Partial list of formulas that have to be memorized for Test 1

\[ E = hf = \hbar \omega \]
\[ hf = q \phi + E_{\text{kin}} \]
\[ p = \hbar k \]
\[ E_{\text{kin}} = \frac{m v^2}{2} \]

\[ (\Delta x)(\Delta p_x) \geq \frac{\hbar}{2} \]  
\[ (\Delta x)(\Delta p_y) \geq \frac{\hbar}{2} \]

\[ P = \iiint |\psi(x, y, z)|^2 dV = \iiint \psi * \psi^* dV \quad \text{or} \quad E_{ph} = hf = E_{n_2} - E_{n_1} \]

1D quantum problems:
\[ E = E_n, \quad \psi = \psi_n(x), \quad n = 1, 2, 3... \]

Hydrogen atom:
\[ \psi = \psi_{n_l m}(r, \theta, \phi) \quad n = 1, 2, 3... \]
\[ l = 0, 1, 2,...n-1 \]
\[ m = -l, ..., -1, 0, 1, ..., l \]

\[ E_{\text{tot}} = E_{\text{kin}} + V = \frac{p^2}{2m} + V = \frac{\hbar^2 k^2}{2m} + V \]

Only for free particle:
\[ E_{\text{tot}} = E_{\text{kin}} = \frac{\hbar^2 k^2}{2m} \]

Intrinsic semiconductor:
\[ n_0 = p_0 = n_i \]
\[ n_0 p_0 = n_i^2 \quad E_g = E_C - E_V \]

Extrinsic semiconductor:
\[ n_0 = N_d \quad \text{or} \quad p_0 = N_a \]
\[ \text{Extrinsic compensated:} \quad n_0 = N_d - N_a \quad \text{or} \quad p_0 = N_a - N_d \]

\[ n_0 p_0 = n_i^2 \]