Sample Problem 7.5  Applying the Uncertainty Principle

PROBLEM: An electron moving near an atomic nucleus has a speed $6 \times 10^6 \pm 1\%$. What is the uncertainty in its position ($\Delta x$)?

PLAN: The uncertainty ($\Delta x$) is given as $\pm 1\%$ ($0.01$) of $6 \times 10^6$ m/s. Once we calculate this, plug it into the uncertainty equation.

SOLUTION:

$$\Delta x = (0.01)(6 \times 10^6 \text{ m/s}) = 6 \times 10^4 \text{ m/s}$$

$$\Delta x \geq \frac{\hbar}{4\pi m}$$

$$\Delta x \geq \frac{6.626 \times 10^{-34} \text{ kg} \cdot \text{m}^2/\text{s}}{4\pi (9.11 \times 10^{-31} \text{ kg}) (6 \times 10^4 \text{ m/s})} \geq 1 \times 10^{-9} \text{ m}$$

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Quantum Numbers and Atomic Orbitals

An atomic orbital is specified by three quantum numbers.

$n$ the principal quantum number - a positive integer

$l$ the angular momentum quantum number - an integer from 0 to $n-1$

$m_l$ the magnetic moment quantum number - an integer from $-l$ to $+l$

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<table>
<thead>
<tr>
<th>Name, Symbol (Property)</th>
<th>Allowed Values</th>
<th>Quantum Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal, $n$ (size, energy)</td>
<td>Positive integer</td>
<td>$1$, $2$, $3$, ...</td>
</tr>
<tr>
<td>Angular momentum, $l$ (shape)</td>
<td>0 to $n-1$</td>
<td>0, 1, 2, 3</td>
</tr>
<tr>
<td>Magnetic, $m_l$ (orientation)</td>
<td>$-l$, ..., $0$, ..., $+l$</td>
<td>$-2$, $-1$, $0$, $+1$, $+2$</td>
</tr>
</tbody>
</table>
Sample Problem 7.6  Determining Quantum Numbers for an Energy Level

PROBLEM: What values of the angular momentum ($l$) and magnetic ($m_l$) quantum numbers are allowed for a principal quantum number ($n$) of 3? How many orbitals are allowed for $n = 3$?

PLAN: Follow the rules for allowable quantum numbers found in the text. 

For $n = 3$, $l = 0, 1, 2$
- For $l = 0$, $m_l = 0$
- For $l = 1$, $m_l = -1, 0, +1$
- For $l = 2$, $m_l = -2, -1, 0, +1, +2$

There are 9 $m_l$ values and therefore 9 orbitals with $n = 3$.

SOLUTION:

Sample Problem 7.7  Determining Sublevel Names and Orbital Quantum Numbers

PROBLEM: Give the name, magnetic quantum numbers, and number of orbitals for each sublevel with the following quantum numbers:

(a) $n = 3, l = 2$
(b) $n = 2, l = 0$
(c) $n = 5, l = 1$
(d) $n = 4, l = 3$

PLAN: Combine the $n$ value and $l$ designation to name the sublevel. Knowing $l$, we can find $m_l$ and the number of orbitals.

<table>
<thead>
<tr>
<th>$n$</th>
<th>$l$</th>
<th>Sublevel Name</th>
<th>Possible $m_l$ Values</th>
<th># of Orbitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>3</td>
<td>3d</td>
<td>-2, -1, 0, 1, 2</td>
<td>5</td>
</tr>
<tr>
<td>(b)</td>
<td>2</td>
<td>2s</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(c)</td>
<td>5</td>
<td>5p</td>
<td>-1, 0, 1</td>
<td>3</td>
</tr>
<tr>
<td>(d)</td>
<td>4</td>
<td>4f</td>
<td>-3, -2, -1, 0, 1, 2, 3</td>
<td>7</td>
</tr>
</tbody>
</table>

SOLUTION:

Sample Problem 7.8  Identifying Incorrect Quantum Numbers

PROBLEM: What is wrong with each of the following quantum numbers designations and/or sublevel names?

(a) $n = 1$ only  $l = 0$. Name 1s.
(b) $l = 3$ is an $f$ sublevel. Name 4f.
(c) $l = 1$ can only have $m_l$ of -1, 0, +1.

SOLUTION:

(a) $n = 1$ only  $l = 0$. Name 1s.
(b) $l = 3$ is an $f$ sublevel. Name 4f.
(c) $l = 1$ can only have $m_l$ of -1, 0, +1.

Figure 7.17

Figure 7.18

The 2p orbitals.

Figure 7.19

The 3d orbitals.
Figure 7.19 continued

Figure 7.20
One of the seven possible 4f orbitals.

Figure 7.21
The energy levels in the H atom.