Useful Information

Constants

$c = 2.998 \times 10^8$ m/s
$h = 6.626 \times 10^{-34}$ J.s.
$k = 1.381 \times 10^{-23}$ J/K
$e = 1.602 \times 10^{-19}$ C
$a_o = 5.292 \times 10^{-11}$ m
$G = 6.674 \times 10^{-11}$ N.m^2/kg^2
$m_e = 9.109 \times 10^{-31}$ kg $= 0.511 \frac{MeV}{c^2}$
$m_N = 1.675 \times 10^{-27}$ kg $= 939.6 \frac{MeV}{c^2}$
$m_p = 1.673 \times 10^{-27}$ kg $= 938.3 \frac{MeV}{c^2}$
$m_{\pi^o} = 135 \frac{MeV}{c^2}$
$\sigma = 5.67 \times 10^{-8} \frac{W}{m^2K^4}$.

Special Relativity

- $$\gamma = \frac{1}{\sqrt{1-\beta^2}}$$
- $$\beta = \frac{v}{c}$$
- Time Dilation $$\Delta t = \gamma \Delta t_0$$
- Length Contraction $$L = \frac{L_0}{\gamma}$$
- Lorentz transformation for $S \to S'$
$$\begin{aligned} x' &= \gamma(x - vt) \\ y' &= y \\ z' &= z \\ t' &= \gamma(t - \frac{v}{c^2}x) \end{aligned}$$
- Lorentz velocity transformation for $S \to S'$
$$\begin{aligned} u'_x &= \frac{u_x - v}{1 - \frac{v}{c^2}u_x} \\ u'_y &= \frac{u_y}{\gamma(1 - \frac{v}{c^2}u_x)} \\ u'_z &= \frac{u_z}{\gamma(1 - \frac{v}{c^2}u_x)} \end{aligned}$$
- Doppler Effect for light $$f = f_0\sqrt{\frac{1 \pm \beta}{1 \mp \beta}}$$
- relativistic momentum $$\bar{p} = m\bar{v}\gamma$$
- relativistic energy $$E = K + mc^2 = \gamma mc^2$$
- $$E^2 = (pc)^2 + (mc^2)^2$$
- Schwarzchild radius $$R_s = \frac{2Gm}{c^2}$$

Particles and Waves

- blackbody radiation $$P = \sigma A T^4$$
- $$\lambda_{\text{max}} T = 2.898 \times 10^{-3} \text{mK}$$
- $$R(\lambda) = \frac{2\pi hc^2}{\lambda^5} \frac{1}{e^{hc/\lambda kT} - 1}$$
- photoelectric effect $$eV_s = hf - \Phi$$
- Compton effect $$\Delta\lambda = \frac{h}{mc}(1 - \cos\phi)$$
- $$\theta = \tan^{-1}\left[\frac{\sin\phi}{\frac{\lambda'}{\lambda} - \cos\phi}\right]$$
- photons $$E = hf, \;\; p = \frac{h}{\lambda}$$
- matter waves $$\lambda = \frac{h}{p}$$
- $$\Delta x \Delta p_x \geq \frac{\hbar}{2}$$
- $$\Delta E \Delta t \geq \frac{\hbar}{2}$$

Interference and Diffraction

- Two-slit experiment $$\Delta y = \frac{\lambda D}{d}\text{(fringe spacing)}$$
- Bragg condition $$\Gamma = n\lambda = d\sin\phi$$
- Single-slit diffraction $$\sin\phi = \frac{\lambda}{d}\text{(first min)}$$

Bohr Model

- Radius $$r_n = a_0 n^2$$
- Energy $$E_n = \frac{-13.6eV}{n^2}$$

Quantum Mechanics

- 1-D TISE
$$\frac{-\hbar^2}{2m}\frac{d^2\Psi(x)}{dx^2} + U\Psi(x) = E\Psi(x)$$
- $$k = \frac{\sqrt{2m(E-U)}}{\hbar} = \frac{2\pi}{\lambda}$$
- Probability to find particle between x_1 and x_2
$$P = \int_{x_1}^{x_2} |\Psi(x)|^2 dx$$
- expectation value of x
$$x_{av} =< x >= \int_{-\infty}^{\infty} |\Psi(x)|^2 x dx$$
- Infinite Square Well
$$\Psi_n(x) = \sqrt{\frac{2}{L}} \ \sin\frac{n\pi x}{L} \quad n = 1, 2, 3....$$
- $$E_n = \frac{n^2\hbar^2\pi^2}{2mL^2}$$
- $$\lambda_n = \frac{2L}{n}$$
- 1-D step $$R = (\frac{k_I - k_{II}}{k_I + k_{II}})^2$$
- Potential Barrier $T \sim e^{-2\alpha L}$
- $$\alpha = \frac{\sqrt{2m(V_o - E)}}{\hbar}$$
- Hydrogen Atom $$E_n = \frac{-13.6eV}{n^2}$$
- $$\Psi_{100} = \frac{1}{\sqrt{\pi}a_0^{3/2}} \ e^{-r/a_0}$$
- $$P(r)dr = \frac{4r^2}{a_0^3} \ e^{-2r/a_0} dr \quad \text{in ground state}$$
- Harmonic Oscillator
$$E_n = (n + \frac{1}{2})\hbar\sqrt{\frac{k}{m}} \quad n = 0, 1, 2...$$
- $$\Psi(x) = \left(\frac{\sqrt{km}}{\hbar\pi}\right)^{\frac{1}{4}} e^{-\frac{\sqrt{km}}{2\hbar}x^2} \quad \text{in ground state}$$