Astronomy Today, 9e **(Chaisson/McMillan)**
Chapter 3 Radiation: Information from the Cosmos

3.1 True/False Questions

1) Radio waves, visible light, and X-rays are all a type of electromagnetic radiation.
Answer: TRUE
Diff: 1
Section Ref: 3.1

2) You would perceive a change in a visible light wave's amplitude as a change in its color.
Answer: FALSE
Diff: 1
Section Ref: 3.1

3) The frequency of a water wave gives us its height.
Answer: FALSE
Diff: 1
Section Ref: 3.1

4) Gamma rays are a type of electromagnetic radiation.
Answer: TRUE
Diff: 1
Section Ref: 3.1

5) If a new wave arrives on shore every two seconds, then its frequency is 2 Hz.
Answer: FALSE
Diff: 2
Section Ref: 3.1

6) If a new wave arrives on shore every half second, then its frequency is 2 Hz.
Answer: TRUE
Diff: 2
Section Ref: 3.1

7) The greater the disturbance of the medium, the higher the amplitude of the wave.
Answer: TRUE
Diff: 2
Section Ref: 3.1

8) 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: 3.1

9) While gravity is always attractive, electromagnetic forces are always repulsive.
Answer: FALSE
Diff: 1
Section Ref: 3.2

10) Changing the electric field will have no effect on the magnetic fields of a body.
Answer: FALSE
Diff: 1
Section Ref: 3.2

11) 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: 3.2

12) X-rays travel at a greater speed than radio waves.
Answer: FALSE
Diff: 1
Section Ref: 3.2

13) Wave energy can only be transmitted through a material medium.
Answer: FALSE
Diff: 2
Section Ref: 3.2

14) Observations in the X-ray portion of the spectrum are routinely done from the surface of the Earth.
Answer: FALSE
Diff: 2
Section Ref: 3.3

15) The type of radiation that is most able to damage living cells is ultraviolet.
Answer: FALSE
Diff: 1
Section Ref: 3.3

16) In a vacuum, X-rays travel faster than radio waves.
Answer: FALSE
Diff: 2
Section Ref: 3.3

17) Radio waves travel at the speed of sound; X-rays travel at the speed of light.
Answer: FALSE
Diff: 1
Section Ref: 3.3

18) A blue star has a higher surface temperature than a red star.
Answer: TRUE
Diff: 1
Section Ref: 3.4

19) Wien's law relates the peak wavelength of the blackbody to its size. The larger the blackbody, the shorter its peak wavelength.
Answer: FALSE
Diff: 1
Section Ref: 3.4

20) According to Wien's law, the higher the surface temperature of a star, the redder its color.
Answer: FALSE
Diff: 2
Section Ref: 3.4

21) 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: 3.4

22) Doubling the temperature of a blackbody will double the total energy it radiates.
Answer: FALSE
Diff: 2
Section Ref: 3.4

23) As a star's temperature increases, the frequency of peak emission also increases.
Answer: TRUE
Diff: 2
Section Ref: 3.4

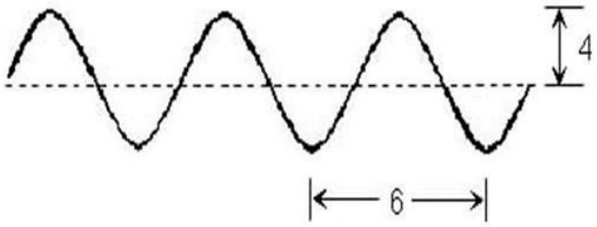
24) An observer will measure the wavelength of waves emanating from a source that is moving away as longer than it really is.
Answer: TRUE
Diff: 2
Section Ref: 3.5

3.2 Multiple Choice Questions

1) 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: 3.1

2) The number of waves passing the observer per second is:
A) the wavelength in angstroms.
B) the amplitude in nm.
C) the frequency in Hertz.
D) the period in seconds.
E) the energy in milliwatts.
Answer: C
Diff: 1
Section Ref: 3.1

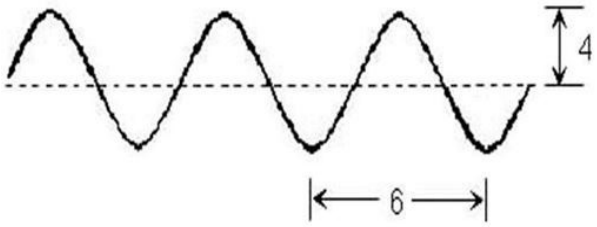
3) Consider this diagram. Which statement is true?



A) The wavelength is 4.
B) The wavelength is 6.
C) The wavelength is 8.
D) The wavelength is 12.
E) The wavelength cannot be determined from this diagram.
Answer: B
Diff: 2
Section Ref: 3.1

4) If a wave's frequency doubles, its wavelength:
A) is halved.
B) is also doubled.
C) is unchanged, as c is constant.
D) is now 4 times longer.
E) becomes 16 times longer.
Answer: A
Diff: 2
Section Ref: 3.1

5) Consider this diagram. Which statement is true?



A) The amplitude is 4.
B) The amplitude is 6.
C) The amplitude is 8.
D) The amplitude is 12.
E) The amplitude cannot be determined from this diagram.
Answer: A
Diff: 2
Section Ref: 3.1

6) Both sound waves and electromagnetic radiation:
A) travel at the speed of light.
B) require a medium to move through space.
C) can move through space without a medium.
D) transfer energy.
E) are transverse waves.
Answer: D
Diff: 2
Section Ref: 3.1, 3.2

7) What does the phenomenon of diffraction demonstrate?
A) the wave nature of light
B) the polarization of light waves
C) the quantization of atomic orbitals
D) the particle nature of the photon
E) the process of ionization
Answer: A
Diff: 1
Section Ref: 3.4

8) What does the phenomenon of interference demonstrate?
A) the wave nature of light
B) the polarization of light waves
C) the quantization of the atomic orbitals
D) the particle nature of the photon
E) the process of ionization
Answer: D
Diff: 3
Section Ref: 3.4

9) Which of these is constant for ALL types of electromagnetic radiation in a vacuum?
A) amplitude
B) wavelength
C) frequency
D) velocity
E) photon energy
Answer: D
Diff: 1
Section Ref: 3.2

10) Which statement gives the relationship between the waves in the electric and magnetic fields in an electromagnetic wave?
A) They are in phase and parallel with each other in space.
B) They are 90 degrees out of phase but parallel in space.
C) They are in phase but perpendicular to each other in space.
D) They are 180 degrees out of phase and random in their inclinations to each other.
E) They are in phase but opposite in direction of motion.
Answer: C
Diff: 2
Section Ref: 3.2

11) 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: 3.2

12) The temperature scale that places zero at the point where all atomic and molecular motion ceases is:
A) Fahrenheit.
B) Celsius.
C) Kelvin.
D) centigrade.
E) Ransom.
Answer: C
Diff: 2
Section Ref: 3.4

13) The speed of light in water compared to the speed of light in a vacuum is
A) slower.
B) faster.
C) the same.
D) can be faster or slower depending on the color.
E) can be faster or slower depending on the intensity.
Answer: A
Diff: 2
Section Ref: 3.3

14) Which type of electromagnetic radiation travels fastest in a vacuum?
A) radio
B) visible light
C) X-ray
D) gamma rays
E) They all travel at the same speed.
Answer: E
Diff: 2
Section Ref: 3.3

15) Which form of electromagnetic radiation is absorbed by carbon dioxide and water vapor in our atmosphere?
A) visible light
B) ultraviolet
C) infrared
D) radio
E) gamma rays
Answer: C
Diff: 1
Section Ref: 3.3

16) Which form of electromagnetic radiation would be blocked in the stratosphere by ozone?
A) cosmic rays
B) ultraviolet
C) visible light
D) infrared
E) microwaves
Answer: B
Diff: 1
Section Ref: 3.3

17) Of all the forms of electromagnetic radiation, the one with the lowest frequency is:
A) gamma rays.
B) ultraviolet rays.
C) visible light.
D) microwaves.
E) radio waves.
Answer: E
Diff: 1
Section Ref: 3.3

18) The Earth's ionosphere partially blocks which form of electromagnetic radiation?
A) gamma rays
B) ultraviolet
C) visible light
D) infrared
E) radio
Answer: E
Diff: 1
Section Ref: 3.3

19) The two forms of electromagnetic radiation that penetrate the atmosphere best are:
A) X-rays and gamma rays.
B) ultraviolet and visible light.
C) visible and infrared light.
D) visible and radio waves.
E) infrared and microwaves.
Answer: D
Diff: 1
Section Ref: 3.3

20) The hottest objects, with temperatures in the millions of Kelvins, give off most of their radiation in which part of the electromagnetic spectrum?
A) visible
B) radio
C) ultraviolet
D) X-ray
E) gamma ray
Answer: D
Diff: 2
Section Ref: 3.3

21) X-ray telescopes are located in orbit around the Earth because:
A) X-ray telescopes on Earth would have to be too big.
B) X-ray telescopes are cheap and easy to launch into space.
C) there are too many X-ray telescopes on Earth, so now they are put in space.
D) X-rays don't reach the surface of Earth.
E) the X-rays that come out of the telescopes are dangerous to humans.
Answer: D
Diff: 2
Section Ref: 3.3

22) Electromagnetic radiation with a wavelength of 700 nm would be:
A) X-rays.
B) red light.
C) violet light.
D) ultraviolet light.
E) microwaves.
Answer: B
Diff: 2
Section Ref: 3.3

23) The visible color of electromagnetic radiation that has the shortest wavelength is:
A) red.
B) orange.
C) green.
D) blue.
E) violet.
Answer: E
Diff: 2
Section Ref: 3.3

24) Colors appear different to us because of their photons' different:
A) speeds.
B) amplitudes.
C) frequencies.
D) magnetic fields.
E) polarization.
Answer: C
Diff: 2
Section Ref: 3.3

25) There are no X-ray telescopes on Earth because:
A) they are too expensive to build.
B) no one has yet invented an X-ray telescope that works.
C) we can't figure out how to direct an X-ray beam through space.
D) X-rays don't penetrate Earth's atmosphere.
E) there are no astronomical objects that emit X-rays.
Answer: D
Diff: 2
Section Ref: 3.3

26) There are no radio telescopes in space because:
A) no one has built an antenna large enough to reach astronomical objects yet.
B) radio telescopes are too fragile and expensive to make to put into space.
C) there is too much radio noise in space, so a radio telescope won't work out there.
D) radio waves penetrate Earth's atmosphere so there is no need to put one in space.
E) you need an array, like the VLA, to detect ANY radio radiation, so it is just not realistic to put an entire array in space.
Answer: D
Diff: 2
Section Ref: 3.3

27) The radiation our eyes are most sensitive to lies in 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 nanometers.
E) black at 227 nm.
Answer: B
Diff: 2
Section Ref: 3.3

28) Which type of electromagnetic radiation has the shortest wavelength?
A) radio
B) infrared
C) visible light
D) ultraviolet
E) gamma ray
Answer: E
Diff: 1
Section Ref: 3.3

29) Which type of radiation can be observed well from Earth's surface?
A) gamma ray
B) X-ray
C) ultraviolet
D) visible
E) infrared
Answer: D
Diff: 3
Section Ref: 3.3

30) 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 curve would be doubled in wavelength.
E) It has a complete absence of thermal energy.
Answer: C
Diff: 1
Section Ref: 3.4

31) According to Wien's Law, if the surface temperature is increased by a factor of 2, its peak wavelength will:
A) increase by a factor of 2.
B) decrease by a factor of 2.
C) increase by a factor of 4.
D) decrease by a factor of 4.
E) not change; Wien's law has nothing to do with peak wavelength.
Answer: B
Diff: 1
Section Ref: 3.4

32) Star A has a temperature 1/2 that of star B, but star A is 5 times bigger than star B. Which statement below is correct?
A) Star A is redder and dimmer than star B.
B) Star A is bluer and dimmer than star B.
C) Star A is redder and brighter than star B.
D) Star A is bluer and brighter than star B.
E) Star A and star B have the same color, but star A is brighter.
Answer: C
Diff: 2
Section Ref: 3.4

33) Star A and star B have the same temperature, but different luminosities. What can you infer about these two stars?
A) Star A must be bigger.
B) Star B must be bigger.
C) Star A must be redder.
D) Star B must be redder.
E) Nothing can be inferred from the information given.
Answer: E
Diff: 2
Section Ref: 3.4

34) Star A has a temperature 1/2 that of star B, but star A is 3 times bigger than star B. Which statement below is correct?
A) Star A is redder and dimmer than star B.
B) Star A is bluer and dimmer than star B.
C) Star A is redder and brighter than star B.
D) Star A is bluer and brighter than star B.
E) Star A and star B have the same color, but star A is brighter.
Answer: A
Diff: 2
Section Ref: 3.4

35) 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 cube root of its temperature.
E) the cube of its temperature.
Answer: A
Diff: 2
Section Ref: 3.4

36) Star A and star B have the same temperature, but star B is more luminous than star A. What can you infer about these two stars?
A) Star A must be bigger.
B) Star B must be bigger.
C) Star A must be redder.
D) Star B must be redder.
E) Nothing can be inferred from the information given.
Answer: B
Diff: 2
Section Ref: 3.4

37) At which of these Kelvin temperatures would a blackbody radiate mostly at visible wavelengths?
A) 6 K
B) 60 K
C) 600 K
D) 6000 K
E) None of these; a blackbody doesn't radiate visible light.
Answer: D
Diff: 2
Section Ref: 3.4

38) The wavelength at which a blackbody radiates most depends on its:
A) radius.
B) mass.
C) magnetic fields.
D) temperature.
E) direction of motion.
Answer: D
Diff: 2
Section Ref: 3.4

39) Star A has a temperature 3 times that of star B. Both star A and star B are the same physical size. Which statement about star A and star B below is correct?
A) Star A is redder and dimmer than star B.
B) Star A is bluer and dimmer than star B.
C) Star A is redder and brighter than star B.
D) Star A is bluer and brighter than star B.
E) Star A and star B have the same color, but star A is brighter.
Answer: D
Diff: 2
Section Ref: 3.4

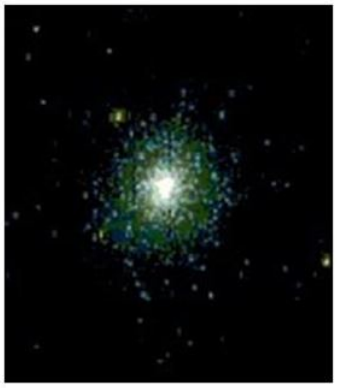
40) Star A and star B have the same temperature, but star A is 5 times bigger than star B. Which statement below is correct?
A) Star A is redder and dimmer than star B.
B) Star A is bluer and dimmer than star B.
C) Star A is redder and brighter than star B.
D) Star A is bluer and brighter than star B.
E) Star A and star B have the same color, but star A is brighter.
Answer: E
Diff: 2
Section Ref: 3.4

41) Star A has a temperature 1/4 that of star B. Both star A and star B are the same physical size. Which statement below is correct?
A) Star A is redder and dimmer than star B.
B) Star A is bluer and dimmer than star B.
C) Star A is redder and brighter than star B.
D) Star A is bluer and brighter than star B.
E) Star A and star B have the same color, but star A is brighter.
Answer: A
Diff: 2
Section Ref: 3.4

42)

Very low temperature molecular clouds emit most of their light in which part of the electromagnetic spectrum?
A) the visible
B) the X-ray
C) the ultraviolet
D) the radio
E) the infrared
Answer: D
Diff: 2
Section Ref: 3.4

43)



Very hot, young stars, like those in Messier 2 emit most of their light in which part of the electromagnetic spectrum?
A) the visible
B) the X-ray
C) the ultraviolet
D) the radio
E) the infrared
Answer: C
Diff: 2
Section Ref: 3.4

44)

A dim, young star like Herbig-Haro 68 emits most of its light in which part of the electromagnetic spectrum?
A) the visible
B) the X-ray
C) the ultraviolet
D) the radio
E) the infrared
Answer: E
Diff: 2
Section Ref: 3.4

45)

Stars like our Sun emit most of their light in which part of the electromagnetic spectrum?
A) the visible
B) the X-ray
C) the ultraviolet
D) the radio
E) the infrared
Answer: A
Diff: 2
Section Ref: 3.4

46) To see the Sun's hot corona (a temperature of 1,000,000 K), which part of the electromagnetic spectrum should one observe?
A) the visible
B) the X-ray
C) the ultraviolet
D) the radio
E) the infrared
Answer: B
Diff: 2
Section Ref: 3.4

47) 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: 3.4

48) Increasing the temperature of a blackbody by a factor of 2 will increase its energy by a factor of:
A) $\sqrt{2}$.
B) 4.
C) 8.
D) 16.
E) 32.
Answer: D
Diff: 3
Section Ref: 3.4

49) As the Sun evolves into a red giant in the distant future, then according to Wien's Law:
A) most of its energy must become shorter in wavelength.
B) its peak on the Planck curve will move into the infrared.
C) its total luminosity must decrease.
D) it will disappear from the universe of visible light.
E) its light will be slowed down by its increasing mass.
Answer: B
Diff: 3
Section Ref: 3.4

50) Stefan's Law says:
A) the hotter a star's surface, the bluer it looks to us.
B) $E = mc^2$.
C) the energy radiated by a blackbody is proportional to T^3.
D) that if the Sun's temperature were doubled, it would give off 16X more energy.
E) that doubling the star's temperature would also double its peak wavelength.
Answer: D
Diff: 3
Section Ref: 3.4

51) Per unit area (such as a square centimeter), a B star whose surface temperature is 10,000 K will put out how much radiation compared to an O star whose surface temperature is 30,000 K?
A) 81 times as much
B) 9 times as much
C) 1/81 as much
D) 1/9 as much
E) 1/3 as much
Answer: C
Diff: 3
Section Ref: 3.4

52) The Doppler Effect is a phenomenon that allows one to measure an object's:
A) temperature.
B) radius.
C) radial motion.
D) tangential motion.
E) chemical composition.
Answer: C
Diff: 1
Section Ref: 3.5

53) The light from an object moving tangentially (to your left or right) will exhibit:
A) a blueshift.
B) a redshift.
C) a shift in peak wavelength towards the red.
D) a shift in peak wavelength towards the blue.
E) no shift.
Answer: E
Diff: 2
Section Ref: 3.5

54) If a light source is approaching you at a speed very close to the speed of light, it will appear:
A) redder than it is.
B) bluer than it is.
C) brighter than it is.
D) fainter than it is.
E) lower temperature than it is.
Answer: B
Diff: 2
Section Ref: 3.5

55) If a beam of blue light with a wavelength of 400 nm is emitted by an object moving away from you at 1% of the speed of light, what wavelength would you see from this light?
A) 396 nm
B) 399 nm
C) 400 nm
D) 401 nm
E) 404 nm
Answer: A
Diff: 2
Section Ref: 3.5

3.3 Fill-in-the-Blank Questions

1) The distance from a wave's crest to its undisturbed state is the _____.
Answer: amplitude
Diff: 1
Section Ref: 3.1

2) The product of the wavelength times the frequency of a wave is its _____.
Answer: velocity
Diff: 1
Section Ref: 3.1

3) The distance between two successive wave crests is the _____ of a wave.
Answer: wavelength
Diff: 1
Section Ref: 3.1

4) In a wave, the distance from peak to peak is called the wave's _____.
Answer: wavelength
Diff: 2
Section Ref: 3.1

5) The part of the electromagnetic spectrum with the shortest wavelengths is called _____.
Answer: gamma rays or gamma
Diff: 2
Section Ref: 3.1

6) Light that has all the electrical fields vibrating in the same plane is said to be _____.
Answer: polarized
Diff: 2
Section Ref: 3.2

7) The type of electromagnetic radiation that is most able to damage living cells is _____.
Answer: gamma rays
Diff: 1
Section Ref: 3.3

8) The Earth's atmosphere allows astronomers to clearly observe electromagnetic radiation that is either _____ or _____.
Answer: visible light, radio
Diff: 2
Section Ref: 3.3

9) A cool star like Antares would produce more _____ than visible light.
Answer: infrared
Diff: 1
Section Ref: 3.4

10) The Sun's blackbody curve peaks in the _____ portion of the spectrum.
Answer: visible
Diff: 1
Section Ref: 3.4

11) Stars that appear blue or white in color are _____ than our yellow Sun.
Answer: hotter
Diff: 1
Section Ref: 3.4

12) Knowing the peak emission wavelength of a blackbody allows you to determine its _____.
Answer: temperature
Diff: 2
Section Ref: 3.4

3.4 Short Answer Questions

1) 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: 3.2

2) 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: 3.2

3) 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: 3.2

4) Describe the relationship between frequency and wavelength.
Answer: The higher the frequency, the shorter the wavelength.
Diff: 2
Section Ref: 3.2

5) How can you determine the distance to a spacecraft from the time it takes its radio signal to reach Earth?
Answer: In 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: 3.2

6) 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: 3.3

7) 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 penetrating than IR, as anyone who has experienced a sunburn is aware.
Diff: 2
Section Ref: 3.3

8) Why can't long-wavelength radio observations be made from Earth's surface?
Answer: Earth's ionosphere reflects electromagnetic radiation with wavelengths greater than about 10m, which prevents these radio waves reaching radio telescopes on Earth's surface.
Diff: 2
Section Ref: 3.3

9) 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: 3.4

10) 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: 3.5

3.5 Essay Questions

1) What is meant by the wavelength of light? By its frequency? Show how they are related to each other.
Answer: The wavelength is the distance between successive wave crests, while the frequency is the number of waves that pass the observer per second. All forms of EM radiation travel in a vacuum at 300,000 km/sec., and this velocity is the product of the wavelength X the frequency of the radiation.
Diff: 2
Section Ref: 3.2

2) 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: 3.2

3) What is white light? Why do we perceive different colors with a prism?
Answer: White light is composed of all the colors blended together uniformly. The colors are all present, as is shown when a prism spreads them back apart; each color corresponds to a different wavelength of EM radiation.
Diff: 3
Section Ref: 3.3

4) How can Wien'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 photospheric temperature. Basically, the bluer the star's radiation, the hotter its surface will be.
Diff: 1
Section Ref: 3.4

5) 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: 3.4

6) How do 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: 3.4

7) Use Wien's Law to determine the peak wavelength of a star whose temperature is 10,000 K (similar temperature to the star Sirius). What color is this? Explain.
Answer: Wien's Law says that the peak wavelength (λ) is 2.9 mm divided by the temperature (T) in kelvins, or λ_{max} = 2.9 mm / T. Using 10,000 K, that gives λ_{max} = 2.9 mm / 10,000 = 290 nm. Since ultraviolet has wavelengths from 10 nm to 400 nm, that would be ultraviolet.
Diff: 3
Section Ref: 3.4

8) What are the similarities and differences between the Kelvin and Fahrenheit temperature scales? Identify the freezing point of water on both scales.
Answer: The Fahrenheit scale is an archaic scale that has no obvious starting point. The Kelvin scale was devised to begin at the lowest possible temperature in the universe. In Fahrenheit the freezing point of water is 32, in Kelvin it's 273.
Diff: 3
Section Ref: 3.4

9) 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: 3.5

10) Give and explain an example of the use of the Doppler Effect on the highway.
Answer: The radar gun of a highway patrol officer 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: 3.5

11) 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 will measure the difference in velocity between the two sides of the storm to determine if it is rotating.
Diff: 3
Section Ref: 3.5

12) A star whose temperature is 8000 K has a peak wavelength of 362.5 nm, according to Wien's Law. If the star is in the Andromeda Galaxy, which is moving towards us at about 402,000 km/hour, what would an observer on Earth see as the peak wavelength for this star (show your work, and use c = 300,000 km/s)?
Answer: The Doppler Effect says that the apparent wavelength / true wavelength = 1 + recession velocity / wave speed. Changing 402,000 km/hour to km/s is done by dividing by 3600 seconds per hour. Filling in the numbers, using λ for the unknown wavelength, gives $\lambda/362.5 = 1 + (402{,}000/3600)/300{,}000$. So $\lambda = 362.5[1 + (402{,}000/3600) / 300{,}000] = 362.635$ nm.
Diff: 3
Section Ref: 3.5