Krane Chapter 4

Problem 2

(a)

$$K = 3kT/2 = 1.5 \times 8.6174 \times 10^{-5}\,\text{eV/K} \times 293\,\text{K} = 0.0379\,\text{eV}$$

(b) As K <<<mc^2

$$p = \sqrt{2mK} = \sqrt{2mc^2K}/c = \sqrt{2 \times 939.6 \times 10^6\,\text{eV} \times 0.0379\,\text{eV}}/c = 8.44 \times 10^3\ \text{eV/c}$$

$$\lambda = hc/pc = 1240/(8.44 \times 10^3) = 0.15nm$$

Problem 4

(a) The wavelength should be roughly the size of (or smaller than) the object under study. $\lambda \le 0.1\mu m = 100nm.$

(b) $p = hc/\lambda c = 1240/100c = 12.4$ eV/c

$K = p^2/2m = p^2c^2/2mc^2 = (2.4)^2/(2 \times 0.511 \times 10^6 eV) = 1.5 \times 10^{-4}$ eV

$V = 1.5 \times 10^{-4}$ volts.

This value would be the lower limit on the accelerating voltage. For much smaller accelerating voltage, the wavelength is too large and details would be lost due to diffraction.

Problem 7

(a) $p = \sqrt{2mK} = \sqrt{2mc^2K}/c = \sqrt{2 \times 3727 \times 10^6\,\text{eV} \times 0.020\,\text{eV}}/c = 1.22 \times 10^4$ eV/c

$\lambda = hc/pc = 1240/(1.22 \times 10^4) = 0.10nm$

(b) The fringes are sepaated by about 9000nm

$\lambda = d\Delta y/D = (8 \times 10^{-6})(9000 \times 10^{-9})/0.64 = 0.11$ nm.

Problem 10

$\lambda = d\sin(\phi)/2 = 0.215 \times \sin(55\,\text{deg})/2 = 0.0881\,\text{nm}$

$cp = hc/\lambda = 1240/0.0881 = 1.408 \times 10^4$ eV

$K = p^2c^2/2mc^2 = (1.408 \times 10^4)^2/(2 \times 0.511 \times 10^6 eV) = 194$ eV

$V = 194$ volts.

Problem 18

(a) $\Delta E \sim \hbar/\Delta t = 6.58 \times 10^{-16}\,\text{eV-s}/1.2 \times 10^{-9}\,\text{s} = 5.5 \times 10^{-7}$ eV

Problem 26

(a) $\Delta x = \mathbf{v}\Delta t = 330 \times 2 = 660\,\text{m}$

(b) $\lambda = \mathbf{v}/\nu = 330/1000 = 0.33$ mm

(c) $\Delta\lambda \sim \lambda^2/(2\pi\Delta x) = (0.33)^2/4150 = 0.026mm$

(d) $\Delta\omega \sim 1/\Delta t \qquad \Delta\nu \sim 1/(2\pi\Delta t) = 1/(2\pi \times 2.0) = 0.080 Hz$