Midterm Exam 3

Ch. 39

Muliple Slits (N slits, separation d between slits):

prinicpal maxima: $d\,sin\theta = m\lambda$ where order $m = 0, \pm1, \pm2, \ldots$

$$I = I_0 \left[\frac{sin(N\beta)}{sin\beta}\right]^2 \quad \text{where} \quad \beta = \frac{\pi d\, sin\theta}{\lambda}$$

angular disperion: $\dfrac{\Delta\theta}{\Delta\lambda} = \dfrac{m}{d\,cos\theta}$

resolving power: $R = \dfrac{\lambda}{\Delta\lambda} = mN$

Single Slit (width a):

destructive interference: $sin\theta = \dfrac{m\lambda}{a}$ where $m = \pm1, \pm2, \ldots$

$$I = I_{\max} \frac{sin^2\alpha}{\alpha^2} \quad \text{where} \quad \alpha = \frac{\pi a\, sin\theta}{\lambda}$$

minima in terms of α: $\alpha = n\pi$ where $n = \pm1, \pm2, \pm3, \ldots$

multiple slits (width a separated by distance d):

$I_{\text{total}} = I_{\text{muliple slit}} I_{\text{single slit}}$

$\theta_{\min} \simeq \dfrac{\lambda}{D}$

$S_{\min} = s\theta_{\min}$

Bragg's Law (θ is measured from a Bragg plane surface in a crsytal)

$2d\,sin\theta = n\lambda$ where $n = 1, 2, 3, \ldots$

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$\lambda = \dfrac{h}{p}$ $\qquad h = 6.63\times10^{-34}$ J·s

Photons: $E = hf$ $\qquad p = \dfrac{hf}{c}$

Tunneling:

fraction getting through $\simeq e^{\left[-(2/\hbar)a\sqrt{2m(\langle U\rangle - E)}\right]}$

$\Delta x \Delta p_x > \hbar$ $\qquad \hbar = \dfrac{h}{2\pi} = 1.05\times10^{-34}$ J·s

$\Delta E \Delta t > \hbar$

1eV=1.6022×10^{-19} J

Energy density for blackbody radiation:

$$u(f,T) = \frac{8\pi h}{c^3}\frac{f^3}{e^{hf/kT} - 1}$$

Photoelectric effect:

$\dfrac{1}{2}mv^2 = hf - W$

Compton effect:

$\lambda' - \lambda = \dfrac{h}{mc}(1 - cos\theta)$

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Bohr Model (hydrogen atom):

$L = n\hbar$, where $n = 1, 2, 3\ldots$

$$E_n = -\frac{m_e}{2n^2}\left(\frac{e^2}{4\pi\varepsilon_0\hbar}\right)^2 = \frac{-13.6\ \text{eV}}{n^2}$$

$$\frac{1}{\lambda} = \frac{E_i - E_f}{hc} = R_\infty\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

$hf = E_i - E_f$

Boltzmann factor: $P_n \sim e^{-E_n/kT}$

Heisenberg-Scroedinger:

for energy level E_n:

n^2 states characterized by angular momentum ℓ

$L^2 = \ell(\ell+1)\hbar^2$ where $\ell = 0, 1, 2\ldots(n-1)$

L can project onto the z-axis to give

$L_z = m_\ell\hbar$ where $m_\ell = \ell, \ell-1, \ell-2, \ldots 1, 0, -1, -(\ell-1)$,-$\ell$

Furthermore, since each electron can also has an intrinsic spin $s = \dfrac{1}{2}$ each angular momentum state is split into two spin states, one with $m_s = +\dfrac{1}{2}$ and the other with $m_s = -\dfrac{1}{2}$

Pauli exclusion principle: No two electron can appear in the same quantum state in the same atom

$\rightarrow$ no two electrons may have **all** their quantum numbers (n,ℓ,m$_\ell$,and m$_s$) match