The McGraw-Hill Companies

Unit II - Lecture 7

Chemistry

The Molecular Nature of Matter and Change

Fifth Edition

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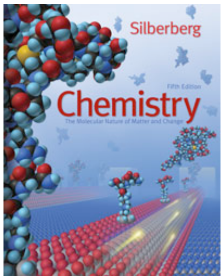


Sample Problem 7.5 Applying the Uncertainty Principle

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

PLAN: The uncertainty (Δx) is given as ±1% (0.01) of 6×10^6 m/s. Once we calculate this, plug it into the uncertainty equation.

SOLUTION:

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

$$\Delta x * m\,\Delta u \geq \frac{h}{4\pi}$$

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

The Schrödinger Equation

$$H\Psi = E\Psi$$

$$\underbrace{\frac{d^2\Psi}{dx^2} + \frac{d^2\Psi}{dy^2} + \frac{d^2\Psi}{dz^2}}_{\text{how } \psi \text{ changes in space}} + \frac{8\pi^2 m_{\Theta}}{h^2}(E - V(x,y,z)\Psi(x,y,z) = 0$$

wave function

mass of electron

potential energy at *x*,*y*,*z*

how ψ changes in space

total quantized energy of the atomic system

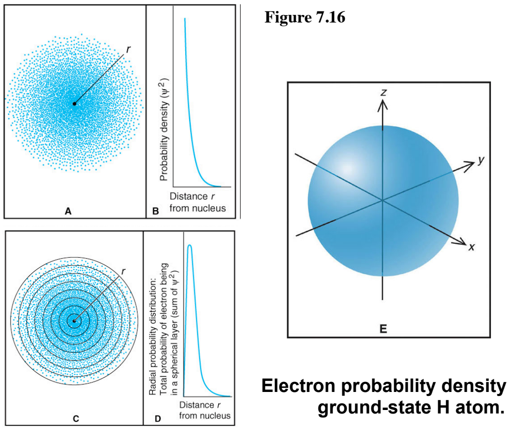


Figure 7.16

Electron probability density in the ground-state H atom.

Quantum Numbers and Atomic Orbitals

An atomic orbital is specified by three quantum numbers.

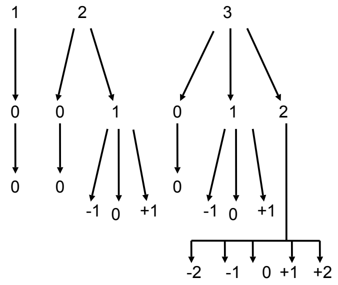
n the principal quantum number - a positive integer

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 $+l$

Table 7.2 The Hierarchy of Quantum Numbers for Atomic Orbitals

Name, Symbol (Property)	Allowed Values	Quantum Numbers
Principal, *n* (size, energy)	Positive integer (1, 2, 3, ...)	1 2 3
Angular momentum, *l* (shape)	0 to *n*-1	0 0 1 0 1 2
Magnetic, m_l (orientation)	$-l,\ldots,0,\ldots,+l$	0 0 -1 0 +1 0 -1 0 +1 -2 -1 0 +1 +2



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.

l values can be integers from 0 to n-1; m_l can be integers from -l through 0 to + l.

SOLUTION: For $n = 3$, $l = 0, 1, 2$

For $l = 0$ $m_l = 0$

For $l = 1$ $m_l = -1, 0,$ or $+1$

For $l = 2$ $m_l = -2, -1, 0, +1,$ or $+2$

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

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.

SOLUTION:

	n	l	sublevel name	possible m_l values	# of orbitals
(a)	3	2	3*d*	-2, -1, 0, 1, 2	5
(b)	2	0	2*s*	0	1
(c)	5	1	5*p*	-1, 0, 1	3
(d)	4	3	4*f*	-3, -2, -1, 0, 1, 2, 3	7

Sample Problem 7.8 Identifying Incorrect Quantum Numbers

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

	n	l	m_l	Name
(a)	1	1	0	1*p*
(b)	4	3	+1	4*d*
(c)	3	1	-2	3*p*

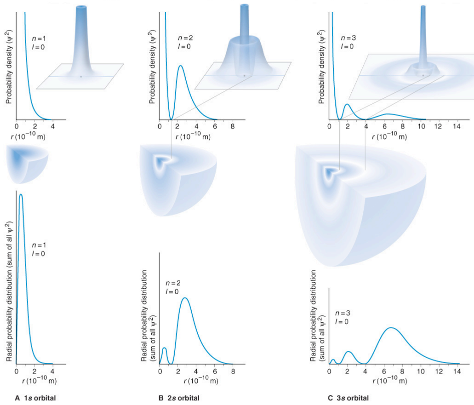
SOLUTION:

(a) $n = 1$ only $l = 0$. Name 1*s*.

(b) $l = 3$ is an *f* sublevel. Name 4*f*.

(c) $l = 1$ can only have m_l of -1, 0, +1.

Figure 7.17



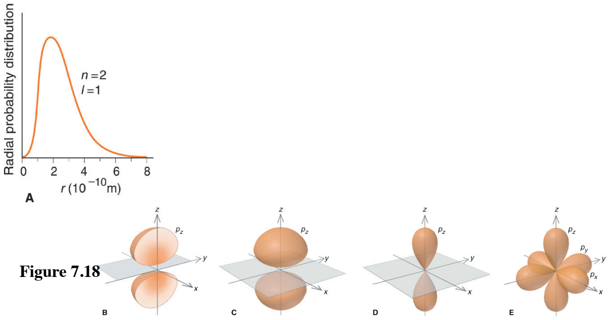


Figure 7.18

The 2*p* orbitals.

Figure 7.19 **The 3*d* orbitals.**

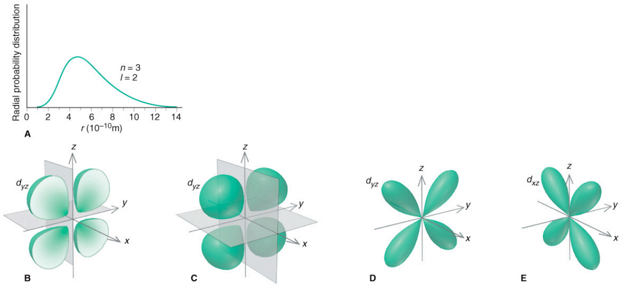


Figure 7.19 continued

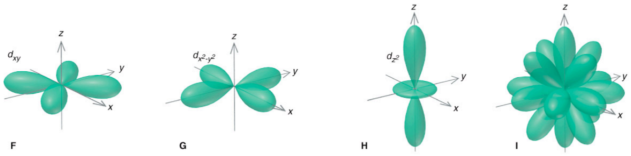


Figure 7.20

One of the seven possible 4*f* orbitals.

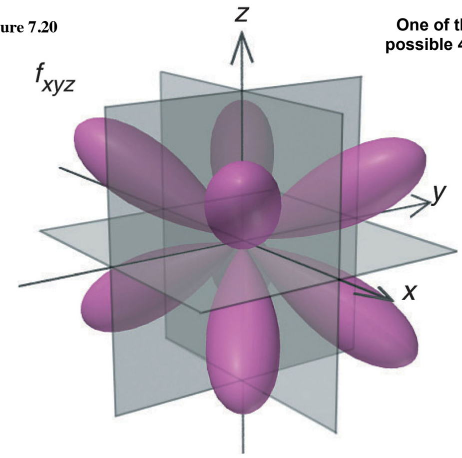


Figure 7.21

The energy levels in the H atom.