Chapter 1

PERIODIC TABLE, PERIODICALLY PROPERTIES AND VARIATIONS OF PROPERTIES

DOBEREINER'S TRIAD - DEFINITION

Dobereiner arranged the element in increasing order of atomic masses. He found that the atomic mass of the middle

element was approximately equal to the arithmetic mean (average) of the atomic masses of the other two elements of that triad when they are arranged in their increasing order of atomic mass, e.g., Li, Na, K. The atomic mass of Li is 9 and K is 39. The average of two atomic number is 23 that is the atomic number of sodium.

Newlands law of octaves giving examples. Newlands Law : When the elements are arranged in increasing order of their atomic masses, the properties of the eighth element are similar to that of the first. Examples : ... The eight element from lithium is sodium. Similarly, eight element from sodium is potassium.

the Russian chemist Dmitri Mendeleev also had a similar thought, and he published the first periodic table in 1869 with the then-known elements. In this table were all the known elements arranged in the increasing order of their atomic masses and according to their chemical properties.

His table also had empty spaces for the still unknown and undiscovered elements since Mendeleev believed

these gaps would be filled by the properties of these unknown elements. Since then to now, the periodic table has been expanded to include all the elements that have been discovered so far and their chemical behaviour.

Henry Mosley is credited with the modern periodic table (published in 1913). The modern periodic table that we use, is an arrangement of chemical elements with a

configuration of their chemical properties based on the atomic number.

GROUP IN A PERIODIC TABLE - DEFINITION

A group (also known as a family) is a column of elements in the periodic table of the chemical elements. There are 18 numbered groups in the periodic table, but the f-block columns

(between groups 2 and 3) are not numbered.

MODERN PERIODIC LAW - LAW

The properties of elements are the periodic function of their atomic number i.e number of protons.

PERIOD IN A PERIODIC TABLE - DEFINITION

In the periodic table of the elements, each numbered row

is a period. In the periodic table of the elements, elements are arranged in a series of rows (or periods) so that those with similar properties appear in a column.

MODERN PERIODIC TABLE - DEFINITION

There are 18 vertical columns in the periodic table. Each column is called a group. All

elements in a group have similar chemical and physical properties because they have the same number of outer electrons.

In periodic table elements are arranged in a series of rows. Elements of the same period have the same number of electron shells.

FEATURES OF LONG FORM OF PERIODIC TABLE - DEFINITION

1. 18 vertical columns known as groups.

2. 7 Horizontal rows known as periods.

3. Light metals These are elements of periodic table of group 1 and 2.

4. Heavy metals or Transition metals - These are elements of periodic table of group 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12.

5. Non-Metals These are elements of periodic table of group 13, 14, 15, 16 and 17.

6. Zero group These are elements of periodic table of group 18.

DETERMINE THE PERIOD NUMBER OF ELEMENTS - SHORTCUT

All of the elements in a period have the samenumber of atomic

orbitals. For example, every element in the top row (the first period) has one orbital for its electrons. All of the elements in the second row (the second period) have two orbitals for their electrons.

GROUP NUMBER IN A PERIODIC TABLE - DEFINITION

1. In any group, outermost shell electron are known as valance electrons and these

electrons are same so main properties of elements of group is similar.

2. Elements are divided into four blocks, which is s, p, d, f according to valance electrons.

3. s-block elements elements of 1 and 2 group.

4. p-block elements elements of 13 to 18 group.

5. d-block elements elements of 3 to 12 group.

6. f-block elements elements of the Lanthanide and Actinide series.

7. Representative Elements elements of s-block and p-block collectively called as Representative elements also known as Normal elements or Typical elements.

8. Transition Elements elements of d-block.

9. Inner Transition Elements elements of f-block, also

known as Rare Earth Elements.
10. Alkali Metals elements of 1st group.
11. Alkaline Earth Metas elements of 2nd group.

DETERMINE THE GROUP NUMBER OF ELEMENTS - SHORTCUT

The group number is an identifier used to describe the column of the standard periodic table in

which the element appears. Groups 1-2 (except hydrogen) and 13-18 are termed main group elements. Groups 3-11 are termed transition elements.

Electronic configuration of Sodium is 2, 8, 1. So the number of group is 1

LONG FORM OF PERIODIC TABLE - DEFINITION

The periodic table is a tabular arrangement of the chemical elements, ordered by their atomic number , electron configuration, and recurring chemical properties. This ordering shows periodic trends such as elements with similar behavior in the same column. It also shows four rectangular blocks with some approximately similar chemical

properties. In general, within one row (period) the elements are metals on the lefthand side, and non-metals on the righthand side.
The rows of the table are called periods, the columns are called groups. Six groups (columns) have names as well as numbers: for example, group 17 elements are the halogens and group 18, the noble gases. The periodic table can be used to derive

relationships between the properties of the elements, and predict the properties of new elements yet to be discovered or synthesized.

Periodic properties of elements

The basic law governing modern periodic table states that the properties of elements are periodic functions of their atomic number. These properties reappear at regular

intervals or follow a particular trend at regular intervals. This phenomenon is known as the periodicity of elements.

The periodic properties of elements occur due to the recurrence of similar electronic configuration that is having the same number of electrons in the outermost orbit. In a particular group, the number of valence electrons remains the same. On the other hand, the number of valence

electrons increases, as we move from left to right across a period. The chemical property of an element depends on the number of electrons in the valence shell.

Explanation for periodic properties

The periodic properties of an element depend on valency and number of shells in an atom. As we move down a group the number of shell increases successively such that

the number of the shell of an element is equal to the number of periods to which it belongs. As we move across a period, the number of shell remains the same. For example, elements of the second period have two shells.

The combining capacity of an atom is known as its valency. It is equal to the number of electrons that an atom can accept or donate in order to complete its octet. As we move

down a group, the number of electrons in the valence shell remains the same. Hence the valency of a group is constant. Valency depends on the number of electrons in the outermost shell of an atom. If the number of electrons is 1, 2, 3, 4 then the respective valences will be 1, 2, 3, 4. If the number of electrons in the outermost shell will be 5, 6, 7 then the valency will be 8 – 5 = 3, 8 – 6 = 2 and 8 – 7 = 1. Valency

is the combining capacity of an atom hence will always have a positive value and largely affects the periodic properties.

In a period, the number of electrons increases from left to right. As a result, the number of electrons needed to complete the octet also changes. Hence, the valency successively increases to four in group 14 and then subsequently decreases to 1 in group 17.

Periodic Properties of Elements with Examples

1) Atomic Radius:

Atomic radius of elements decreases as we go from left to right in periodic table. Reason is that; atomic number of elements increase from left to right in same period, thus increase in the number of protons causes increases in attraction of electrons by protons. On the contrary, in same group, as we go from top

to bottom, atomic radius of elements increase. Since number of shells increase in same group from top to bottom, attraction of electrons by protons decrease and atomic radius increase.

Example: Find relation between atomic radius of elements $_{3}X$, $_{11}Y$ and $_{5}Z$.

We first find the locations of elements in periodic table.

$_{3}X:1s^{2}2s^{1}$ 2. period I A group

$_{11}Y:1s^2 2s^2 2p^6 3s^1$ 3. period and I A group

$_{5}Z:1s^2 2s^2 2p^1$ 2. period and III A group.

	I A	III A
2. period	X	Z
3. period	Y	

Since atomic radius increase from right to left and top to bottom;

Y>X>Z

2) Ionization Energy:

Energy required to remove an electron from atoms or ions is

called ionization energy. Energy required to remove first valence electron is called first ionization energy, energy required to remove second valence electron is called second ionization energy etc. Following reactions show this process;

$X + IE_1 \rightarrow X^{+} + e^{-}$

$X^{+} + IE_2 \rightarrow X^{+2} + e^{-}$

$X^{+2} + IE_3 \rightarrow X^{+3} + e^{-}$

Increasing in the attraction force applied by nucleus to

electrons makes difficult to remove electrons from shells. Second ionization energy is larger than first ionization energy, second ionization energy is larger than third ionization energy. We can say that;

$IE_1 < IE_2 < IE_3 < ....$

When electrons are removed from atom, attraction force per electron increases, thus removing electron from atom becomes more difficult. Atoms

having electron configuration ns^2np^6 has spherical symmetry property and removing electron is difficult and ionization energy is high. Moreover, atoms having $ns^2np^6ns^1$ has lower ionization energy, because removing one electron from these atoms make them noble gas and more stable. Thus, it is easy to remove electron from them. For example;

$_{10}Ne: 1s^2 2s^2 2p^6$ and

$_{11}Na: 1s^2 2s^2 2p^6 3s^1$

$IE_{Ne} > IE_{Na}$

Knowing sequential ionization energies of atom, helps us to find number of valence electrons of atoms. Examine following example;

IE_1	IE_2	IE_3	IE_4	IE_5
176	347	1850	2520	3260

Increase in second to third ionization energy is greater than others, thus atom has 2 valence electrons.

Example:

$Na(gas) + IE_1 \rightarrow Na^+ + e^-$

$Na(gas) + IE_2 \rightarrow Na^{+2} + 2e^-$

$Na(solid) + IE_3 \rightarrow Na^+ + e^-$

$Na^+(solid) + IE_4 \rightarrow Na^{+2} + e^-$

Which one of the following statements related to chemşcal equations given above are false.

I. E_1 is the first ionization energy of Na

II. $E_3 > E_1$

III. E_2 is second ionization energy of Na

IV. $E_4 > E_1$

V. $E_2 = E_1 + E_4$

First ionization energy is the energy required for removing one electron from neutral atom in gas state. I is true.

E_3 is the sum of energies E_1 and sublimation energy. Thus, $E_3 > E_1$ II is true

Second ionization energy is the energy required for removing one electron from +1 charged ion in gas state.Thus, III is false.

E_4 is the second ionization energy and E_1 is first ionization energy. Thus; $E_4 > E_1$ IV is true

$Na(gas) + IE_1 \rightarrow Na^+ + e^-$

$Na^+(solid) + IE_4 \rightarrow Na^{+2} + e^-$

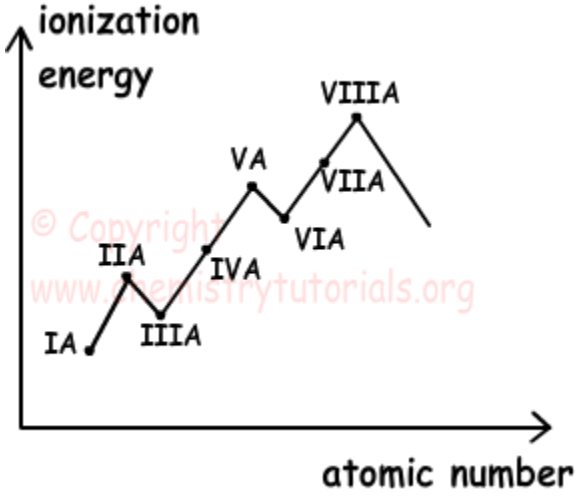
$Na(gas) + (E_1+E_4) \rightarrow Na^{+2}(gas) + 2e^-$

So; $E_2 = E_1 + E_4$ V is true

Changes of Ionization Energy in Periodic Table;

I A<III A<II A<IV A<VI A<V A<VII A<VIII A

Since II A and V A has spherical symmetry property they have greater ionization energies then III A and VI A. Graph given below shows relation between ionization energy and atomic number.



3) Electron Affinity:

If an electron is added to neutral atom in gas state, energy is given off. We call this energy "electron affinity".Following chemical equation shows this process.

$$X(gas) + e^- \rightarrow X^-(gas) + E$$

In general, electron affinity increases as we go from left to right in period. On the contrary, electron affinity decreases in a group from top to bottom.

4) Electronegativity:

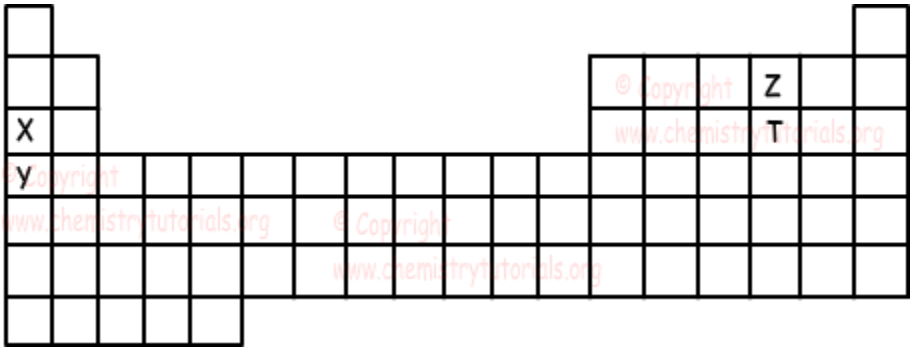
In a chemical bond, electron attraction capability of atoms is called electronegativity. From left to right in period electronegativity increases and from top to bottom in a group electronegativity decreases.

Since noble gases do not form chemical bonds, we can not talk about their electronegativity.

5) Metal-Nonmetal Property: Capability of giving electron is called metal property and capability of getting electron is called non metal property of elements. Moving in period from left to right, metal property increases and non metal property decreases. In a group of metals, from top to

bottom metal property increases. In a groups of non metals, from top to bottom non metal property of atoms decreases.

Example: Which one of the following statement is true related to given elements in the periodic table below.



I. Metal property of X is larger than Y, Z and T.
II. Atomic radius of Z is larger than X, Y and T.
III. Ionization energy of T is larger than IE of X.
IV. The most electronegative element is Y.

Metal property increases from right to left and top to bottom.

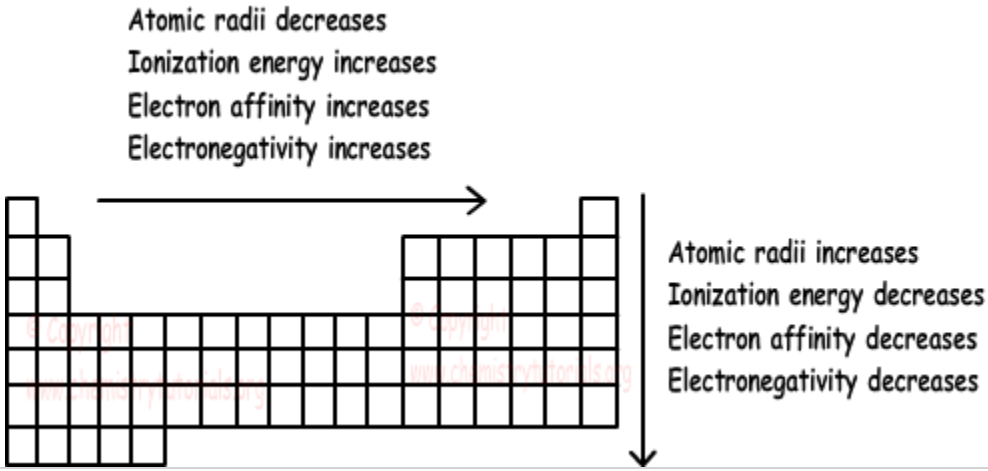
Thus Y is the most metallic element. I is false.

Atomic radii increases from right to left and top to bottom. Thus Y has greater atomic radii. II is false.

Ionization energy increases from left to right in same period. Thus, $IE_T > IE_X$. III is true.

Electronegativity increases from left to right and bottom to top. Z is the most electronegative element.

Summary of periodic properties is given in the picture below.



ATOMIC NUMBER - DEFINITION

The number of protons in the atom of an element is known as atomic number. Since the

atom is electrically neutral so the number of protons and number of electrons are equal.

FORMULA OF ATOMIC NUMBER - FORMULA

Atomic number (Z) of an element = number of protons = number of electrons.

Atomic number = Atomic mass - number of neutrons

FORMULA OF MASS NUMBER - FORMULA

Mass number(A) = Number of protons (p) + Number of neutrons (n)

Number of protons = Atomic number (Z)

So, $A=Z+n$

EXAMPLE OF ATOMIC NUMBER - EXAMPLE

Sodium has 11 electrons.

Therefore, the atomic number

is equal to the number of electrons i.e 11.

MASS NUMBER - DEFINITION

Since electrons carry negligible mass, the mass of an atom is almost the mass of the protons and neutrons in the nucleus of the atom. Mass number of the atom is the total number of protons and the neutrons in the atom of an element.

EXAMPLE OF MASS NUMBER - EXAMPLE

Aluminium has 13 protons and 14 neutrons.

Therefore, the atomic mass = Number of protons + Number of neutrons=13+14=27

- **QUESTIONS FOR PRACTISE**

Long Answer Questions

1. An element has an atomic number 16, State:

a. The period to which it belongs

b. The number of valence electrons.

c. Whether it is a metal or non metal.

2. Define the following terms: I.E and E.A

3. a) The following questions refer to the periodic table:

(i) Name the first and the last element in period 2.

(ii) What happens to the atomic size of elements

on moving from top to bottom in a group?

(iii) Which of the element has the greatest electron affinity among the halogens?

(iv) What is the common feature has of the electronic configurations of the elements in group 17?

(b) Supply the missing word from those in the brackets.

(do not write the out the sentence)

(i) If an element has a low ionization energy then it is likely to be_____(metallic/nonmetallic)

(ii) If an element has seven electrons in its outermost sheel then it is likely to have the _____(largest/smallest) atomic size among all the

elements in the elements in the same period.

(c) (i) The metal of group 2 from top to bottom are: Be, Mg, Ca, Sr, Ba. Which of these metals will form ions most readily and why?

(ii) What property of an element and neon is the last element is measured by electro negativity?

4. A group of elements in the periodic table is given below:

Boron, aluminum, gallium, indium, and thallium.

(boron is the first member of the group and thallium is the last)

Answer the following questions in relation to the above group of elements:

(a) Which element has the most metallic character?

(b) Which element would be expected to have the highest electrone gativity?

(c) If the electronic configuration of aluminum is 2, 8, 3, how many electrons will be there in the outermost shell of thallium?

(d) The atomic number of boron is 5. Write the chemical formula of the compound formed when boron reacts with chlorine.

(e) Will the elements in the group to the right of this

boron group be more metallic or less metallic in character? Justify your answer.

5. The elements of one short period of the periodic table are given bellow in order from left to right: Li, Be, B, C, O, F and Ne.

(a) To which period, do these elements belong?

(b) One element of this period is missing. Which is

the missing element and where should it be placed?

(c) Which one of the elements in this period shows the property of catenation?

(d) Place the three elements, beryllium and nitrogen, in the order of increasing electronegativity.

(e) Which one of the above elements belongs to the halogen series?

6. Parts (a) to (e) refer to changes in the properties of elements on moving from left to right across a period of the periodic table. For each property, change the letter corresponding to the correct answer from the choice A,B, C and D.

(a) The non- metallic character of the elements

(i) Decreases.

(ii) Increases.

(iii) Remains the same. (iv) Depends on the period.

(b) The electronegativity

(i) Depends on the number of electrons. (ii) Remains the same.

(iii)

Decreases.

(iv)Increases.

c) The ionisation potential

i) Goes up and down. (i

i) Decreases and then increases.

(iii) Increases.

(iv)Decreases.

(d) The atomic size

(i) Decreases

(ii) Increases

(iii) Remains the same

(iv) Sometimes increases sometimes decreases.

(e) The electron affinity of the elements in group 1 to 7

(i) Goes up and then down. (ii) Decreases and then increases.

(iii) Increases.

(iv) Decrease.

7. Choose the word or phrase from the bracket which correctly completes each of the following statements:

(a) The elements below sodium in the same group would be expected to have a - _____(lower/higher) electronegaivity than sodium and the element above chlorine would be expected to have a

_____(lower/higher) ionization potential than chlorine.

(b) On moving from left to right in a period the number of shells _____(remains the same /increases/decreases).

c) On moving down a group the number of valence electrons_____(remai

ns the same/increases/decreases).

8. You are provided with the first three periods of the Modern periods tables. Study the table and answer the questions that follow:

(a) Write the formula of the sulphate of element with atomic number 13.

(b) What type of bonding will be present in the oxide

of element with atomic number one?

(c) Which feature of the atomic structure for the similarities in the chemical properties of the elements in group 17 of the periodic table?

(d) Name the element that has the highest ionization potential.

(e) How many electrons are present in the valence

shell of an element with atomic number 18?

(f) What is the term given to the energy when an atom, in this isolated gaseous state, accept an electron to from an anion?

(g) What is the electronic configuration of the third period that gains one electron to change into an anion?

(h) Fill in the blanks.

The atomic size _____as we move from left to right across the period because the _____increases but the _____remains the same.

9.(a) What is meant by a group in the periodic tables?

(b) Within a group, where would you find the element with

(i) The greatest metallic character?

(ii) The largest atomic size?

(c) State whether the ionization potential increase or decreases on going down a group.

(d) How many elements are there in period 2?