

TOPIC 4: PERIODICITY 1

Topic competency: The learner analyses the trends and periodic properties of elements, to explain and predict the reactivity and properties of elements in the Periodic Table.

SUB-TOPIC 4.1: The Periodic Table

Learning outcome

- The learner should be able to evaluate how the Periodic Table is organized based on atomic number and properties, recognizing its historical significance

Brief History of periodic table

1. Early Ideas (Ancient-1700s)

- Ancient Greeks proposed basic elements (earth, air, fire, water).
- Lavoisier (1789); compiled the first list of 33 elements.

2. Early Classifications (1800s)

- Döbereiner (1817) grouped elements into "triads."
- Newlands (1864); noticed repeating properties ("Law of Octaves").

3. Mendeleev's Breakthrough (1869)

- Created the first periodic table, arranging elements by atomic weight and predicting missing ones.

4. Modern Table (20th Century)

- Moseley (1913) reordered elements by atomic number (protons)
- Seaborg (1940s) added the lanthanide & actinide series

5. The Modern Periodic Table

- **Current Basis:** Elements are ordered by **atomic number (Z)** and electron configuration.
- **Groups (Columns):** Elements with similar chemical properties (e.g., halogens, noble gases).
- **Periods (Rows):** Indicate electron shell filling.
- **Blocks (s, p, d, and f):** Based on electron subshells.

Learner activity 1

Item 1

A local manufacturer is producing batteries but is unsure about choosing safe and reactive metals. They hear about "eka-aluminum," a predicted element from the past, and want to know how scientists could predict properties of unknown elements. Your team is hired to explain how scientists in the 1800s could make such predictions without modern tools.

Guided Questions for Learners:

- a) What criteria did Mendeleev use to arrange elements?

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- b) Why did he leave gaps?
- c) How were predictions about "eka-elements" later proven right ?

Item 2

A science museum exhibit is displaying an old periodic table organized by atomic mass. Visitors are confused by elements that seem out of place (e.g., iodine and tellurium). The curators ask your group to investigate and prepare a presentation on why this happened and how Moseley's discovery fixed the inconsistencies.

Task:

- a) What is the difference between atomic mass and atomic number?
- b) How did Moseley use X-ray spectroscopy in his discovery?
- c) How did this affect the arrangement of elements?

THE MODERN PERIODIC TABLE

In the modern periodic table, the elements are arranged in order of increasing atomic number in horizontal

Periodic Table of the Elements

The periodic table is color-coded according to the legend:

- State of matter (color of name):** GAS (red), LIQUID (orange), SOLID (green), UNKNOWN (grey).
- Subcategory in the metal-metalloid-nonmetal trend (color of background):** Alkali metals (red), Alkaline earth metals (orange), Transition metals (blue), Lanthanides (light blue), Actinides (dark blue), Metalloids (yellow), Post-transition metals (purple), Reactive nonmetals (light green), Noble gases (pink), Unknown chemical properties (grey).

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rows.

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The elements with similar properties occur at regular intervals.

Therefore,

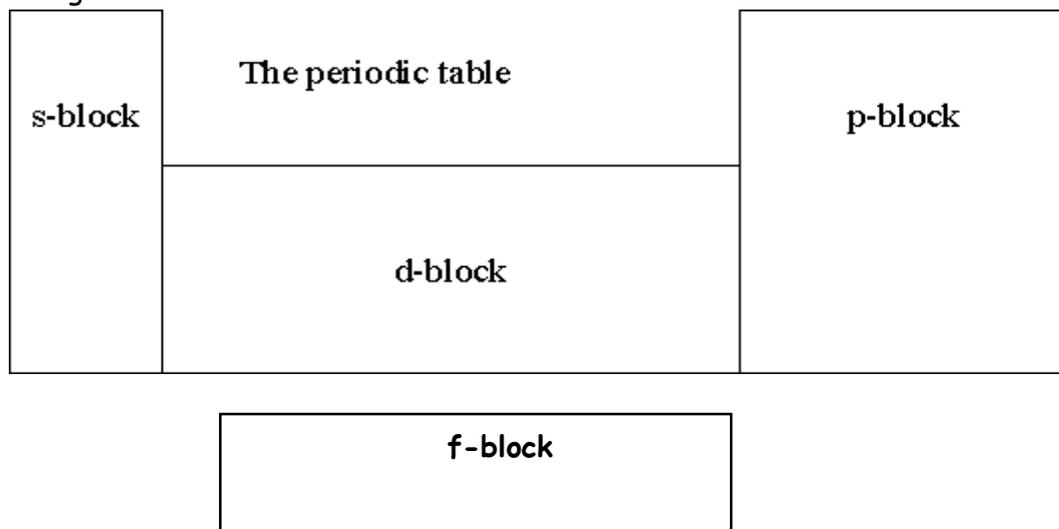
1. The **horizontal arrangements of elements** are called **periods**. With the exception of the first period, each period begins with an alkali metal and ends with a noble gas.
 - Period 2 begins with lithium and ends with neon.
 - Period 3 begins with sodium and ends with argon.
2. The **vertical arrangement of elements** in a periodic table is called **group**. Here the elements with similar properties are placed in a vertical column.
 - Group (I) elements are lithium, sodium, potassium etc.

❖ The periodic law

It states that, "*the properties of elements vary in relation to their atomic numbers*". Therefore, the properties of elements are a periodic function of their atomic number.

The properties of elements depend on the electronic arrangement of atom, which in turn depends on atomic number.

The modern periodic table is divided into blocks of elements depending on which sub energy level is filling.



- For the s-block elements, the filling electrons ends at ns , where s = sub energy level and n = principal quantum number.
- For the p-block elements, the filling electrons end at np . Where n = principal quantum number and p = sub energy level.

The d-block elements where the filling electrons end at nd . These are usually called the **transition elements**. If they were to be left out, periods would be of equal length each having 8 elements.

- The f- block elements where electrons are filled in the f- sub energy level.

More about arrangement of elements in the periodic table The groups

The elements which are placed in the same group have similar properties. This is because the properties of elements depend on the electron arrangement.

All the elements in the same group have similar outer electron arrangement. E.g.

- Li: $1s^2 2s^1$
- K: $1s^2 2s^2 2p^6 3s^2 3p^6 3s^1$

All have one electron in the outer most shell and are found in-group (I) (alkali metals). Hydrogen does not exactly fit in the above group because it is a gas and forms negative ions (H⁻) with metals.

Helium is placed in group (VIII) together with neon, argon etc. the periods

The elements, which are placed in the same period, have the same number of shells i.e have the same type of shell filling e.g.

- Li $1s^2 2s^1$
- B $1s^2 2s^2 2p^1$
- C $1s^2 2s^2 2p^2$

In the above case, they all have the second shell filling.

The period in which the element belongs is given by the number of shells that have electrons e.g.

- Boron ($1s^2 2s^2 2p^1$) has two shells and therefore it belongs to period 2.
- Potassium ($1s^2 2s^2 2p^6 3s^2 3p^6 3s^1 4s^1$). The principal quantum number of the outer most shell is 4 therefore it is in period 4.

The Relationship between the Position of Elements in the Periodic Table and Their Chemical Properties

- **Groups (Vertical Columns):** Elements in the same group have similar valence electron configurations, resulting in comparable chemical properties. For example, Group 1 elements (alkali metals) are highly reactive metals, while Group 17 elements (halogens) are highly reactive nonmetals.
- **Periods (Horizontal Rows):** As you move across a period from left to right, the number of valence electrons increases, affecting reactivity and chemical behavior. For example, metallic character decreases and non-metallic character increases across a period.
- **Valence Electrons:** The number of valence electrons determines an element's chemical reactivity and the types of bonds it can form. Elements with the same number of valence electrons (same group) tend to have similar properties and form similar compounds.

- **Metallic and Non-metallic Character:** Elements on the left side and center of the periodic table (Groups 1-12) are metals and tend to lose electrons to form positive ions.

Elements on the right side (excluding noble gases) are non-metals and tend to gain electrons to form negative ions.

The metallic character increases down a group and decreases across a period.

Reactivity Trends:

- **Metals:** Reactivity increases down a group as the outer electrons are farther from the nucleus and more easily lost.
- **Non-metals:** Reactivity decreases down a group as the ability to attract electrons decreases.

Electronegativity, Ionization Energy, and Atomic Radius:

- **Electronegativity:** Increases across a period and decreases down a group; affects how strongly an element attracts electrons in a bond.
- **Ionization Energy:** Increases across a period and decreases down a group; affects how easily an atom loses an electron.
- **Atomic Radius:** Decreases across a period and increases down a group.

Activity 4.1a

Item 1

A water treatment company is evaluating the reactivity of elements to determine which metals are most suitable for removing impurities. They have five elements with atomic numbers: 3, 11, 12, 19, and 20.

Task

- Arrange these elements in order of increasing atomic number
- Classify them according to their group and period in the periodic table.
- Identify the most and least reactive element with a reason

Item 2

In a mining site, geologists found traces of five elements with atomic numbers: 26, 29, 13, 30, and 20. They were confused about the nature of the element

Task

- Write the electronic configuration of the elements
- State the group, block and period of each element
- Identify the transition metals among them

Item 3

An electronics manufacturer is testing five non-metal elements for conductivity and strength with atomic numbers: 6, 7, 8, 15, and 16. Help them classify these non-metals by increasing atomic number and identify their periods.

Item 4

A pharmaceutical lab is analyzing halogens to make disinfectants. They are using elements with atomic numbers: 9, 17, 35, 53, and 85.

- a) Write the electronic configuration of the elements
- b) State the group, block and period of each element
- c) Categorize the elements

