Chemical Bonds:

Chemical bonding is one of the most basic fundamentals of chemistry that explains other concepts such as molecules and reactions.

Bond: A link or force between neighboring atoms in a molecule or compound.

Stability of atoms: Most atoms are considered stable (nonreactive) when their highest (outer) energy level is filled to eight (electrons). The noble gases-neon, argon, krypton, xenon, and radon-all have eight electrons in their highest energy level. They are stable. Atoms that do not have eight outer electrons may lose, gain, or share their valence electrons with other atoms in order to reach a more stable structure with lower chemical potential energy. This process of rearrangement of the valence electrons is responsible of chemical reactions between atoms.

Symbols and Formulas:

A symbol not only identifies an element but also represents one atom of that element. Thus, the symbol Cu designates the element copper and also indicates one atom of copper (two atoms of copper are designated as 2Cu). [2O, 2Cl….].

A formula consists of a group of symbols that represents the elements present in a substance. It also indicates one molecule of that substance. Thus, the formula NaCl indicates that the compound (sodium chloride) consists of one atom of sodium (Na) and one atom of chlorine (Cl). In the compound HNO_3 (nitric acid) there is one atom of hydrogen (H), one atom of nitrogen (N), and three atoms of oxygen (3O).

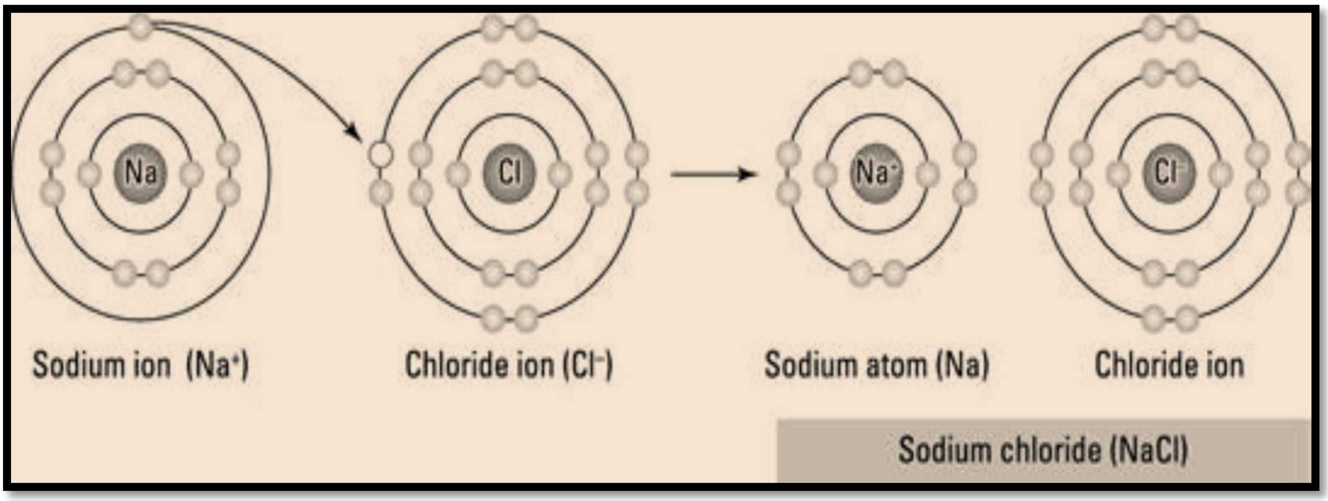
Chemical Bonds can be divided into:

*1- **ionic bonds :**

Some atoms become more stable by gaining or losing an entire electron (or several electrons) can give an atom a filled outermost electron shell and make it energetically more stable.

Forming ions:

Ions come in two types: **Cations** are positive ions formed by losing electrons. For instance, a sodium atom loses an electron to become a sodium cation Na^+. Negative ions are formed by electron gain and are called **anions**. Anions are named using the ending "-ide": for example, the anion of chlorine (Cl^-)is called chloride.



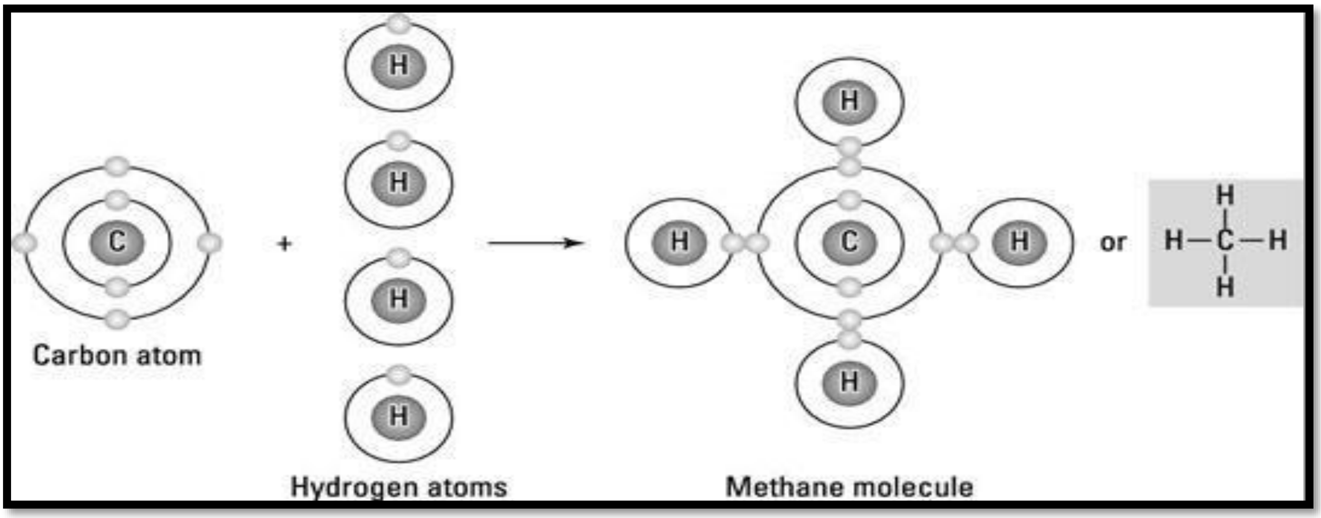
 Results from reaction between Metal and Nonmetal

 Metal loses electrons to form cation, Nonmetal gains electrons to form anion.

 Ionic bond is the attraction between a positive ion and negative ion.

*2- **Covalent bond**

The most common bond in organic molecules, a **covalent bond** involves the sharing of electrons between two atoms. The pair of shared electrons forms a new orbit that extends around the nuclei of both atoms, producing a molecule.



Oxidation number: also called **Oxidation State**, the total number of electrons that an atom either gains or losses in order to form a chemical bond with another atom.

1.**(Ionic bond):** The oxidation number of simple ions is equal to the charge on the ion. The oxidation number of sodium in the Na^+ ion is +1, for example, and the oxidation number of chlorine in the Cl^- ion is -1.

2.(**Covalent bond**): where electrons are shared and not transferred, oxidation numbers are assigned to elements using the following rules.

1- The oxidation number of **hydrogen is +1** when it is combined with a nonmetal as in CH_4, NH_3, H_2O, and HCl.

2- The oxidation number of **hydrogen is -1** when it is combined with a metal as in. LiH, NaH, CaH_2, and $LiAlH_4$.

3- Oxygen usually has an oxidation number of -2. Exceptions include molecules and polyatomic ions that contain O-O bonds, such as O2, O3, H2O2, and the $O2^{2-}$ ion.

4- The sum of the oxidation numbers in a neutral compound is zero.

H_2O: 2(+1) + (-2) = 0

Table 2-2 indicates the oxidation numbers of various elements.

Name	**Symbol**	**Oxidation number**
Hydrogen	H^{+}	+1
Sodium	Na^{+}	+1
Potassium	K^{+}	+1
Silver	Ag^{+}	+1
Calcium	Ca^{2+}	+2
Magnesium	Mg^{2+}	+2
Aluminum	Al^{3+}	+3
Ammonium	NH_4^{+}	+1
Iron	Fe^{2+} and Fe^{3+}	+2 and +3
Copper	Cu^{+} and Cu^{2+}	+1 and +2
Tin	Sn^{2+} and Sn^{4+}	+2 and +4
Chloride	Cl^{-}	-1
Bromide	Br^{-}	-1
Iodide	I^{-}	-1
Sulfide	S^{2-}	-2
Oxide	O^{2-}	-2

***3-Hydrogen bonding**: In 1920, Latimer and Rodebush introduce the idea of Hydroger Bond to explain the nature of association in liquid state of substance like water hydrogen fluoride, ammonia,and formic acid,etc.

DEFINITION An electrostatic attractive force between the covalent bonded H- atom of one molecule and an electronegative atom (such as F,O,N) of other molecule

usually a hydrogen bond is represented by: Dotted lines(----)

Covalent bond is represented by: SOLID LINE(______)

• Hydrogen bond is weaker as compare to a covalent bond.

• H bond energy is only 2-10 kcal/mol, as compared to the covalent bond energy of 50-100 kcal/mol but it is grater than vander waals attraction which is <1kcal/mole.

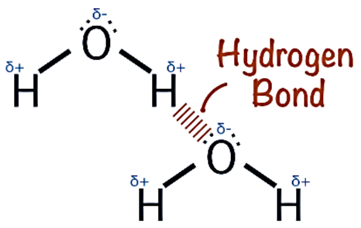
CONDITIONS FOR H-BONDING

• Hydrogen Atom Should Be Linked To A Highly Electronegative Atoms Such As F,O,N.

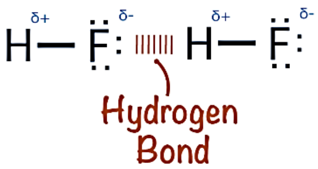
• The size of electronegative atom should be small.

There are Two Types of hydrogen bonding:

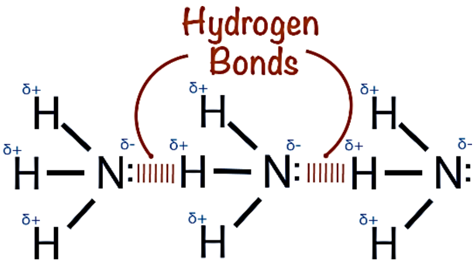
1- INTERMOLECULAR H BONDING: This type of bonding is between two or more same or different molecules when combine together to form a dimer or polymer respectively and leads to a phenomenon called association.



H_2O (water)



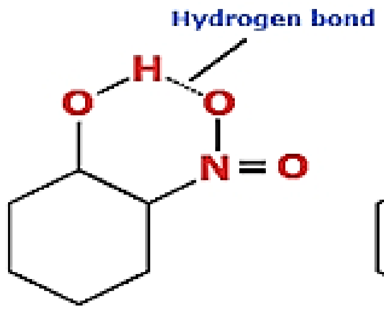
HF (hydrogen flouride)



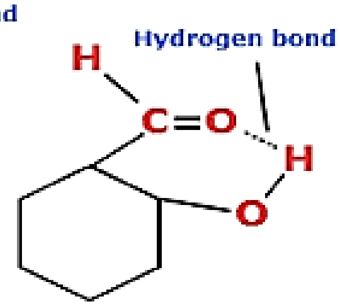
NH_3 (ammonia)

Intermolecular H bonding increase the boiling points of the compound and also its solubility in water

2- INTRAMOLECULAR H-BONDING: This type of bonding occurs within two atoms of the same molecule and leads to a phenomenon called Chelation. This type of hydrogen binding frequently occurs in organic compound and result in the Cyclisation (six or five member ring) of the molecule and is weaker than intermolecular H-bonding



Ortho-Nitro phenol



Salicilaldehyde

APPLICATION OF HYDROGEN BONDING

1. MELTING POINT & BOILING POINT : Intermolecular Hydrogen bonding resulting in the association of molecule raises MP & BP & decreased in intramolecular H- bonding. Example:-
   $H_2O > H_2S$
   R-OH>R-SH
   ALCOHOL> ALDEHYDE OR KETONE

2. SOLUBILITY OF WATER :- COMPOUNDS WHOSE MOLECULE CAN FORM HYDROGEN BOND WITH WATER MOLECULE ARE SOLUBLE IN WATER. Intermolecular hydrogen bonding increases solubility of the compound in water intramolecular hydrogen bonding decrease.
3. SPECTRAL PROPERTY :- Hydrogen bonding shifts the positions of bands (peaks) in Ultraviolet (UV), Infrared (IR) and H_1NMR Spectra.
4. H-bonding In Paints Dyes & Textile Material
5. H-bonding In Clothing Material: - it makes them rigid and creates tensile strength.
   6.Cleaning Action Of Soaps And Detergent
6. H Bonding In Carbohydrate
7. H Bonding In DNA(single Or Double Helix):

4-Van der Waals forces: include attraction and repulsions between atoms, molecules, as well as other intermolecular forces. They differ from covalent and ionic bonding in that they are caused by correlations in the fluctuating polarizations of nearby particles.

***5-Metallic bonding** is a type of chemical bonding that arises from the electrostatic attractive force between conduction electrons (in the form of an electron cloud of delocalized electrons) and positively charged metal ions. It may be described as the sharing of *free* electrons among a structure of positively charged ions (cations). Metallic bonding accounts for many physical properties of metals, such as strength, ductility, thermal and electrical resistivity and conductivity, opacity, and lustre

Lec1

Chemistry: is the science that study the matter and the ways in which different forms of matter combine with each other. You study chemistry because it helps you to understand the world around you. Everything you touch or taste or smell is a chemical, and the interactions of these chemicals with each other define our universe. Chemistry forms the fundamental basis for biology and medicine. From the structure of proteins and nucleic acids, to the design, synthesis and manufacture of drugs

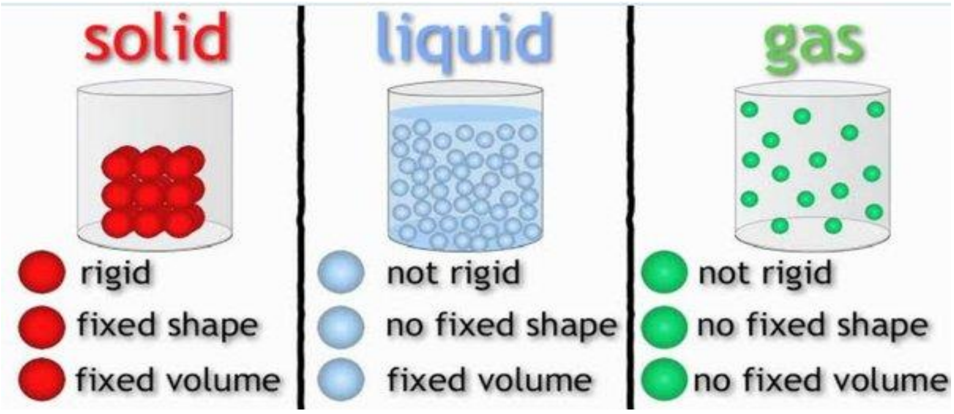
Matter:

Matter is any substance which has mass and occupies space. States of Matter are solid, liquid, and gas.

-A solid has a definite volume, and maintains its shape regardless of the container in which it is placed. The particles of a solid lie close together, and are arranged in a regular three- dimensional array

-A liquid has a definite volume, but takes on the shape of the container it occupies. The particles of a liquid are close together, but they can randomly move around, sliding past one another.

-A gas has no definite shape or volume. The particles of a gas move randomly and are separated by a distance much larger than their size. The particles of a gas expand to fill the volume and assume the shape of whatever container they are put in.



Matter is characterized by its physical properties and chemical properties.

Physical properties are those that can be observed or measured without changing the composition of the material.

chemical properties are those that can be observed or measured with changing the composition of the material.

All matter can be classified as either a pure substance or a mixture.

A pure substance, can be characterized by its physical properties, because these properties do not change from sample to sample. A pure substance cannot be broken down to other pure substances by any physical change.

A mixture is composed of more than one component. The composition of a mixture can vary depending on the sample.

Mixtures are classified into two types.

- **A heterogeneous mixture**: is a mixture that consists of physically distinct parts, each with different properties. example is salt and sugar that have been stirred together. If you were to look closely, you would see the separate crystals of sugar and salt.

- **A homogeneous mixture** (also known as a solution): is a mixture that is uniform in its properties throughout given samples. When sodium chloride is dissolved in water, you obtain a homogeneous mixture, or solution. Air is a gaseous solution, principally of two elementary substances, nitrogen and oxygen, which are physically mixed but not chemically combined.

Measurement:

▪ The Metric System

Name	The Number	Prefix	Symbol
trillion	1,000,000,000,000	tera	T
billion	1,000,000,000	giga	G
million	1,000,000	mega	M
thousand	1,000	kilo	k
hundred	100	hecto	h
ten	10	deka	da
unit	**1**		
tenth	0.1	deci	d
hundredth	0.01	centi	c
thousandth	0.001	milli	m
millionth	0.000 001	micro	µ
billionth	0.000 000 001	nano	n
trillionth	0.000 000 000 001	pico	p

-**Measuring Mass** Although the terms **mass and weight** are often used interchangeably, they really have different meanings.

-**Temperature**: is a measure of how hot or cold an object is. Three temperature scales are used: Fahrenheit (most common in the United States), Celsius (most commonly used by scientists and countries other than the United States), and Kelvin The Fahrenheit and Celsius scales are both divided into degrees. On the Fahrenheit scale, water freezes at 32 °F and boils at 212 °F. On the Celsius scale, water freezes at 0 °C and boils at 100 °C. General chemistry Lecture 1 To convert temperature values from one scale to another, we use two equations, where °C is the Celsius temperature and °F is the Fahrenheit temperature.

Celsius To Fahrenheit

$$F = \frac{9}{5}C + 32$$

Fahrenheit To Celsius

$$C = \frac{5}{9}(F - 32)$$

Celsius to kelvin

$$K = °C + 273.15$$

Kelvin to Celsius

$$°C = K - 273.15$$

-Density is a physical property that relates the mass of a substance to its volume. Density is reported in grams per milliliter (g/mL) or grams per cubic centimeter (g/cm^3) or (kg/m^3). Density is the ratio of mass to volume.

Density(ρ) = mass (m)/ volume (V)

-Specific gravity: is a quantity that compares the density of a substance with the density of water at the same temperature

$$SG = \rho / \rho H_2O$$

SG = specific gravity
ρ = density of fluid or substance (kg/m^3)
ρH_2O = density of water (kg/m^3)

Atom: is the smallest unit of ordinary matter that forms a chemical element. Every solid, liquid, gas, and plasma is composed of neutral or ionized atoms.

Element: is a pure substance which cannot be broken down by chemical means, consisting of atoms which have identical numbers of protons in their atomic nuclei. The number of protons in the nucleus is the defining property of an element, and is referred to as the atomic number (represented by the symbol Z).

Ex.

- A piece of iron is made up of many atoms of iron.
- A piece of copper is made up of many atoms of copper.
- A piece of silver is made up of many atoms of silver.

The atoms of one element differ from those of another and so, give characteristic properties of each element.

Size: An atom has a diameter of approximately (1/ 100, 000,000) cm.

The number atoms in gram-atom is 6.0235×10^{23} (Avogadro number)

Weight: An atom weights very little.

An **atom** itself is made up of **three tiny kinds of particles called subatomic particles: protons, neutrons, and electrons.** The protons and the neutrons make up the center of the atom called the nucleus and the electrons fly around above the nucleus in a small cloud. The electrons carry a negative charge and the protons carry a positive charge. In a normal (neutral) atom the number of protons and the number of electrons are equal.

Table (1-1) show the types of fundamental particles of atom.

particle	Symbol & charge	Weight amu	Location
Protons	p or p^+	1	Inside nucleus
Electrons	e or e^-	1/837	Outside nucleus
Neutrons	n or n^0	1	Inside nucleus

Atomic weight: The relative weight of an atom, it is the average mass of atoms of an element, calculated using the relative abundance of isotopes in a naturally-occurring element.

Hydrogen=12 Carbon=12 oxygen=16

Atomic number: the number of a chemical element in the periodic system, is the number of protons are in an atom whereby the elements are arranged in order of increasing number of protons in the nucleus. Accordingly, the number of protons, which is always equal to the number of electrons in the neutral atom, is also the atomic number. An atom of iron has 26 protons in its nucleus; therefore, the atomic number of iron is 26.

Mass number is defined as the total number of protons and neutrons in an atom The mass number of a nucleus is equal to the total number of protons and neutrons in that nucleus.

To calculate the number of neutrons in the nucleus of an atom is simple. proton number of the element, and you subtract it from the element's mass number. For example, take the isotope of copper, Cu-63. It contains 29 protons and has a mass number of 63, For example, take the isotope of copper, Cu-63. It contains 29 protons and has a mass number of 63. Therefore, Cu-63 contains 29 protons, and 46 neutrons.

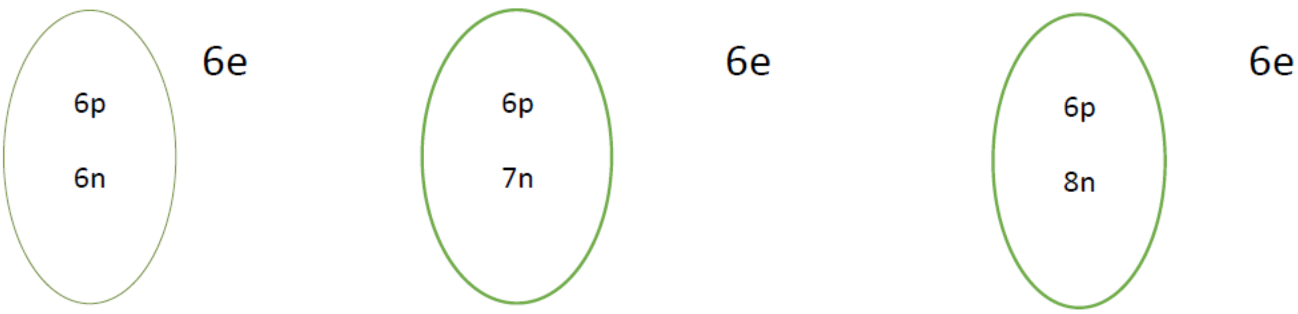
Mass number = no. of protons + no. of neutrons

Isotopes

Atoms of an element having the same atomic number but different mass number.

The first isotope of chlorine **(Cl^-)** atomic number 17 and mass number 35-has 17 protons in its nucleus, 17 electrons outside its nucleus, and 18 neutrons (35-17) in its nucleus. The second isotope of chlorine-atomic number 17 and mass number 37-has 17 protons in its nucleus, 17 electrons outside its nucleus, and 20 neutrons (37-17) in its nucleus.

The element carbon-atomic number 6 has three isotopes. Their mass number are:



In general, isotopes have identical chemical properties because they contain the same number of electrons as well as protons. However, isotopes have different physical properties.

Radioactivity:

Is the property of emitting radiation from the nucleus of an atom

The three types of radiation are alpha (α), beta (β electrons), and gamma (Electromagnetic Radiation or neutrons .)

Radioisotopes:

The isotopes produced artificially by bombardment with one of the various particles (radioactive isotopes or radioisotopes). Some radioisotopes used in medicine and in biochemistry.

Iodine =131:

This isotopes is used in the diagnosis and treatment of thyroid conditions.

Technetium = 99:

is one of the most widely used radioisotopes for various types of scans.

Cobalt = 60:

This radioisotopes is employed in the treatment of many different types of cancer.

Periodic Table of the Elements Notes

- Arrangement of the known elements **based on** atomic number and chemical and physical properties.
- Divided into three basic categories:
    - Metals (left side of the table)
    - Nonmetals (right side of the table)
    - Metalloids (touching the zig zag line)

Basic Organization by:

- Atomic structure
- Atomic number
- Chemical and Physical Properties

Uses of the Periodic Table

Useful in predicting:

- chemical behavior of the elements
- trends
- properties of the elements

Atomic Structure Review:

- Atoms are made of protons, electrons, and neutrons.
- Elements are atoms of only one type.
- Elements are identified by the atomic number (# of protons in nucleus).

Energy Levels Review:

- Electrons are arranged in a region around the nucleus called an electron cloud. Energy levels are located within the cloud.

- At least 1 energy level and as many as 7 energy levels exist in atoms

Energy Levels & Valence Electrons

- Energy levels hold a specific amount of electrons:

    - 1st level = up to 2
    - 2nd level = up to 8
    - 3rd level = up to 8 (first 18 elements only)

- The electrons in the outermost level are called valence electrons.

    - Determine reactivity - how elements will react with others to form compounds
    - Outermost level does not usually fill completely with electrons

Using the Table to Identify Valence Electrons

- Elements are grouped into vertical columns because they have similar properties.
- These are called groups or families.
- Groups are numbered 1-18.

- **Group numbers** can help you determine the number of valence electrons:
  - Group 1 has 1 valence electron.
  - Group 2 has 2 valence electrons.
  - Groups 3–12 are transition metals and have 1 or 2 valence electrons.
  - Groups 13–18 have **10 fewer than the group number**. For example:
  - Group 1**3** has **3** valence electrons.
  - Group 1**5** has **5** valence electrons.
  - Group 1**8** has **8** valence electrons (except He)

Elements & Reactivity

- Reactivity is a chemical property that determines how elements will react with others to form compounds.

- **What makes an element reactive?**
  - Number of valence electrons of each atom
  - When outer levels are full, atoms are stable.
  - When they are not full, they react:
    - gain, lose, or share 1 or 2 electrons

- The **most reactive metals** are the elements in Groups 1 and 2.

  - Elements in Group 1 generally lose an electron so their outer energy level is empty.
  - Elements in Group 2 generally lose two electrons so their outer energy level is empty.

- These groups **easily give up** their valence electrons to make a compound.

- The **most reactive nonmetals** are the elements in Groups 16 and 17.

  - Elements in Group 16 need two more electrons to fill their outer energy level.
  - Elements in Group 17 need one more electron to fill their outer energy level.

- These groups gain valence electrons to make a compound.

Groups

- Groups run vertically in the periodic table.
- They are numbered from 1–18.
- Elements in the same groups have the same number of valence electrons in the outer energy level.
- Grouped elements behave chemically in similar ways.

Group 1: Alkali Metals

- Contains: Metals
- Valence Electrons: 1
- Reactivity: Very Reactive – most reactive group on the Periodic Table
- Properties:
  - solids
  - soft
  - react violently with water
  - shiny
  - low density

Group 2: Alkaline-Earth Metals

- Contains: Metals
- Valence Electrons: 2
- Reactivity: very reactive, but less reactive than alkali metals (Group 1)
- Properties:
  - Solids
  - Silver colored
  - More dense than alkali metals

Groups 3-12 Transition Metals

- Contain: Metals
- Valence electrons: 1 or 2
- Reactivity: less reactive than alkali and alkaline-earth metals
- Properties:
  - Higher density
  - Good conductors of heat and electricity

Groups 3-12 Transition Metals--Below Main Table

- Contain: The Lanthanide and Actinide Series
  - These two rows are pulled out of sequence and placed below the main table to keep the table from being too wide.
  - Lanthanides are atomic numbers 57–70.
  - Actinides are atomic numbers 89–102.

Groups 3-12 Rare Earth Elements ~ Lanthanides

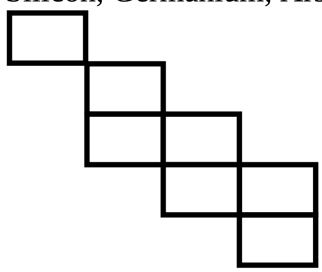
- Lanthanides follow the transition metal atomic number 57 Lanthanum in Period 6.
- Valence electrons: 3
- Reactivity: Very reactive
- Properties:
  - High luster, but tarnish easily
  - High conductivity for electricity
  - Very small differences between them

Groups 3-12 Rare Earth Elements ~ Actinides

- Actinides follow the transition metal atomic number 89 Actinium in Period 7
- Valence electrons: 3 (but up to 6)
- Reactivity: unstable
  - All are radioactive
  - Most made in laboratories

Metalloids

- A zig-zag line that separates metals from metalloids
- Elements from Groups 13–16 contain some metalloids.
- Metalloids are Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium and Polonium



- These elements have characteristics of metals and nonmetals.

Group 13: Boron Group

- Group 13: Boron Group
- Contains: 1 metalloid and 4 metals
- Valence Electrons: 3
- Reactivity: Reactive
- Other shared properties:
  - Solid at room temperature

Group 14: Carbon Group

- Contains: 1 non-metal, 2 metalloids, and 2 metals
- Valence Electrons: 4
- Reactivity: Varies
- Other shared properties:
  - Solid at room temperature

Group 15: Nitrogen Group

- Contains: 2 non-metals, 2 metalloids, and 1 metal
- Valence electrons: 5
- Reactivity: Varies
- Other shared properties:
  - All but N are solid at room temperature

Group 16: Oxygen Group

- Contains: 3 non-metals, 2 metalloids
- Valence Electrons: 6
- Reactivity: Reactive
- Other shared properties:
    - All but O are solid at room temperature.

Groups 17: Halogens

- Contain: Nonmetals
- Valence Electrons: 7
- Reactivity: Very reactive
- Other shared properties
    - Poor conductors of electric current
    - React violently with alkali metals to form salts
    - Never found uncombined in nature

Group 18 Noble Gases

- Contains: Nonmetals
- Valence Electrons: 8 (2 for He)
- Reactivity: Nonreactive (least reactive group)
- Other shared properties:
    - Colorless, odorless gases at room temperature
    - Outermost energy level full
    - All found in atmosphere

Hydrogen Stands Apart

- H is set apart because its properties do not match any single group.
- Valence electrons: 1
- Reactivity: very, but loses the 1 electron easily
- Properties:
    - Similar to those of non-metals rather than metals

Periods

- Periods run horizontally across the Periodic Table
- Periods are numbered 1–7
- All the elements in a period will have the same number of energy levels, which contain electrons. Examples:
    - Period 1 atoms have 1 energy level.
    - Period 2 atoms have 2 energy levels.
    - Period 5 atoms have 5 energy levels.