

5. PERIODIC CLASSIFICATION OF ELEMENTS

■ Definition

Periodic table may be defined as the arrangement of all the known elements according to their properties in such a way that the elements of similar properties are grouped together in a tabular form.

■ Dobereiner triads

- He made groups of three elements having similar chemical properties called Triads.
- In Dobereiner triad, atomic weight of middle element is nearly equal to the average atomic weight of first and third element. **e.g.**

$$\left[\begin{array}{ccc} \text{Cl} & \text{Br} & \text{I} \\ 35.5 & 80.0 & 127 \\ x = \frac{35.5 + 127}{2} = 81.2 \end{array} \right] \quad \left[\begin{array}{ccc} \text{Ca} & \text{Sr} & \text{Ba} \\ 40 & 87.5 & 137 \\ x = \frac{40 + 137}{2} = 88.5 \end{array} \right] \quad \left[\begin{array}{ccc} \text{Li} & \text{Na} & \text{K} \\ 7 & 23 & 39 \\ x = \frac{7 + 39}{2} = 23 \end{array} \right]$$

Where x=average atomic weight

- Other examples – (K, Rb, Cs), (P, As, Sb), (S, Se, Te), (H, F, Cl), (Sc, Y, La)
- For a Dobereiner's triad, all the three elements should belong to the same group.
- For a Dobereiner's triad, difference in the atomic number should be 8 or 18.

Drawbacks or Limitations : All the known elements could not be arranged as triads. It is not applicable for d and f-block elements.

■ Newlands octave rule

- ▶ He arranged the elements in the increasing order of their atomic weight and observed that properties of every 8th element was similar to the 1st one, like in the case of musical vowel notation.

Sa	Re	Ga	Ma	Pa	Dha	Ne	Sa
1	2	3	4	5	6	7	8

- ▶ At that time inert gases were not known.

Li	Be	B	C	N	O	H
Na	Mg	Al	Si	P	S	F
K	Ca					Cl
↓	↓	↓	↓	↓	↓	↓

- ▶ The properties of Li are similar to 8th element i.e. Na, Be are similar to Mg and so on.
- ▶ Newland was the first scientist who given the term periodicity.

■ Drawbacks or limitations

- ▶ This rule is valid only upto Ca because after Ca due to presence of d-block element there is difference of 18 elements instead of 8 element.
- ▶ After the discovery of inert gases they become the 8th element from alkali metal so this law had to be dropped out.

■ Mendeleev's Periodic law

In other words, Mendeleev's Periodic law may also be stated as "**When elements are arranged in order of their increasing atomic masses, elements with similar properties are repeated after certain regular intervals. This repetition of properties of elements after certain regular intervals is called periodicity of properties**".

● Characteristics of the periodic table

Mendeleev arranged the elements in increasing order of their atomic masses in horizontal rows in such a way that element with similar properties fall under the same vertical columns.

His periodic table consists of :-

- (i) Seven horizontal rows called **periods**.
- (ii) Eight vertical columns called **groups**. These are designated as I, II, III, IV, V, VI, VII, VIII. Except VIII group, each group is divided into two subgroups -A (Constituting representative elements) and B (constituting transition elements). VIII group contains 9 transition elements.

■ Achievements of Mendeleev's periodic table

- ▶ While grouping elements together he kept 2 things in mind
 - (a) Increasing atomic masses
 - (b) Grouping of similar elements together.
- ▶ Prediction of new elements : Eka-Aluminium- Gallium (Ga), Eka- Boron- Scandium (Sc), Eka Silicon- Germanium (Ge), Eka- Manganese-Technetium (Tc)
- ▶ Noble gases when discovered were placed in a new group without disturbing the existing order.
- ▶ Atomic masses of several elements were corrected on the basis of periodic table.

■ Drawbacks

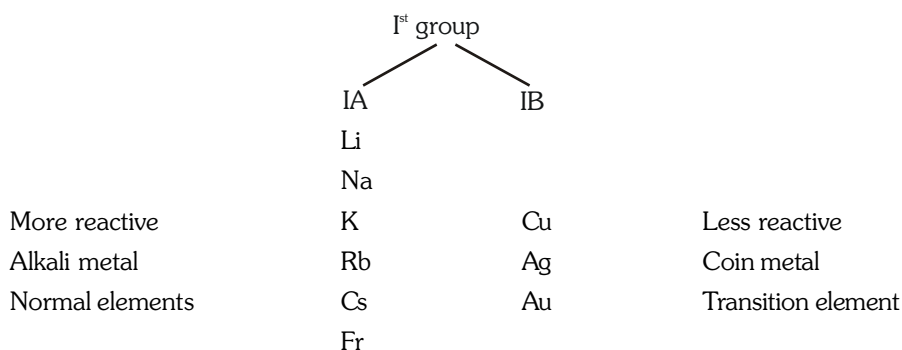
- (a) Position of hydrogen : Hydrogen resembles both, the alkali metals (IA) and the halogens (VIIA) in properties so Mendeleev could not decide where to place it.
- (b) Position of isotopes : As atomic wt. of isotopes differs, they should have been placed in different position in Mendeleev's periodic table. But there were no such places for isotopes in Mendeleev's table.
- (c) Anomalous pairs of elements : There were some pair of elements which did not follow the increasing order of atomic weights.

e.g. Ar and Co were placed before K and Ni respectively in the periodic table, but having higher atomic weights.

- (d) Like elements were placed in different groups : There were some elements like Platinum (Pt) and Gold (Au) which have similar properties but were placed in different groups in Mendeleev's table.

VIII	IB
Pt	Au

- (e) Unlike elements were placed in same group



Cu, Ag and Au placed in Ist group along with Na, K etc. While they differ in their properties (Only similar in having ns¹ electronic configuration)

It was not clear that '**Lanthanides** and **Actinides**' are related with IIIA group or IIIB group.

- (f) Mendeleev could not explain the cause of periodicity in the physical and chemical properties of the elements.

■ Modern periodic law

The properties of elements are a periodic function of their atomic numbers.

■ Cause of periodicity

The cause of periodicity in the properties of the elements is due to the repetition of similar outer electronic configuration after certain regular intervals.

Since the nucleus is located well inside an atom, it is not very much linked with the properties of the elements particularly the chemical properties. These are related to the number of the electrons & also the distribution of the electrons in different energy shells. The number of electrons in an atom are given by the atomic numbers which forms the basis of the classification of the elements in periodic table.

■ Modern periodic table

Characteristics of modern periodic table

- (a) 18 vertical columns called groups.
- (b) Ist to VIII group + 0 group of inert gases.
- (c) Inert gases were introduced in periodic table by Ramsay.
- (d) 7 horizontal rows called periods.

Long form / Present form of Modern periodic table

(It is also called as 'Bohr, Bury & Rang, Werner Periodic Table')

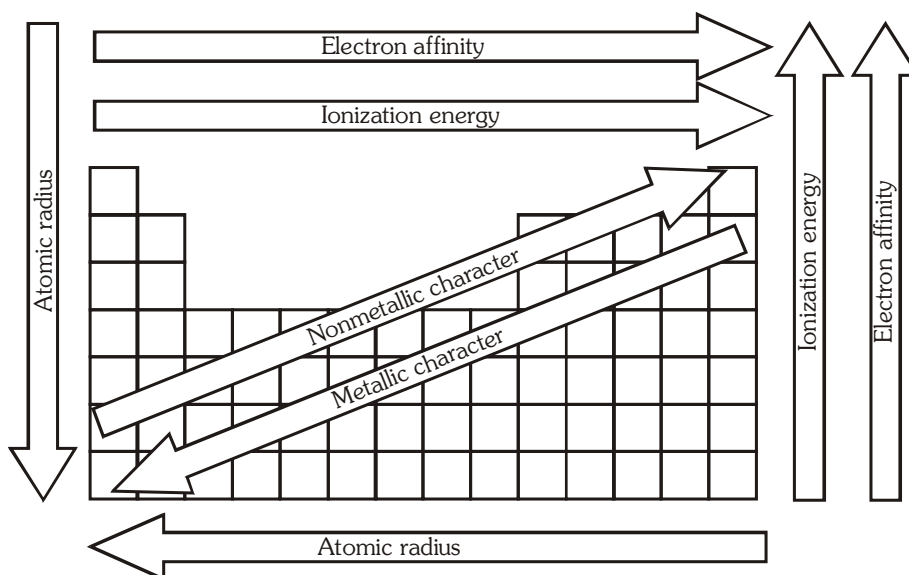
- (i) It is based on the Bohr-Bury electronic configuration concept and atomic number.
- (ii) This model is proposed by Rang & Werner.
- (iii) 7 periods and 18 vertical columns (groups).
- (iv) According to IUPAC, 18 vertical columns are named as Ist to 18th group.

Elements belonging to same group having same number of electrons in the outermost shell so their properties are similar.

- ▶ The number of elements in any period is equal to the maximum number of electrons that can be accommodated in that particular shell.
- ▶ Maximum number of electrons that can be accommodated in any shell is given by the formula $2n^2$, where n = no. of given shell.

■ Trends in modern periodic table

Memory map



PERIODIC CLASSIFICATION OF ELEMENTS

EXERCISE

- Cl, Br, I, if this is a Dobereiner's triad and the atomic masses of Cl and I are 35.5 and 127 respectively the atomic mass of Br is
(1) 162.5 (2) 91.5
(3) 81.25 (4) 45.625
- If the two members of a Dobereiner triad are phosphorus and antimony, the third member of this triad is
(1) Arsenic (2) Sulphur
(3) Iodine (4) Calcium
- The 'law of octaves' was enunciated by
(1) Lothar Meyer (2) Mendeleev
(3) Dobereiner (4) Newlands
- Newlands could classify elements only upto -
(1) Copper (2) Chlorine
(3) Calcium (4) Chromium
- According to Mendeleev's periodic law, the properties of elements are a periodic function of their
(1) Atomic number (2) Atomic masses
(3) Atomic volumes (4) Atomic sizes
- From top to bottom in a group of the periodic table the electropositive character of the element
(1) increases (2) decreases
(3) remains unchanged (4) changes irregularly
- The atoms of elements belonging to the same group of periodic table have same number of
(1) protons
(2) electrons
(3) neutrons
(4) electrons in outermost shell
- The long form of periodic table consists of
(1) seven periods and eight groups
(2) seven periods and eighteen groups
(3) eight periods and eighteen groups
(4) eighteen periods and eight groups
- Which of the following pair of atomic numbers represents elements in the same group ?
(1) 11, 19 (2) 6, 12 (3) 4, 16 (4) 8, 17
- The alkali metals are in which group of the periodic table ?
(1) Group 1 (2) Group 2
(3) Group 3 (4) Group 4
- "The properties of the elements are periodic function of their atomic numbers". The statement was given by
(1) N. Bohr (2) J.W. Dobereiner
(3) D.I. Mendeleev (4) H.G.J. Moseley
- The group number and period number respectively of an element with atomic number 8 is
(1) 6, 2 (2) 16, 2
(3) 6, 8 (4) 16, 4
- An atom has an electronic configuration 2, 8, 5. To which of the following elements would it be chemically similar ?
(1) F (9) (2) Na (11)
(3) N (7) (4) Ar (18)
- All the elements in a period in the periodic table have the same
(1) atomic number
(2) electronic configuration
(3) atomic weight
(4) valence shell
- All the members in a group of a long form of periodic table have the same
(1) valency
(2) number of valence electrons
(3) chemical properties
(4) All of the above
- The elements with atomic numbers 3, 11, 19, 37 and 55 belong to
(1) alkali metals (2) alkaline earth metals
(3) halogens (4) noble gases
- An element X belongs to group 14 and 2nd period of the periodic table. Its atomic number will be
(1) 6 (2) 14 (3) 7 (4) 15
- Which of the following elements is expected to show nonmetallic character ?
(1) As (2) Be (3) B (4) Br
- The noble gases are unreactive because
(1) they react with sodium
(2) they have a full outer shell of electrons
(3) they have a half-filled outer shell of electrons
(4) they have large number of neutrons
- Which set of the elements have four electrons in their valence shell ?
(1) C, Si, Sn (2) O, S, Se
(3) B, Al, Ga (4) Ne, Ar, Kr
- Which of the following pair of atomic numbers represents s-block elements ?
(1) 7, 15 (2) 6, 12
(3) 9, 17 (4) 3, 20

- 22.** In the periodic table, the element with atomic number 16 will be placed in the group
(1) Fourteen (2) Sixteen
(3) Thirteen (4) Fifteen
- 23.** Which of the following statements is not a correct statement about the trends when going from left to right across the periods of the periodic table ?
(1) The elements become less metallic in nature
(2) The number of valence electrons increases
(3) The atoms lose their electrons more easily
(4) The oxides become more acidic
- 24.** Which of the following remains unchanged on going down the group in the periodic table ?
(1) Valence electrons (2) Atomic size
(3) Density (4) Metallic character
- 25.** Which statement is wrong about C and Si ?
(1) They have similar chemical properties
(2) They have same electronic configuration
(3) They form double bonds
(4) None of these
- 26.** Element X forms a chloride with formula XCl_4 which is a solid with low melting point. X would most likely be in the same group of the periodic table is
(1) Na (2) Mg (3) Al (4) Si
- 27.** If an element belongs to group 13 and the second period of the periodic table, which of the following sets of properties would it exhibit ?
(1) Liquid, most metallic
(2) Gaseous, moderately metallic
(3) Solid, non-metallic
(4) Solid, less metallic
- 28.** Which of the following increases along the period ?
(1) Number of valence electrons
(2) Atomic size
(3) Electropositive character
(4) All of these
- 29.** Which of the following elements has three valence electrons ?
(1) Cs (2) Ca (3) Al (4) S
- 30.** Each of the following element forms univalent ions except
(1) Li (2) Na (3) Mg (4) K
- 31.** Which of the following pairs are chemically dissimilar ?
(1) Na, K (2) Ba, Sr (3) C, Si (4) Ca, Cs
- 32.** The valency of noble gases, in general is
(1) zero (2) one (3) two (4) eight
- 33.** An element M has an atomic number 9 and atomic mass 17. Its ion will be represented by
(1) M (2) M^{+2}
(3) M^- (4) M^{-2}
- 34.** Which element has the largest size in the second period ?
(1) N (2) F (3) Li (4) Be
- 35.** Which has the maximum atomic radius ?
(1) Al (2) Si (3) P (4) Mg
- 36.** In the third period of the periodic table, the element having smallest size is
(1) Na (2) Ar (3) Cl (4) Si
- 37.** Among O, C, F, Cl, Br the correct order of increasing atomic radii is
(1) F, O, C, Cl, Br (2) F, C, O, Cl, Br
(3) F, Cl, Br, O, C (4) C, O, F, Cl, Br
- 38.** Alkali metals in each period have
(1) Smallest size
(2) Lowest I.E.
(3) Highest E.A.
(4) Highest electronegativity
- 39.** From top to bottom in a group of the periodic table the electropositive character of the elements
(1) increases (2) decreases
(3) remains unchanged (4) changes irregularly
- 40.** Elements of which group form anions most readily
(1) oxygen family (2) nitrogen group
(3) halogens (4) alkali metals
- 41.** Arrange S, O and Se in ascending order of electron affinity ?
(1) $\text{Se} < \text{S} < \text{O}$ (2) $\text{Se} < \text{O} < \text{S}$
(3) $\text{S} < \text{O} < \text{Se}$ (4) $\text{S} < \text{Se} < \text{O}$
- 42.** Which pair of elements of the following sets is likely to have similar chemical behaviour ?
(1) Sodium and aluminium
(2) Argon and potassium
(3) Boron and germanium
(4) Nitrogen and phosphorus
- 43.** Considering the elements B, Al, Mg and K, the correct order of their metallic character is
(1) $\text{B} > \text{Al} > \text{Mg} > \text{K}$
(2) $\text{Al} > \text{Mg} > \text{B} > \text{K}$
(3) $\text{Mg} > \text{Al} > \text{K} > \text{B}$
(4) $\text{K} > \text{Mg} > \text{Al} > \text{B}$

- 44.** In the periodic table, the metallic character of elements

 - (1) decreases from left to right and down the group
 - (2) decreases from left to right and increases down the group
 - (3) increases from left to right and down the group
 - (4) increases from left to right and decreases down the group

45. Gradual addition of electronic shells in the noble gases causes a decrease in their

 - (1) Ionisation energy
 - (2) Atomic radius
 - (3) Boiling point
 - (4) Density

46. Which of the following elements has the least nonmetallic character ?

 - (1) Fluorine
 - (2) Chlorine
 - (3) Bromine
 - (4) Iodine

47. Why are the elements lithium, sodium and potassium called alkali metals ?

 - (1) Because they react with water to form alkalis
 - (2) Because they form acidic oxides
 - (3) Because they are present in first group
 - (4) Because they are less reactive in nature

48. Which of the following oxides is amphoteric in nature ?

 - (1) CaO
 - (2) CO_2
 - (3) SiO_2
 - (4) SnO_2

49. Which of the following hydroxides is most basic ?

 - (1) $\text{Be}(\text{OH})_2$
 - (2) $\text{Ba}(\text{OH})_2$
 - (3) $\text{Ca}(\text{OH})_2$
 - (4) $\text{Mg}(\text{OH})_2$

50. Which of the following elements will form acidic oxide ?

 - (1) Sodium
 - (2) Magnesium
 - (3) Aluminium
 - (4) Sulphur

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	1	4	3	2	1	4	2	1	1	4	2	3	4	4	1	1	4	2	1
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	4	2	3	1	2	4	3	1	3	3	4	1	3	3	4	3	1	2	1	3
Que.	41	42	43	44	45	46	47	48	49	50										
Ans.	1	4	4	2	1	4	1	4	2	4										