Chapter 5: Models of the Atom Name: _____
Period: _____ Date: _____

Chemistry Content Standard:
Atomic and Molecular Structure
1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:
i.* *Students know* the experimental basis for the development of the quantum theory of atomic structure and the historical importance of the Bohr model of the atom.
j.* *Students know* that spectral lines are the result of transitions of electrons between energy levels and that these lines correspond to photons with a frequency related to the energy spacing between levels by using Planck's relationship (E = *hv).*

Chapter 5: Models of the Atom

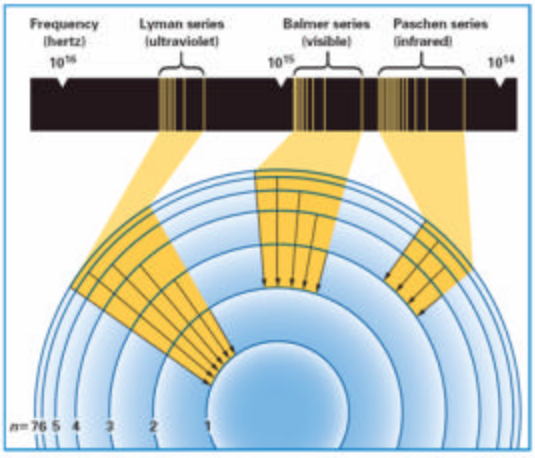
I. The Development of Atomic Models

A. Rutherford's atomic model (1911) could not explain
   1. the chemical properties of elements.
   2. why objects change color when heated. (black to red to yellow to white)

II. The Bohr Model

A. Bohr proposed that an electron is found only in specific circular paths, or _____, around the nucleus.
B. Each possible electron orbit in Bohr's model has a _____.
   1. The fixed energies an electron can have are called _____
   2. A **quantum** of energy -

   3. Like the rungs of the strange ladder, the energy levels in an atom are not equally spaced.
   4. The _____ the energy level occupied by an electron, the _____energy it takes to move from that energy level to the next higher energy level.



III. The Quantum Mechanical Model

A. The quantum mechanical model solves a mathematical equation (Schrödinger equation), which describes the behavior of the electron in a hydrogen atom. The modern description of the electrons in atoms comes from these solutions.

B. This model determines how likely it is

C. The probability of finding an electron within a certain volume of space surrounding the nucleus can be represented as a _____. The cloud is more dense where the probability of finding the electron is _____.

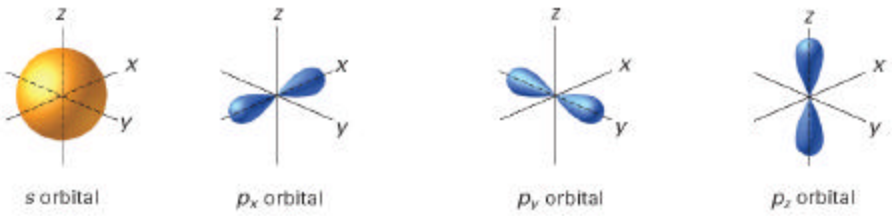
IV. Atomic Orbitals

A. **Atomic orbital** –

B. **Energy sublevel –**

1. Each energy sublevel corresponds to

2. Different atomic orbitals are denoted by letters. The ___orbitals are spherical, and ___ orbitals are dumbbell-shaped. Four of the five *d* orbitals have the same shape but different orientations in space.



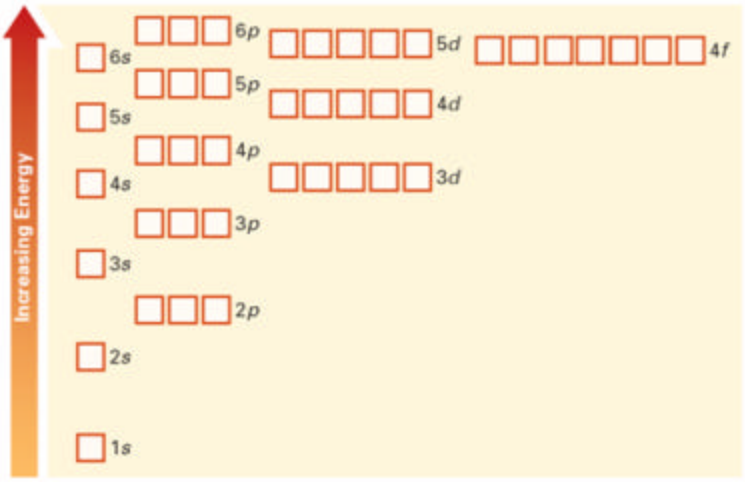
3. The numbers and kinds of _____ depend on the _____.

The number of electrons allowed in each of the first four energy levels are :

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)



V. Electron Configurations

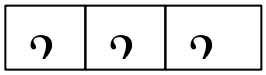
A. **Electron Configuration** -

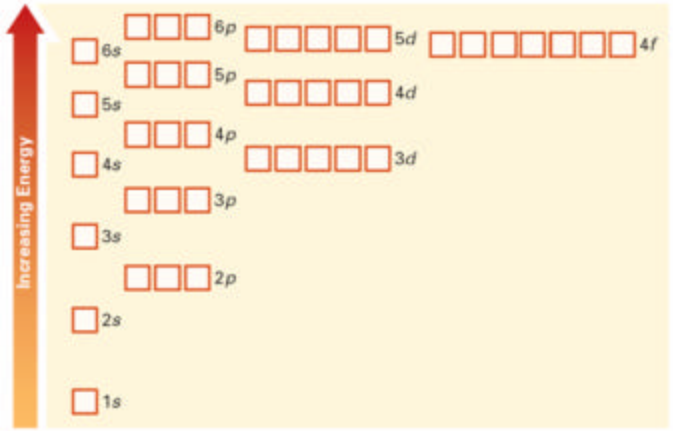
B. The electron configurations are based on three rules

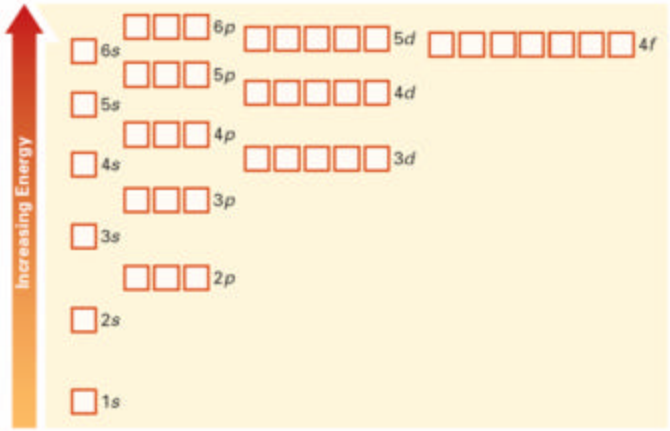
1. Aufbau Principle **-**

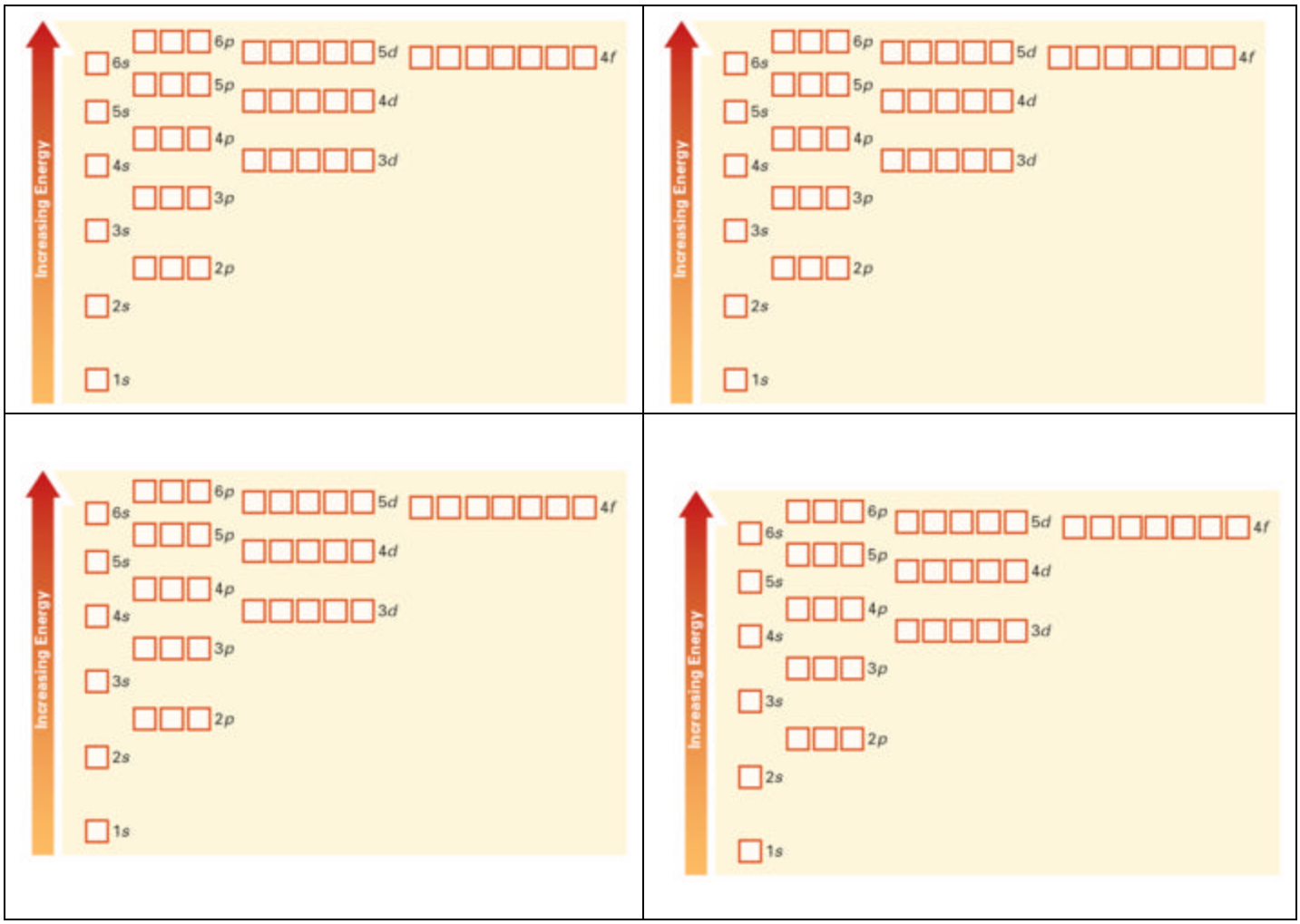
2. **Pauli Exclusion Principle -** An atomic orbital may hold a maximum of _____ electrons. To occupy the same orbital, two electrons must have _____. (the electron spins must be paired)

3. **Hund's rule** – When there are several orbitals of equal energy, _____. Their spins will be in the _____ direction.









Conceptual Problem 1.1

Writing Electron Configurations

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

9. Write the electron configuration for each atom. How many unpaired electrons does each atom have?

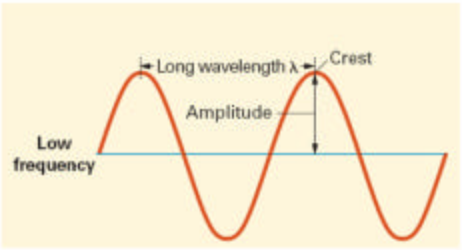
a. boron **b.** silicon

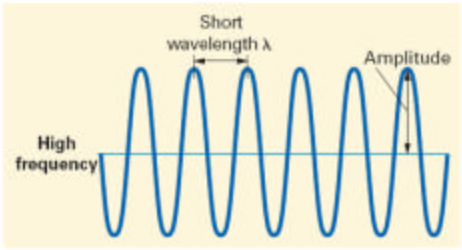
VI. Physics and the Quantum Mechanical Model

A. Light

1. Light consists of _____

2. A wave is described by its





Amplitude

Wavelength (?) -

Frequency (?) -

The SI unit of frequency, cycles per second, is called _____

1. The wavelength and frequency of light are _____ proportional to each other.
2. Higher the frequency, _____ the wavelength.
3. The product of the frequency and wavelength always equals _____ _____

$$c = \lambda \nu$$

Electromagnetic radiation -

1. Includes

2. All electromagnetic waves travel in a vacuum at a speed of 2.998×10^8 m/s.

3. Sunlight consists of light with a _____ range of wavelengths and frequencies.
   a. When sunlight passes through a prism, the different frequencies separate into a _____ of colors.
   b. In the visible spectrum, red light has the _____ wavelength and the _____ frequency.

The electromagnetic spectrum -

Diagram of the electromagnetic spectrum:

V. Atomic Spectra

A. A prism separates light into the colors it contains. When white light passes through a prism, it produces a _____rainbow of colors.

B. Atomic emission spectrum –

C. When light from a helium lamp passes through a prism, _____ are produced.
   1. The frequencies of light emitted by an element separate into discrete lines to give the _____ of the element.

D. In the Bohr model, the lone electron in the hydrogen atom can have only certain specific energies.
   1. When the electron has its lowest possible energy, the atom is in its _____.
   2. When an electron absorbs energy, raises the atom from the ground state to an _____.
   3. A_____ of energy in the form of light is emitted when the electron drops back to a lower energy level.

Check Your Understanding.

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.

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.

3. What is the lowest-numbered principal energy level in which *p* orbitals are found?
   a) 1 b) 2 c) 3 d) 4

4. Identify the element that corresponds to the following electron configuration: $1s^2 2s^2 2p^5$.
   a) F
   b) Cl
   c) Ne
   d) O

5. Write the electron configuration for the atom N.
   a) $1s^2 2s^2 2p^5$
   b) $1s^2 2s^2 2p^3$
   c) $1s^2 2s 1p^2$
   d) $1s^2 2s^2 2p^1$

6. The electron configurations for some elements differ from those predicted by the aufbau principle because the
   a) the lowest energy level is completely filled.
   b) none of the energy levels are completely filled.
   c) half-filled sublevels are less stable than filled energy levels.
   d) half-filled sublevels are more stable than some other arrangements.

7. The lines in the emission spectrum for an element are caused by
   a) the movement of electrons from lower to higher energy levels.
   b) the movement of electrons from higher to lower energy levels.
   c) the electron configuration in the ground state.
   d) the electron configuration of an atom.