Chapter 29

Problems & Exercises

1.

(a) 0.070 eV

(b) 14

3.

(a) 2.21×10^{34} J

(b) 2.26×10^{34}

(c) No

4.

263 nm

6.

3.69 eV

8.

0.483 eV

10.

2.25 eV

12.

(a) 264 nm

(b) Ultraviolet

14.

1.95×10^{6} m/s

16.

(a) 4.02×10^{15} /s

(b) 0.256 mW

18.

(a) $-1.90\ eV$

(b) Negative kinetic energy

(c) That the electrons would be knocked free.

20.

6.34×10^{-9} eV, 1.01×10^{-27} J

22.

2.42×10^{20} Hz

24.

$$\begin{aligned} \text{hc} &= \left(6.62607 \times 10^{-34}\ \text{J} \cdot \text{s}\right)\left(2.99792 \times 10^{8}\ \text{m/s}\right)\left(\frac{10^{9}\ \text{nm}}{1\ \text{m}}\right)\left(\frac{1.00000\ \text{eV}}{1.60218 \times 10^{-19}\ \text{J}}\right) \\ &= 1239.84\ \text{eV} \cdot \text{nm} \\ &\approx 1240\ \text{eV} \cdot \text{nm} \end{aligned}$$

26.

(a) 0.0829 eV

(b) 121

(c) 1.24 MeV

(d) 1.24×10^{5}

28.

(a) 25.0×10^{3} eV

(b) 6.04×10^{18} Hz

30.

(a) 2.69

(b) 0.371

32.

(a) 1.25×10^{13} photons/s

(b) 997 km

34.

8.33×10^{13} photons/s

36.

181 km

38.

(a) 1.66×10^{-32} kg $\cdot$ m/s

(b) The wavelength of microwave photons is large, so the momentum they carry is very small.

40.

(a) 13.3 m

(b) 9.38×10^{-2} eV

42.

(a) 2.65×10^{-28} kg · m/s

(b) 291 m/s

(c) electron 3.86×10^{-26} J, photon 7.96×10^{-20} J, ratio 2.06×10^{6}

44.

(a) 1.32×10^{-13} m

(b) 9.39 MeV

(c) 4.70×10^{-2} MeV

46.

$E = \gamma mc^2 \mathrm{mc}^2$ and $P = \gamma mu$, so

$\frac{E}{P} = \frac{\mathrm{mc}^2}{\mathrm{mu}} = \frac{\mathrm{c}^2}{\mathrm{u}}$.

As the mass of particle approaches zero, its velocity u will approach c, so that the ratio of energy to momentum in this limit is

$lim_{m \to 0} \frac{E}{P} = \frac{c^2}{c} = c$

which is consistent with the equation for photon energy.

48.

(a) 3.00×10^{6} W

(b) Headlights are way too bright.

(c) Force is too large.

49.

7.28×10^{-4} m

51.

6.62×10^{7} m/s

53.

1.32×10^{-13} m

55.

(a) 6.62×10^{7} m/s

(b) 22.9 MeV

57.

15.1 keV

59.

(a) 5.29 fm

(b) 4.70×10^{-12} J

(c) 29.4 MV

61.

(a) 7.28×10^{12} m/s

(b) This is thousands of times the speed of light (an impossibility).

(c) The assumption that the electron is non-relativistic is unreasonable at this wavelength.

62.

(a) 57.9 m/s

(b) 9.55×10^{-9} eV

(c) From Table 29.1, we see that typical molecular binding energies range from about 1eV to 10 eV, therefore the result in part (b) is approximately 9 orders of magnitude smaller than typical molecular binding energies.

64.

29 nm,

290 times greater

66.

1.10×10^{-13} eV

68.

3.3×10^{-22} s

70.

2.66×10^{-46} kg

72.

0.395 nm

74.

(a) 1.3×10^{-19} J

(b) 2.1×10^{23}

(c) 1.4×10^{2} s

76.

(a) 3.35×10^5 J

(b) 1.12×10^{-3} kg $\cdot$ m/s

(c) 1.12×10^{-3} m/s

(d) 6.23×10^{-7} J

78.

(a) 1.06×10^3

(b) 5.33×10^{-16} kg $\cdot$ m/s

(c) 1.24×10^{-18} m

80.

(a) 1.62×10^3 m/s

(b) 4.42×10^{-19} J for photon, 1.19×10^{-24} J for electron, photon energy is 3.71×10^5 times greater

(c) The light is easier to make because 450-nm light is blue light and therefore easy to make. Creating electrons with 7.43 μeV of energy would not be difficult, but would require a vacuum.

81.

(a) 2.30×10^{-6} m

(b) 3.20×10^{-12} m

83.

3.69×10^{-4} C

85.

(a) 2.00 kJ

(b) 1.33×10^{-5} kg $\cdot$ m/s

(c) 1.33×10^{-5} N

(d) yes

87.

(a) $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{550 \times 10^{-9}}$kg m/s $= 1.21$ kg $\times 10^{-27}$ m/s

(b) $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{650 \times 10^{-9}}$kg m/s $= 1.02 \times 10^{-27}$kg m/s

(c) Yes, conservation of momentum applies.

(d) The photon with the longer wavelength has less momentum than the one with the shorter wavelength.