

Homework Solution Chapter 5

$$5-4. \quad \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}} = \frac{hc}{\sqrt{2mc^2E_k}} \quad (\text{from Equation 5-2})$$

$$(a) \text{ For an electron: } \lambda = \frac{1240 \text{ eV}\cdot\text{nm}}{[(2)(0.511 \times 10^6 \text{ eV})(4.5 \times 10^3 \text{ eV})]^{1/2}} = 0.0183 \text{ nm}$$

$$(b) \text{ For a proton: } \lambda = \frac{1240 \text{ eV}\cdot\text{nm}}{[(2)(938.3 \times 10^6 \text{ eV})(4.5 \times 10^3 \text{ eV})]^{1/2}} = 4.27 \times 10^{-4} \text{ nm}$$

$$(c) \text{ For an alpha particle: } \lambda = \frac{1240 \text{ eV}\cdot\text{nm}}{[(2)(3.728 \times 10^9 \text{ eV})(4.5 \times 10^3 \text{ eV})]^{1/2}} = 2.14 \times 10^{-4} \text{ nm}$$

$$5-7. \quad (a) \quad \text{If there is a node at each wall, then } n(\lambda/2) = L \text{ where } n = 1, 2, 3, \dots \text{ or } \lambda = 2L/n.$$

$$(b) \quad p = h/\lambda = hm/2L \quad E = p^2/2m = (hn/2L)^2/2m = h^2n^2/8mL^2$$

$$E_n = \frac{(hc)^2 n^2}{8mc^2 L^2}$$

$$\text{For } n = 1: E_1 = \frac{(1240 \text{ eV}\cdot\text{nm})^2 (1)^2}{8 (938 \times 10^6 \text{ eV})(0.01 \text{ nm})^2} = 2.05 \text{ eV}$$

$$\text{For } n = 2: E_2 = 2.05 \text{ eV}(2)^2 = 8.20 \text{ eV}$$

5-10. $n\lambda = D \sin \phi$ (Equation 5-5)

$$\sin \phi = \frac{n\lambda}{D} = \frac{n}{D} \frac{hc}{\sqrt{2mc^2 E_k}} \quad (\text{see Problem 5-6})$$

$$= \frac{1}{0.215 \text{ nm}} \cdot \frac{1240 \text{ eV} \cdot \text{nm}}{[2(5.11 \times 10^5 \text{ eV})]^{1/2} \sqrt{E_k}} = \frac{(5.705 \text{ eV})^{1/2}}{\sqrt{E_k}}$$

(a) $\sin \phi = \frac{(5.705 \text{ eV})^{1/2}}{\sqrt{75 \text{ eV}}} = 0.659 \quad \phi = \sin^{-1}(0.659) = 41.2^\circ$

(b) $\sin \phi = \frac{(5.705 \text{ eV})^{1/2}}{\sqrt{100 \text{ eV}}} = 0.570 \quad \phi = \sin^{-1}(0.570) = 34.8^\circ$

5-6. $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}} = \frac{hc}{\sqrt{2mc^2 E_k}} = \frac{1240 \text{ eV} \cdot \text{nm}}{[2(939.57 \times 10^6 \text{ eV})(0.02 \text{ eV})]^{1/2}} = 0.202 \text{ nm}$

5-12. (a) $n\lambda = D \sin \phi \quad \therefore D = \frac{n\lambda}{\sin \phi} = \frac{nhc}{\sin \phi \sqrt{2mc^2 E_k}}$

$$= \frac{(1)(1240 \text{ eV} \cdot \text{nm})}{(\sin 55.6^\circ)[2(5.11 \times 10^5 \text{ eV})(50 \text{ eV})]^{1/2}} = 0.210 \text{ nm}$$

(b) $\sin \phi = \frac{n\lambda}{D} = \frac{(1)(1240 \text{ eV} \cdot \text{nm})}{(0.210 \text{ nm})[2(5.11 \times 10^5 \text{ eV})(100 \text{ eV})]^{1/2}}$

$$= 0.584 \quad \phi = \sin^{-1}(0.584) = 35.7^\circ$$