Useful constants and equations

$e = 1.602 \times 10^{-19}\ C$ $\quad \frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9\ N\,m^2/C^2$ $\quad \frac{e^2}{4\pi\epsilon_0} = 1.44\ eV\,nm$

$c = 3.00 \times 10^8\ m/s$ $\quad h = 6.626 \times 10^{-34}\ J\,s = 4.136 \times 10^{-15}\ eV\,s$ $\quad \hbar = \frac{h}{2\pi}$

$hc = 1240\ eV\,nm$ $\quad \hbar c = 197.3\ eV\,nm$ $\quad 1\ eV = 1.602 \times 10^{-19}\ J$ $\quad R_\infty = 1.097 \times 10^7\ m^{-1}$

$m_e = 9.11 \times 10^{-31}\ kg = 511\ keV/c^2$ $\quad a_0 = 0.0529\ nm$ $\quad E_0 = -13.6\ eV$

$\sigma = 5.670 \times 10^{-8}\ \mathrm{W/m^2K^4}$

Electromagnetic Waves:

$c = \lambda\nu = \omega/k \qquad k = 2\pi/\lambda$

$E = \hbar\omega = pc = hc/\lambda$

$D \sin\theta = n\lambda$ (Bragg condition)

for plane waves:

$\vec{E} = \vec{E}_0 \cos(\vec{k}\cdot\vec{r} - \omega t)$

$\vec{B} = \vec{B}_0 \cos(\vec{k}\cdot\vec{r} - \omega t)$

$\vec{B} = \frac{1}{\omega}\,\vec{k}\times\vec{E}$ and $E_0 = c\,B_0$

Particle Waves:

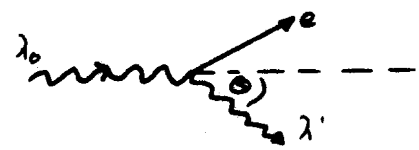
$p = h/\lambda = \hbar k$

$E = h\nu = \hbar\omega = \sqrt{(pc)^2 + (mc^2)^2}$

$v_{phase} = \omega/k$

$v_{group} = d\omega/dk|_{k_0} = [v_{phase} + k\ dv_{phase}/dk]_{k_0}$

Compton Scattering:



$\lambda' = \lambda_0 + \frac{h}{mc}(1 - \cos\theta)$

Blackbody radiation: $\quad R = \sigma\,T^4 \qquad \lambda_{\max}T = 2.898 \times 10^{-3}\ \mathrm{mK}$

Photoelectric effect: $\quad E = h\nu = K_e + \Phi = e\,V_s + \Phi$

Heisenberg: $\quad \Delta p_x\,\Delta x \sim \hbar \qquad \Delta E\,\Delta t \sim \hbar$

Schrödinger Equation:

$$\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + U\,\Psi = i\hbar\frac{\partial\Psi}{\partial t} \qquad \text{for } \Psi = \psi(x)\,e^{-i\frac{E}{\hbar}t} \text{ we obtain } \quad -\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + U(x)\,\psi(x) = E\psi(x)$$

$P\,dx = |\psi|^2\,dx$ and $|\psi|^2 = \psi\,\psi^*$

Infinite square well: $\quad \psi_n(x) = \sqrt{\frac{2}{L}}\sin\left(\frac{n\pi}{L}x\right) \qquad E_n = \frac{\pi^2\hbar^2}{2mL^2}n^2 \qquad n = 1, 2, 3, 4$

Harmonic Oscillator: $\quad E_n = \left(n + \frac{1}{2}\right)\hbar\omega \qquad n = 0, 1, 2, 3$

Operators: $\quad [p_x] = \frac{\hbar}{i}\frac{\partial}{\partial x} \qquad [E] = i\hbar\frac{\partial}{\partial t} \qquad [KE] = \frac{[p_x^2]}{2m} = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$

Reflection coefficient: $R = \left|\frac{B}{A}\right|^2$ for wave $\psi_1 = Ae^{ikx} + Be^{-ikx}$ incident from left on potential step

with: $R + T = 1$ where T is transmission coefficient

Hydrogen Atom: $\quad E = \frac{-13.6\ eV}{n^2}$ with $n = 1, 2, 3, \cdots \qquad l < n \qquad -l \le m \le +l$

Generalized Balmer Formula: $\quad \frac{1}{\lambda} = R_\infty\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

Rutherford Scattering: $\quad N(\theta) = k\left(\frac{z\cdot Z}{2K_e}\right)^2\left(\frac{e^2}{4\pi\epsilon_0}\right)^2\frac{1}{\sin^4(\theta/2)}$ with $k(=\text{const}) \propto nt$

θ = scattering angle $\quad n$ = particle density and t = foil thickness