Chapter 2 Light and Matter: The Inner Workings of the Cosmos

1) Radio waves, visible light, and X-rays are all types of electromagnetic radiation.
Answer: TRUE
Diff: 1
Section Ref.: 2.1

2) The frequency of a water wave gives us its height.
Answer: FALSE
Diff: 1
Section Ref.: 2.1

3) If a new wave arrives on shore every two seconds, then its frequency is 2 Hz.
Answer: FALSE
Diff: 2
Section Ref.: 2.1

4) The greater the disturbance of the medium, the higher the amplitude of the wave.
Answer: TRUE
Diff: 2
Section Ref.: 2.1

5) While gravity is always attractive, electromagnetic forces are always repulsive.
Answer: FALSE
Diff: 1
Section Ref.: 2.2

6) Changing the electric field will have no effect on the magnetic fields of a body.
Answer: FALSE
Diff: 1
Section Ref.: 2.2

7) As they move through space, the vibrating electrical and magnetic fields of a light wave must move perpendicular to each other.
Answer: TRUE
Diff: 1
Section Ref.: 2.2

8) Wave energy can only be transmitted through a material medium.
Answer: FALSE
Diff: 2
Section Ref.: 2.2

9) As white light passes through a prism, the red (longer) wavelengths bend less than the blue (shorter) wavelengths, so forming the rainbow of colors.
Answer: TRUE
Diff: 2
Section Ref.: 2.3

10) Observations in the X-ray portion of the spectrum are routinely done from the surface of the Earth.
Answer: FALSE
Diff: 2
Section Ref.: 2.3

11) In blackbody radiation, the energy is radiated uniformly in every region of the spectrum, so the radiating body appears black in color.
Answer: FALSE
Diff: 2
Section Ref.: 2.4

12) According to Wein's law, the larger the blackbody, the shorter its peak wavelength.
Answer: FALSE
Diff: 1
Section Ref.: 2.4

13) A blue star has a higher surface temperature than a red star.
Answer: TRUE
Diff: 1
Section Ref.: 2.4

14) According to Wein's law, the higher the surface temperature of a star, the redder its color.
Answer: FALSE
Diff: 2
Section Ref.: 2.4

15) Doubling the temperature of a blackbody will double the total energy it radiates.
Answer: FALSE
Diff: 2
Section Ref.: 2.4

16) As a star's temperature increases, the frequency of peak emission also increases.
Answer: TRUE
Diff: 2
Section Ref.: 2.4

17) The spectral lines of each element are distinctive to that element, whether we are looking at emission or absorption lines.
Answer: TRUE
Diff: 1
Section Ref.: 2.5

18) An absorption line spectrum, with dark lines crossing the rainbow of the continuum, is produced by a low-density hot gas.
Answer: FALSE
Diff: 2
Section Ref.: 2.5

19) An emission line results from an electron falling from a higher to lower energy orbital around its atomic nucleus.
Answer: TRUE
Diff: 1
Section Ref.: 2.6

20) The shorter a wave's wavelength, the greater its energy.
Answer: TRUE
Diff: 1
Section Ref.: 2.6

21) Spectral lines are produced when an electron makes a transition from one energy state to another.
Answer: TRUE
Diff: 1
Section Ref.: 2.6

22) In the Bohr model of the atom, an electron can only exist in specific, well-defined energy levels.
Answer: TRUE
Diff: 2
Section Ref.: 2.6

23) When an electron in a hydrogen atom drops from the second to the first excited energy state it emits a bright red emission line called hydrogen alpha.
Answer: TRUE
Diff: 2
Section Ref.: 2.6

24) The Zeeman effect reveals the presence of strong magnetic fields by the splitting of spectral lines.
Answer: TRUE
Diff: 2
Section Ref.: 2.8

25) The broader the spectral line, the higher the pressure of the gas that is creating it.

Answer: TRUE
Diff: 2
Section Ref.: 2.8

26) In the Doppler effect, a red shift of spectral lines shows us the source is receding from us.
Answer: TRUE
Diff: 1
Section Ref.: 2.7

27) The larger the red shift, the faster the distant galaxy is rushing toward us.
Answer: FALSE
Diff: 1
Section Ref.: 2.7

28) If a fire truck's siren is rising in pitch, it must be approaching us.
Answer: TRUE
Diff: 1
Section Ref.: 2.7

29) You would perceive a change in a visible light wave's amplitude as a change in its color.
Answer: FALSE
Diff: 1
Section Ref.: 2.3

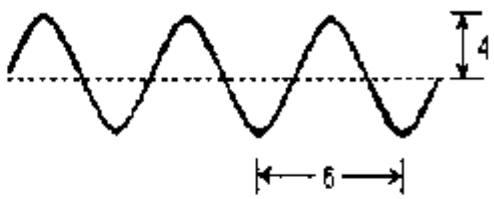
30) Spectroscopy of a star can reveal its temperature, composition, and line-of-sight motion.
Answer: TRUE
Diff: 1
Section Ref.: 2.8

31) The Doppler effect can reveal the rotation speed of a star by the splitting of the spectral lines.
Answer: FALSE
Diff: 2
Section Ref.: 2.8

32) Which of these is not a form of electromagnetic radiation?
A) DC current from your car battery
B) light from your camp fire
C) X-rays in the doctor's office
D) ultraviolet causing a suntan
E) radio signals
Answer: A
Diff: 1
Section Ref.: 2.1

33) A wave's velocity is the product of the
A) frequency times the period of the wave.
B) period times the energy of the wave.
C) amplitude times the frequency of the wave.
D) frequency times the wavelength of the wave.
E) amplitude times the wavelength of the wave.
Answer: D
Diff: 1
Section Ref.: 2.1

34) Consider this diagram. Which statement is true?



A) The amplitude is 4 and the wavelength is 6.
B) The amplitude is 6 and the wavelength is 4.
C) The amplitude is 8 and the wavelength is 6.
D) The amplitude is 4 and the wavelength is 12.
E) The amplitude is 8 and the wavelength is 12.
Answer: A
Diff: 2
Section Ref.: 2.1

35) If a wave's frequency doubles and its speed stays constant, its wavelength
A) is halved.
B) is also doubled.
C) is unchanged, as c is constant.
D) is now 4× longer.
E) becomes 16× longer.
Answer: A
Diff: 2
Section Ref.: 2.1

36) The speed of light in a vacuum is
A) 300,000 km/sec.
B) 768 km/hour.
C) 186,000 miles per hour.
D) h = E/c.
E) not given.
Answer: A
Diff: 1
Section Ref.: 2.2

37) Which of these is the same for all forms of electromagnetic (E-M) radiation in a vacuum?

A) amplitude
B) wavelength
C) frequency
D) speed
E) photon energy
Answer: D
Diff: 1
Section Ref.: 2.3

38) The two forms of electromagnetic (E-M) radiation that experience the least atmospheric opacity are
A) visible light and radio waves.
B) visible light and infrared waves.
C) microwaves and radio waves.
D) X and gamma radiation.
E) ultraviolet and infrared waves.
Answer: A
Diff: 2
Section Ref.: 2.3

39) The radiation our eyes are most sensitive to is the color
A) red at 6563 Angstroms.
B) yellow-green at about 550 nm.
C) violet at 7,000 Angstroms.
D) blue at 4,321 nm.
E) black at 227 nm.
Answer: B
Diff: 2
Section Ref.: 2.3

40) Medium A blocks more of a certain wavelength of radiation than medium B. Medium A has a higher
A) transparency.
B) seeing.
C) clarity.
D) opacity.
E) albedo.
Answer: D
Diff: 2
Section Ref.: 2.3

41) In the Kelvin scale, absolute zero lies at
A) zero K.
B) 273 degrees C
C) -373 degrees C.
D) Both A and B are correct.
E) Both A and C are correct.
Answer: A
Diff: 1
Section Ref.: 2.4

42) What is true of a blackbody?
A) It appears black to us, regardless of its temperature.
B) Its energy is not a continuum.
C) Its energy peaks at the wavelength determined by its temperature.
D) If its temperature doubled, the peak in its radiation curve would be doubled in wavelength.
E) It has a complete absence of thermal energy.
Answer: C
Diff: 1
Section Ref.: 2.4

43) What is the name of the temperature scale that places zero at the point where all atomic and molecular motion ceases?
A) Fahrenheit
B) Celsius
C) Kelvin
D) Centigrade
E) Ransom
Answer: C
Diff: 2
Section Ref.: 2.4

44) The total energy radiated by a blackbody depends on
A) the fourth power of its temperature.
B) the square of its temperature.
C) the square root of its temperature.
D) the fourth root of its temperature.
E) the cube of its temperature.
Answer: A
Diff: 2
Section Ref.: 2.4

45) Increasing the temperature of a blackbody by a factor of 3 will increase its energy by a factor of
A) 3
B) 6
C) 9
D) 12
E) 81
Answer: E
Diff: 3
Section Ref.: 2.4

46) If a star was the same size as our Sun, but was 81times more luminous, it must be
A) twice as hot as our Sun.
B) three times hotter than the Sun.
C) four times hotter than the Sun.
D) nine times hotter than the Sun.
E) 81 times hotter than the Sun.
Answer: B
Diff: 3
Section Ref.: 2.4

47) The Sun's observed spectrum is
A) a continuum with no lines, as shown by the rainbow.
B) a continuum with emission lines.
C) only absorption lines on a black background.
D) a continuum with absorption lines.
E) only emission lines on a black background.
Answer: D
Diff: 1
Section Ref.: 2.5

48) The element first found in the Sun's spectrum, then on Earth 30 years later, is
A) hydrogen.
B) helium
C) solarium.
D) technicum.
E) aluminum.
Answer: B
Diff: 2
Section Ref.: 2.5

49) A jar filled with gas is placed directly in front of a second jar filled with gas. Using a spectroscope to look at one jar through the other you observe dark spectral lines. The jar closest to you contains
A) the hotter gas.
B) the cooler gas.
C) gas at the same temperature as the other jar.
D) the exact same gas as the other jar.
E) gas at very high pressure.
Answer: B
Diff: 3
Section Ref.: 2.5

50) Which of these is emitted when an electron falls from a higher to lower orbital?
A) another electron
B) a positron
C) a neutrino
D) a photon
E) a graviton
Answer: D
Diff: 2
Section Ref.: 2.6

51) In Bohr's model of the atom, electrons
A) only make transitions between orbits of specific energies.
B) are not confined to specific orbits.
C) are spread uniformly through a large, positive mass.
D) can be halfway between orbits.
E) move from one orbit to the next orbit in many small steps.
Answer: A
Diff: 2
Section Ref.: 2.6

52) In general, the spectral lines of molecules are
A) more complex than those of atoms.
B) the same as the atoms they contain.
C) only absorption lines.
D) less complex than those of atoms.
E) nonexistent.
Answer: A
Diff: 2
Section Ref.: 2.6

53) Electromagnetic radiation
A) can only travel in a dense medium.
B) has only the properties of waves.
C) can behave both as a wave and as a particle.
D) is the same as a sound wave.
E) has nothing in common with radio waves.
Answer: C
Diff: 2
Section Ref.: 2.6

54) In a hydrogen atom, a transition from the 2nd to the 1st excited state will produce
A) the bright red Balmer alpha emission line.
B) no emission line.
C) a dark absorption line.
D) an ultraviolet spectral line.
E) three different emission lines.
Answer: A
Diff: 3
Section Ref.: 2.6

55) For hydrogen, the transition from the first to third excited state produces
A) a red emission line.
B) a blue green absorption line.
C) a violet emission line.
D) an infrared line.
E) an ultraviolet line.
Answer: B
Diff: 3
Section Ref.: 2.6

56) The observed spectral lines of a star are all shifted towards the red end of the spectrum. Which statement is true?
A) This is an example of the photoelectric effect.
B) This is an example of the Doppler effect.
C) The second law of Kirchhoff explains this.
D) The star is not rotating.
E) The star has a radial velocity towards us.
Answer: B
Diff: 2
Section Ref.: 2.7

57) If a source of light is approaching us at 3,000 km/sec, then all its waves are
A) blue shifted by 1%.
B) red shifted by 1%.
C) not affected, as c is constant regardless of the direction of motion.
D) blue shifted out of the visible spectrum into the ultraviolet.
E) red shifted out of the visible into the infrared.
Answer: A
Diff: 2
Section Ref.: 2.7

58) If the rest wavelength of a certain line is 600 nm, but we observe it at 594 nm, then
A) the source is approaching us at 1 % of the speed of light.
B) the source is approaching us at 0.1 % of the speed of light.
C) the source is receding from us at 10% of the speed of light.
D) the source is getting 1% hotter as we watch.
E) the source is spinning very rapidly, at 1% of the speed of light.
Answer: A
Diff: 2
Section Ref.: 2.7

59) According to the Zeeman effect, the splitting of a sunspot's spectral lines is due to
A) their rapid rotation.
B) temperature variations.
C) their magnetic fields.
D) their radial velocity.
E) a Doppler shift.
Answer: C
Diff: 2
Section Ref.: 2.8

60) The distance from a wave's crest to its undisturbed position is the ________.
Answer: amplitude
Diff: 1
Section Ref.: 2.1

61) The product of the wavelength times the frequency of a wave is its ________.
Answer: velocity
Diff: 1
Section Ref.: 2.1

62) A wave with a period of .01 seconds has a frequency of ________ Hz.
Answer: 100
Diff: 2
Section Ref.: 2.1

63) A frequency of one hundred ________ means the wave is vibrating one hundred million times per second; this is a typical carrier frequency for FM (frequency modulation) radio.
Answer: megahertz or million hertz
Diff: 2
Section Ref.: 2.1

64) A wave with a frequency of 2 Hz will have a period of ________.
Answer: one half second (0.5 s)
Diff: 2
Section Ref.: 2.1

65) An FM station broadcasts at a frequency of 100 MHz. The wavelength of its carrier wave is ________.
Answer: 3 meters
Diff: 3
Section Ref.: 2.1, 2.3

66) In electromagnetic waves, the electric and magnetic fields vibrate ________ to each other.
Answer: perpendicular
Diff: 2
Section Ref.: 2.2

67) A featureless spectrum, such as a rainbow, is said to be ________.
Answer: continuous
Diff: 1
Section Ref.: 2.4

68) Stars that appear blue or white in color are ________ than our yellow Sun.
Answer: hotter
Diff: 1
Section Ref.: 2.4

69) According to Wein's law, the wavelength of the peak energy will be ________ if the temperature of the blackbody is doubled.
Answer: halved
Diff: 1
Section Ref.: 2.4

70) The Sun's blackbody curve peaks in the ________ portion of the spectrum.
Answer: visible
Diff: 1
Section Ref.: 2.4

71) Knowing the peak emission wavelength of a blackbody allows you to determine its ________.
Answer: temperature
Diff: 2
Section Ref.: 2.4

72) Stefan's law notes that total energy radiated is proportional to the ________ power of the temperature of the blackbody.
Answer: fourth
Diff: 2
Section Ref.: 2.4

73) A dense, hot body will give off a(n) ________ spectrum.
Answer: continuous
Diff: 1
Section Ref.: 2.5

74) Fraunhofer was the German astronomer who first noted ________ lines in the Sun's spectrum.
Answer: absorption
Diff: 2
Section Ref.: 2.5

75) The common element with bright red, blue-green, and violet emission lines is ________.
Answer: hydrogen
Diff: 2
Section Ref.: 2.5

76) The common element discovered in the Sun's spectrum before it was found here is ________.
Answer: helium
Diff: 2
Section Ref.: 2.5

77) When an electron moves from a lower to a higher energy state, a photon is ________.
Answer: absorbed
Diff: 1
Section Ref.: 2.6

78) An electron has a ________ electric charge.
Answer: negative
Diff: 1
Section Ref.: 2.6

79) The most energetic photons are ________.
Answer: gamma rays or gamma
Diff: 2
Section Ref.: 2.6

80) The energy of the photon depends on its ________.
Answer: frequency or wavelength.
Diff: 2
Section Ref.: 2.6

81) Why can't we be certain that the Andromeda Galaxy exists today?
Answer: Since it lies 2.5 million light years distant, the most recent image we have is still 2.5 million years out of date, so we cannot prove it is still there. It probably is, though.
Diff: 2
Section Ref.: 2.1

82) How do sound and light waves differ?
Answer: Sound waves travel much slower, and need a physical medium, such as air, to be transmitted. Light travels best in the vacuum of space.
Diff: 2
Section Ref.: 2.1

83) An AM station is broadcasting at 980 kHz, while an FM station up the road is assigned 98 MHz. How do their carrier waves compare?
Answer: As the frequency of the FM station is 100 times higher than the AM station, the FM carrier wave must be 100 shorter in wavelength.
Diff: 3
Section Ref.: 2.1

84) No one can hear you scream (or fire a weapon) in space, regardless of the Hollywood special effects. Explain why.
Answer: Sound waves must travel though a material medium, and cannot pass through a vacuum. The blast might be seen, but the boom will not be heard.
Diff: 1
Section Ref.: 2.2

85) What two regions of the electromagnetic spectrum are best utilized by ground-based astronomers, and why?
Answer: The atmosphere is opaque to most radiation except visible and radio waves.
Diff: 2
Section Ref.: 2.3

86) How can you determine the distance to a spacecraft from the time it takes its radio signal to reach Earth?
Answer: In a vacuum, all electromagnetic radiation, including radio waves, travel at the same speed: 300,000 km/s. Measuring the time it takes the radio signal to reach us and multiplying by 300,000 km/s gives the distance to the spacecraft.
Diff: 3
Section Ref.: 2.2

87) Newton found that when light passed through a prism, it was dispersed into the component colors. Which bent the least, and why?
Answer: The red waves are bent less by the glass than are the other colors because they have the longest wavelength. Shorter wavelengths bend more than longer wavelengths.
Diff: 2
Section Ref.: 2.3

88) What do infrared and ultraviolet waves have in common? How do they differ?
Answer: Both are forms of electromagnetic radiation, both travel at c in a vacuum, and both are largely absorbed by our atmosphere. They differ greatly in frequency, wavelength, and photon energy, however, with UV much more energetic than IR.
Diff: 2
Section Ref.: 2.3

89) What do gamma rays, X-rays, light, and radio waves all have in common?
Answer: While they vary widely in wavelengths and frequencies, they are all forms of electromagnetic radiation and all travel at *c*, the speed of light, in a vacuum.
Diff: 2
Section Ref.: 2.3

90) How does human vision's peak in color sensitivity relate to the Sun?
Answer: Our eyes are tuned to utilize best the type of radiation our star produces the most of, and yellow lies in the middle of the visible spectrum.
Diff: 2
Section Ref.: 2.3

91) Give at least two advantages of the Kelvin temperature scale for astronomers.
Answer: It is an absolute scale, so there are never any negative readings. Wein's and Stefan's laws are only mathematically correct if Kelvin temperatures are used.
Diff: 3
Section Ref.: 2.4

92) The Great Nebula in Orion, M-42, is a low-density cloud of hot gas. Use Kirchhoff's laws to describe its spectrum.
Answer: Kirchhoff's second law notes that a hot thin gas will create an emission spectrum of bright lines through the spectroscope.
Diff: 2
Section Ref.: 2.5

93) According to Kirchhoff's first law why do dense, hot bodies create the type of spectrum they

do?
Answer: Kirchhoff's first law states that a dense, hot medium emits light of all wavelengths, creating a continuous spectrum.
Diff: 3
Section Ref.: 2.5

94) If the magnetic fields are very strong, such as around sunspots, how are spectral lines affected by the Zeeman effect?
Answer: A strong magnetic field will cause the lines to appear split apart.
Diff: 3
Section Ref.: 2.6

95) State the relationship between frequency, photon energy, and wavelength.
Answer: The higher the frequency, the greater the energy the photon carries, but the shorter its wavelength.
Diff: 2
Section Ref.: 2.3, 2.6

96) Explain how the Zeeman effect allows us to study stellar magnetic fields.
Answer: The Zeeman effect causes spectral lines to appear split into two. This tells us magnetic fields are present. The greater the observed splitting, the stronger the magnetic fields are.
Diff: 3
Section Ref.: 2.8

97) Explain how Bohr's model creates emission and absorption lines in the spectrum.
Answer: Bohr's model has the electron orbitals quantized into discrete energies. Each upward transition to a higher energy state produces an absorption line (energy is absorbed). Each downward transition produces an emission line (energy is emitted). The energy absorbed or emitted is exactly equal to the difference in energy levels.
Diff: 3
Section Ref.: 2.6

98) What information about a star can be inferred from its Doppler shift?
Answer: The Doppler shift gives the star's radial velocity, either towards or away from us.
Diff: 2
Section Ref.: 2.7

99) A binary star system is one with two stars orbiting each other. How can the Doppler Effect be used to find binary stars whose orbital plane is along our line of sight and determine their periods?
Answer: As the two stars orbit each other rapidly, one will approach us, creating a blue shift of its spectral lines, while its retreating companion shows a red shift. The time to go through two splits and recombinations of their lines is their orbital period.
Diff: 3
Section Ref.: 2.7

100) Explain what types of information can be obtained from a line spectrum.
Answer: The element which created it, the line-of-sight velocity of the source, its rotation speed,

temperature, the pressure of the gas emitting the radiation, and even its magnetic field may also be found.
Diff: 2
Section Ref.: 2.8

101) If we increased the pressure in a gas, how will its spectral lines be affected?
Answer: The lines will broaden (or even disappear if the density becomes too great)
Diff: 2
Section Ref.: 2.8

102) Contrast the speeds of sound and light in watching a flash of lightning, then listening for the thunder to follow.
Answer: Light travels at 300,000 km/sec, so the flash of light is almost instantaneous from a few miles away; sound travels at about a fifth of a mile per second, so if the thunder follows the lightning by five seconds, the bolt hit about a mile away.
Diff: 3
Section Ref.: 2.2

103) How can Wein's law be used to determine the temperature of a star?
Answer: Careful analysis of the blackbody curve of the star's entire radiation spectrum will reveal a peak that is unique to a given temperature. Basically, the bluer the star's radiation, the hotter its surface will be.
Diff: 1
Section Ref.: 2.4

104) Why would a hotter star appear blue-white while a cooler star appear red or not be visible at all?
Answer: Stefan's law notes that the higher the temperature, the more luminous the body is, so such stars produce great amounts of visible light. The hotter the star the shorter the wavelength it peaks at. A star that emits light across the entire visible spectrum would appear white. One that peaked beyond the visible would appear blue-white. A cooler star may peak in the red part of the spectrum, or even in the infrared.
Diff: 2
Section Ref.: 2.4

105) How does Stefan's law and a knowledge of Earth's history tell us that the Sun's temperature cannot have varied much in the last 3.5 billion years?
Answer: Since even a small change in temperature, raised to the fourth power, would result in a large change in the total solar energy radiated, if the Sun had cooled much, our oceans would have frozen and life would have ceased to exist here.
Diff: 3
Section Ref.: 2.4

106) Explain the appearance of the Sun's spectrum, as noted by Fraunhofer.
Answer: The Sun is dense, and gives rise to a continuous spectrum, peaked in the color yellow as dictated by the 5800K temperature of its surface. Then the cooler, less dense gas above the surface absorbs some of the energy in transit, revealing its composition by the particular absorption lines we observe from Earth.
Diff: 3
Section Ref.: 2.5

107) How does the energy of a water wave differ from the energy of a photon?
Answer: Amplitudes of sound (and water) waves can differ greatly and still have the same wavelength and frequency, as they are the result of the motions of large numbers of molecules. For photons, the energy is quantized, so that each photon of a given wavelength must carry the same amount of energy.
Diff: 3
Section Ref.: 2.5

108) Why do we know that the red Balmer emission line in hydrogen represents a smaller quantum leap than the violet line?
Answer: Red light has a longer wavelength than violet light; therefore a red photon contains less energy than a violet one. Since the photon given off when an electron's energy level changes has an energy equal to the energy difference between the two levels, the less energetic photon represents a smaller difference.
Diff: 3
Section Ref.: 2.6

109) Give an example of the Doppler Effect being used in a baseball game.
Answer: The Doppler "gun" can focus on the motion of the baseball, and give us the speed that the pitcher is delivering it to the plate.
Diff: 1
Section Ref.: 2.7

110) Give and explain an example of the use of the Doppler Effect on the highway.
Answer: The radar gun of a highway patrolman sends out a pulsed beam to be reflected back, thus giving the speed of your car and perhaps netting you a ticket.
Diff: 2
Section Ref.: 2.7

111) How can the Doppler Effect be used to determine if a storm is forming into a tornado?
Answer: Radar can determine the distance to a storm cloud. Since a tornado rotates very rapidly, Doppler radar can measure the difference in velocity between the two sides of the storm to determine if it is rotating.
Diff: 3
Section Ref.: 2.7

112) Explain how the Doppler Effect has been used to detect invisible planets orbiting other Sun-like stars.
Answer: The planets are massive enough to pull their star slightly off course as they orbit from one side to the other, producing a cycle of red and blue shifts that allow us to deduce that the planet is present, and how long it takes to orbit its star.
Diff: 3
Section Ref.: 2.7