Chapter 8- Introducing the Periodic Table

8.1- Development of the Periodic Table

How did early scientists attempt to organize the elements?

Early scientists organized the elements according to their observable properties:

- Ancient Greeks proposed that all matter was composed of only four elements: earth, water, air, and fire.
- Lavoisier (1700s) made of list of 33 elements. He made a distinction between metals and nonmetals.
- Dobereiner (1817) proposed the Law of Triads. These triads were the first **groups**; each included three elements similar in appearance and reactivity.
- Berzelius (1828) proposed symbols for the elements based on their Latin names.
- Newlands (1863-64) arranged the known elements in order of increasing atomic mass along rows. The rows were seven elements long, and he believed elements that fit in the eighth spot would be discovered. This was the first arrangement by **period**.

How and why did Mendeleev organize the elements the way he did?

Mendeleev took a risk and organized the 63 known elements differently:

- **Mendeleev** proposed a table based on **periodicity** of the known elements. He arranged the elements in order of increasing atomic mass.
- Mendeleev observed repeating patterns in physical and chemical properties of the elements.
- Mendeleev also left gaps in his table where he believed new, undiscovered elements would fit.
- Mendeleev's table emphasized the predictability of elements' properties.

Other scientists built on Mendeleev's work to refine the periodic table:

- Meyer (1869) developed a table similar to the one developed by Mendeleev, but he did not allow for undiscovered elements.
- Ramsay (1894) discovered the inert (noble) gases as Newlands predicted.
- Research by Rutherford (1900) showed that atomic structure relates to the periodicity of elements.
- Moseley (1913-14) determined the atomic number of each **element**. This showed that the elements should be ordered by atomic number, not atomic mass, on the periodic table.
- Lewis (1916) proposed valence bond theory.
- A team led by Seaborg (1940) synthesized nine of the Period 7 elements in the periodic table.

8.2- Structure of the Periodic Table

How do scientists distinguish between metals, metalloids, and nonmetals?

Scientists distinguish between **metals**, **metalloids**, and **nonmetals** based on their chemical and physical properties.

- Metals are located on the left-hand side of the periodic table, and they tend to lose valence electrons. Metals exhibit similar properties, including high melting points, **ductility**, **malleability**, conductivity, and luster.
- Nonmetals are located on the right-hand side of the periodic table, and they tend to gain valence electrons. Nonmetals exhibit similar properties such as low melting points, brittleness, poor conductivity, and dull surfaces.
- Metalloids exhibit properties of both metals and nonmetals, and are found between metals and nonmetals on the periodic table. Most metalloids are semiconductors.

How are the columns of the periodic table organized, and what do the elements in each group have in common?

The columns of the periodic table are organized based on similarities between elements. The columns are also referred to as "**groups**" or "**families**."

- Group 1 is called the **Alkali Metals**.
- Group 2 is called the **Alkaline Earth Metals**.
- Group 17 is called the **Halogens**.
- Group 18 is called the Noble Gases.
- Groups 3-12 are collectively known as the **Transition Metals**.

The rows of the periodic table also indicate similarities between elements. The rows are referred to as periods.

- The elements in a **period** contain the same number of energy levels in their atoms.
- The **lanthanide series** is part of Period 6. Its elements have properties similar to those of lanthanum (element 57). Lanthanides are usually displayed under the main body of the periodic table.
- The **actinide series** is part of Period 7. Its elements have properties similar to those of actinium (element 89). Actinides are usually displayed under the main body of the periodic table.

8.3- Periodic Trends

Is there a relationship between the observed chemical reactivity of an element and its position on the periodic table?

The elements follow trends in reactivity that can be described using the periodic table.

- Metal reactivity increases down within a group and decreases from left to right across a period.
- Nonmetal reactivity varies in the opposite way as observed for metals. Nonmetal reactivity increases up within a group and decreases from right to left across a period.

How can the observed periodic trends in reactivity of the elements be explained?

Periodic trends in **chemical reactivity** are based on the ease of gain or loss of valence electrons by an element.

- For many atoms, the closer the atom is to being able to achieve eight valence electrons in its s and p orbitals, the more reactive it is.
- The most reactive metals are on the bottom, left of the table. Excluding the noble gases, the most reactive nonmetals are on the top, right of the table.
- When moving from one period to the next, the distance of the outermost electrons from the nucleus and shielding of these electrons from nuclear charge by inner electrons are important.
- In metals, increasing distance and shielding increases the tendency to lose electrons; this increases reactivity.
- In nonmetals, increasing distance and shielding decreases the tendency to gain electrons; this decreases reactivity.

What other periodic trends occur beside reactivity, and how are they explained?

Properties of elements that follow periodic trends include **atomic radius**, **ionic radius**, **metallic character**, **ionization energy**, and **electronegativity**. Trends observed for these properties can be explained by three factors:

- the total number of electrons in an atom
- the size of the nuclear charge and the distance between the nucleus and the outermost electrons