#6

4.46

a small retarding voltage is needed to prevent very low energy electrons from reaching the collector plate

if $\Delta V_{grid-collector}$ were not there all electrons would reach the collector

5.11

b) $T = \frac{p^2}{2m}$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mT}} = \frac{hc}{\sqrt{2mc^2 T}}$$ ✓

a) $E^2 = p^2c^2 + m^2c^4$

$E = T + mc^2$

$p^2c^2 = E^2 - m^2c^4$

$= (T + mc^2)^2 - m^2c^4$

$= T^2 + 2Tmc^2 + m^2c^4 - m^2c^4$

$$p = \left(T^2 + \frac{2Tmc^2}{c}\right)^{1/2}$$

$$\lambda = \frac{h}{p} = \frac{hc}{\left(T^2 + 2Tmc^2\right)^{1/2}}$$ ✓

5.12

need to use relativity

$$p^2 = \frac{E^2 - m^2c^4}{c^2}$$

$$p = \frac{\left(50^2 - (0.511)^2\right)^{1/2}}{c} \approx 50 \text{ GeV/c}$$

$$\lambda = \frac{h}{p} = \frac{hc}{p(\text{GeV})} = \frac{1240 \text{ eV nm}}{50 \times 10^9}$$

$$= \boxed{2.48 \times 10^{-17} \text{ m}}$$

$$\text{fraction} = \frac{2.48 \times 10^{-17}}{2 \times 10^{-15}} = \boxed{0.012}$$

$$E = T + mc^2$$

(5.21) 2 keV e^-

$$p = \frac{\left(E^2 - m^2c^4\right)^{1/2}}{c} = \left(513^2 - \frac{511^2}{c}\right)^{1/2}$$

$$= .45 \text{ keV}/c$$

$$\lambda = \frac{h}{p} = \frac{hc}{pc} = \frac{1240 \text{ eV nm}}{45 \times 10^3} = 2.75 \times 10^{-2} \text{ nm}$$

now $2\theta = \tan^{-1}\frac{r}{L}$

$$\Rightarrow \theta_1 = \frac{1}{2}\tan^{-1}\frac{2.1}{35} = 1.717^\circ$$

$$\theta_2 = \frac{1}{2}\tan^{-1}\frac{2.3}{35} = 1.880^\circ$$

$$\theta_3 = \frac{1}{2}\tan^{-1}\frac{3.2}{35} = 2.612^\circ$$

Bragg $\lambda = 2d\sin\theta \Rightarrow d = \frac{\lambda}{2\sin\theta}$

$$\Rightarrow d_1 = \frac{2.75\times10^{-2}}{2\sin 1.717^\circ} = \boxed{0.457 \text{ nm}}$$

$$d_2 = \frac{2.75\times10^{-2}}{2\sin 1.880^\circ} = \boxed{0.412 \text{ nm}}$$

$$d_3 = \frac{2.75\times10^{-2}}{2\sin 2.612} = \boxed{0.301 \text{ nm}}$$

5.27

$$\psi = \psi_1 + \psi_2$$

$$= 0.003 \sin(6x - 300t) + 0.003 \sin(7x - 250t)$$

$$\sin a + \sin b = 2 \sin \frac{a+b}{2} \cos \frac{a-b}{2}$$

a. $$\psi = 0.003 \left\{ \sin(6.5x - 275t) \cos(-0.5x - 25t) \right.$$

b. $$v_{ph} = \frac{\omega_{avg}}{k_{avg}} = \frac{275}{6.5} = 42.3 \text{ m/s}$$

$$v_{gr} = \frac{\Delta\omega}{\Delta k} = \frac{25}{0.5} = 50 \text{ m/s}$$

c. 0's at $\frac{\Delta k x_1}{2} = \frac{\pi}{2} \Rightarrow \Delta x = \frac{2\pi}{\Delta k} = 2\pi$ for $\Delta k = 7 - 6$ $(x_2 - x_1)$

d. $$\Delta x \, \Delta k = 2\pi$$