Unit

3

Classification of Elements and Periodicity in Properties

Introduction

The unit deals with the periodic classification of elements, its need and the historical aspects leading to the development of periodic table. The structure and application of modern periodic table is discussed on the basis of electronic configuration of elements. Some important atomic properties like atomic size, ionization enthalpy, electron gain enthalpy, electro negativity, etc are discussed and correlated to electronic configuration. The periodic trends in physical and chemical porperties are discussed in the light of atomic properties.

Concepts & Process skills	Process/Activity with assessment	Learning outcome
Grouping of elements, development of periodic table, law of triads and law of octaves. • Classifying • Observing	• Group discussion on development of periodic table on the basis of law of triads and law of octaves. Assessment • Participation in discussion (Process)	Recognises the concept of grouping elements based on their properties, law of triads and law of octaves.
Mendeleev's periodic law, modern periodic law. electronic configuration and periodic classification • Classifying • Predicting	• Group discussion on periodic law • Problem solving on periodic classification, relationship between electronic configuration and properties of elements Assessment • Participation in discussion (Process) • Problem solving (process)	Recognises the periodic law and explains the importance of atomic number, electronic configuration and periodic classification.
IUPAC nomenclature of elements with Z >100 • Predicting • Using number relationships	• Group discussion on IUPAC nomenclature • Charting of elements wih Z>100 Assessment • Participation in discussion (Process) • Chart (Port folio)	Lists the elements with Z > 100 according to IUPAC nomenclature.
s, p, d and f block elements and their characterestics. • Predicting • Classifying	• Small group discussion • Problem solving Assessment • Participation in discussion (Process) • Solving problems (Process)	Recognises s, p, d and f block elements and their characteristics.

Concepts & Process skills	Process/Activity with assessment	Learning outcome
Periodic trends in physical and chemical properties of elements • Inferring • Predicting • Observing • Classifying	• General discussion, data analysis, sketching (graph) on - Atomic and ionic size Ionisation enthalpy Electron gain enthalpy Chemical reactivity Assessment • Participation in discussion (Process) • Graph (Portfolio)	Identifies the periodic trends in physical and chemical properties of elements.
Periodic trends in chemical properties - Valence/Oxidation State. - Anomalous properties of second period elements • Observing • Inferring • Classifying	• General discussion on valence, oxidation state and anomalous behaviour of second period elements Assessment • Participation in discussion (Process)	Compares the reacticity of elements and explain reasons for the anomalous behaviour
Chemical reactivity and position of element in the periodic table. • Inferring • Predicting	• General discussion on chemical reactivity. • Predicting the chemical formulae of compound using valence. Assessment • Participation in discussion (Process)	Recognises the periodic trends, the relation between chemical reactivity and the position of element in the periodic table.

Entry level activity

By citing the example of a library having thousands of different books, the teacher lead the students to the importance of classification.

Discussion Points

- How elements can be classified?
- On which basis elements can be classified?

After the discussion, teacher can conclude the necessity of classification and the importance of periodic table.

Content :- Law of triads and Law of octaves

Suggested Activity 3.1 - General discussion with the help of charts (1 period)

With the help of charts of groups of elements having similar physical and chemical properties, teacher conducts a discussion on the topic - Law of triads and Law of Octaves.

Dobereiner's Triads	
Element	Atomic weight
Li	7
Na	23
k	39
Ca	40
Sr	88
Ba	137

Newland's Octaves							
Elements	Li	Be	B	C	N	O	F
Atomic weight	7	9	11	12	14	16	19
Element	Na	Mg	Al	Si	P	S	Cl
Atomic Weight	23	24	27	29	31	32	35.5
Element	K	Ca					
Ato.wgt.	39	40					

Consolidation

Law of triads, Law of Octaves

Content :- Mendeleev's Periodic classification

Suggested Activity 3.2 - General discussion on Mendeleev's periodic classification - Merits and demerits (1 period)

Discussion Points

- Merits of law of triads and law of Octaves.
- Demerits of law of triads and law of octaves.
- Discovery of new elements and need of another classification.

Through a general discussion, the works of Lother Meyer and Dmitri Mendeleev are explained.

Mendeleev's periodic table can be shown to the students. With the help of the table, teacher asks the following questions.

- What is the basis of this classification?
- What are the merits and demerits?

Through these questions, students can state Mendeleev's periodic law with the help of teacher.

Also by analysing the table shown in the classroom, the students are able to get an idea about groups, periods, merits and demerits of Mendeleev's periodic table.

Consolidation - Mendeleev's periodic law, merits and demerits

Suggested Activity 3.3 - General discussion on Modern Periodic table (½ period)

Discussion points

- demerits of Mendeleev's periodic table
- need for another classification and a new periodic table.

From the discussion of the demerits of Mendeleev's periodic table and mentioning the work of Moseley on X-ray, teacher introduces the modern periodic law. By analysing the modern periodic table shown in the classroom, the students answer questions like...

- How many periods are there?
- How many groups are there?
- How many elements are present in each period
- How does electronic configuration of elements influence the structure of modern periodic table.

After the discussion, the students can explain the importance of atomic number, electronic configuration, and periodic classification.

Consolidation

Modern periodic law.

Content :- IUPAC nomenclature of elements with Z >100

Suggested Activity 3.4 - General discussion on IUPAC Nomenclature (1 period)

General discussion using a chart on the general methods of naming (IUPAC) elements and the teacher helps the students to name a few elements with atomic number Z >100.

Consolidation

IUPAC nomenclature of elements with atomic number Z >100.

Content :- s, p, d and f block elements and their general characterestics.

Suggested Activity 3.5 - Group discussion on different blocks (1 period)

Divide the students into 4 groups. The teacher ask them to write the general electronic configuration of the elements given to them.

Groups 1 - s block elements
Group 2 - p block elements
Group 3 - d block elements
Group 4 - f block elements

With the help of teacher, students can divide elements into 4 blocks based on the sub shell in which the highly energetic electron enters.

Discussion Points

- Is there any similiarity between the subshell in which the last electron enters in the case of elements of same group?
- Is there any similiarity in properties of elements belonging to a particular group of elements in which the last electron enters in the same subshell?

After discussion, different blocks of elements are introduced.

On the basis of electronic configuration the general properties of elements in each block can be explained. Using a periodic table, students locate positions of elements in each block in the table.

Activity Question

Classify the following elements into s, p, d or f - block and justify your answer Si, Na, Br, Cr, Bk, Zr, Mg, U.

Consolidation - 4 blocks of elements, their properties, and position in the periodic table.

Content :- Periodic properties

Suggested Activity 3.6 - General discussion on atomic size (½ period)

Discussion Points

- Is there any relation between size of atom and number of shells present?

- What happens to the atomic size as we move from top to bottom in a group and from left to right in a period? Why does this happen?

Consolidation

- Atomic size and factors affecting it.

Suggested activity 3.7 - General discussion on Ionization energy/Ionization enthalpy (½ period)

Discussion Points

- Is there any relation between the size of an atom and the attractive force exerted by the nucleus on the outermost electrons?
- How the outermost electron in an atom can be removed?

After the discussion based on the above questions, the term ionisation energy/enthalpy can be introduced along with its relation with the size of atom and nuclear charge. Also its variation along a period and a group can be discussed.

Consolidation - Ionisation enthalpy and its relation with the size of atom and nuclear charge.

Suggested Activity 3.8 - General discussion on First, second, third ionisation energy & so on (1 period)

Discussion points

Questions like

- Is it true that the same amount of energy is enough to remove one outermost electron from a neutral atom and a monopositive ion, both in the gaseous ground state?
- What about the energy required to remove the outermost electron from a dipositive gaseous ion?

From the discussion based on the above questions, the terms first ionisation energy, second ionisation energy, third ionisation energy etc can be introduced. Relation between successive ionization enthalpy and electronic configeration may be dicussed.

Activity Question -1

Elements	Li	Be	B	C	N	O	F	Ne
Atomic Number	3	4	5	6	7	8	9	10
Ionisation Enthalpy ($kJmol^{-1}$)	520	899	801	1086	1402	1314	1681	2080

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Atomic Number	3	4	5	6	7	8	9	10
Ionisation Enthalpy ($kJmol^{-1}$)	520	899	801	1086	1402	1314	1681	2080

Based on the above the data, draw a graph connecting the atomic number and ionisation enthalpy. Explain the abnormalities in the graph.

Discussion based on this question leads to answer; questions like why.

- Noble gases have high ionisation enthalpy?
- Ionisation enthalpy of nitrogen is more than that of oxygen?
- Beryllium has high ionisation enthalpy than Boron?

Activity Question - 2

Aluminium, Magnesium - compare the first ionisation energy of these elements.

Based on this question shielding effect or screening effect can be discussed. Also the penetration effect can be discussed here.

Activity Question - 3

Is there any relation between metallic character/Non-metallic character with ionisation enthalpy?

Consolidation

Ionisation enthalpy and the factors influencing ionisation enthalpy.

Factors influencing the ionisation enery (Ionisation Enthapy).

i. Atomic size
ii. Nuclear charge
iii. Shielding effect
iv. Penetration effect
v. Stability of the species

Content: Electron gain Enthalpy

Suggested Activity 3.9 - Group discussion on electron gain enthalpy (1 period)

Discussion points

- Stability of elements having octet in the valence shell.
- Tendency of atoms to attain octet by accepting electron/electrons.
- Noble gases have no tendency to accept electron.

Based on the discussion, electron gain enthalpy is introduced. The general relation between the electron gain enthalpy and the atomic number can also

be discussed here. Variation of electron gain enthalpy of elements along a period and in a group can be discussed. The negaive value of electron gain enthalpy may be highlighted.

Activity Questions

- Fluorine, chlorine - Compare the electron gain enthalpy of these elements.
- Noble gases are having positive electron gain enthalpy. Justify.

Consolidation

Electron gain enthalpy and the factors influencing the electron gain enthalpy.

Content: Electro negativity

Suggested Activity 3.10 - General discussion on electro negativity (1 period)

Discussion points

- Equal sharing of bonded pair of electrons in molecules like H_2, Cl_2, F_2, O_2, N_2 etc.
- Unequal sharing of electrons in molecules like HF, HCl etc.
- Is there any relation between the size of an atom forming a covalent bond and its ability to attract shared pair of electrons towards it?
- Is there any relation between the nuclear charge of an atom and the ability of an atom to attract the shared pair of electrons towards it?

Based on the above discussion the term electronegativity is introduced. Also the variation of electronegativity along a period and down a group can be explained using the above discussion. (Electronegativity values of elements of some periods and some groups on Pauling scale can be shown to the students using charts).

Consolidation

Electronegativity and the factors influencing the electronegativity.

Content :- Periodic trends in chemical properties

Suggested Activity 3.11 - General discussion on valence/oxidation state (½ period)

Discussion points

- Which electrons in an atom usually take part in chemical reactions?
- Is there any relation between the number of electrons present in the valence shell of an atom and the reactivity of that element?

Based on the above discussion the concept of valence can be introduced. Also, prediction of the molecular formulae of compounds using the concept of valence can be explained with the help of valence of the elements.

Activity Question - 4

Predict the formula of the compound formed between sodium and sulphur.

Variation of valence along a period from left to right can be discussed using a table containing molecular formula of oxide and hydrogen of elements of period 2 & 3.

Consolidation

Valence, its variation along a period and a group, predictions of molecular formula using the valence.

Suggested Activity 3.12 - General discussion on nomalous properties of second period element (1 period)

- Is there any similarity in properties of elements belonging to a particular group?
- Is there any difference between the properties of the first member of each group from the rest of the members of the group?
- Discussion based on the chart showing the different properties of each group of representative elements, the deviation in the properties of the first member of each group from the remaining members of the group (anomalous properties) can be explained. Diagonal relationship can also be considered during the discussion.

Based on the table of properties such as ionisation enthalpy, electro negativity, atomic size, absence of dorbitals, the different reasons for anomalous behaviour can be revealed.

Suggested Activity 3.13 - General discussion on Chemical reactivity and position of an element in periodic table (1 period)

Discussion points

- Variation of different properties like ionisation enthalpy, electron gain enthalpy, etc.
- Is there any relation between reactivity of elements and the various properties like ionisation enthalpy, electron gain enthalpy, etc.?

Based on the above discussion the following conclusions can be done.

1. Elements present in the left side of the periodic table are highly reactive because of low ionisation enthalpy value (high metallic character).

2. Elements present in the right side of the periodic table are also highly reactive (except noble gases) because they are having high electron gain enthalpy values (high non - metallic character).
3. The chemical reactivity of an element can best be shown by its reactions with oxygen and halogens. For example, elements on two extremes of a period easily combine with oxygen to form oxides. Oxides formed by elements on the left are basic and that of elements on the right are acidic in nature. Oxides of elements in the centre are amphoteric or neutral.

Activity Question-5

- Classify the following oxides into acidic, basic, amphoteric or neutral. Justify.

  Na_2O, Cl_2O_7, Al_2O_3, K_2O, CaO, NO_2, SO_2, As_2O_3

Consolidation

Chemical reactivity of an element can be correlated with its position in the periodic table.

Repository of CE Activities

Process Assessment

- General discussion
- Group discussion
- Completion of worksheet
- Presentation of Multidata animation

Portfolio Assessment

- Suggested activity log
- Worksheets
- Charts

Unit Assessment

- Oral assessment
- Preparation of text items and their indicators
- Openbook assessment
- Performance assessment

Unitwise TE Questions

1. Arrange the following species in the increasing order of size.
   Cl^-, S^{2-}, K^+, Ca^{2+}. Justify your answer.
2. Compare the sizes of a neutral atom, its cation and its anion.

3. Complete the table.

Atomic Number	Electronic Configuration	Group	Block
10	-	-	-
-	$1s^2 2s^2 2p^6 3s^1$		

4. Predict the elements present in the following group and period.
   a. 2nd group, 3rd period b. 17th group, 3rd period
5. Complete the table.

No.	Atomic No: of Element	IUPAC Name
1	112	----------
2	175	----------
3	-------	Unbibium

6. Find the position of the following elements in the periodic table, and then predict whether the oxides of these elements are acidic or basic?
   a. Chlorine b. Sodium c. Calcium d. Sulphur
7. Justify the following statements.
   a. The first ionisation enthalpy of nitrogen is higher than that of oxygen even though nuclear charge of nitrogen is less compared to oxygen.
   b. Noble gases are having high ionisation enthalpies.
8. Give reason
   a. Alkali metals (group I elements) are not found free in nature.
   b. Atomic radius of gallium is less than that of aluminium.
   (Z of Al = 13, Z of Ga = 31)

Classification of elements and periodicity in properties

1. The name proposed for Gallium by Mendeleev was
   a. Eka-aluminium b. Eka-Zinc
   c. Eka-silicon d. Eka-germanium

2. The pair of elements diagonally related is
   a. Ca-Ba b. Cu-Ni
   c. C-Si d. Be-Al
3. Incompletely filled orbitals in representative elements are
   a. s- and d- b. s- and f-
   c. s- and p- d. d- and f-
4. The increasing order of size of the following ions is
   a. O^{2-}, Na^{+}, N^{3-}, Mg^{2+} b. Mg^{2+}, Na^{+}, O^{2-}, N^{3-}
   c. Na^{+}, N^{3-}, Mg^{2+}, O^{2-} d. N^{3-}, O^{2-}, Na^{+}, Mg^{2+}
5. Which of the following pairs of atomic numbers represents elements of similar chemical properties.
   a. 13, 22 b. 4, 24 c. 3, 11 d. 2, 1
6. Which is the correct order of increasing first ionisation enthalpy of K, Cs, Rb and Ca.
   a. Rb, Cs, K, Ca b. Cs, Rb, K, Ca
   c. Ca, Cs, Rb, K d. K, Cs, Rb, Cs
7. Which of the following metal forms amphoteric oxide.
   a. Ca b. Fe c. Cu d. Zn
8. Which of the following is not expressed in unit?
   a. Electro negativity b. Electron affinity
   c. Ionisation potential d. Excitation energy
9. The correct order of electron gain enthalpy (with negative sign) of the given atomic species.
   a. F<Cl<O<S b. S<O<Cl<F
   c. Cl<F<S<O d. O<S<F<Cl
10. Which of the following is expected to be the least stable anion.
    a. Li^{-} b. Be^{-} c. B^{-} d. C^{-}

Reference

1. Principles of In organic chemistry - Puri, Sharma, Pathania
2. Inorganic chemistry - Olmsted & Williams
3. Inorganic chemistry - Hubeey, Kester
4. Physical chemistry - Castellan, 3rd Edition