

# Atoms & The Periodic Table

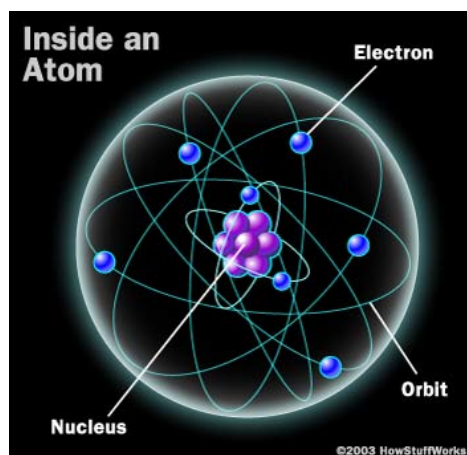
(Chapter 12)

**Student Learning Outcome:** Recall the defining properties of regular atoms and isotopes; recall and apply the trends in the periodic table; apply the Bohr model to the behavior of the atom.

1. *What are the defining properties of regular atoms and isotopes?*
2. *What are the basic trends and regions in the periodic table?*
3. *What are physical and conceptual models?*
4. *How do atoms emit and absorb light?*
5. *What does the shell model indicate?*
6. *What are the properties of valence electrons?*

*What are the defining properties of regular atoms and isotopes?*

- ❖ Atoms have a central core of protons and neutrons about which electrons orbit.



**Go To:** <http://www.pond5.com/stock-footage/68580/atom5.html>

**Question:** What keeps the electrons in orbit around the nucleus?

- ❖ All physical material and all chemical compounds are composed of atoms.
- ❖ An atom is mostly empty space.
- ❖ The break down of *any* atom yields the same three particles (protons, neutrons, and electrons).

### Questions:

1. Where is most of the mass in an atom?
2. What contributes most to the size of an atom?
3. What prevents the atoms of one object from passing through the atoms of another object?

❖ **All of one type of atom is classified as an element.**

❖ **What makes each atom, each element, unique is the number of protons.**

### Questions:

1. Why would it not be a good idea to classify elements according to how many electrons they have?
2. Where do you think most atoms are formed?

❖ A neutral, regular atom has the same number of protons, neutrons and electrons.

❖ **Isotopes** are atoms that have a different number of neutrons than protons in the core. Isotopes have a different mass than regular atoms.

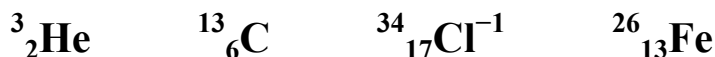
❖ Ions and isotopes maintain the same chemical identity as regular atoms.

❖ The **atomic number** in the periodic table is always equal to the number of protons one atom has.

❖ The **mass number** is the total number of particles in the nucleus. (neutrons + protons)

Example:  $^{17}_{8}\text{O}^{-2}$

**Question:** How many protons, and how many neutrons, does each contain? Is it an isotope or a regular atom? Is it an ion?



What are the basic trends in the periodic table?

❖ **Most of the elements in the periodic table are metals.**

- Metals are defined as materials that are shiny, opaque, and good conductors of electricity.
- A few of these metals are liquid at normal room temperatures.

**Question:** Which elements are liquid under normal atmospheric conditions?

❖ The periodic table organizes the elements in order of increasing atomic mass, starting a new **atomic period** as “the pattern” begins again. (rows)

❖ Each **atomic group** of the periodic table contains elements with similar physical and chemical properties. (columns)

- The “A” groups are called the main elements.
- The “B” groups are called the transition elements.

❖ An element is identified by its atomic number, symbol, and mass.

2	←	<b>Atomic number:</b> number of protons in one atom
He	←	<b>Atomic symbol:</b> abbreviation for the element name
4.00260	←	<b>Atomic mass:</b> average mass of one atom of the element

$$1 \text{ amu} = 1.661 \times 10^{-24} \text{ grams}$$

❖ In General...

- **Chemical reactivity** decreases L → R.
- **Radius** decreases along a period L → R.
- **Electronegativity** increases lower L → upper R. Measures how strongly atom will pull on shared electrons.
- **Ionization energy** increases as the atomic number increases. It becomes harder to lose electrons as the number protons increases.

❖ **The names of the groups:**

<i>Group</i>	<i>Name</i>	<i>Attributes</i>
IA	<b>Alkali metals</b>	Highly Reactive
IIA	<b>Alkali Earth metals</b>	
Middle	<b>Transition Metals</b>	High Melting Point
IIIA	<b>Metalloids</b>	Diagonal break between metals/ non-metals
VIA	<b>Chalcogens</b>	Ore Forming Elements
VIIA	<b>Halogen gases</b>	Salt Forming Elements
VIIA	<b>Noble gases</b>	No Reactivity



- Groups IA and IIA react with water and make it alkaline (slippery)
- Middle groups include **Lanthanides** (58-71) and **Actinides** (90-103).
  - Lanthanides tend to be found in geologic zones
  - Actinides are synthesized in labs (except Uranium)

**Questions:**

1. Which of the following would be most reactive?
  - a. Group IIIA elements
  - b. Group VIA elements
2. Where are the precious metals?
3. Use the periodic table to list the defining attributes of Bromine (Br).

*What are physical and conceptual models?*

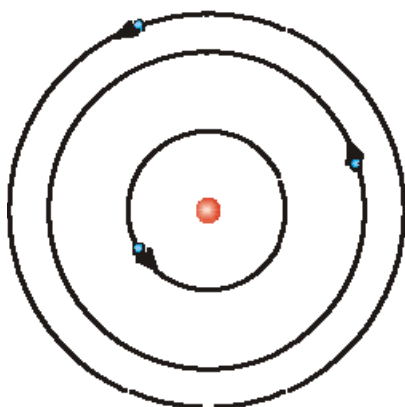
- ❖ A scientific model is a best representation of something we cannot see with our eyes.
- ❖ A **physical model** is a model we can see and touch that represents an object that is very large or very small.

-  Scale model of solar system
-  Model of a molecule

- ❖ A **conceptual model** is a description of what is expected based on what has been observed with particular systems.

- ✚ Weather
- ✚ Behavior of an atom

*How do atoms emit and absorb light?*



- ❖ Each atom has a specific pattern of allowed orbits, based on the number of protons it has.
  - Each pattern is different.
  - Each orbit has a specific energy associated with it.
  - The farther an electron is from the nucleus, the higher its energy level.

- ❖ The electron can never exist in areas between allowed orbits, between allowed energies.
- ❖ As long as an electron remains in a quantized orbit, it emits no radiation.
- ❖ Electrons **quantum jump** (make a discontinuous transition) from one allowed orbit to another changing the energy state of the atom.

**Go To:** <http://www.colorado.edu/physics/2000/quantumzone/bohr.html>

- ❖ **If the electron jumps to a higher energy orbit, the atom is in an excited state.** Energy is absorbed (collisions and photons)
  - An atom can only absorb a photon if the photon has the correct amount of energy for the electron to make an allowed jump.
- ❖ **When the electron jumps back to a lower energy orbit, the atom returns to a lower energy state.** Energy is emitted (photons)
- ❖ When all electrons in the atom occupy the lowest energy levels, the atom is in the **ground state**.

- ❖ Each element emits a distinctive glow comprised of a specific set of colored lines when excited, called an **atomic spectrum**.

**Go To:** <http://astro.u-strasbg.fr/~koppen/discharge/>  
<http://hyperphysics.phy-astr.gsu.edu/HBASE/quantum/atspect.html>

- ❖ Each type of atom has its own set of energy levels, its own allowed orbits, and emits its own specific wavelengths of photons.

*Carbon*

Main Energy Level	Energy in Joules
n = 1	$5.072 \times 10^{-19}$
n = 2	$5.070 \times 10^{-19}$
n = 3	$4.879 \times 10^{-19}$
n = 4	$4.877 \times 10^{-19}$

*What does the shell model indicate?*

- ❖ No two electrons can have the exact same energy state. This is the **Pauli Exclusion Principle**.
  - As a result, only a certain number of electrons can be in any one orbit.
- ❖ The shell model is a conceptual model of how many electrons we can expect to find in each main energy level.
  - This model shows what makes the periodic table periodic.
  - **This model allows us to predict chemical reactions.**
- ❖ The number of shells available in the ground state is equal to the period number in the periodic table.

Shell	Number e <sup>-</sup> Allowed
1	2
2	8
3	8
4	18
5	18
6	32
7	32

- ❖ There are additional shells, energy levels, available to an excited atom.

**Questions:** How many shells are available and how many electrons are in each shell? Assume each atom is in the ground state.

1. **N**      2. **Kr**      3. **Mg**      4. **O**

- ❖ Electrons attempt to have configurations that match those in group VIIIA which have octets of electrons. This is the **octet rule**.

$$\mathbf{8 - \text{unpaired electrons} = \text{Group Number}}$$

- ❖ The more unpaired electrons an atom has in the outermost shell, the more reactive it is.

*What are the properties of valence electrons?*

- ❖ **The electrons in the outermost shell of an atom are called valence electrons.**

- First to be lost or gained
- Shared in chemical bonds
- In highest energy orbit
- Determine how reactive an atom is

- ❖ Valence electrons are what make the physical and chemical properties of the atoms in a group similar.
- ❖ The group number on the periodic table indicates the number of unpaired valence electrons, the number of chemical bonds that can be formed.
- ❖ Each period begins with one electron in the outer most shell and ends with a full outer most shell.