Example 1.1 A metal has a workfunction of 4.3 V. What is the minimum photon energy in Joule to emit an electron from this metal through the photo-electric effect? What are the photon frequency in Terahertz and the photon wavelength in micrometer? What is the corresponding photon momentum? What is the velocity of a free electron with the same momentum?

Solution The minumum photon energy, E_{ph}, equals the workfunction, Φ_M, in units of electron volt or 4.3 eV. This also equals

$$E_{ph} = q\Phi_M = 1.6\times10^{-19}\times4.3 = 6.89\times10^{-19} \text{ Joule}$$

The corresponding photon frequency is:

$$n = \frac{E_{ph}}{h} = \frac{6.89\times10^{-19}}{6.626\times10^{-34}} = 1040 \text{ THz}$$

The corresponding wavelength equals:

$$l = \frac{hc}{E_{ph}} = \frac{6.626\times10^{-34}\times3\times10^{8}}{6.89\times10^{-19}} = \frac{1.24 \text{ } m\text{m}}{E_{ph} \text{ (eV)}} = 0.288 \text{ } m\text{m}$$

The photon momentum, p, is:

$$p = \frac{h}{l} = \frac{6.626\times10^{-34}}{0.288\times10^{-6}} = 2.297\times10^{-27} \frac{\text{kg m}}{\text{s}}$$

And the velocity, v, of a free electron with the same momentum equals

$$v = \frac{p}{m_0} = \frac{2.297\times10^{-27}}{9.11\times10^{-31}} = 2522 \text{ m/s}$$

Where m_0 is the free electron mass.