1 Chapter 1

- Energy E of a photon of light in eV:

$$\lambda = \frac{1.24eV}{E}$$

- Distance D between adjacent planes in cubic lattices:

$$D = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

- Angle between 2 Miller index directions A and B:

$$\cos\theta = \frac{A \bullet B}{|A||B|}$$

2 Chapter 2

- Planck relationship:

$$E = hv = (\frac{h}{2\pi})(2\pi v) = \hbar\omega$$

- Classical energy of a particle:

$$\frac{1}{2}mv^2 = \frac{1}{2}\frac{m^2v^2}{m} = \frac{\rho^2}{2m}$$

- De Broglie:

$$\lambda = \frac{h}{\rho} = \frac{h}{mv} \Rightarrow \rho = \frac{h}{\lambda} = \frac{h}{2\pi}\frac{2\pi}{\lambda} = \hbar k$$

- Momentum or energy in terms of k can be derived by combining De Broglie with the classical energy of a particle:

$$E = \hbar\omega = \frac{\rho^2}{2m} = \frac{\hbar^2k^2}{2m}$$

- Rydberg Constant:

$$R = 109,678cm^{-1}$$

- Lyman:

$$v = cR(\frac{1}{1^2} - \frac{1}{n^2}), n = 2, 3, 4, ...$$

- Balmer:

$$v = cR(\frac{1}{2^2} - \frac{1}{n^2}), n = 3, 4, 5...$$

- Paschen:
$$v = cR(\frac{1}{3^2} - \frac{1}{n^2}), n = 4, 5, 6, ...$$
- Postulate for Bohr:
$$\rho_0 = n\hbar, n = 1, 2, 3, 4, ...$$
- Finding radial forces on orbiting electron:
(Electrical force toward nucleus) = (Equivalent force in terms of radial acceleration)
$$-\frac{q^2}{kr^2} = -\frac{mv^2}{r}$$
$$\rho_0 = n\hbar = mvr \Rightarrow mv^2 = \frac{m^2v^2}{m} = \frac{n^2\hbar^2}{mr^2}$$
$$\frac{q^2}{kr^2} = \frac{1}{mr}\frac{n^2\hbar^2}{r^2} \Rightarrow r_n = \frac{kn^2\hbar^2}{mq^2}$$
$|r_n$ is the radius of the nth orbit
$$-\frac{q^2}{kr^2} = -\frac{mv^2}{r} \Rightarrow \frac{n\hbar}{rm} = \frac{q^2}{kn\hbar}$$
by subbing r from above.

$\Rightarrow$ K.E. of e^- =
$$\frac{1}{2}mv^2 = \frac{mq^4}{2k^2n^2\hbar^2}$$

P.E. of e^- =
$$-\frac{q^2}{kr_n} = -\frac{mq^4}{k^2n^2\hbar^2}$$
by subbing r

Total Energy of e^- =
$$E_n = KE = PE = -\frac{mq^4}{2k^2n^2\hbar^2} = -KE$$
- Energy difference between orbits:
$$E_{n2} - E_{n1} = \frac{mq^4}{2k^2\hbar^2}(\frac{1}{n_1^2} - \frac{1}{n_2^2})$$
- Frequency of light given by a transition between orbits:
$$V_{21} = \left[\frac{mq^4}{2k^2\hbar^2h}\right](\frac{1}{n_1^2} - \frac{1}{n_2^2})$$

- Heisenberg uncertainty principle:
  $(\Delta x)(\Delta \rho_x) \geq \frac{\hbar}{2}$
  $(\Delta E)(\Delta t) \geq \frac{\hbar}{2}$

2.1 Quantum Mechanics

Classical Variable	$\rightarrow$	Quantum Operator
x	$\rightarrow$	x
$f(x)$	$\rightarrow$	$f(x)$
$\rho(x)$	$\rightarrow$	$\frac{\hbar}{j}\frac{\partial}{\partial x}$
E	$\rightarrow$	$-\frac{\hbar}{j}\frac{\partial}{\partial t}$

- Normalization of the probability density (the wave function is the probability density):

$$\int_{-\infty}^{\infty} \Psi^* \Psi dxdydz = 1 \tag{1}$$

- Time averaged expectation of the particle state

$$< Q >= \int_{-\infty}^{\infty} \Psi^* Q_{op} \Psi dxdydz \tag{2}$$

- Classical energy of a partical:

$$KE + PE = E \Rightarrow \frac{1}{2}mv^2 + V = E$$

$$\frac{1}{2}mv^2 = \frac{1}{2}\frac{(mv)^2}{m} = \frac{1}{2}\frac{\rho^2}{m} = \frac{\rho^2}{2m} \Rightarrow \frac{\rho^2}{2m} + V = E \tag{4}$$

$$\rho \rightarrow \frac{\hbar}{j}\frac{\partial}{\partial x}, E \rightarrow -\frac{\hbar}{j}\frac{\partial}{\partial t}$$

$$\Rightarrow \frac{-1}{2m}\hbar\frac{\partial^2}{\partial x^2}\Psi(x,t) + V(x)\Psi(x,t) = \frac{-\hbar}{j}\frac{\partial \Psi(x,t)}{\partial t}$$

where

$$(\frac{\partial}{\partial x})^2 \rightarrow \frac{\partial^2}{\partial x^2}, j^2 = -1$$

- Wave function in 3D then:

$$\frac{-\hbar}{2m}\nabla^2\Psi + V\Psi = \frac{-\hbar}{j}\frac{\partial \Psi}{\partial t} \ni \nabla^2\Psi = \frac{\partial^2 \Psi}{\partial x^2} + \frac{\partial^2 \Psi}{\partial y^2} + \frac{\partial^2 \Psi}{\partial z^2} \tag{5}$$

- Separation of variables:

$$\frac{-\hbar}{2m}\frac{\partial^2 \Psi(x,t)}{\partial x^2} + V(x)\Psi(x,t) = \frac{-\hbar}{j}\frac{\partial \Psi(x,t)}{\partial t} \tag{6}$$

$$\Rightarrow$$

$$-\frac{\hbar}{2m}\frac{\partial^2\psi(x)}{\partial x^2}\phi(t) + V(x)\psi(x)\phi(t) = -\frac{\hbar}{j}\psi(x)\frac{\partial\phi}{\partial t} \tag{7}$$

$$\Rightarrow$$

$$\frac{d\phi(t)}{dt} + \frac{j}{\hbar}E\phi(t) = 0 \tag{8}$$

(time dependent portion)

$$-\frac{\hbar}{2m}\frac{d^2\psi(x)}{dx^2} + V(x)\psi(x) = E\psi(x) \tag{9}$$

(time independent portion)

- E $\equiv$ equivalent constant, corresponds to total energy of the particle
- Wave function as linear combination of various eigenfunctions

$$\psi(x,t) =_n C_n\Psi_n e^{-j\frac{E_n}{\hbar t}} \ni E_n \equiv nth\ prefactor \tag{10}$$

- Infinite potential well

$$V(x) = \begin{cases} 0 & , x \neq 0 and x \neq L \\ \infty & , x = 0 or x = L \end{cases}$$

$$\Rightarrow$$

$$(\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V(x))\psi(x) = E\psi(x) \Rightarrow \frac{d^2\psi(x)}{dx^2} = \frac{2m}{\hbar}E\psi(x) \tag{11}$$

$$\Rightarrow$$

$$\frac{d^2\psi(x)}{dx^2} + \frac{2m}{\hbar^2}E\psi(x) = 0 \tag{12}$$

$$\Rightarrow$$

$$\psi(x) = \{\sin(kx), \cos(kx)\} \ni k = \frac{\sqrt{2mE}}{\hbar} \tag{13}$$

3 Chapter 3

- Equilibrium number of EHP's in pure Si at room temp:

$$10^{10}\frac{EHP}{cm^3}$$

- Si atom density in pure Si at room temp:

$$5 * 10^{22}\frac{atoms}{cm^3}$$