

Classification of Elements and Periodicity in Properties

1. **Classification** means identifying similar species and grouping them together.
2. **Lavoisier** divided elements into two main types known as **metals** and **non-metals**.
3. **Doberiner's Law of triads:**

According to this law, "*in certain triads (group of three elements) the atomic mass of the central element was the arithmetic mean of the atomic masses of the other two elements.*" But in some triads all the three elements possessed nearly the same atomic masses, therefore the law was rejected.

e.g., atomic masses of Li, Na and K are respectively 7, 23 and 39, thus the mean of atomic masses of 1st and 3rd element is $= 7 + 39 = 23$

Limitations of Doberiner's Triads: He could identify only a few such triads and so the law could not gain importance. In the triad of Fe, Co, Ni, all the three elements have a nearly equal atomic mass and thus does not follow the above law.

4. **Newland's Law of octaves:**

According to this law "*the elements are arranged in such a way that the eighth element starting from a given one has properties which are a repetition of those of the first if arranged in order of increasing atomic weight like the eight note of musical scale.*"

Drawback of Newland's law of octaves:

- (i) According to Newland only 56 elements exists in nature and no more elements would be discovered in the future. But later on several new element were discovered whose properties did not fit into law of octaves.
- (ii) In order to fit new elements into his table Newland adjust two elements in the same column, but put some unlike elements under the same column.

Thus, Newland's classification was not accepted.

5. **Mendeleev's periodic table :**

Mendeleev arranged 63 elements known at that time in the periodic table. According to Mendeleev "*the properties of the elements are a periodic function of their atomic masses.*" The table consists of eight vertical column called '*groups*' and horizontal rows called '*periods*'.

Merits of Mendeleev's periodic table:

- (i) At some places the order of atomic weight was changed in order to justify the chemical and physical nature.

- (ii) Mendeleev left some gap for new elements which were not discovered at that time.

- (iii) One of the strengths of Mendeleev's periodic table was that, when inert gases were discovered they could be placed in a new group without disturbing the existing order.

Characteristics of the periodic table : Its main characteristics are :

- (i) In the periodic table, the elements are arranged in vertical rows called **groups** and horizontal rows called **periods**.
- (ii) There are **eight groups** indicated by Roman Numerals I, II, III, IV, V, VI, VII, VIII. The elements belonging to first seven groups have been divided into **sub-groups** designated as **A** and **B** on the *basis of similarities*. The elements that are present on the left hand side in each group constitute sub-group A while those on the right hand side form sub-group B. Group VIII consists of nine elements arranged in **three triads**.
- (iii) There are **six periods** (numbered 1, 2, 3, 4, 5 and 6). In order to accomodate more elements, the periods 4, 5, 6 are divided into two halves. The first half of the elements are placed in the upper left corners and the second half occupy lower right corners in each box.

Achievements of Mendeleev's periodic table

- (i) The arrangement of elements in groups and periods *made the study of elements quite systematic* in the sense that if properties of one element in a particular group are known, those of the others can be easily predicted.
- (ii) **Prediction of new elements and their properties :** Many gaps were left in this table for undiscovered elements. However, properties of these elements could be predicted in advance from their expected position. This helped in the discovery of these elements. The elements *silicon*, *gallium* and *germanium* were discovered in this manner.
- (iii) **Correction of doubtful atomic masses :** Mendeleev corrected the atomic masses of certain elements with the help of their expected positions and properties.

Limitations of Mendeleev's classification :

- (i) He could not assign a correct position of hydrogen in his periodic table, as the properties of hydrogen resembles both with alkali metals as well as with halogens.
- (ii) The isotopes of the same element will be given different position if atomic number is taken as basis, which will disturb the symmetry of the periodic table.

- (iii) The atomic masses do not increase in a regular manner in going from one element to the next. So it was not possible to predict how many elements could be discovered between two elements.

6. **Modern periodic law :** This law was given by **Henry Moseley** in 1913. It states, “*Properties of the elements are the periodic function of their atomic numbers*”.

Cause of periodicity : Periodicity may be defined as the repetition of the similar properties of the elements placed in a group and separated by certain definite gap of atomic numbers.

The cause of periodicity is the resemblance in properties of the elements is the repetition of the same valence shell electronic configuration.

7. **Modern periodic table**

Moseley proposed this modern periodic table and according to which “*the physical and chemical properties of elements are periodic function of their atomic number and not the atomic weight.*”

- (i) The modern periodic table has 18 vertical columns called “*groups*” and seven horizontal rows called “*periods*”. The groups have been numbered 1, 2, 3.....18 from left to right.
- (ii) The elements belonging to a particular group make a family and usually named after the first member. In a group all the elements contain the same number of valence electrons.
- (iii) In a period all the elements contain the same number of shells, but as we move from left to right the number of valence shell electrons increases by one unit.

The maximum number of electrons that can be accommodated in a shell can be calculated by the formula $2n^2$ where n is the number of the given shell from the nucleus.

8. **Trends in modern periodic table :** The trends observed in some important properties of the elements in *moving down the group* (from top to bottom of the table) and *across a period* (from left to right in a period) are discussed below :

(i) **Valency :** Valency may be defined as “*the combining capacity of the atom of an element with atoms of other elements in order to acquire the stable configuration (i.e. 8 electron in valence shell. In some special cases it is 2 electrons).*”

(ii) **Atomic size :** It refers to the distance between the centre of nucleus of an isolated atom to its outermost shell containing electrons.

The atomic radius decreases on moving from left to right along a period. This is due to an increase in nuclear charge which tends to pull the electrons closer to the nucleus and reduces the size of the atom.

In a group atomic size decreases from top to bottom due to increase in number of shells.

(iii) **Metallic and non-metallic properties :** In a period from left to right metallic nature decreases while non-metallic character increases.

In a group metallic character increases from top to bottom while non-metallic character decreases.

(iv) **Electronegativity :** The relative tendency of an atom to attract the shared pair of electrons towards itself is called **electronegativity**.

In a period from left to right, the value of electronegativity increases while in a group from top to bottom the value of electronegativity decreases.

EXERCISE

- The early attempt to classify elements as metals and non-metals was made by
(a) Mendeleev (b) Lothar Meyer
(c) Lavoisier (d) Henry Moseley
- Newlands could classify elements only upto
(a) copper (b) chlorine
(c) calcium (d) chromium
- Mendeleev classified elements in
(a) increasing order of atomic groups
(b) eight periods and eight groups
(c) seven periods and eight groups
(d) eight periods and seven groups
- The long form of periodic table consists of
(a) seven periods and eight groups
(b) seven periods and eighteen groups
(c) eight periods and eighteen groups
(d) eighteen periods and eight groups
- All the members in a group in long form of periodic table have the same
(a) valence
(b) number of valence electrons
(c) chemical properties
(d) All of these
- Which of the following properties generally decrease along a period?
(a) Atomic size
(b) Non-metallic character
(c) Metallic character
(d) Both (a) and (c)
- An element 'M' has an atomic number 9 and its atomic mass 19. The ion of M will be represented by
(a) M (b) M^{2+}
(c) M^{-} (d) M^{2-}
- The element with smallest size in group 13 is
(a) beryllium (b) carbon
(c) aluminium (d) boron
- The elements with atomic numbers 2, 10, 18, 36, 54 and 86 are all
(a) halogen (b) noble gases
(c) noble metals (d) light metals
- The number of elements in the third period of periodic table is
(a) 2 (b) 8
(c) 18 (d) 32
- Which of these choices is not a family of elements?
(a) Halogens (b) Metals
(c) Inert gases (d) All of these
- The element which has least tendency to lose electron is
(a) H (b) Li
(c) He (d) Na
- The most metallic element in the fourth period is
(a) Ca (b) K
(c) S (d) P
- The elements of group sixteen are called
(a) halogens (b) chalcogens
(c) pnictogens (d) noble gases
- Which of the following is correct set of Dobereiner Triads?
(a) Na, Si, Cl (b) Be, Mg, Ca
(c) F, Cl, I (d) Li, Na, Be
- The metal which is hard and has high m.p. and used in electric bulbs is
(a) Ni (b) Pt
(c) Fe (d) W
- The lightest liquid metal is
(a) Hg (b) Ga
(c) Cs (d) Fr
- Which is not true about noble gases?
(a) They are non-metallic in nature
(b) They exist in atomic form
(c) They are radioactive in nature
(d) Xenon is the most reactive among them
- Elements of which group form anions most readily?
(a) Oxygen family (b) Nitrogen family
(c) Halogens (d) Alkali metals
- On moving horizontally across a period, the number of electrons in the outermost shell increases from to
(a) 2, 8 (b) 2, 18
(c) 1, 8 (d) 1, 18
- Which of the following is not a representative element?
(a) Fe (b) K
(c) Ba (d) N
- The scientist who made maximum contribution towards periodic table was
(a) Chadwick (b) Rutherford
(c) Dalton (d) Mendeleev
- Which of the following elements A, B, C, D and E with atomic number 3, 11, 15, 18 and 19 respectively belong to the same group?
(a) A, B, C (b) B, C, D
(c) A, D, E (d) A, B, E
- Element A belongs to Group VII in *p*-block and element B belongs to Group I in *s*-block of the periodic table. Out of the following assumptions, the correct one is :
(a) A and B are metals
(b) A and B are non-metals
(c) A is a metal and B is a non-metal
(d) A is a non-metal and B is a metal
- The element with atomic number 14 is hard and forms acidic oxide and a covalent halide. To which of the following categories does the element belong?
(a) Metal (b) Metalloid
(c) Non-metal (d) Left-hand side element

26. Which of the following properties do not match elements of halogen family ?
 - (a) They have seven electrons in their valence shell
 - (b) They are diatomic in their molecular form
 - (c) They are highly reactive chemically
 - (d) They are metallic in nature
27. Which fact is not valid for Dobereiner's triads?
 - (a) The atomic weight of middle element is roughly average of the other two elements
 - (b) The properties of middle element is roughly average of the other two elements
 - (c) The elements of triads belong to the same group of modern periodic table
 - (d) The elements of triads have same valency electrons.
28. Which of the following statements is incorrect from the point of view of modern periodic table ?
 - (a) Elements are arranged in the order of increasing atomic number
 - (b) There are eighteen vertical columns called groups
 - (c) Transition elements fit in the middle of long periods
 - (d) Noble gases are arbitrarily placed in eighteenth group
29. Which of the following group of elements belongs to alkali metals?
 - (a) 1, 12, 30, 4, 62 (b) 37, 19, 3, 55
 - (c) 9, 17, 35, 53 (d) 12, 20, 56, 88
30. Which of the following elements will form acidic oxide?
 - (a) Sodium (b) Magnesium
 - (c) Aluminium (d) Sulphur
31. Which one of the following is most electropositive element?
 - (a) Sodium (b) Calcium
 - (c) Aluminium (d) Silicon
32. The atomic number of an element tells you the number of in a neutral atom.
 - (a) positrons (b) neutrons
 - (c) electrons (d) All of these
33. As you move down the group, the alkali metals become
 - (a) brighter (b) hotter
 - (c) more reactive (d) less reactive
34. Which is a metalloid?
 - (a) Pb (b) Sb
 - (c) Bi (d) Zn
35. Which one of the following elements exhibit maximum number of valence electrons?
 - (a) Na (b) Al
 - (c) Si (d) P
36. Which of the following elements does not lose an electron easily?
 - (a) Na (b) F
 - (c) Mg (d) Al
37. To which block is related an element having electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ in the periodic table—
 - (a) s-block (b) p-block
 - (c) d-block (d) f-block
38. If the valence shell electronic configuration for an element is $ns^2 np^5$, this element will belong to the group of —
 - (a) alkali metals (b) inert metals
 - (c) noble gases (d) halogens
39. Which shows variable valency —
 - (a) s-block elements (b) p-block elements
 - (c) d-block elements (d) Radioactive elements
40. The noble gases are unreactive because
 - (a) they react with sodium
 - (b) they have a full outer shell of electrons
 - (c) they have a half outer shell of neutrons
 - (d) they are too thin
41. Which scientist came up with the concept of a periodic table that included all of the known elements?
 - (a) Joseph Priestly (b) Dmitri Mendeleev
 - (c) Antoine Lavoisier (d) Albert Einstein
42. If the two members of a Dobereiner triad are phosphorus and antimony, the third member of this triad is —
 - (a) arsenic (b) sulphur
 - (c) iodine (d) calcium

ANSWER KEY									
1	(c)	11	(b)	21	(a)	31	(a)	41	(b)
2	(c)	12	(c)	22	(d)	32	(c)	42	(a)
3	(c)	13	(b)	23	(d)	33	(c)		
4	(b)	14	(b)	24	(d)	34	(b)		
5	(d)	15	(b)	25	(b)	35	(d)		
6	(d)	16	(d)	26	(d)	36	(b)		
7	(c)	17	(c)	27	(b)	37	(a)		
8	(d)	18	(c)	28	(d)	38	(d)		
9	(b)	19	(c)	29	(b)	39	(c)		
10	(b)	20	(c)	30	(d)	40	(b)		

HINTS AND SOLUTIONS

3. (c) Mendeleev's periodic table consists of seven periods and eight groups.
5. (d) Because of the presence of same number of valence electrons the elements of same group have similar chemical properties.
6. (d) As atomic size decreases along a period valence electrons becomes more firmly held with nucleus. Thus more amount of energy is required to remove valence electrons which reduces metallic character
7. (c) The electronic configuration of M is 2, 7. It needs one electron to complete its octet. It has a strong tendency to gain 1 electron and so its ion will be M^- .
8. (d) In group 13, boron is above aluminium. Rest of elements not belong to group 13.
9. (b) All these are noble gases with completely filled outermost shell.
11. (b) A family of elements consists of elements present in a group of the periodic table.
12. (c) He is an inert gas.
13. (b) The fourth period contains elements with atomic number 19 to 36. K ($Z = 19$) is the first member and so it is most metallic.
14. (b) Elements of oxygen family are known as chalcogens.
16. (d) Tungsten (W) is used in electric bulbs.
17. (c) Cs is a metal. It is liquid at room temperature. It is lighter than Hg (also a liquid metal).
18. (c) Only Radon (Rn) is radioactive whereas other noble gases (i.e., He, Ne, Ar, Kr, Xe) are non-radioactive.
19. (c) Halogens are most electronegative elements i.e., they are likely to form anions most readily.
21. (a) Fe is a transition element.
23. (d) A ($Z = 3$); B ($Z = 11$) and E ($Z = 19$) are all alkali metals.
24. (d) Element A belong to halogens (Group VII) group and is a non-metal. While element B belongs to alkali metal group (Group I) and is a metal.
25. (b) The given element belongs to carbon family.
26. (d) The members of the halogen family are non-metallic in nature. However, iodine and astatine are crystalline solids and have lustre just like metals.
29. (b) Alkali metals have 1 electron in valence shell.
30. (d) Oxides of non-metals are acidic.
31. (a) Alkali metals are most electropositive in their respective period. i.e. they have maximum tendency to lose electron and form a cation.
35. (d) P is in group 5 and has 5 valence electron. Number of valence electrons in Na, Al and Si are 1, 3 and 4.
36. (b) F has a tendency to gain an electron.
41. (b). Dmitri Mendeleev is credited with designing the modern periodic table. Joseph Priestly and Antoine Lavoisier were both chemists. Albert Einstein developed theories on photoelectric effect.