Unit 2: Atomic Structure and Electronic Configuration

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Honors Chem

Unit 1 Learning Objectives:

By the end of the unit students will be able to…

- Describe how atomic model was developed
- Describe Niel Bohr's Bright Line Spectrum experiment and interpret the results
- Briefly describe, using the Quantum Mechanics Model of the atom, the position of electrons in the atom and what an orbital is.
- Show how electrons are arranged in the orbitals in a ground state atom using the electron configuration language, and recognize excited state electron configurations.
- Describe the different properties of light

Monday	Tuesday	Wednesday	Thursday	Friday
September 10 HOLIDAY	**11** **Density Writing Assignment** ** Back to School Night	**12** History of the Atomic Model Atomic Configuration	**13** Average Atomic Mass	**14** Ions **Activity: Atomic Structure Puzzle**
17 Bohr Diagrams **Activity: Bohr Diagrams**	**18** Periodic Table Features **Individual Quiz**	**19** HOLIDAY	**20** Properties of Light & Atomic Spectra	**21** **Lab: Atomic Spectra**
24 Quantum Mechanics & Orbital Notation	**25** Electron Configuration	**26** **Activity: Electron Configuration Battleship**	**27** Review of Unit 2	**28** **Unit 2 Test** **HW Packet #2 Due**

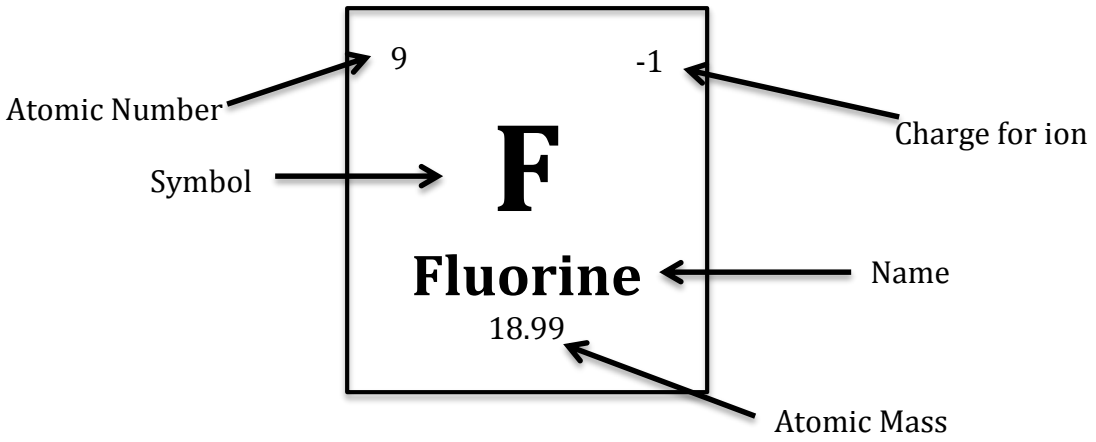
History of Atomic Theory:

**** See Worksheet:** *History of Atomic Theory*

Properties of Subatomic Particles

Subatomic Particle	Charge	Relative Mass	Location

Atomic Configuration



Name:

Each element has a specific name. New elements are generally named by the discoverer(s), but the names must be approved for adoption by **IUPAC** (International Union of Pure and Applied Chemistry)

Symbol:

The chemical symbol is either one UPPERCASE letter **OR** one UPPERCASE letter followed by one lowercase letter. The symbol may derive from the name of the element in a variety of languages. Some elements have been known since ancient times, and many have been discovered more recently.

Atomic Number:

The atomic number is different for each element.
***The atomic number is always equal to the number of PROTONS!*

Atomic Mass:

The atomic mass can be found below an element on the periodic table. The atomic mass is the combined mass of all the subatomic particles. Since electrons do not significantly contribute to mass, the atomic mass is the sum of the number of protons and the number of neutrons.

ATOMIC MASS = _____ + _____

Therefore, an equation can be written to determine the number of neutrons in an atom.

NEUTRONS = _____ - _____

We can find the # of electrons in at atom using the following:

1. The number of electrons is EQUAL to the number of protons in a NEUTRAL (uncharged) atom.
2. _____
3. _____

Practice: Use the periodic table to fill out the following table for NEUTRAL (uncharged) atoms.

Atomic Number	Elemental Name	Symbol	Atomic Mass (amu)	# of Protons	# of Neutrons	# of Electrons
	Cobalt	*Co*	*58*	*27*	*31*	*27*
			208	84		
		Ba	138			
	Helium		4			
		Br	80			
	Gold		196			79
			131		77	
		H	1	1		
	Potassium		39	19		
		Mt	278			

Isotopes

Isotopes:_____

_____

The name of an isotope is written by giving the name of an element followed by its (atomic) mass.

Ex. Lithium-6 or Lithium-7

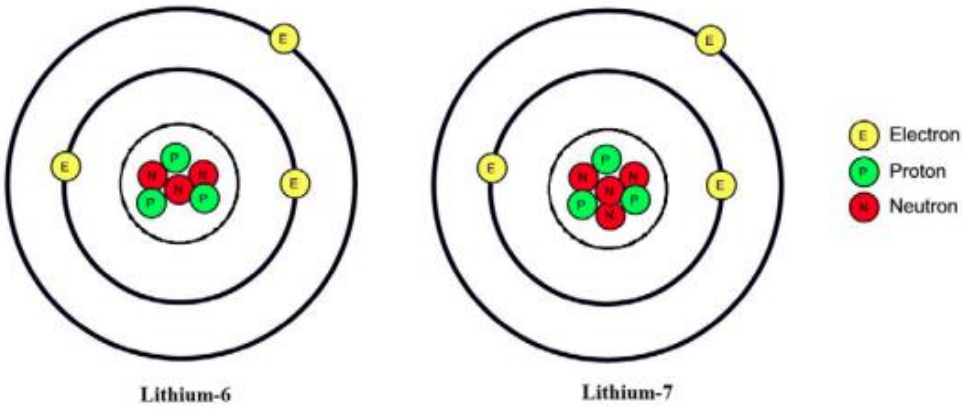
Average Atomic Mass

The atomic mass on the periodic table is actually the weighted ***<u>average atomic mass</u>*** of all of the isotopes for that atom.

You can calculate atomic mass using the following equation:

Ave. Atomic Mass = ( )( )+( )( )….

To distinguish between different isotopes, considering the following example of Lithium-6 and Lithium-7.



Lithium-6 Lithium-7

1. How many protons are in Lithium-6?_____ In Lithium-7? _____
2. How many neutrons are in Lithium-6? _____ In Lithium-7? _____
3. What does the number of protons in Lithium-6 and Lithium-7 tell us about isotopes?

_____

_____

_____

4. What does the number of neutrons in Lithium-6 and Lithium-7 tell us about isotopes?

5. If scientists determined that Lithium-6 was an abundance of 7.59% and lithium-7 was an abundance of 92.41%, what is the average atomic mass for lithium that would appear on the periodic table?

Practice: Answer the following questions about isotopes and average atomic mass.

1. There are two isotopes of chlorine: chlorine-35 (abundance 75.8 %) and chlorine-37 (abundance 24.2 %)
    a. How many neutrons does each isotope have?

    b. Calculate the average atomic mass of chlorine (round your answer to one decimal place)

2. There are three isotopes of neon: neon-20 (90.48 %), neon-21 (0.27 %), and neon (9.25%).
    a. How many neutrons does each isotope have?

    b. Calculate the average atomic mass of neon (round your answer to one decimal place)

IONS

Ions: _____

Atoms are most stable when they have a full valence shell (like the noble gases).
Atoms can both LOSE and GAIN electrons to establish a full valence shell.
When electrons are lost or gained, then the atom becomes charged, or an ion.

When an electron is ***lost*** it becomes _____ charged, and is called a(n)_____.

When an electron is ***gained*** it becomes _____ charged, and is called a(n)_____.

Practice: Determine the number of electrons for each ion. (Show your work)

1. Ca^{2+}

2. F^{-}

3. As^{3-}

4. Ta^{5+}

Practice: Give the symbol and charge for the ion of each element and determine the number of electrons for the ion.

1. Oxygen

2. Potassium

3. Antimony

4. Lanthanum

Practice: Complete the following table for **IONS**

Atomic Number	Elemental Name	Symbol	Atomic Mass (amu)	# of Protons	# of Neutrons	# of Electrons
3						
	Phosphorus					
			78			
		Sr^{2+}				

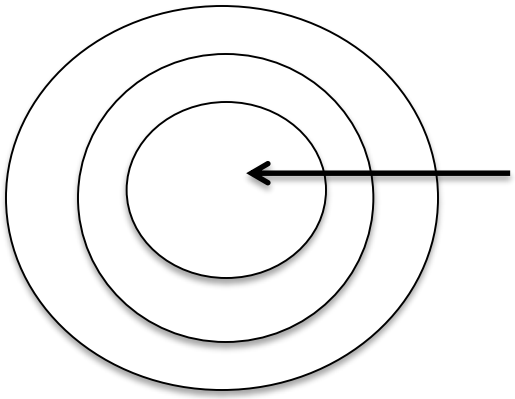
Bohr Diagrams

Orbital Model: _____

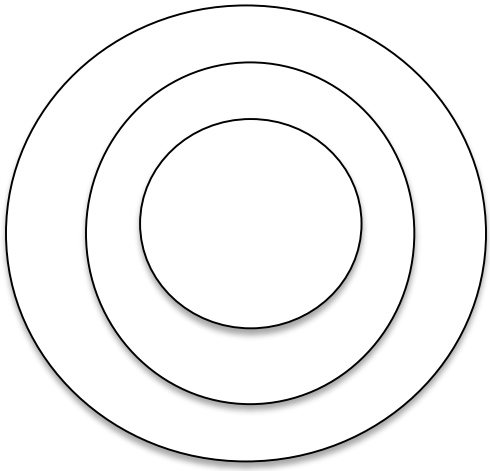
_____

Orbital: _____

Orbital/Shell	Number of Electrons
1st	2
2nd	8
3rd	8
4th	18



Example: Draw a Bohr Diagram for Magnesium-25



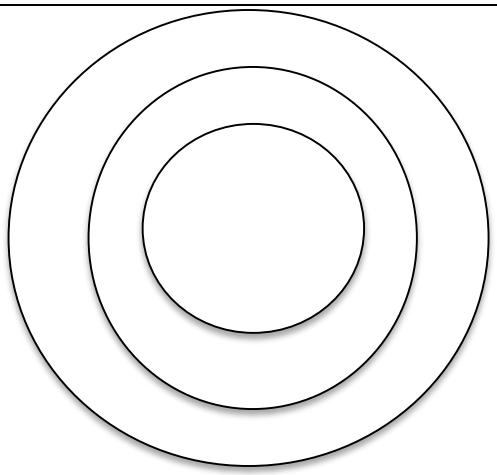
This isotope has:

Protons: _____

Neutrons:_____

Electrons:_____

Practice: Draw a Bohr Diagram, and find the number of protons, neutrons, and electrons for each element.



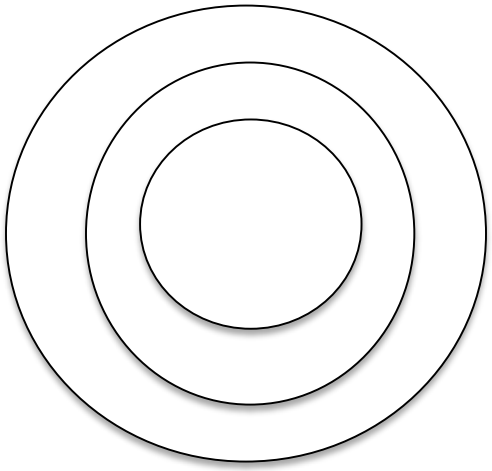
Silicon-28

This isotope has:

Protons: _____

Neutrons: _____

Electrons: _____

	**Chlorine-35** This isotope has: **Protons: _____** **Neutrons: _____** **Electrons: _____**

Practice: Draw Bohr Diagrams for each of the following atoms. State wether each atom should LOSE or GAIN a(n) electron(s) to become more like a nobel gas. Then, draw a Bohr diagram for this new atom.

1. Sulfur-32

2. Oxygen-16

Periodic Table Features

The periodic table was first devised by the Russian chemist _____ in 1869.

He arranged the few known elements in rows by _____ and columns by _____. The columns are arranged into _____ of elements that share similar properties, like families. The rows (horizontal) are numbered with Arabic numbers from top to bottom. And the groups (vertical columns) are numbered with roman numerals. Thus, the periodic table has a funny shape. It is called periodic because as you

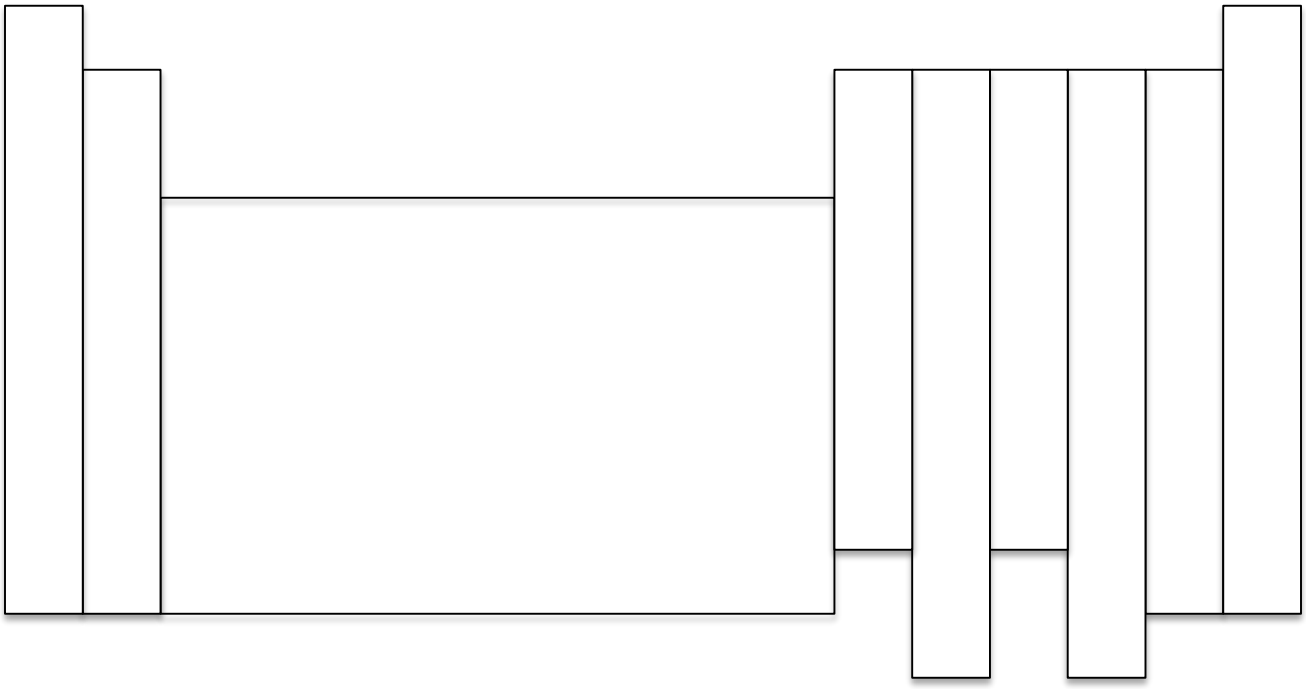
go across the rows, chemical and physical properties _____ like the days of the week in a calendar.

Based on the pattern he found, Mendeleev was able to _____ the existence of three yet to be discovered elements by describing what their masses and properties would be. He was correct in all of his predictions!

Here are the features of the basic modern periodic table:

1. _____
   _____

2. _____
   _____



Valence Electrons: _____

The number of orbitals/shells of an atom is equal to the row number.

Practice: Give the number of valence electrons for each element.

1. Oxygen

2. Chlorine

Properties of Light

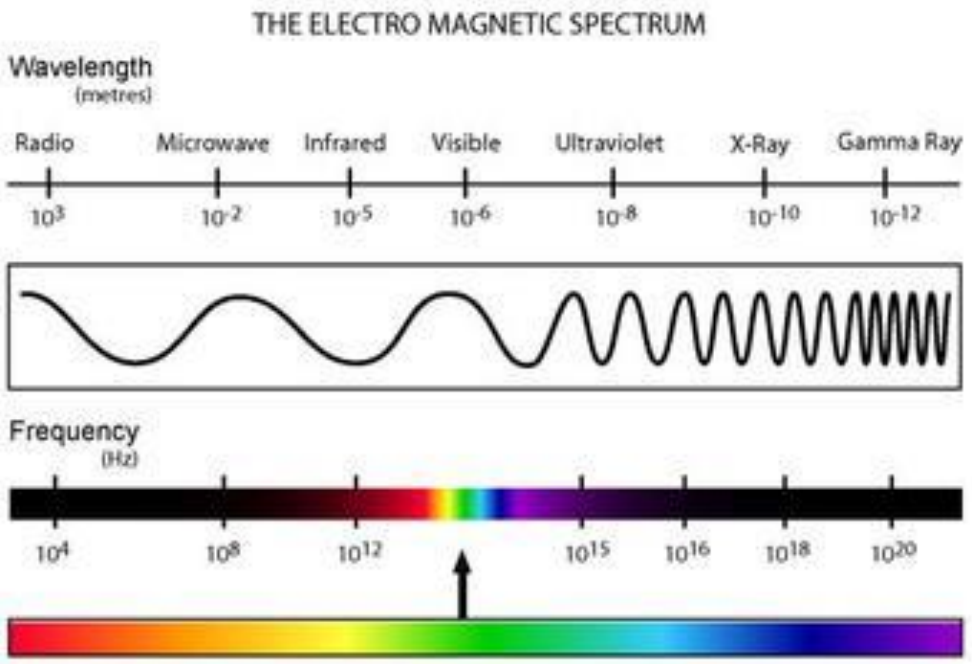
Now that we have looked at the Bohr model (which models the atom), we can look back and see how these models came into existence. We are going to look at light because the interaction of light with atoms helped to shape these models of the atom.

Light can behave as both a _____ and a _____.

Light as a Wave:
Light is an example of electromagnetic radiation.

Electromagnetic radiation: _____

_____



Each type of electromagnetic radiation has a specific wavelength and frequency.

Wavelength: _____

Draw a wave with a short wavelength vs. a wave with a long wavelength.

Frequency: _____

Wavelength and frequency are related and can be calculated using the following equation

Practice: Answer the following questions using the above equation.

1. A gamma ray has a wavelength of 1.8×10^{12} meters, what is the frequency?

2. A radio wave has a frequency of 10^4 Hz, what is the wavelength?

Light can also act as a particle:

Before the advent of quantum mechanics, light was described exclusively as a wave of electromagnetic energy traveling through space. However, Albert Einstein discovered that only some experiments could be explained by describing light as a particle!

Photon: _____

Photoelectric Effect: _____

_____

_____

_____

_____

Energy can be calculated using the following equation:

Practice: Answer the following questions using the above equation:

1. A microwave has a wavelength of 0.0245 m, what is the energy?

2. A gamma ray has a frequency of 9.4×10^{20} Hz; what is the energy?

Atomic Spectrum

Spectrum: _____

When an atom absorbs energy (in the form of heat, light, or electricity) it often re-emits that energy in the form of light. For example a neon sign is composed of one or more gas filled tubes filled with gaseous neon atoms. When an electrical current is passed through the tub, the neon atoms absorb some of the electrical energy and re-emit it as a familiar red light of a neon sign.

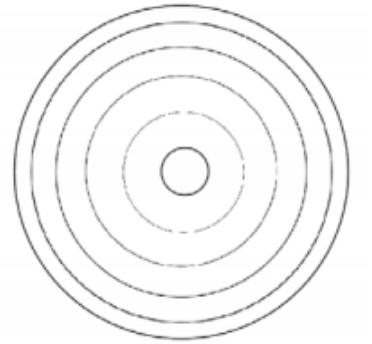
Atoms of a given element emit light of unique colors (or unique wavelengths) because when an atom absorbs energy an electron may become "excited" and move from the ground state to an excited state. *When the electron falls back down to the ground state from the excited state this emits a specific wavelength that is often visible to the naked eye.*

Practice: Answer the following questions about atomic spectrum.
In a hydrogen atom, the light emitted when an electron falls from the fourth energy level to the second energy level is 486 nm and the light emitted falls from the fifth energy level to the second energy level is 434 nm.

1. Determine the frequency of each of these wavelengths.

2. Determine the energy of each of these wavelengths.

3. Draw a diagram to show the transition-taking place. Label the energy of each transition.



4. What energy radiation would be emitted when an electron falls from the fifth energy level to the fourth energy level?

5. What is the frequency and wavelength of light emitted when an electron falls from the fifth energy level to the fourth energy level? Does this radiation fall into the visible range? (380nm-740 nm)

Bohr's model of the atom (in the notes previously) does a good job at explaining the spectra of smaller atoms (like H and He), but when the spectra of larger atoms are examined, they are found to be much more complex. This indicates that the orbitals are must more complex so a new theory called *quantum mechanics* was developed to further explain the structure of atoms.

Quantum Mechanics

In the Bohr model of the atom, a single quantum number (n) specifies each orbit. In the quantum-mechanical model, a number and a letter specify an orbital (or orbitals).

Principal Quantum Number has a symbol of *n.*

- The Quantum numbers give the main energy level of an orbital and indicate how close the orbital is to the nucleus.
- Higher values of n indicate farther/larger orbitals, which are higher in energy. The principle quantum number is written in front of the letter used to represent the orbital.

Angular Momentum Quantum Number has a symbol *l.*

The angular momentum gives the shape of the orbital. There are four different shapes of orbitals (s, p, d and f)

Magnetic Quantum Number has a symbol of m_l

- The magnetic quantum number gives the orientation of the orbital.
- The number of possible orientations for each type of orbital can be represented by an orbital diagram.
    - (s has 1 orientation, p has 3 orientations, d has 5 orientations, and f has 7 orientations.

Spin Quantum Number has a symbol of m_s

The spin quantum number gives the "spin" of an electron.

- Electrons can either have a spin of + ½ or – ½.
- Each orbital can hold two electrons or opposite spin. Arrows represent electrons: $\uparrow or \downarrow$ (up shows a positive spin and down shows a negative spin.

Type of Orbital	*l*	Orbital Diagram	Number of electrons	Orbitals

Orbital Notation:

1. **Aufbau Principal:** _____

   _____

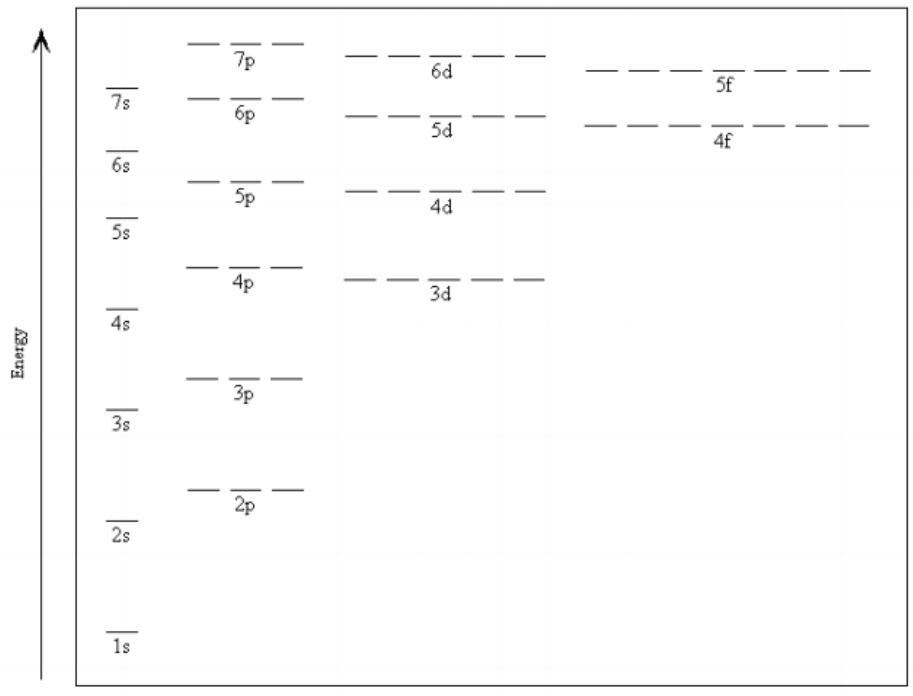
2. **Pauli Exclusion Principal:** _____

   _____

3. **Hund's Rule**: _____

   _____

Energy Level Diagram

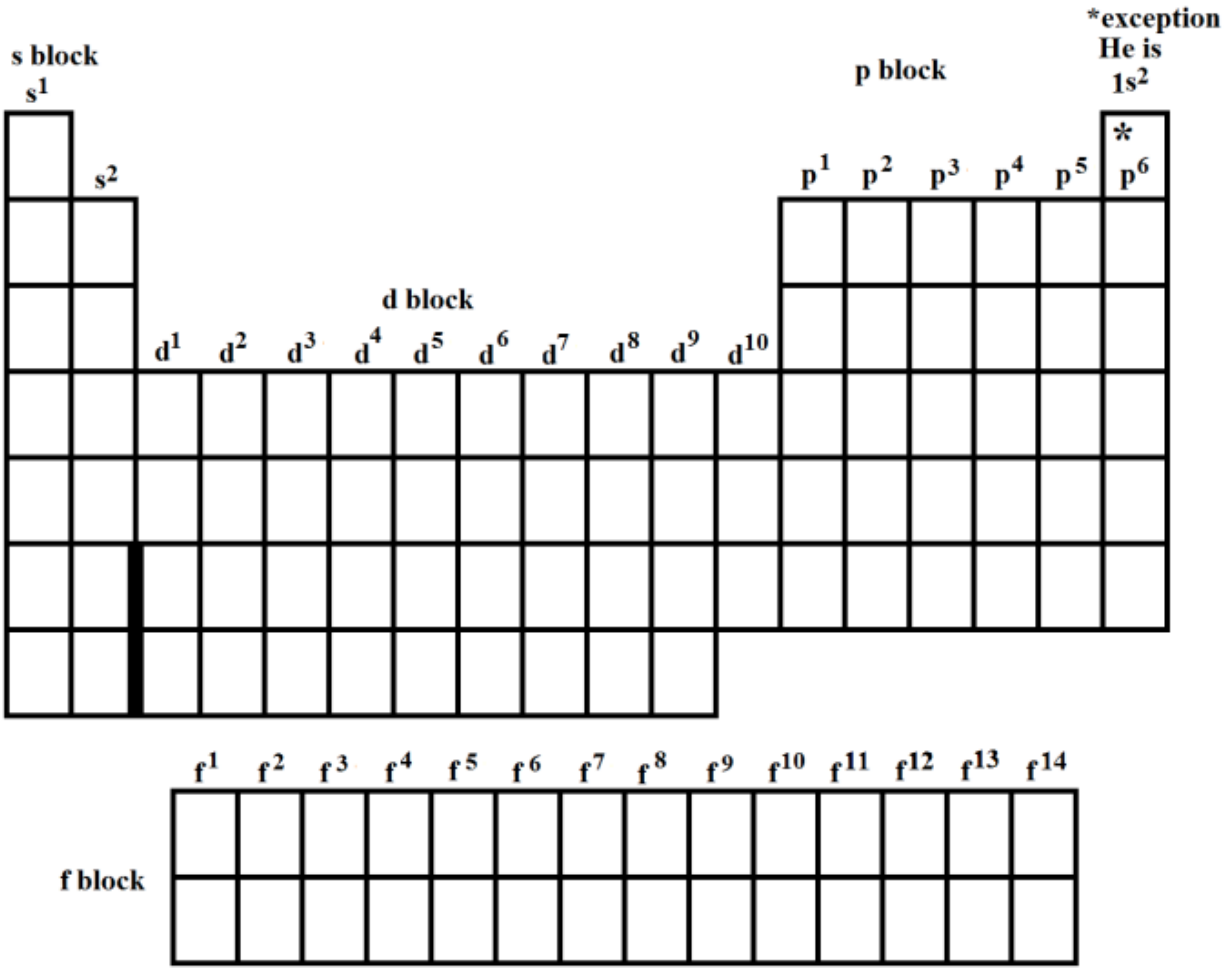


Electron Configuration:

Electron configurations are a written language that shows how the electrons are arranged in the orbitals and energy shells of the atom. The order of orbitals can be seen from the arrangement of elements on the periodic table. There are four blocks of elements: S block, P block, D block, and F block. The elements in each column end with a specific electron configuration.

The principal quantum number of the shells can be determined from the row number.

- S block and P block: the principle quantum number is equal to the row number
- D block: the principle quantum number is equal to the row number
- F block: the principle quantum number is two less than the row number.



Practice: Write the electron configuration for each of the following elements:

1. Ba
2. Sb
3. Pm
4. Nb

Excited States:

In an excited state, one or more electrons move to a higher energy orbital. There are many possible excited states for a given atom.

Example:

Exceptions to Electronic Configurations:

There are many elements that actually do not follow the expected order or orbital. The first two examples are Chromium and Copper.

Element	Expected Configuration	Actual Configuration
Cr	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^4$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$
Cu	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^9$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$

Noble Gas Notation:

Gives the noble gas that comes before the element and electrons that follow the noble gas.

Ex: Write the electron configuration for oxygen, and write the noble gas notation for oxygen.

Practice: Give the noble gas notation for the following elements.

1. Zr

2. Fr

Ions

Electrons are gained (anions) or lost (cations) to form a charged ion.

Practice: Write the electron configuration notation and the noble gas notation for the following ions.

1. N^{3-}

2. Ca^{2+}

SUMMARY:

	Bohr Diagram	**Orbital Notation**	**Electron Configuration**
How are electrons displayed?			
How are orbitals displayed?			
How are protons and neutrons displayed?			
What is unique?			