Physics II
1st Practice, solution

1. An electron has a kinetic energy of 1.5 eV. a) What is its velocity? b) What is its momentum? c) What is the wavelength of the associated de Broglie wave?

   - $m_e = 9.1 \cdot 10^{-31} kg$, $E_m = 1.5eV = 2.4 \cdot 10^{-19} J$, $h = 6.626 \cdot 10^{-34} Js$ Planck constant
   - $v = \sqrt{\frac{2E_m}{m}} = 7.26 \cdot 10^5 \frac{m}{s}$
   - $\lambda = \frac{h}{mv} = 1 \cdot 10^{-9} m$
   - $p = \frac{h}{\lambda} = 6.626 \cdot 10^{-25} kg \frac{m}{s}$

2. A metal surface is illuminated with light of wavelength $1.5 \cdot 10^7 m$. What is the velocity of the emitted electrons if the photoelectric effect starts at light with a wavelength of $2.67 \cdot 10^{-7} m$? ($m_e = 9.1 \cdot 10^{-31} kg$).

   - $\lambda = 1.5 \cdot 10^{-7} m$, $\lambda_{border} = 2.67 \cdot 10^{-7} m$, $c = 3 \cdot 10^8 \frac{m}{s}$ c : speed of light

$$v = \sqrt{\frac{\left(\frac{1}{\lambda} - \frac{1}{\lambda_{border}}\right)}{m}} = 1.12 \cdot 10^6 \frac{m}{s}$$

3. A photon ejects an electron with a maximum kinetic energy of $0.54eV$ from a metal for which the work function is $3.74eV$. a) What is the energy of the photon in electronvolts? b) What is the wavelength of the applied ultraviolet radiation?

   - $E_m = 0.54eV = 0.86 \cdot 10^{-19} J$, $W_{out} = 3.74eV = 5.98 \cdot 10^{-19} J$
   - $E_{photon} = h \cdot f = \frac{1}{2} m v^2 + W_{out} = 0.54eV + 3.74eV = 6.848q \cdot 10^{-19} J$
   - $\lambda = \frac{hc}{E_{photon}} = 2.90 \cdot 10^{-7} m$

4. In a Compton scattering experiment, X-rays with a wavelength of 0.124 nm are used. ($m_e = 9.1 \cdot 10^{-31} kg$) a) At what scattering angle does the wavelength of the radiation increase by 1%? b) At what angle does the wavelength become 0.05% larger?

   - $\lambda = 0.124nm = 0.124 \cdot 10^{-9} m$, $m_e = 9.1 \cdot 10^{-31} kg$
   - φ_1, $\Delta\lambda = +1\%$
   - φ_2, $\Delta\lambda = +0.005\%$
   - $c = 3 \cdot 10^8 \frac{m}{s}$, speed of light

- $h = 6.626 \cdot 10^{-34} Js$, Planck constant

$$a)\Delta\lambda = \frac{h}{m_e c}\left(1 - \cos\varphi\right), \qquad \lambda_c = \frac{h}{m_e c}.$$

$$\Delta\lambda = 0.124 \cdot 10^{-9} m \cdot 0.01 = 1.24 \cdot 10^{12} m$$
$$\cos\varphi_1 = 1 - \frac{\Delta\lambda m_e c}{h} = 0.4891$$
$$\varphi_1 = 60.7184^\circ$$

$$b)\Delta\lambda = \lambda \cdot 0.05\% = 6.2 \cdot 10^{-14} m$$
$$\cos\varphi_1 = 1 - \frac{\Delta\lambda m_e c}{h} = 0.974455$$
$$\varphi_2 = 12.978^\circ$$