4. The work function of tungsten is 4.53 eV. If ultraviolet light of wavelength 150 nm is incident on this surface, what is the speed of the emitted electron? (5 points)

$$K_{max} = hf - \phi = \frac{1}{2} m_e v^2$$

$$\Rightarrow v = \sqrt{\frac{2(hf-\phi)}{m_e}} = \sqrt{\frac{2(6.626\times10^{-34}\times\frac{3\times10^{8}}{150\times10^{-9}} - 4.53\times1.6\times10^{-19}}{9.1\times10^{-31}}}$$

$$\boxed{v = 1.15\times10^{6}\ m/s}$$

5. X-rays of energy 200 keV are incident on a target and undergo Compton scattering. Calculate

(a) the energy of the X-rays scattered at an angle of 60^0 to the incident direction. (4 points)

$$E = 200\ keV \Rightarrow \lambda = \frac{hc}{E} = \frac{12400\ eV.\mathring{A}}{200\times10^{3}\ eV} = 0.062\mathring{A}$$

$$\lambda' = \lambda + \lambda_c(1-\cos\theta)$$

$$= 0.062\mathring{A} + 0.0243\mathring{A}(1-\cos60^{\circ}) = 0.07415\mathring{A}$$

$$E' = \frac{hc}{\lambda'} = \frac{12400\ eV\mathring{A}}{0.07415\mathring{A}} = \boxed{167\ keV}$$

(b) the kinetic energy of the recoiling electron. (2 points)

$$E_p = E_p' + K_e \Rightarrow K_e = E_p - E_p' = (200-167)keV$$

$$\boxed{K_e = 33\ keV}$$

(c) the angle of the recoiling electron. (4 points)

Conservation of linear momentum

$$p = p'\cos\theta + p_e\cos\phi$$

$$0 = p_e\sin\phi - p'\sin\theta \Rightarrow \tan\phi = \frac{p'\sin\theta}{p - p'\cos\theta}$$

$$\tan\phi = \frac{\frac{\sin\theta}{\lambda'}}{\frac{1}{\lambda} - \frac{\cos\theta}{\lambda'}} = \frac{11.68}{9.39} = 1.24 \Rightarrow \boxed{\phi = 51^{\circ}}$$