Chapter 5: 15, 22, 25, 33; Chapter 6: 3, 4

15. \( D = 0.315 \text{ mm} \) 350 eV electron \( \lambda = \frac{1.23}{\sqrt{350}} = 0.006 \text{ nm} \)

Since \( 5\lambda = 0.33 \text{ mm} > D \) only 4 orders are possible

\[ m \lambda = D \sin \phi \]

<table>
<thead>
<tr>
<th>( m )</th>
<th>( \sin \phi )</th>
<th>( \phi )</th>
<th>( \Delta = \phi / 2 )</th>
<th>( \tan \phi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.21</td>
<td>12°</td>
<td>6°</td>
<td>.1</td>
</tr>
<tr>
<td>2</td>
<td>0.42</td>
<td>25°</td>
<td>12°12'</td>
<td>.22</td>
</tr>
<tr>
<td>3</td>
<td>0.6</td>
<td>37°</td>
<td>18°12'</td>
<td>.33</td>
</tr>
<tr>
<td>4</td>
<td>0.8</td>
<td>53°</td>
<td>26°12'</td>
<td>.5</td>
</tr>
</tbody>
</table>

There are all possible families of planes, although 140 would be pretty weak.

22. Double slit for 5 eV electrons

\( \lambda = 0.55 \text{ nm} \)

Writing of the problem is ambiguous. Diffraction refers to the blending of waves by the single slit while the pattern from two slits is called interference.

From the context, the authors must mean interference.

\[ d \sin \theta = \frac{\lambda}{2} \]

\( \theta = 5° \)

\[ d = \frac{0.55}{2 \times 0.087} = 3.15 \text{ mm} \]

The slit opening \( d \) is not specified.

\[ 2\theta = 10° \quad \tan 2\theta = 0.18 = \frac{1}{x} \quad x = 5.7 \text{ cm} \]
5-25. \( \psi(x,0) = A e^{-x^2/4\sigma^2} \) \[ |\psi(x,0)|^2 = (A|^2) e^{-x^2/2\sigma^2} \]

\[ \int |\psi(x)|^2 dx = 1 \Rightarrow |A|^2 = \frac{1}{12\pi^1/2} \]

X Prob. electron most likely will be near \( x=0 \)

\( \sigma = 1/\sqrt{2} \)

\( \sigma = 1/\sqrt{e} \)

\( \sigma = 1/2 \)

\( \sigma = 1/\sqrt{e^2} \)

5-33. Titanium \( Z=22, A=48 \) \( \tau = 6.6 \times 10^{-16} \text{ eV sec.} \)

\( \tau_1 = 1.4 \text{ ps} \quad \Gamma_1 = 4.7 \times 10^{-4} \text{ eV} \)

\( T = 1.3 \times 10^{-17} \text{ MeV} \)

\( T_2 = 3.0 \text{ ps} \quad \Gamma_2 = 2.2 \times 10^{-4} \text{ eV} \)

\( \gamma \text{ ray width } \Gamma = (\Gamma_1^2 + \Gamma_2^2)^{1/2} = 5.2 \times 10^{-4} \text{ eV} \)

\( \Gamma/E = 4 \times 10^{-10} \) (note: the text does not add the widths in quadrature-it just adds them, which is incorrect.)

Hard line \( M=3 \rightarrow m=2 \).

\( E = 13.6 \times 5/36 = 1.89 \text{ eV} \)

Text says each lifetime \( 1.3 \times 10^{-8} \text{ sec.} \) which is not true,

but if we assume it is,

\( \Gamma_1 = 6.6 \times 10^{-8} \text{ eV} = \Gamma_2 \)

\( \Gamma = 6.6 \sqrt{2} \times 10^{-8} \text{ eV} \)

\( \frac{\Delta E}{E} = \frac{9.2 \times 10^{-8}}{1.9} = 4.8 \times 10^{-8} \) again the text is off by \( \sqrt{2} \).

Possible transitions are \( m=3, l=2 \rightarrow m=2, l=1 \) and \( m=3, l=1 \rightarrow m=2, l=0 \)

and \( m=3, l=0 \rightarrow m=2, l=1 \)

\( m=2, l=0 \) is metastable, \( \tau \approx 10^{-3} \text{ sec.} \)

\( m=2, l=1 \rightarrow m=2, l=0 \) with \( \tau = 1.6 \times 10^{-16} \text{ sec.} \)

Each \( n=2 \) \( l \) \( m \) have its own transition rate \( \Gamma m=2. \)
Set # 9 cont'd

Chap 6

3. \( \psi(x) = A e^{-x^2/2L^2} \)

\[ E = \frac{\hbar^2}{2mL^2} \]

\( (\frac{1}{L^2} + \frac{x^2}{L^4}) \psi + (\frac{1}{L^2} - \frac{2m}{\hbar^2} V(x)) \psi = 0 \)

So \( \frac{2m}{\hbar^2} V(x) = \frac{x^2}{L^4} \) \Rightarrow \( V(x) = \frac{\hbar^2}{2mL^4} x^2 \) harmonic oscillator.

24.1 \( E = E_k + V(x) \)

\[ E_k = \frac{\hbar^2}{2mL^2} - \frac{\hbar^2}{2mL^2} \frac{x^2}{L^2} = \frac{\hbar^2}{2mL^2} \left( 1 - \frac{x^2}{L^2} \right) \]

\( x = \pm L \) are the turning points.

\( V(x) = \frac{1}{2} k x^2 \) \( k = \text{force constant} = \frac{\hbar^2}{mL^4} = \text{mass} \)

\( \omega_0 = \frac{\hbar}{mL^2} \) \( E = \frac{\hbar \omega_0}{2} \) which is the 1.0 ground state.

\( \psi(x) \) is the ground state wave function.