

**Answers to Period 2 Exercises**

**E.1** Each of the following travels, in a vacuum, at the speed of light except

a) radio waves  
b) sound waves  
c) X-rays  
d) infrared rays  
e) All of the above travel at the speed of light.

All forms of electromagnetic radiation travel at $3 \times 10^8$ meters/second in a vacuum. Sound waves travel only about one-millionth as fast as radiation waves.

E.1 = b

**E.2** Which of the following does NOT make use of wave motion?

a) A bowling ball strikes a bowling pin.  
b) A radio plays music transmitted from a radio station.  
c) A microwave oven heats a slice of pizza.  
d) Jane is reading by the light of an incandescent lamp.  
e) A tennis ball floating on the river bobs up and down as a boat passes by.

E.2 = a
E.3 Estimate the wavelength of a 1500 Hz sound wave. What would be the wavelength of an electromagnetic wave of the same frequency?

a) 0.23 m; $5 \times 10^{-6}$ m
b) 0.23 m; $2 \times 10^5$ m
c) 4.4 m; $5 \times 10^{-6}$ m
d) 4.4 m; $2 \times 10^5$ m
e) 8.8 m; $6.2 \times 10^5$ m

\[ s = fL, \text{ so } L = \frac{s}{f} \]

approximate speed of a sound wave = \[340 \text{ m/s}\]
\[ L = \frac{340 \text{ m/s}}{1,500 \text{ 1/s}} = 0.23 \text{ m} \]

speed of electromagnetic wave = \[3 \times 10^8 \text{ m/s}\]
\[ L = \frac{3 \times 10^8 \text{ m/s}}{1.5 \times 10^3 \text{ 1/s}} = 2 \times 10^5 \text{ m} \]

E.3 = b
E.4 The index of refraction of a piece of glass is 1.5. What is the speed of the photons of light in this glass?

a) \(2 \times 10^8 \text{ m/s}\)
b) \(3 \times 10^8 \text{ m/s}\)
c) \(4.5 \times 10^8 \text{ m/s}\)
d) The speed depends on the period of the electromagnetic wave.
e) The speed depends on the frequency of the wave.

index of refraction \(= n = \frac{\text{speed of light in vacuum}}{\text{speed of light in material}}\)

speed of light in glass \(= \frac{3 \times 10^8 \text{ m/s}}{1.5} = 2 \times 10^8 \text{ m/s}\)

E.4 = a

E.5 Which of the following sequences has the various regions of the electromagnetic spectrum arranged in order in increasing wavelength?

a) infrared, visual, ultraviolet, gamma ray
b) radio, infrared, ultraviolet
c) ultraviolet, visual, microwave, radio
d) X-ray, visual, microwave, infrared
e) gamma ray, X-ray, microwave, visual

E.5 = c
E.6 In a vacuum, microwaves travel _______ waves of visible light.
   a) faster than
   b) slower than
   c) at the same speed as
   
   E.6 = c

E.7 Which of the following statements about the microwaves used in microwave ovens is not correct?

   a) Microwaves are electromagnetic radiation.
   b) Microwaves are the same wavelength as waves used in radio broadcasting.
   c) Microwaves have wavelengths longer than those of visible light.
   d) Microwaves heat food by the conversion of radiant energy into thermal energy.
   e) All of the statements are correct.

   Microwaves have a shorter wavelength than radio waves but a longer wavelength than visible light.

   E.7 = c
E.8 How many photons of wavelength $6 \times 10^{-5}$ meters are required to produce electromagnetic radiation with $3.32 \times 10^{-15}$ joules of energy?

a) $1 \times 10^{-6}$ photons  
b) $1 \times 10^3$ photons  
c) $1 \times 10^6$ photons  
d) $5 \times 10^6$ photons  
e) $1 \times 10^{14}$ photons

Find the energy of one photon using $E = \frac{hc}{\lambda}$

$$E = \frac{(6.63 \times 10^{-34} \text{ J s}) \times (3 \times 10^8 \text{ m/s})}{6 \times 10^{-5} \text{ m}} = 3.32 \times 10^{-21} \text{ J per photon.}$$

Use ratios to find the number of photons needed.

$$\frac{1 \text{ photon}}{3.32 \times 10^{-15} \text{ J}} \times 3.32 \times 10^{-21} \text{ J} = 1 \times 10^6 \text{ photons}$$

$E.8 = c$
Period 2 Answers

E.1 = b
E.2 = a
E.3 = b
E.4 = a
E.5 = c
E.6 = c
E.7 = c
E.8 = c