

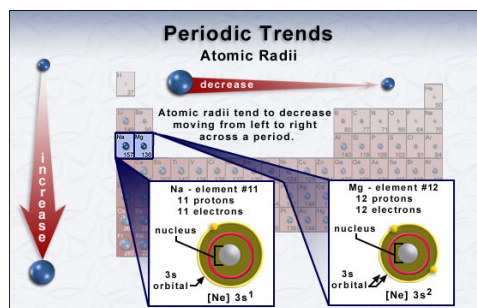
Periodic Properties of Elements

Trends in the Periodic Table

The properties of the elements exhibit trends. These trends can be predicted using the periodic table and can be explained and understood by analyzing the electron configurations of the elements. Elements tend to gain or lose valence electrons to achieve stable octet formation. Stable octets are seen in the inert gases, or noble gases, of Group VII of the periodic table. In addition to this activity, there are two other important trends. First, electrons are added one at a time moving from left to right across a period. As this happens, the electrons of the outermost shell experience increasingly strong nuclear attraction, so the electrons become closer to the nucleus and more tightly bound to it. Second, moving down a column in the periodic table, the outermost electrons become less tightly bound to the nucleus. This happens because the number of filled principal energy levels (which shield the outermost electrons from attraction to the nucleus) increases downward within each group. These trends explain the periodicity observed in the elemental properties of atomic radius, ionization energy, electron affinity, and electronegativity.

Atomic Radius

The atomic radius of an element is half of the distance between the centers of two atoms of that element that are just touching each other. Generally, the atomic radius decreases across a period from left to right and increases down a given group. The atoms with the largest atomic radii are located in Group I and at the bottom of groups.



Moving from left to right across a period, electrons are added one at a time to the outer energy shell. Electrons within a shell cannot shield each other from the attraction to protons. Since the number of protons is also increasing, the effective nuclear charge increases across a period. This causes the atomic radius to decrease.

Element Types - Chemistry of Groups

Part 1: Metals

Location on the Periodic Table

Metals are located on the left side and the middle of the periodic table. Group IA and Group IIA (the [alkali metals](#)) are the most active metals. The [transition elements](#), groups IB to VIIIB, are also considered metals.

Properties

Metals are shiny solids at room temperature (except mercury), with characteristic high melting points and densities. Many of the properties of metals, including large atomic radius, low ionization energy, and low electronegativity, are due to the fact that the electrons in the valence shell of a metal atom can be removed easily. One characteristic of metals is their ability to be deformed without breaking. Malleability is the ability of a metal to be hammered into shapes. Ductility is the ability of a metal to be drawn into wire. Because the valence electrons can move freely, metals are good heat conductors and electrical conductors.

Summary of Common Properties

- Shiny 'metallic' appearance
- Solids at room temperature (except mercury)
- High melting points
- High densities
- Large atomic radii
- Low ionization energies
- Low electronegativities
- Usually, high deformation
- Malleable
- Ductile
- Thermal conductors
- Electrical conductors

Element Types - Chemistry of Groups

Part 2: Nonmetals

Location on the Periodic Table

The nonmetals are located on the upper right side of the periodic table. Nonmetals are separated from [metals](#) by a line that cuts diagonally through the region of the periodic table containing elements with partially filled p orbitals.

Properties

Nonmetals have high ionization energies and electronegativities. They are generally poor conductors of heat and electricity. Solid nonmetals are generally brittle, with little or no metallic luster. Most nonmetals have the ability to gain electrons easily. Nonmetals display a wide range of chemical properties and reactivities.

Summary of Common Properties

- High ionization energies
- High electronegativities
- Poor thermal conductors
- Poor electrical conductors
- Brittle solids
- Little or no metallic luster
- Gain electrons easily

Element Types - Chemistry of Groups

Part 3: Metalloids or Semimetals

Location on the Periodic Table

The metalloids or semimetals are located along the line between the [metals](#) and [nonmetals](#) in the periodic table. The metalloids are boron, silicon, germanium, arsenic, antimony, and tellurium. Polonium is often considered a metalloid, too.

Properties

The electronegativities and ionization energies of the metalloids are between those of the metals and nonmetals, so the metalloids exhibit characteristics of both classes. Silicon, for example, possesses a metallic luster, yet it is an inefficient conductor and is brittle. The reactivity of the metalloids depends on the element with which they are reacting. For example, boron acts as a nonmetal when reacting with sodium yet as a metal when reacting with fluorine. The boiling points, melting points, and densities of the metalloids vary widely. The intermediate conductivity of metalloids means they tend to make good semiconductors.

Summary of Common Properties

- Electronegativities between those of metals and nonmetals
- Ionization energies between those of metals and nonmetals
- Possess some characteristics of metals/some of nonmetals
- Reactivity depends on properties of other elements in reaction
- Often make good semiconductors

Element Types - Chemistry of Groups

Part 4: Alkali Metals

Location on the Periodic Table

The alkali metals are the elements located in Group IA of the periodic table.

Properties

The alkali metals exhibit many of the physical properties common to [metals](#), although their densities are lower than those of other metals. Alkali metals have one electron in their outer shell, which is loosely bound. This gives them the largest atomic radii of the elements in their respective periods. Their low ionization energies result in their metallic properties and high reactivities. An alkali metal can easily lose its valence electron to form the univalent cation. Alkali metals have low electronegativities. They react readily with nonmetals, particularly halogens.

Summary of Common Properties

- Lower densities than other metals
- One loosely bound valence electron
- Largest atomic radii in their periods
- Low ionization energies
- Low electronegativities
- Highly reactive

Element Types - Chemistry of Groups

Part 5: Alkaline Earths

Location on the Periodic Table

The alkaline earths are the elements located in Group IIA of the periodic table.

Properties

The alkaline earths possess many of the characteristic properties of [metals](#). Alkaline earths have low electron affinities and low electronegativities. As with the [alkali metals](#), the properties depend on the ease with which electrons are lost. The alkaline earths have two electrons in the outer shell. They have smaller atomic radii than the alkali metals. The two valence electrons are not tightly bound to the nucleus, so the alkaline earths readily lose the electrons to form divalent cations.

Summary of Common Properties

- Two electrons in the outer shell
- Low electron affinities
- Low electronegativities
- Readily form divalent cations.

Element Types - Chemistry of Groups

Part 6: Halogens

Location on the Periodic Table

The halogens are located in Group VIIA of the periodic table, and are a particular class of [nonmetals](#).

Properties

These reactive nonmetals have seven valence electrons. As a group, halogens exhibit highly variable physical properties. Halogens range from solid (I_2) to liquid (Br_2) to gaseous (F_2 and Cl_2) at room temperature. The chemical properties are more uniform. The halogens have very high electronegativities. [Fluorine](#) has the highest electronegativity of all elements. The halogens are particularly reactive with the [alkali metals](#) and [alkaline earths](#), forming stable ionic crystals.

Summary of Common Properties

- Very high electronegativities
- Seven valence electrons (one short of a stable octet)
- Highly reactive, especially with alkali metals and alkaline earths

Element Types - Chemistry of Groups

Part 7: Noble Gases

Location on the Periodic Table

The noble gases, also known as the inert gases, are located in Group VIII of the periodic table. Group VIII is sometimes called Group 0.

Properties

The noble gases are relatively nonreactive. This is because they have a complete valence shell. They have little tendency to gain or lose electrons. The noble gases have high ionization energies and negligible electronegativities. The noble gases have low boiling points and are all gases at room temperature.

Summary of Common Properties

- Fairly nonreactive
- Complete valence shell
- High ionization energies
- Very low electronegativities
- Low boiling points (all gases at room temperature)

Element Types - Chemistry of Groups

Part 8: Transition Elements

Location on the Periodic Table

The transition elements are located in groups IB to VIII B of the periodic table.

Properties

Because they possess the properties of [metals](#), the transition elements are also known as the transition metals. These elements are very hard, with high melting points and boiling points. Moving from left to right across the periodic table, the five *d* orbitals become more filled. The *d* electrons are loosely bound, which contributes to the high electrical conductivity and malleability of the transition elements. The transition elements have low ionization energies. They exhibit a wide range of [oxidation states](#) or positively charged forms. The positive oxidation states allow transition elements to form many different ionic and partially ionic compounds. The formation of complexes causes the *d* orbitals to split into two energy sublevels, which enables many of the complexes to absorb specific frequencies of light. Thus, the complexes form characteristic colored solutions and compounds. Complexation reactions sometimes enhance the relatively low solubility of some compounds.

Summary of Common Properties

- Low ionization energies
- Positive oxidation states
- Very hard
- High melting points
- High boiling points
- High electrical conductivity
- Malleable
- Five *d* orbitals become more filled, from left to right on periodic table