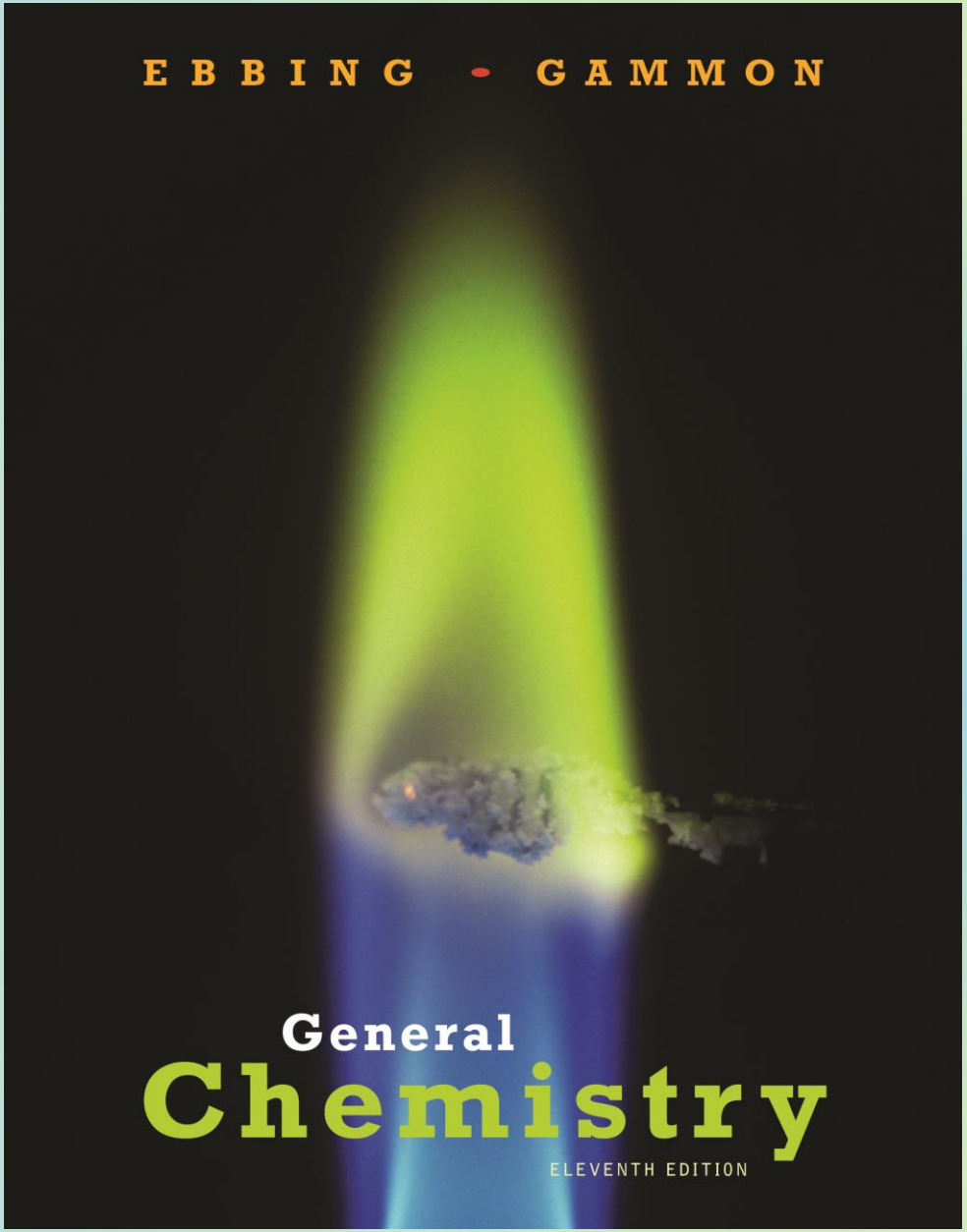


Quantum Theory of The Atom

- **Note: This is a summary of the lecture. Much more was discussed during the lecture!**
- **Quantum Numbers:**

✓ The allowed values and general meaning of each of the four quantum numbers of an electron in an atom are as follows:

1. Principal Quantum Number (n)

This quantum number is the one on which the energy of an electron in an atom principally depends.

it can have any positive value: 1, 2, 3, and so on

Letter	*K*	*L*	*M*	*N* . . .
n	1	2	3	4 . . .

2. Angular Momentum Quantum Number (l) (Also Called Azimuthal Quantum Number)

This quantum number distinguishes orbitals of given n having different shapes. it can have any integer value from 0 to n − 1.

Letter	*s*	*p*	*d*	*f*	*g* . . .
l	0	1	2	3	4 . . .

✓ Orbitals of the same *n* but different *l* are said to belong to different *subshells* of a given shell

3. Magnetic Quantum Number (m_l)

This quantum number distinguishes orbitals of given n and l,that is, of given energy and shape but having a different orientation in space; the allowed values are the integers from −l to +l.

✓ There are 2*l* + 1 orbitals in each subshell of quantum number *l*.

4. Spin Quantum Number (m_s)

This quantum number refers to the two possible orientations of the spin axis of an electron; possible values are +1/2 *and* -1/2

(Q) State whether each of the following sets of quantum numbers is permissible for an electron in an atom. If a set is not permissible, explain why.

a. $n = 1, l = 1, m_l = 0, m_s = +\frac{1}{2}$

b. $n = 3, l = 1, m_l = -2, m_s = -\frac{1}{2}$

c. $n = 2, l = 1, m_l = 0, m_s = +\frac{1}{2}$

d. $n = 2, l = 0, m_l = 0, m_s = 1$

Table 7.1 Permissible Values of Quantum Numbers for Atomic Orbitals

n	l	m_l*	Subshell Notation	Number of Orbitals in the Subshell
1	0	0	$1s$	1
2	0	0	$2s$	1
2	1	$-1, 0, +1$	$2p$	3
3	0	0	$3s$	1
3	1	$-1, 0, +1$	$3p$	3
3	2	$-2, -1, 0, +1, +2$	$3d$	5
4	0	0	$4s$	1
4	1	$-1, 0, +1$	$4p$	3
4	2	$-2, -1, 0, +1, +2$	$4d$	5
4	3	$-3, -2, -1, 0, +1, +2, +3$	$4f$	7

Exercise 7.7 Explain why each of the following sets of quantum numbers is not permissible for an orbital.

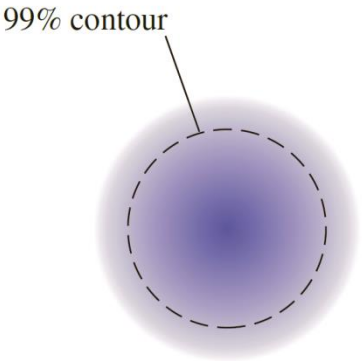
a. $n = 0, l = 1, m_l = 0, m_s = +\frac{1}{2}$

b. $n = 2, l = 3, m_l = 0, m_s = -\frac{1}{2}$

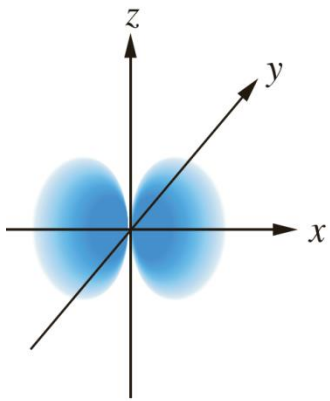
c. $n = 3, l = 2, m_l = +3, m_s = +\frac{1}{2}$

d. $n = 3, 1 = 2, m_l = +2, m_s = 0$

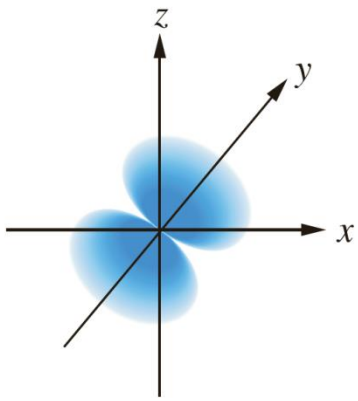
Atomic Orbital Shapes



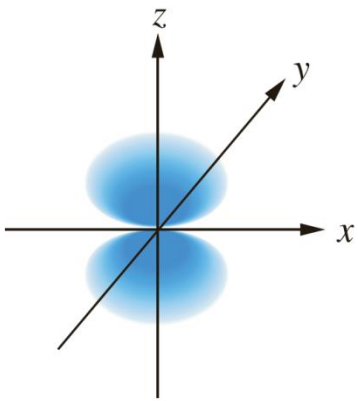
1s orbital



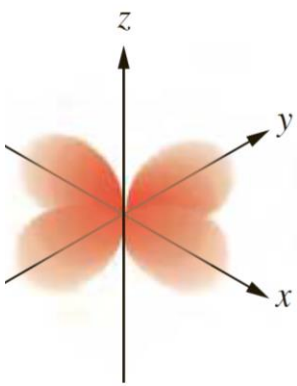
$2p_x$ orbital



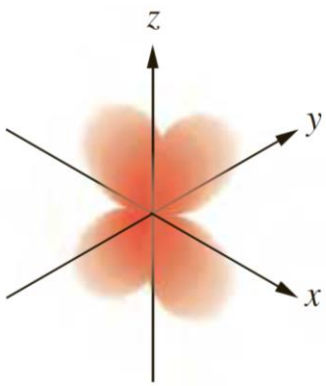
$2p_y$ orbital



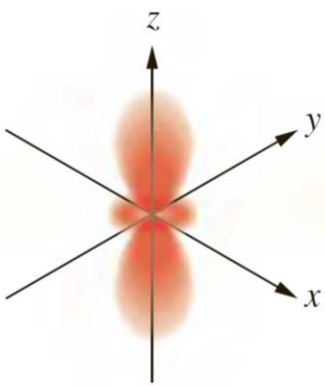
$2p_z$ orbital



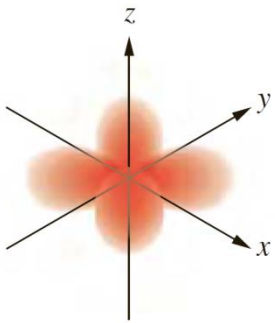
$d_{x^2-y^2}$



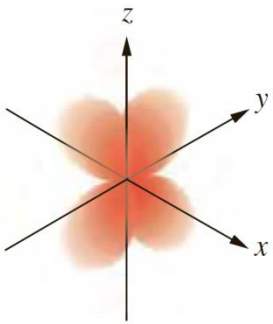
d_{xz}



d_{z^2}



d_{xy}



d_{yz}