Chapter 34 Problem 20 [†]

Given
$h = 6.63 \times 10^{-34}\ J \cdot s$
$1\ eV = 1.6 \times 10^{-19}\ J$

Solution
a) Find the energy in electron volts for a 1.0 MHz radio photon.

The relationship between energy and frequency is

$$E = h \cdot f \tag{1}$$

$$E = (6.63 \times 10^{-34}\ J \cdot s) \cdot (1.0 \times 10^{6}\ Hz)$$

$$E = 6.63 \times 10^{-28}\ J$$

Converting to electron volts gives

$$E = 6.63 \times 10^{-28}\ J \left(\frac{1\ eV}{1.6 \times 10^{-19}\ J} \right) = 4.14 \times 10^{-9}\ eV$$

b) Find the energy in electron volts for a $5.0 \times 10^{14}\ Hz$ optical photon.

Using equation (1) with the new frequency gives

$$E = (6.63 \times 10^{-34}\ J \cdot s) \cdot (5.0 \times 10^{14}\ Hz)$$

$$E = 3.32 \times 10^{-19}\ J$$

Converting to electron volts gives

$$E = 3.32 \times 10^{-19}\ J \left(\frac{1\ eV}{1.6 \times 10^{-19}\ J} \right) = 2.07\ eV$$

c) Find the energy in electron volts for a $3.0 \times 10^{18}\ Hz$ x-ray photon.

Using equation (1) with the new frequency gives

$$E = (6.63 \times 10^{-34}\ J \cdot s) \cdot (3.0 \times 10^{18}\ Hz)$$

$$E = 1.99 \times 10^{-15}\ J$$

Converting to electron volts gives

$$E = 1.99 \times 10^{-15}\ J \left(\frac{1\ eV}{1.6 \times 10^{-19}\ J} \right) = 1.24 \times 10^{4}\ eV$$

[†]Problem from Essential University Physics, Wolfson