Ratna Sagar

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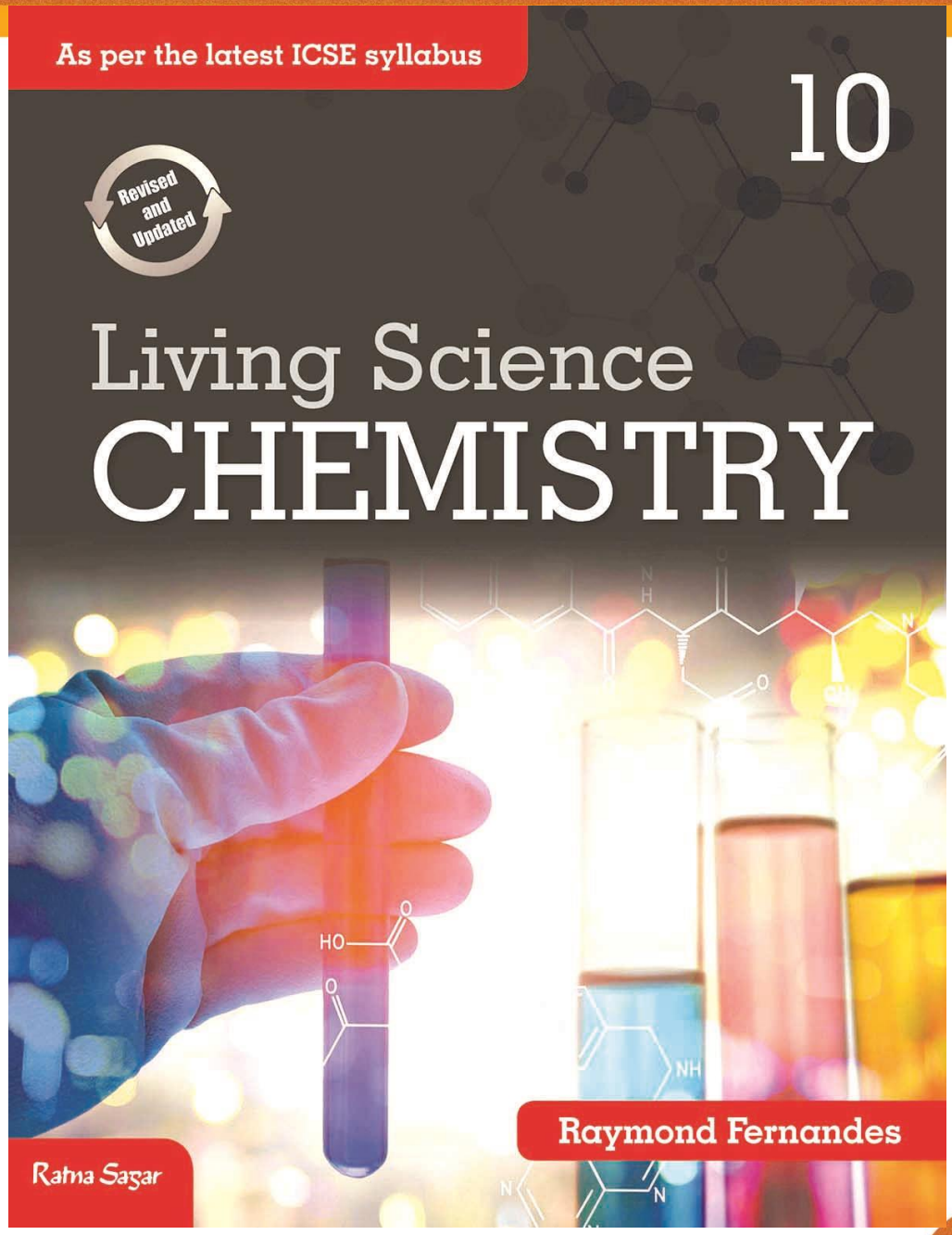
ICSE
Living Science
Chemistry

Class 10

Chapter-1 The Periodic Classification and Periodic Properties of Elements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10
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Living Science
CHEMISTRY
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LEARNING OBJECTIVES

Some Early Attempts of Classification

- ❖Döbereiner's Triads
- ❖Newland's Law of Octaves
- ❖Mendeleev's Periodic Law
- ❖ The Modern Periodic Law

The Layout of the Modern Periodic Table

Types of Elements

- ❖ Properties of transition elements
- ❖ Properties of inner transition elements

Periodicity in Properties of Elements

- ❖ Atomic radius
- ❖ Ionization potential
- ❖ Electron affinity
- ❖ Electronegativity
- ❖ Metallic character
- ❖ Non-metallic character

Why to classify elements?

1. A classification of elements may facilitate their study.

2. A classification may lead to correlating the properties of elements with some fundamental property or characteristic of an element.

3. A classification may further reveal the relationship between one element and the other.

Some Early Attempts of Classification

Some early attempts were made in systematic classification of elements.

Döbereiner's Triads

Law

In a triad, i.e. a group of three elements having similar properties, the atomic weight of the middle element is almost the arithmetic mean of the atomic weights of the other two.

Merits

The law of triad recognized the relationship between the properties of elements and their atomic weights. For example, lithium, sodium and potassium have similar chemical properties and form a triad.

Demerits

Not many elements could be grouped into triads.

Newland's Law of Octaves

Law

If elements are arranged in an increasing order of their atomic weights, every eighth element will have chemical properties similar to the first, just like the repetition of eighth note in an octave of music.

Merits

Atomic weights were made the basis of classification. Periodicity of properties was recognized for the first time.

Demerits

The law of octaves failed because firstly, the existence

Mendeleev's Periodic Law

Law

The physical and chemical properties of elements are the periodic functions of their atomic weights.

Merits

Correction of atomic weights were marked and existence of undiscovered elements were predicted.

Demerits

1. Position of hydrogen was not defined.
2. Lighter elements were placed after heavier elements, contrary to the law.
3. The position of rare earth elements and isotopes was ambiguous.
4. Chemically similar elements were placed in different groups and vice versa.
5. The periodic table did not reflect the electronic configuration of elements.

Modern Periodic Law

Law

The physical and chemical properties of elements are the periodic functions of their atomic numbers.

Merits

It is the most appropriate classification till date.

Demerits

The position of hydrogen is still not certain.

The Layout of the Modern Periodic Table

1. Vertical columns (Groups): 18 **Horizontal rows** (Periods): 7.

2. Elements in the same group have similar properties.

3. Group IA (Alkali metals) [H, Li, Na, K, Rb, Cs, Fr]

Group IIA (Alkaline earth metals) [Be, Mg, Ca, Sr, Ba, Ra]

Group VIIA (Halogens) [F, Cl, Br, I, At]

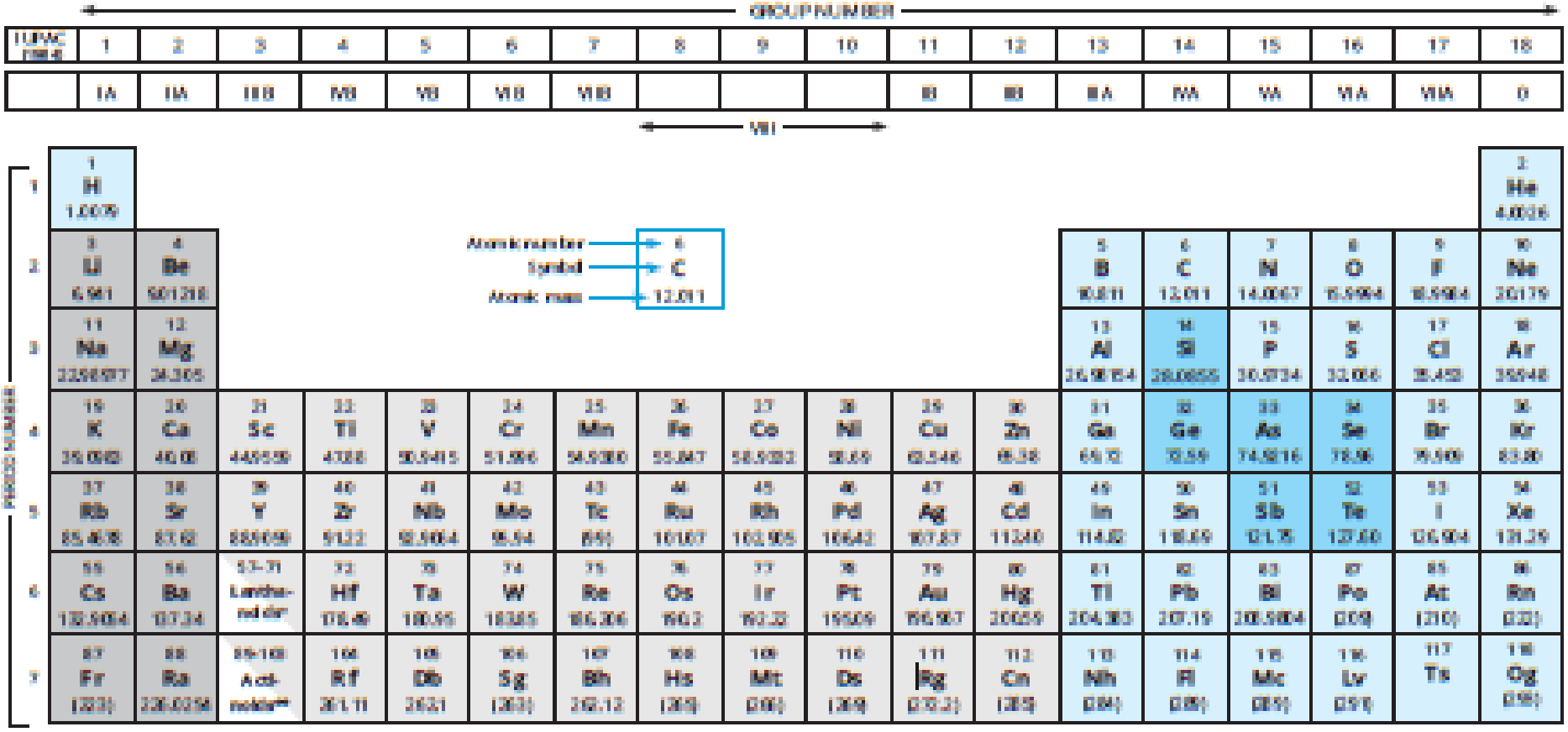
Group Zero (Noble gases) [He, Ne, Ar, Kr, Xe, Rn]

4. Period 1: 2 elements, Periods 2 and 3: 8 elements ,

Periods 4 and 5: 18 elements, Period 6: 32 elements

Period 7 : 32 elements*

MODERN PERIODIC TABLE



5. The inner transition elements:

Lanthanoids: Group III B, Period 6 Number of elements 15

Actinoids: Group III B, Period 7 Number of elements 15

6. All elements in the same period will have the same number of shells but their valence electrons will increase gradually on going from left to right across the period.

The number of valence electrons of normal elements corresponds to the group number.

Transition elements or B group elements generally have 2 electrons in their outermost shell. It is for this reason that they are also referred to as transition metals.

7. All elements in the same group will have the same number of valence electrons but the number of shells will increase on going from top to bottom in the group. The number of shells corresponds to the period number.

Study Tip: To determine group number and period number of an element, first write its electronic configuration. The number of valence electrons determines its group number and number of shells indicates period number.

Types of Elements

The elements can be classified as:

1. Representative or Normal elements: Are also called Group ‘A’ elements. They vary vary from being strongly metallic to strongly non-metallic.

2. Transition elements: They are placed in between the normal elements. They are also referred to as Group ‘B’ elements. Their position in the periodic table is between the metals and the non-metals.

3. Inner transition elements: Are placed within the transition elements. There are two series of fifteen elements each. These series are called the Lanthanoids and the Actinoids.

4. Inert gases

Periodicity in Properties of Elements

The repetition of similar properties of elements after regular intervals of atomic number is called **periodicity.** Elements show periodicity in their properties because of their **valence shell configuration**. All elements showing periodicity in properties have the same number of electrons in the last or valence shell.

Factors that influence the trend in the periodicity of properties of elements are:

Atomic radius

Atomic radius is usually considered as the distance from the centre of the nucleus to the outermost shell, i.e. to a point where the electron density is effectively zero.

The atomic radius decreases across the period from left to right.

Reason: Along a period, the effective nuclear charge increases. This is due to the fact that the number of electrons increases (in the same shell) along with the increase in the number of protons in the nucleus. This pulls the valence shell of electrons in the atom towards the nucleus, thereby bringing the valence shell closer to the nucleus, and thus decreasing the atomic radius.

The atomic radius increases as one moves from top to bottom.

Reason: As we move down a group, the number of shells keeps on increasing along with the number of electrons and subsequently the number of protons . But the increase in the number of shells outweighs the increased nuclear charge. Therefore, due to the increase in the number of shells down the group, the distance of outermost shell from the nucleus increases and hence, the atomic radius increases.

Ionization energy (or ionization potential)

It is the energy required to remove an electron from an isolated gaseous atom in its ground state to form a gaseous positive ion.

The ionization potential increases from left to right in the period

Reason: Along a period the effective nuclear charge increases. This causes the atomic radius to decrease thus getting the valence shell closer to the nucleus. This makes it difficult to remove electrons from the valence shell and therefore the ionization potential increases along a period from left to right.

The ionization potential decreases along the group

Reason: As we move down a group, the number of shells increases and so does atomic size. As the distance from the nucleus to outermost electrons increases, the attraction between them lessens, which makes the electron easier to be removed. Thus, less energy is required to remove electrons from the valence shell. As a result the ionization potential decreases down a group.

Study Tips : Metals have tendency to loose electrons as they have 1, 2 or 3 electrons in the outermost shell and hence, require less energy to do so. Thus, their ionization energy is less than that of non-metals.

Electron affinity

It is the amount of energy released when an isolated gaseous atom accepts an electron to form the gaseous negative ion. Electron affinity is expressed in terms of electron volts (eV) or kilojoule per mole (kJ/mol).

Across the period from left to right the electron affinity increases.

Reason: Along a period, the effective nuclear charge increases and this decreases the atomic radius. Smaller the atomic radius, greater is the tendency of the atom to attract electrons. This increases the electron affinity along a period from left to right.

Down the group the electron affinity decreases.

Reason: As we move down a group, the number of shells keeps on increasing and therefore the atomic size increases. The increase in size and the decrease in the effective nuclear charge both favour the decrease in the electron affinity down a group.

Note: Noble gases have zero electron affinity as they do not accept electrons due to their fully-filled valence shells. Electron affinity is highest for halogens while it is least for alkali metals.

Study Tips: Elements with high value of electron affinity will readily form negative ions.

Electronegativity

The tendency of an atom in a molecule to attract a shared pair of electrons towards itself when combined in a compound is called electronegativity.

Across the period from left to right the electronegativity increases.

Reason: Along a period the effective nuclear charge increases, thus decreasing the atomic radius. This favours the increase in electronegativity and therefore the electronegativity of elements increases along a period from left to right.

Down the group the electronegativity decreases.

Reason: As we move down a group, the number of shells keeps on increasing and therefore the atomic size increases. Therefore, the electronegativity decreases.

Note: Elements with high electronegativities are nonmetallic in nature while elements with low electronegativities are metallic in nature.

Metallic character

Metallic character is defined as the tendency of an atom to lose electrons and form positive ion (cations).

Across the period from left to right the metallic character decreases.

Reason: The metallic character depends upon atomic size and ionization potential. As we move along a period from left to right, the effective nuclear charge increases, thus decreasing the atomic radius. This favours the increase in electronegativity and therefore the tendency to lose electrons is low. This accounts for the decrease in the metallic character along a period.

Down the group the metallic character increases.

Reason: The metallic character depends upon atomic size and ionization potential. As we move down a group, the number of shells keeps on increasing and therefore the atomic size increases. This means that the electronegativity decreases. These factors make the loss of electrons easier and therefore, the metallic character increases down a group.

Note: Greater the tendency to lose electrons, the greater is the reactivity of metals.

Non-metallic character

Non-metallic character is the tendency of an element to gain electrons and form a negative ion (anion).

Across the period from left to right the non-metallic character increases.

Reason: The non-metallic character depends upon atomic size and ionization potential. As we move along a period, the effective nuclear charge increases, thus decreasing the atomic radius. This favours the increase in electronegativity and therefore the tendency to gain electrons is high. This accounts for the increase in the non-metallic character along a period.

Down the group the non-metallic character decreases.

Reason: The non-metallic character depends upon atomic size and ionization potential. As we move down a group, the number of shells keeps on increasing and therefore the atomic size increases. This means that the electronegativity decreases. These factors do not favour the gain of electrons and therefore the non-metallic characteristic decreases down a group.

Note: Greater is the tendency to gain electrons, greater is the reactivity of non-metals.

Alkali Metals

Lithium (Li), sodium (Na), potassium (K), rubidium (Rb), caesium (Cs) and francium (Fr) are the elements that are commonly called alkali metals. They form the first group (group 1) of the periodic table.

Physical properties of alkali metals

1. They are shiny white solids. They are soft and can be easily cut with a knife.
2. Lithium is the hardest metal in the group.
3. They are good conductors of heat and electricity.
4. The density increases with increase in atomic number.
5. Ionization potential in this group is low and decreases from top to bottom.
6. The size of the atom is the largest for a given period.
7. They form monovalent cations.
8. The size of the cation is smaller than the size of the atom.
9. The melting point and boiling point of the elements decrease down the group.
10. Francium is a radioactive element (artificial).

Chemical properties of alkali metals

1. Sodium and potassium catch fire when exposed to air for some time.
2. All alkali metals form oxides.
3. All alkali metals form hydrides.
4. All alkali metals react very vigorously with water to form the corresponding hydroxides and liberate hydrogen.
5. They react with halogens to form the corresponding halides.

Halogens

Fluorine (F), chlorine (Cl), bromine (Br), iodine (I) and astatine (At) are the elements of this group. They form group 17 of the periodic table.

Physical properties of halogens

1. They are non-metals.
2. They form diatomic gases.
3. Fluorine and chlorine are gases, bromine is a red liquid and iodine is a solid.
4. They are bad conductors of heat and electricity.
5. They are highly electronegative. Electronegativity decreases from top to bottom.
6. The melting point and boiling point of these elements increase with increase in atomic number.
7. Iodine possesses a metallic lustre.

Chemical properties of halogens

1. Reactivity of the elements decreases as we move from top to bottom.
2. They are very strong oxidizing agents.
3. The oxidizing property decreases from top to bottom.
4. They react with metals to form ionic halides.
5. They react with non-metals to form covalent halides.

SUMMARY

1. Modern Periodic Table is the most systematic classification of elements till date. It comprises 18 groups and 7 periods. Groups are the vertical columns whereas periods are the horizontal rows.

2. Periodicity: It is the repetition of similar properties of elements after certain regular intervals when elements are arranged in increasing order of their atomic numbers.

3. Periodic repetition of properties is due to the repetition of similar valence shell electronic configuration after certain regular intervals.

4. Ionization potential: It is the amount of energy required to remove an electron from an isolated gaseous atom in its ground state to form gaseous positive ion.

5. Electron affinity: It is the amount of energy released when an isolated gaseous atom accepts an electron to form the gaseous negative ion.

6.Electronegativity: It is the tendency of an element to attract a shared pair of electrons towards itself when combined in a compound.

7. Metallic character: It is the tendency of an atom to lose electrons.

8. Non-metallic character: It is the tendency of an atom to gain electrons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