1. The idea that the speed of light is a constant that could be measured
   A) dates back to Democritus, who hypothesized that atoms move at the speed of light.
   B) goes back as far as Galileo, but he was not able to make the measurement accurately.
   C) is laughable, because we know now that light travels instantaneously through any medium.
   D) was disproved conclusively with Maxwell’s equations.

2. How fast do electromagnetic (em) waves travel?
   A) 70 mph, the same speed as a cheetah.
   B) The same speed as light.
   C) Faster than sound waves, but slower than light.
   D) They do not travel; the wave stays put.

3. What was the significance of Hertz’s experiment in 1887? It showed that
   A) a beam of light knocks electrons off a metal foil, proving that light and electricity were related.
   B) alpha particles are deflected by atomic nuclei, proving that the nucleus is positively charged.
   C) radio waves are electromagnetic, opening the door for Marconi and wireless communication.
   D) an oscillating circuit creates gravitational waves, demonstrating that gravity is magnetic in nature.

4. Electromagnetic waves
   A) include both radio waves and sound waves.
   B) are longitudinal and require a medium to travel through.
   C) are transverse and require a medium to travel through.
   D) include gamma rays, ultraviolet light, and infrared radiation.

5. The electromagnetic spectrum includes
   A) radio, television, and sound waves.
   B) radio, sound, and seismic waves.
   C) visible light, but no other types of waves.
   D) radio, infrared, ultraviolet, and gamma rays.

6. The electromagnetic spectrum
   A) is discrete: you can only have wavelengths or frequencies that are whole numbers.
   B) is continuous: there are no “forbidden” values for wavelength or frequency.
   C) is garbled: there are certain frequencies that correspond to more than one wavelength.

7. Radio waves have a much lower frequency than x-rays. This means that radio waves
   A) have less energy than x-rays.
   B) have more energy than x-rays.
   C) have the same energy as x-rays.
   D) have shorter wavelength than x-rays.

8. Ultraviolet (UV) waves have a much higher frequency than infrared (IR). This means that UV waves
   A) have less energy than IR.
   B) have more energy than IR.
   C) have the same energy as IR.
   D) have longer wavelength than IR.

9. Compare infrared waves with x-rays.
   A) They are unrelated phenomena, so there is nothing to compare.
   B) Infrared waves are lower frequency, lower energy electromagnetic waves. X-rays are high frequency and high energy electromagnetic waves.
   C) Backwards! Both are electromagnetic waves, but infrared waves have higher frequency and energy.
   D) Infrared waves are the electro waves, and x-rays are the magnetic waves.

10. The wavelength of an electromagnetic wave
    A) is a measure of its speed.
    B) increases with increasing frequency.
    C) decreases with increasing frequency.
    D) is unrelated to its frequency.

11. The frequency of a light wave
    A) is a measure of its speed.
    B) increases with increasing wavelength.
    C) decreases with increasing wavelength.
    D) is unrelated to its frequency.

12. The energy of a light wave
    A) is a measure of its speed.
    B) increases with increasing frequency.
    C) decreases with increasing frequency.
    D) is unrelated to its frequency.
13. The speed of light
   A) is fastest in a vacuum.  C) increases as the frequency increases.
   B) is 300,000 m/s.          D) increases as the wavelength increases.

14. Why don't you also need to apply "radio screen" when you apply your ultraviolet-blocking sunscreen lotion before you spend the day outdoors?
   A) Because if the lotion blocks UV rays, it will automatically block all other forms of EM radiation.
   B) Because radio waves have less energy, so they will not damage your skin the way UV rays do.
   C) Because humans have evolved to be immune from damage from everything except UV rays.
   D) Because none of the radio radiation from the sun gets down to the surface of the earth.

15. The sun emits EM radiation
   A) only in the range of visible frequencies; no energy is emitted as radio or ultraviolet.
   B) across the entire EM spectrum. It emits as much energy in the visible range as in the gamma range.
   C) across the entire spectrum, but most of the energy is emitted in the visible range of frequencies.
   D) only at very low frequencies. No energy is emitted at frequencies above the visible.

16. How are photons created?
   A) The Photon Fairy sprinkles Sparkle Dust while we sleep, and it starts to glow when the sun comes up.
   B) A vibrating electron will emit a packet of pure energy. This quantum of energy is a photon.
   C) A small piece of an electron breaks off, and carries photonic energy in the form of electric charge.
   D) The neutrons in the nucleus emit photons, which keep the protons from ejecting each other.

17. Light incident on a surface may be
   A) transmitted, if the medium is transparent.  C) absorbed, causing the medium to heat up.
   B) reflected, causing the medium to heat up.  D) either A or C.

18. When an electron absorbs the energy of a photon,
   A) any electron might absorb any amount of energy from any incoming photon. It's totally random.
   B) it spirals in to the nucleus of the atom. When the electron crashes into the nucleus, the energy released is what we have labeled electromagnetic radiation.
   C) the electron can only absorb a photon with exactly the amount of energy required to jump up to a higher energy orbit. The quantum of energy depends on the type of atom.
   D) it jumps up to a higher energy orbit. Then it immediately spits out a photon with half as much energy, taking it back down half way. At some random later time, it will spit out a second photon with the rest of the energy and drop all the way back down to its original orbit.

19. Light transmission occurs as
   A) a photon "zigs" and "zags" its way through a medium, avoiding the electrons and the nuclei.
   B) electrons absorb and reemit the same photon, like passing a hot potato.
   C) photons are absorbed and reemitted, but it's not the same photon over and over.
   D) striking photons cause electrons on the surface to vibrate and shoot photons back out the way they came.

20. Steel is opaque to visible light because
   A) visible photons are allowed through the medium, and emerge out the other side.
   B) visible photons are absorbed by the medium. Many are reemitted (reflected), and others are absorbed, but none have enough energy to actually penetrate the steel and emerge out the other side.
   C) it has no electrons, so it cannot absorb photons of any frequency. Steel is impenetrable to all forms of electromagnetic radiation.

21. The windshield of your car is
   A) opaque to all forms of electromagnetic radiation.
   B) transparent to all forms of electromagnetic waves.
   C) transparent to UV and IR, but opaque to visible light.
   D) reflective to UV, absorptive to visible, and permeable to IR frequencies.
   E) transparent to visible, but opaque to UV and IR frequencies of radiation.
22. When infrared light strikes a pane of glass,  
A) it is transmitted, and passes right through the pane.  
B) it is reflected, bouncing off straight back along its original path.  
C) it is absorbed, causing the entire glass molecule to vibrate, and the energy is dissipated as heat.  
D) it is transformed into ultraviolet light, as it gains energy from the electrons in the glass.

23. Ed Buckner says it's going to be 94° by noon. You have two clean t-shirts left, one white and one black, and you know you will have to spend some time outside.  
A) Wear the black one. People who wear black are cool!  
B) Wear the white one, since it will reflect more sunlight.  
C) Wear either; both shirts will absorb or reflect light the same way.  
D) Wear neither! That way, you can take advantage of all those natural UVA and UVB rays and get a nice, healthy tan.

24. What is an additive primary color of light?  
A) Additive primary colors of light are any three colors that are 120 apart on an artist's color wheel.  
B) Two colors that can be mixed together to make red, orange, yellow, green, blue, or violet light.  
C) Any two colors that can be mixed together to make red, blue, or yellow are additive primaries.  
D) The additive primary colors can be combined to make black light.  
E) The additive primary colors can be combined to make white light.

25. The additive primary colors of light  
A) are red, blue, and yellow.  
B) are cyan, magenta, and yellow.  
C) are red, green, and yellow.  
D) are red, green, and blue.

26. What is a subtractive primary color?  
A) A color formed by subtracting two colors from white light: white – red – blue = green.  
B) A color formed by subtracting white from red, green, or blue: red – white = magenta.  
C) A color formed by subtracting one color from white light: white – blue = yellow.  
D) Black. Black is the one and only subtractive color, because you only get it when you remove or subtract all light, of every color.

27. Two complementary colors of light  
A) combine to make white.  
B) combine to make an additive primary.  
C) combine to make black.  
D) combine to make a subtractive primary.

28. Which of the following pairs are not complementary colors of light?  
A) Red and cyan.  
B) Blue and yellow.  
C) Green and magenta.  
D) Purple and orange.

29. When mixing colors of light,  
A) red + green = yellow.  
B) white + blue = yellow.  
C) yellow + blue = green.  
D) red + blue + yellow = white.

30. When mixing colors of paint,  
A) red + green = yellow.  
B) white + blue = yellow.  
C) yellow + blue = green.  
D) red + blue + yellow = white.

31. Why don't you get the same results when you mix pigments as when you mix photons?  
A) You do. There is no difference between mixing colors of light and mixing colors of paint.  
B) Because paint pigments are designed to absorb certain frequencies of light.  
C) Because pigments are necessarily impure; if you could get pure pigments, they would mix together exactly the same way light mixes.

32. To reproduce the color photos in your textbook, the printer  
A) uses red, green, blue, and black ink.  
B) uses red, blue, yellow, and black ink.  
C) uses cyan, magenta, yellow, and black ink.  
D) uses as many different colors of ink as there are different colors in the photograph.
33. A blue light shines on a fuschia blossom (which is magenta colored). There are no other sources of light.
   A) The flower looks red, since magenta = red + blue.
   B) The flower looks yellow, since yellow + blue = white light.
   C) The flower absorbs magenta light, so any red or blue light is absorbed. It appears black.
   D) The flower absorbs magenta, which is red + blue. It would look green, since that’s all that’s left.
   E) The flower looks blue, since magenta = red + blue. Blue is reflected, but there is no red to reflect.

34. A red light shines on a blue shirt.
   A) The shirt looks magenta, since red + blue = magenta.
   B) The blue shirt absorbs blue light, so the red light is reflected. It appears red.
   C) No, the shirt reflects blue and absorbs red. It would look black, since there is no blue to reflect.
   D) Blue is blue. The shirt will look the same no matter what color light you shine on it.

35. Words in yellow ink are written on a white page. A red light shines on the paper, and there are no other sources of light.
   A) The page looks red, because it reflects red. The ink disappears because it absorbs the red light.
   B) The page looks red because it reflects red, and the ink looks yellow because it reflects yellow.
   C) The page looks yellow, and so does the ink. Both absorb the red, so you can’t tell them apart.
   D) Page and ink both appear red, so the ink seems to disappear. Both absorb the red light.
   E) Page and ink both appear red because they both reflect all the red light that strikes.

36. The sky is blue because
   A) it reflects the sea.
   B) the atmosphere absorbs all the red light, but allows blue light to pass unimpeded.
   C) blue light from the sun is scattered more by the atmosphere than red light.
   D) dust and pollution efficiently scatter low frequency light.

37. If the molecules in the sky scattered low-frequency light more than high-frequency light,
   A) the noon sky would appear blue, and so would sunsets.
   B) the noon sky would appear blue, but sunsets would be reddish–orange.
   C) the noon sky would appear reddish–orange, while sunsets would appear blue.
   D) the noon sky would appear reddish–orange, and sunsets would too.

38. Sunsets appear reddish–orange because
   A) the atmosphere, with dust and pollution, efficiently scatters the higher frequency blue light.
   B) as the sun sinks lower in the sky, it starts to emit more red photons and fewer blue ones.
   C) the atmosphere transmits all the red light, but reflects blue light right back into space.
   D) the red light is scattered more by the atmosphere than blue light.

39. Say you were a secret agent on Mars, and you stepped outside (wearing the appropriate protective clothing, of course) for a breath of fresh air (ok, to meet your rebel informant). What color is the daytime sky?
   A) Blue sky, same as on the earth. Why would it be any different on Mars?
   C) Red sky. Ok, not like razorback red, but definitely reddish. A pinkish–tan kind of color, because the atmosphere scatters red light more than blue, and there is added scattering of red light by dust particles.

40. Why are clouds white?
   A) Because the water droplets scatter visible light of all frequencies.
   B) Because the water droplets absorb all wavelengths of visible light.
   C) Because the water droplets transmit all wavelengths of visible light.
   D) Because they are pure spun sugar cotton candy! This is why snowflakes taste sweet when you catch them on your tongue! Yummy!
41. Why are storm clouds dark gray?
   A) Because the large water droplets absorb all wavelengths of visible light equally.
   B) Because the large water droplets transmit all wavelengths of visible light.
   C) Because large water droplets scatter red, green, and blue, but absorb cyan, magenta, and yellow.
   D) Because the clouds are made of wisps of gray dryer lint that escapes from vents all over the world.
      The large water droplets soak into the lint and make it look even darker. Ever see a random sock
      on the road? Those are the renegade socks that escape the dryer, up into the clouds. When they
      get too saturated, they fall like rain from the sky. What, you don't believe me? Tell me you've never
      seen a soaking wet sock all alone on the side of the road...

42. Why does water appear cyan?
   A) It doesn't. Water is clear, which means that all frequencies of light just pass right through.
   B) It isn't really cyan. Sure, tropical beaches look all turquoise, but that's just photo retouching to
      make tourists want to spend their vacation dollars. The beaches aren't really that white, either.
      The sand is really mostly gray.
   C) Water molecules happen to absorb red light very effectively. When red light is subtracted from
      white, the result is cyan. In fact, by the time you get 30m below the surface, there is virtually no
      red light left.