 2.0 Hz
C) 2.5 Hz
D) 3.33 Hz
E) 5.0 Hz

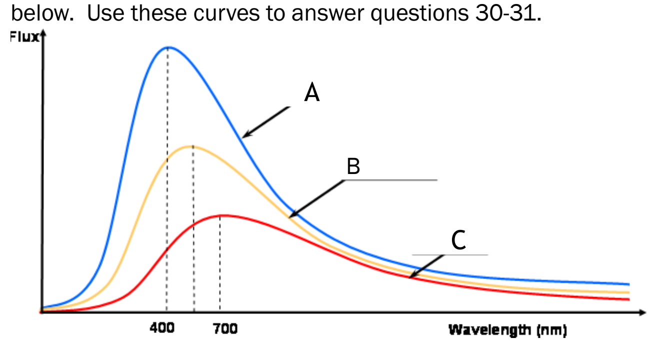
51. If the wave speed is **v = 3 m/s**, what is the **wavelength**?
A) 0.60 m
B) 0.90 m
C) 1.20 m
D) 1.50 m
E) 1.80 m

52. The sun emits low frequency radio waves and high frequency x-rays as well as visible light.
A) The radio waves travel the slowest through space, the x-rays travel the fastest.
B) The x-rays are the slowest, the radio waves are the fastest.
C) Visible light travels through space faster than either the radio or x-rays.
D) All forms of electromagnetic radiation travel at the same speed through space.
E) Electromagnetic radiation cannot travel through the vacuum of space.

53. Human eyes are sensitive to visible light. Why do we not have x-ray vision like Superman?
A) We do. Oh yes, we certainly do.
B) Humans see visible light because it penetrates the atmosphere. We could not have evolved x-ray vision because x-rays do not penetrate the Earth's atmosphere.
C) Because x-rays are dangerous, and (most) cavemen knew this. Any caveman with naturally occurring x-ray vision would have been killed when he left his cave to go outside and look at the x-rays. Thus, only the cavemen without x-ray vision who stayed safe in their caves survived to reproduce.

54. Using the Kelvin scale for temperature, the coldest any object can possibly be is
A) 273 K
B) 212 K
C) 100 K
D) 32 K
E) 0 K

The blackbody curves for three separate stars are shown below. Use these curves to answer questions 30-31.



55. Which of the curves represents the bluest star? **A**

56. Which of the curves represents the most sun-like star? **B**

57. Which of the curves represents the coolest star?
C

58. Which of the curves above represents the reddest star? **C**
D) Stars A, B, an C are all red stars.
E) None of the stars shown are red stars.

59. Star A shows a peak wavelength at 400 nm, or $4x10^{-5}$cm. According to Wien's Law, what is the approximate temperature of this star?
A) $1.16x10^{-5}$ K
B) $7.25x10^{-4}$ K
C) 72.5 K
D) 725 K
E) 7250 K

60. Star B shows a peak wavelength at 550 nm, or $5.5x10^{-5}$cm. According to Wien's Law, what is the approximate temperature of this star?
A) 0 K
B) $1.89x10^{-4}$ K
C) 72.5 K
D) 1890 K
E) 5270 K

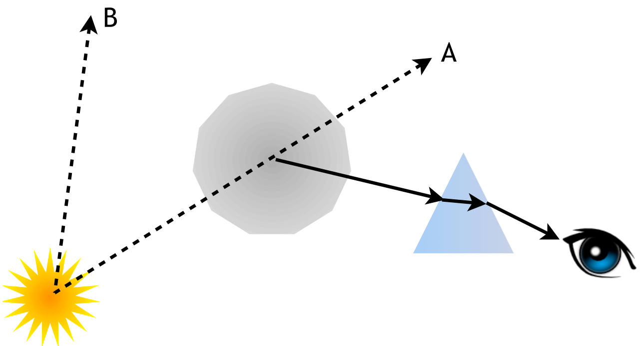
$$T(\mathrm{K}) = \frac{0.29}{\lambda(\mathrm{cm})}$$

$$T = \frac{0.29}{5.5 \times 10^{-5}} = 5720\mathrm{K}$$

61. According to **Stefan's Law**, which star emits more energy (per time per area), A or C? How much more?
A) Star A emits only 0.26 times as much energy as C.
B) Star A emits only 0.57 times as much energy as C.
C) Star A emits 1.75 times as much energy as C.

D) Star A emits 9.4 times as much energy as C.
E) Trick question. Both stars emit precisely the same amount of energy (per time per area), just at different temperatures.

An astronomer is viewing a cloud of interstellar gas, and recording the data spectroscopically. Use the figure below to answer questions 32-33.

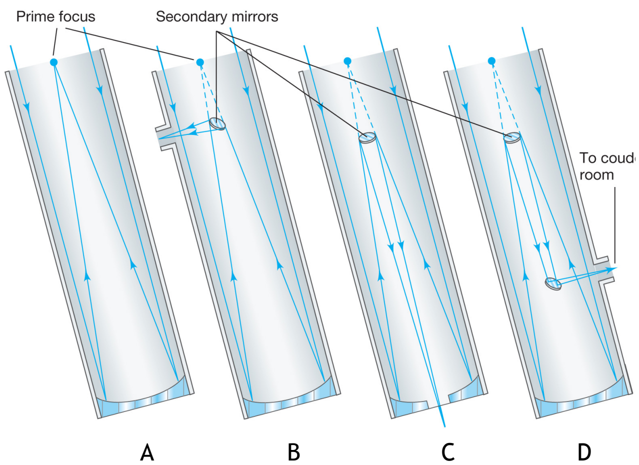


62. The astronomer will record
    A) a continuous spectrum.
    B) a dark-line absorption spectrum.
    C) a bright-line emission spectrum.
    D) nothing whatsoever.
63. Which observer (located at positions A and B) will observe a continuous spectrum?
    A) Observer A.
    B) Observer B.
    C) Both A and B will see a continuous spectrum.
    D) Neither A or B sees a continuous spectrum.
64. Lithium (Li), strontium, and calcium (Ca) each show a strong emission line at a wavelength of 460 nm. How would an astronomer know if she was seeing Li or Ca in her spectral data?
    A) She wouldn't. Spectral analysis is pretty much a guessing game, and she could not know for sure which element was present.
    B) The best way to tell would be to examine the line strength. Because Ca is heavier than Li, its line should be brighter. The brighter the emission line, the more likely it is from Ca.
    C) The Doppler shift would answer this question. Lighter Li would tend to be blue-shifted, so the line would appear at slightly less than 460 nm. If the line shows up at slightly above 460 nm, it is probably red-shifted Ca.
    D) One line is not enough. Calcium has a strong line 420 nm that is not present for Li. Lithium has a strong line at 670 nm which is not present for Ca. Identify more lines!
    E) None of these answers is correct. The only way to know for sure would be to have an actual physical sample of the gas. The real problem here is that the gas is way out there in space, and how are you going to get a sample of *that*?
65. Compare the emission spectrum of a heavier element (like uranium) to a light element (like hydrogen).
    A) A lighter element will always have many more lines than a heavier element.
    B) Heavy elements tend to have many lines because they have so many possible electron transitions. Lighter elements tend to have fewer.
    C) All atomic spectra are the same. The same lines show up at the same wavelengths for every element, regardless of whether it is heavy or light.
    D) Heavier and lighter elements have the same number of lines, just not at the same wavelengths. All atomic spectra have four lines, but the pattern of wavelengths is unique for each element.
    E) Only hydrogen produces emission lines. Other elements do not produce emission lines at all. They may create absorption lines, but not emission lines.
66. You are examining two unlabeled emission spectra, each of which spans wavelengths 400 nm to 700 nm (the entire visible range). Spectrum A shows seven strong emission lines, but Spectrum B only consists of four. None of the lines of A coincide with the lines of Spectrum B.
    A) Because A has more lines, it has to be a lighter element than B. A is probably hydrogen, B is probably helium.
    B) Because A has more lines, it is a heavier element than B, and has more electrons. This would mean that A is helium and B is hydrogen.
    C) You cannot possibly tell which element is heavier just from the number of observed lines. You have to check the wavelengths. The heavier element will have lines at longer (redder) wavelengths, and lighter elements have lines concentrated at shorter (bluer) wavelengths.
    D) Both spectra are from the same element, just recorded at different times. If they were completely different elements, you would expect to see the same number of emission lines for each, and you would expect to see one or two examples where the lines had the same wavelength.
67. When an electron is in an excited state, it wants to return to a lower energy, more stable location. To do this, it must
    A) emit a photon having exactly the right amount of energy to make a quantum jump.
    B) emit a photon having any amount of energy at all, just emit that photon already!
    C) absorb a photon having the precise quantum of energy required to jump to a higher orbit.
    D) absorb a photon having any quantum of energy at all, just get on with the absorbing!
    E) split into a proton and an anti-neutrino.
68. The spectrum of an object in motion toward an observer will be
    A) indistinguishable from the spectrum of a stationary object having the same composition.
    B) red-shifted. All of the spectral lines will be shifted by the same amount in the direction of longer wavelength.
    C) red-shifted. The lines in the orange-red and infrared part of the spectrum are shifted. Any other lines are unaffected.
    D) blue-shifted. The entire spectrum is shifted to the blue, or shorter wavelengths.
    E) blue-shifted. Only the blue-violet and ultraviolet lines are shifted, though. Longer wavelength lines are not affected.
69. The Doppler shift can tell you several things about the motion of an object, but it cannot tell you anything about the object's
    A) distance (increasing or decreasing).
    B) rotational direction.
    C) rotational speed of an object.
    D) radial (line of sight) velocity.
    E) tangential (or transverse) velocity.
70. Galileo is credited with being the first person to use a

telescope to make astronomical observations. What type of telescope did he make for himself?

A) A refracting telescope using a simple primary lens and an eyepiece.
B) A compound refractor using a system of precisely ground achromatic primary lenses coupled with a high-powered eyepiece.
C) A reflecting telescope using a parabolic primary mirror.
D) A Newtonian-style reflector, which was the most common type of telescope available.
E) Trick question. Galileo never used a telescope, but made all of his observations using a sextant and cross-staff.

71. Reflecting telescopes have several advantages over refracting telescopes. Which of the following is *not* an advantage of a reflector?
A) It is mechanically easier to grind and polish a single-sided mirror than a double-sided lens.
B) Mirrors will not have the chromatic aberration that occurs when light of different wavelengths bends slightly differently as it passes through a lens.
C) Mirrors can be made larger than lenses because they can be fully supported from behind.
D) Mirrors can be made of materials which are lighter and less expensive than optical glass.
E) Using a mirror instead of a lens increases the resolution. A mirror has about 10x smaller diffraction-limited resolution than the same size lens would have.



72. Which of the pictured reflecting telescopes above is a Newtonian type? B
E) None of them are Newtonian.

73. Which type of telescope pictured above is the Hubble Space Telescope (HST)? C
E) None of these represents the HST.

74. You are at the Telescope Store comparing a couple of backyard telescopes. The sales associate helpfully informs you that the 10-inch reflector you have your eye on has twice the light gathering power of the less expensive 5-inch reflector on sale for half price.
A) The sales associate is quite right. If you double the diameter of the primary mirror, you will double the telescope's light gathering ability.
B) The sales associate is not *quite* right. Light gathering power depends on the area of the mirror, not the diameter. The 10-inch telescope will actually have *four* times the light gathering ability of the 5-inch.
C) The sales associate is quite wrong. Increasing the size of a telescope's primary mirror has no effect on light gathering. It increases the magnification, but not the amount of light collected.
D) The sales associate is quite persuasive. Not only did you buy the bigger telescope, but you left with a set of Zeiss eyepieces, a tripod with precision motorized equatorial mount, a subscription to *Astronomy Today*, a genuine moon rock autographed by Buzz Aldrin, a bumper sticker that reads "My Other Telescope Is A Cassegrain," and a t-shirt with glow in the dark letters that says **I ♥ STARS!**

75. Compare the light-gathering ability of the 10m Keck telescope with the 30m TMT (Thirty Meter Telescope). In the same amount of time, the TMT collects
A) 1/3 as much light.
B) 3 times more light.
C) 9 times more light.
D) 300 times more light.
E) 900 times more light.

76. Compare the diffraction-limited resolution of the 10m Keck to the 30m TMT. For observations made at the same wavelength, the TMT has
A) has 3x better resolution.
B) has 9x better resolution.
C) has 30x better resolution.
D) has 90x better resolution.
E) has 90x *worse* resolution.

77. Why is it impossible for ground-based telescopes to achieve their diffraction-limited resolution?
A) Light pollution. Too many bright lights from too many cities interfering with the telescopes.
B) Dust pollution. The more dust and smog and pollution in the air, the dirtier the mirrors get. And they can't really be cleaned with Windex and a paper towel, you know.
C) Noise pollution. Because sound waves are vibrations, they cause the mirror to shake.
D) Atmospheric blurring. The motion of molecules in the air distorts the incoming light, resulting in a twinkling effect.
E) Water pollution. The surfaces of the mirrors are being slowly eroded, eaten away by acid rain.

78. The Spitzer Space Telescope (SST) is designed to make observations of infrared wavelengths. If you tried to use it for radio astronomy, you would
A) get an improved resolution. The radio images would be clearer and better resolved, making your IR data look blurry and a little fuzzy.
B) expect a decrease in resolution. Longer wavelength radio waves would give you an increase in the calculated diffraction limited resolution, but a *smaller* number is actually a better resolution!
C) not see any difference in the diffraction limited resolution, since it is independent of wavelength. It only depends on the size of the telescope, so it would be the same either way.
D) be alarmed by receiving the nearly-continuous radio broadcasts of Vogon poetry readings.

79. At a wavelength of 550nm (0.550μm, right in the middle of the visible), the Thirty Meter Telescope should have a diffraction-limited resolution of
A) α = 0.005 arcsec.
B) α = 0.05 arcsec.
C) α = 0.5 arcsec.
D) α = 5 arcsec.

E) α = 5 arcmin.

$$\alpha(\text{arcsec}) = (0.25)\left(\frac{\lambda(\mu\text{m})}{d(\text{m})}\right)$$

$$\alpha = (0.25)\left(\frac{0.550\mu\text{m}}{30\text{m}}\right) = 0.005''$$

80. At a wavelength of 550nm (right in the middle of the visible), the TMT should have a diffraction-limited resolution of $\alpha = 0.005''$. When the telescope sees first light in 2018, you will expect
    A) it to be *awesome*! Ground-based telescopes have no problem achieving resolutions equal to the diffraction limit.
    B) to be disappointed. There is no way to construct a ground-based telescope to get a resolution better than about 1°, so building a bigger dish is kind of pointless.
    C) amazing resolution, though not as low as the diffraction limit. Current predictions stand at about 0.015 arcsec resolution limit.
    D) it to be underwater, what with all the global climate change and rising sea levels and all.
81. You are driving down a long straight stretch of the interstate, and see a car coming towards you in the distance. If the vehicle is a distance d = 1.5km away, and a pair of headlights is typically about s= 1.5m apart, what is the angular separation of the headlights?
    A) θ = 0.34 arcmin
    B) θ = 3.4 arcmin
    C) θ = 34 arcmin
    D) θ = 3.4°
    E) θ = 34°
82. At that distance of 1.5km, can you (a typical human eye) resolve the headlights? Do you see two separate lamps, or a single smeary blur?
    A) Smeary blur.
    B) Two separate headlights.
83. The Very Large Array (VLA) consists of 27 radio telescopes, each having a primary dish 25m across. Why such big dishes?
    A) Radio waves are very high energy, and without a big surface area, they will just bounce right back out of the dish.
    B) Radio waves have a very short wavelength, so they are hard to catch. You want a big dish to maximize your chances.
    C) The atmosphere is partially opaque to radio frequencies. Because it's "drizzling" radio waves and not "pouring," you want the biggest "bucket" you can get to collect them in.
    D) Because you will use the same manufacturing process as you use to make large mirrors, so you might as well make them big. There is no physical reason they have to be that large.
84. Why isn't one dish enough? Why 27 dishes?
    A) The combined dishes act like one single enormous dish. Interferometry, or combining the signals, improves the angular resolution.
    B) Because they mistakenly clicked SUBMIT on the grant proposal form 27 times, and got funded 27 times for 27 dishes. Serendipity.
    C) You need each dish tuned to a different radio frequency. By overlapping the signals at different frequencies, you get an actual 3-dimensional picture, like a hologram!
85. Space telescopes: *Why*?
    A) Why not? They are inexpensive and fun!
    B) It is important to be able to make observations all across the e-m spectrum. Ground-based telescopes cannot observe large regions of the spectrum due to atmospheric opacity.
    C) The only real reason for a space telescope is to eliminate atmospheric blurring. Advances in adaptive optics have now made this unnecessary.
    D) So we will have plenty of advance warning when the Vogons arrive to build their hyperspace bypass.