The Development of Atomic Models

- **Rutherford's atomic model could not explain the chemical properties of elements.**
  - Rutherford's atomic model could not explain why objects change color when heated.

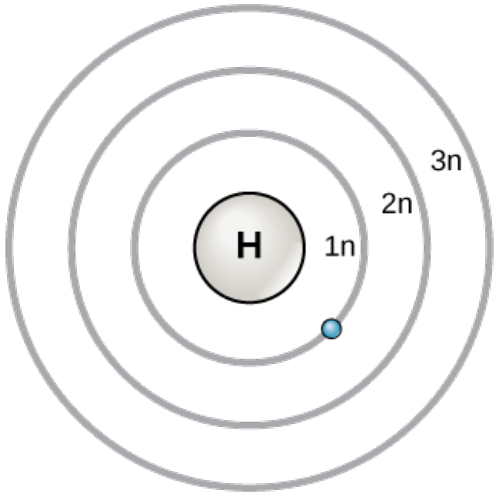
The Bohr Model

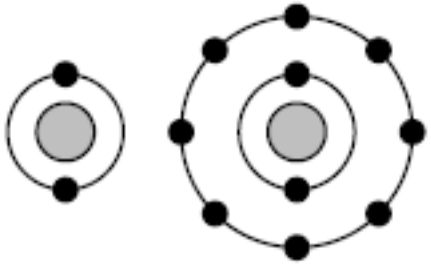
– Electrons are found only in specific circular paths, or orbits, around the nucleus.

The Bohr Model

- Each possible electron orbit in Bohr's model has a fixed energy.
  - The fixed energies an electron can have are called **energy levels.**
  - A **quantum** of energy is the amount of energy required to move an electron from one energy level to another energy level.

Examples of Bohr Atoms

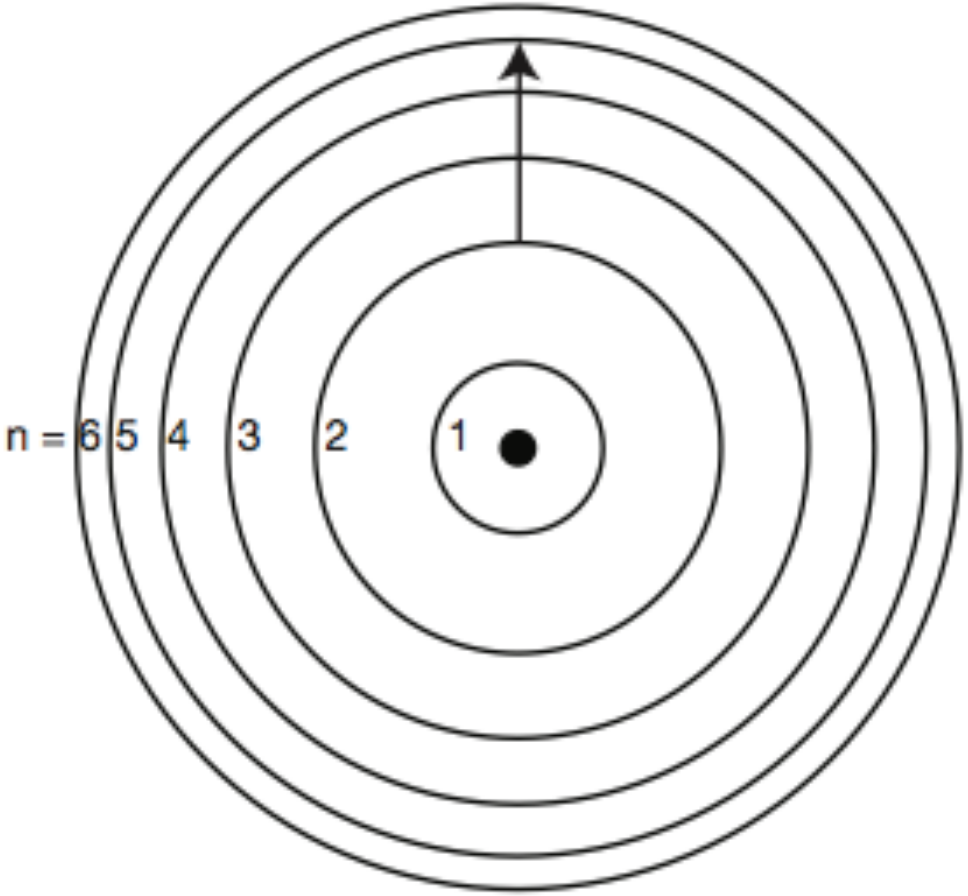




Helium Neon

More accurate Bohr Model……

Orbitals are not equally spaced



The Bohr Model

The Quantum Mechanical Model

- The Quantum Mechanical Model

The Quantum Mechanical Model

– The **quantum mechanical model** determines the allowed energies an electron can have and how likely it is to find the electron in various locations around the nucleus.

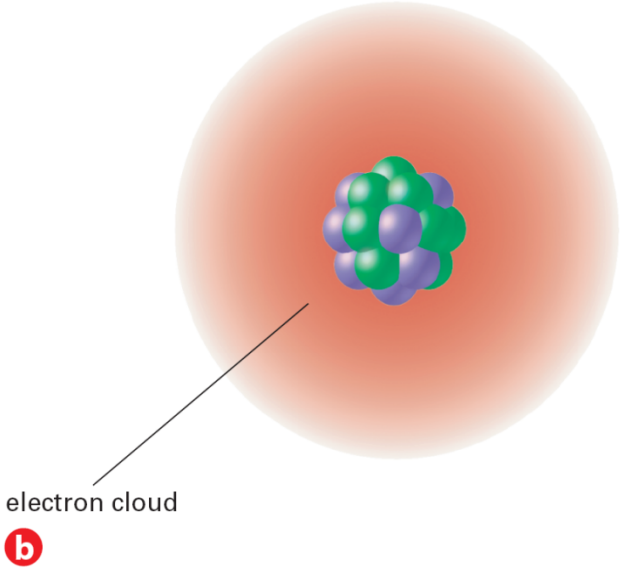
The Quantum Mechanical Model

- The propeller blade has the same probability of being anywhere in the blurry region, but you cannot tell its location at any instant. The electron cloud of an atom can be compared to a spinning airplane propeller.

a

The Quantum Mechanical Model

- In the quantum mechanical model, the probability of finding an electron within a certain volume of space surrounding the nucleus can be represented as a fuzzy cloud. The cloud is more dense where the probability of finding the electron is high.



Atomic Orbitals

- Atomic Orbitals
  - Principal Energy Level- signified by a number (1-7).

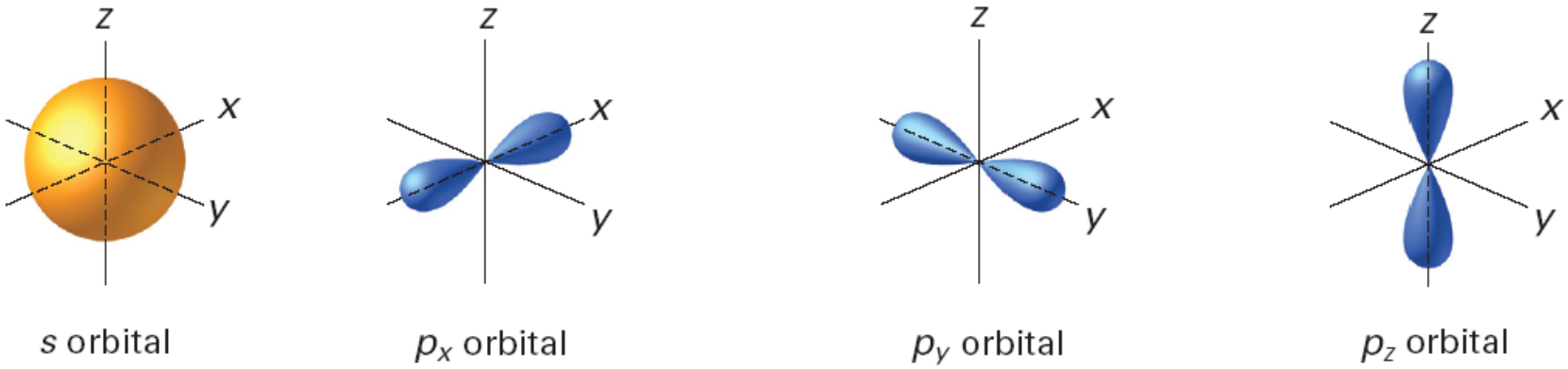
    Each principal level has sublevels.
  - How do sublevels of principal energy levels differ?

Atomic Orbitals

- An **atomic orbital** is often thought of as a region of space in which there is a high probability of finding an electron.
  - Each energy sublevel corresponds to an orbital of a different shape, which describes where the electron is likely to be found.

Atomic Orbitals

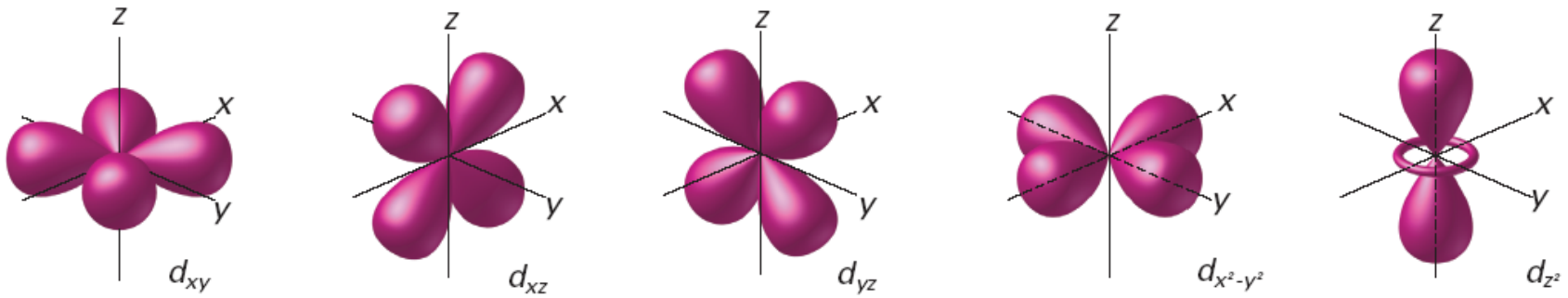
- Different atomic orbitals are denoted by letters. The *s* orbitals are spherical, and *p* orbitals are dumbbell-shaped.



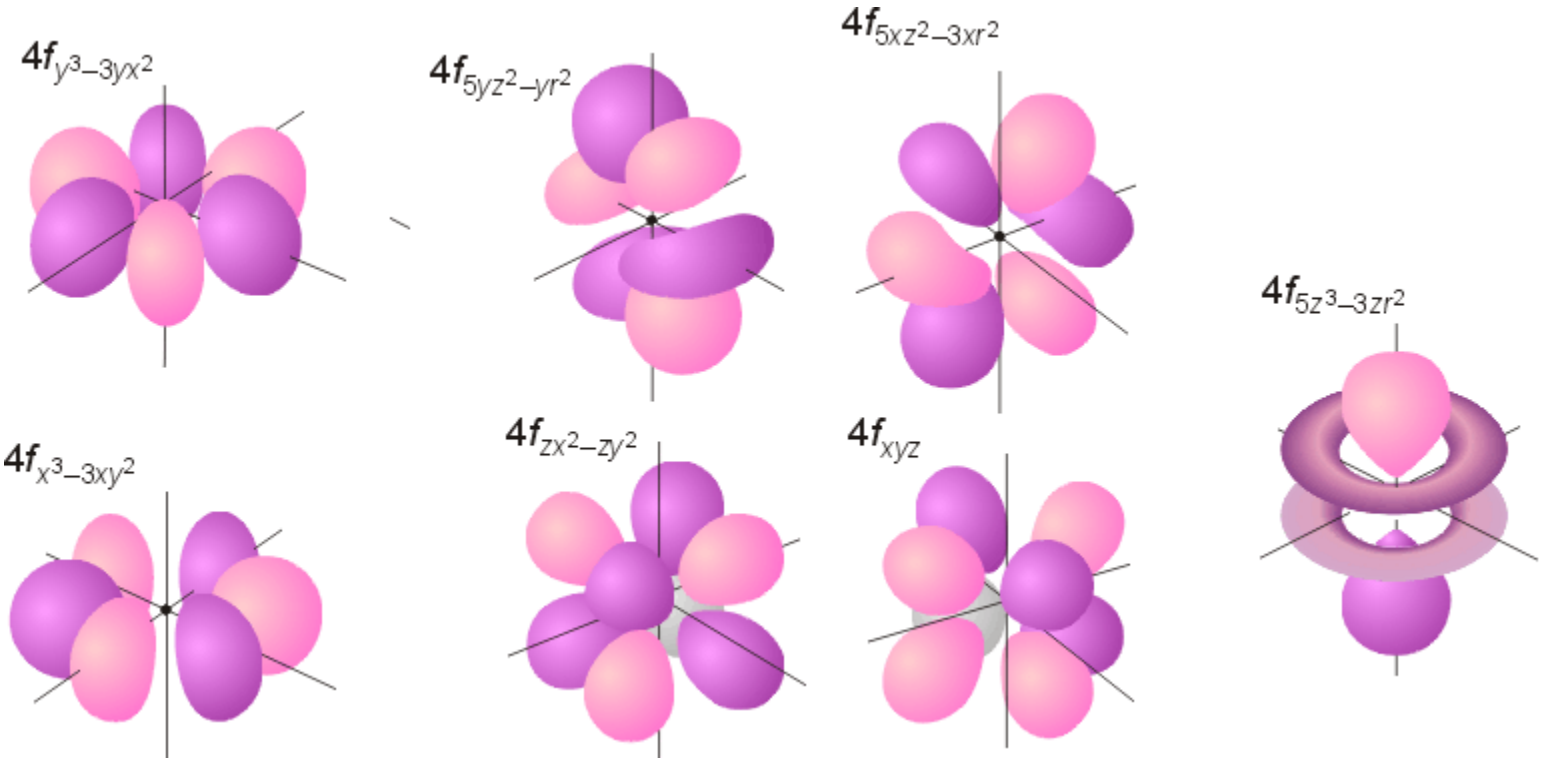
s orbital p_x orbital p_y orbital p_z orbital

Atomic Orbitals

- Four of the five *d* orbitals have the same shape but different orientations in space.



Models of the Atom >



Atomic Orbitals

- The numbers and kinds of atomic orbitals depend on the energy sublevel.

Table 5.1

Summary of Principal Energy Levels, Sublevels, and Orbitals

Principal energy level	Number of sublevels	Type of sublevel
$n = 1$	1	1*s* (1 orbital)
$n = 2$	2	2*s* (1 orbital), 2*p* (3 orbitals)
$n = 3$	3	3*s* (1 orbital), 3*p* (3 orbitals), 3*d* (5 orbitals)
$n = 4$	4	4*s* (1 orbital), 4*p* (3 orbitals), 4*d* (5 orbitals), 4*f* (7 orbitals)

Summary

Principal Energy Level (1-7)

Sublevels (s,p,d,and f)

Orbitals (# depends on sublevel, up to 2 electrons each)

Atomic Orbitals

- The number of electrons allowed in each of the first four energy levels are shown here.

Table 5.2

Maximum Numbers of Electrons

Energy level *n*	Maximum number of electrons
1	2
2	8
3	18
4	32

- The ways in which electrons are arranged in various orbitals around the nuclei of atoms are called **electron configurations.**

- **Example: H: $1s^1$ Li: $1s^2 2s^1$ C: $1s^2 2s^2 2p^2$**

principal energy level

sublevel

# of electrons in sublevel

- Electrons fill the shells by going into the lowest energy levels first. (remember, each orbital can hold 2 electrons)

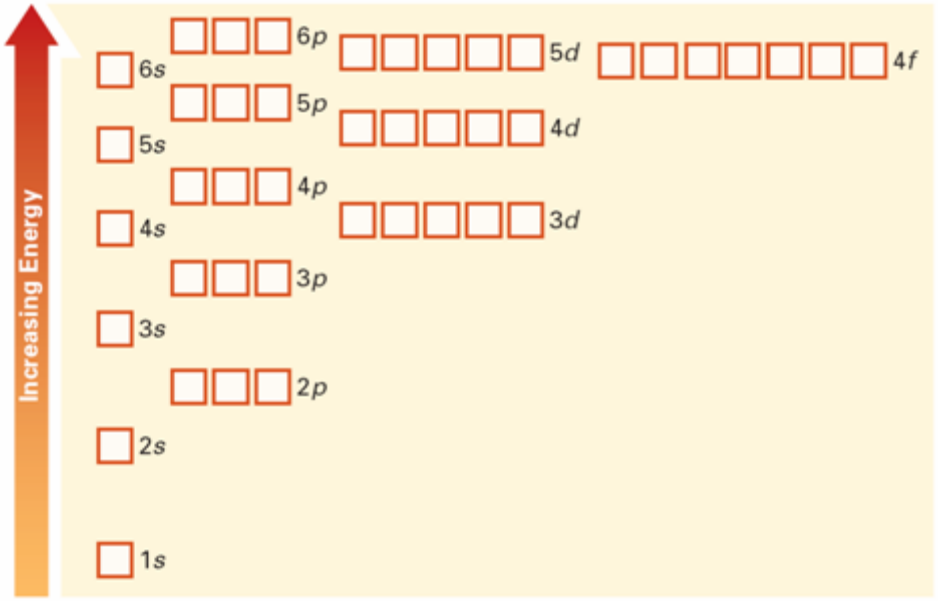


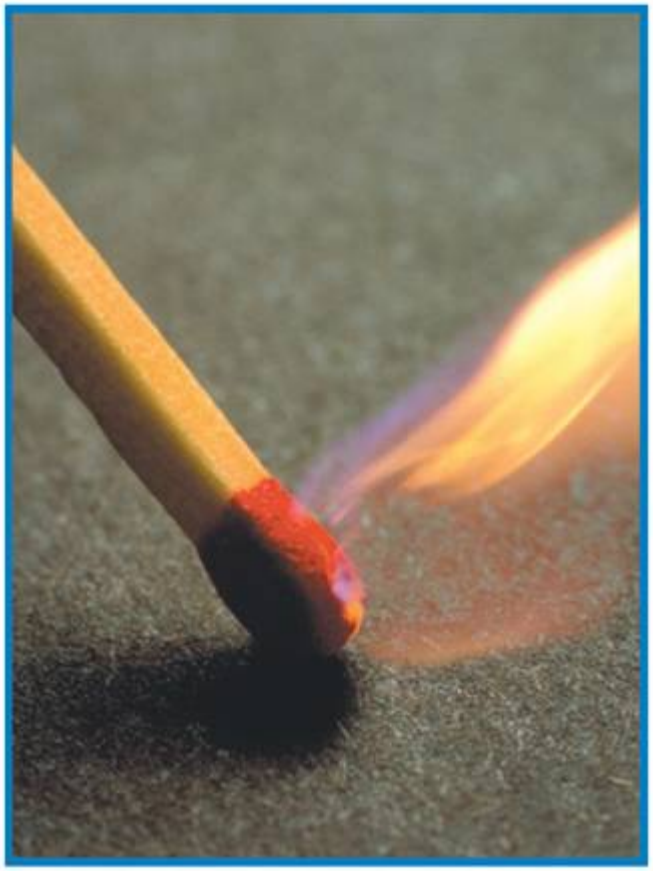
Table 5.3

Electron Configurations for Some Selected Elements

Element	Orbital filling						Electron configuration
	1*s*	2*s*	2p_x	2p_y	2p_z	3*s*	
H	↑						$1s^1$
He	↑↓						$1s^2$
Li	↑↓	↑					$1s^2 2s^1$
C	↑↓	↑↓	↑	↑			$1s^2 2s^2 2p^2$
N	↑↓	↑↓	↑	↑	↑		$1s^2 2s^2 2p^3$
O	↑↓	↑↓	↑↓	↑	↑		$1s^2 2s^2 2p^4$
F	↑↓	↑↓	↑↓	↑↓	↑		$1s^2 2s^2 2p^5$
Ne	↑↓	↑↓	↑↓	↑↓	↑↓		$1s^2 2s^2 2p^6$
Na	↑↓	↑↓	↑↓	↑↓	↑↓	↑	$1s^2 2s^2 2p^6 3s^1$

Writing Electron Configurations

Phosphorus, an element used in matches, has an atomic number of 15. Write the electron configuration of a phosphorus atom.



5.1 Section Quiz.

1. Rutherford's planetary model of the atom could not explain

   a. any properties of elements.

   b. the chemical properties of elements.

   c. the distribution of mass in an atom.

   d. the distribution of positive and negative charges in an atom.

5.1 Section Quiz.

2. Bohr's model of the atom proposed that electrons are found

   a. embedded in a sphere of positive charge.

   b. in fixed positions surrounding the nucleus.

   c. in circular orbits at fixed distances from the nucleus.

   d. orbiting the nucleus in a single fixed circular path.

5.1 Section Quiz.

3. What is the lowest-numbered principal energy level in which *p* orbitals are found?

a. 1

b. 2

c. 3

d. 4

END OF SHOW