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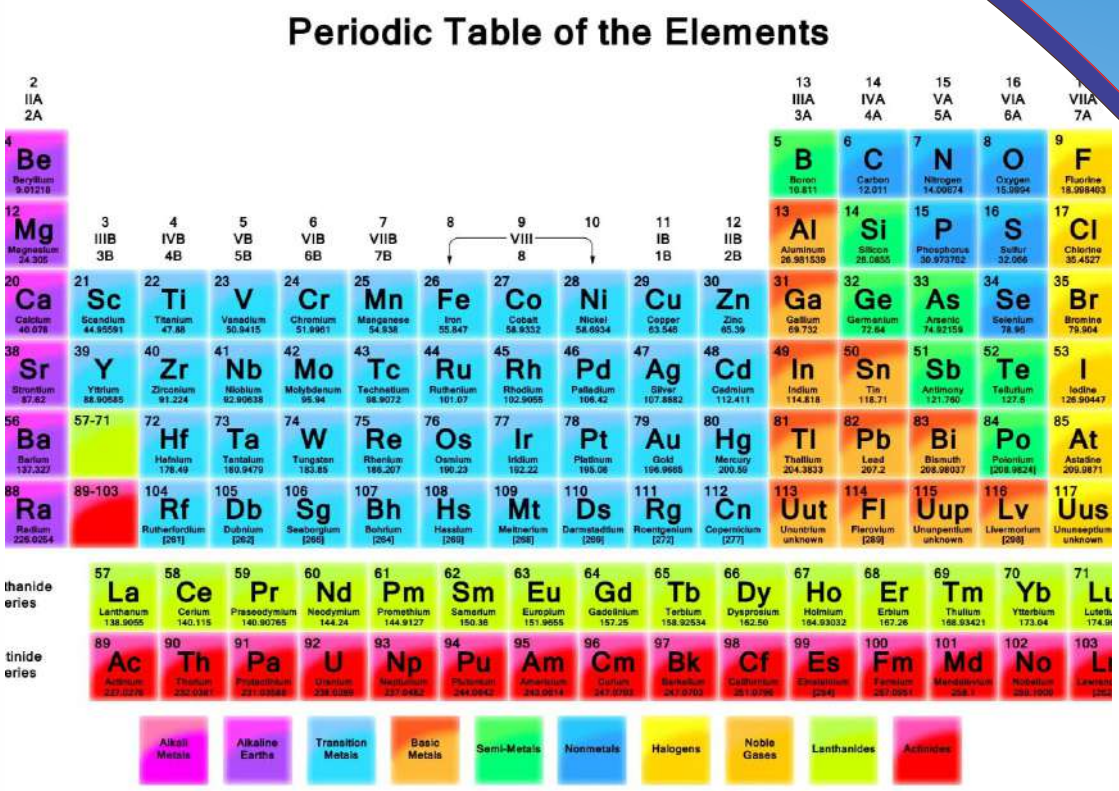

FOUNDATION COURSE

CLASS : 10th

CHAPTER 5

CHEMISTRY

PERIODIC CLASSIFICATION OF ELEMENTS

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INTRODUCTION

Matter around us is present in the form of elements, compounds and mixtures and the elements contain atoms of only one type. At present, 114 elements are known to us. Around the year 1800, only 30 elements were known. All these had seemingly different properties. As different elements were being discovered, scientists gathered more and more information about the properties of these elements. They found it difficult to organise all that was known about the elements. They started looking for some pattern in their properties, on the basis of which they could study such a large number of elements with ease.

You must have visited a library. There are thousands of books in a large library. In spite of this if you ask for a particular book, the library staff can locate it easily. How is it possible? In library the books are classified into various categories and sub-categories. They are arranged on shelves accordingly. Therefore location of books becomes easy. On similar basis scientists made periodic table to arrange elements in proper manner. The periodic table of the chemical elements is a tabular display of the chemical elements.

EARLY ATTEMPTS AT THE CLASSIFICATION OF ELEMENTS

It wasn't until 1649, however, until the first element was discovered through scientific inquiry by Hennig Brand . That element was phosphorous (P). By 1869, 63 elements had been discovered.

This began in 1817 when Johann Dobereiner noticed that the atomic weights of strontium, Sr, was halfway between the weights of calcium and barium. These elements possessed similar chemical properties. By 1829, he had discovered that a halogen triad up of chlorine, bromine, iodine and an alkali metal triad of lithium, sodium and potassium.

Element	Atomic mass
Lithium, Li	7
Sodium, Na	23
Potassium, K	39

He postulated that nature contained triads of elements in which the middle element had properties that were an average of the other two elements.

Mean of the atomic masses of the first (Li) and the third (K) elements(7+39)/2 u The atomic mass of the middle element, sodium, Na is equal to 23 u. Two more examples of Dobereneir's triads

I		II	
Element	**Atomic mass**	**Element**	**Atomic mass**
Calcium, Ca	40	Clorine, Cl	35.5
Strontium, Sr	88	Bromine, Br	80
Barium, Ba	137	Iodine, I	127

Mean of the atomic masses of the first and third elements (I) = (40 +137)/2 = 88.5 u

Mean of the first atomic masses of the first and third elements (II) = (35.5 +127)/2 = 81.25 u

Actual atomic mass of the second element (I) = 88 u

Actual atomic mass of the second element (II) = 80 u

Dobereneir's idea of classification of elements into triads did not receive wide acceptance as he could arrange only a few elements in this manner.

In 1862, **A.E.Beguyer de Chancourtois** was the first person to make use of atomic weights to reveal that the elements were arranged according to their atomic weights with similar elements occurring at regular intervals. He drew the elements as a continuous spiral around a cylinder divided into 16 parts. A list of elements was wrapped around a cylinder so that several sets of similar elements lined up, creating the first geometric representation of the periodic law.

Newland's Law of Octaves

In 1864 John Alexander Newland, an English chemist noticed that "when elements are arranged in the increasing order of their atomic masses every eighth element had properties similar to the first element." Newland called it the Law of Octaves.

Look carefully at the Newland's arrangement of elements shown below:

Li	Be	B	C	N	O	F
(6.9)	(9.0)	(10.8)	(12.0)	(14.0)	(16.0)	(19.0)
Na	Mg	Al	Si	P	S	Cl
(23.0)	(24.3)	(27.0)	(28.1)	(31.0)	(32.1)	(35.5)
K	Ca					
(39.1)	(40.1)					

With the help of the arrangement given above, can you tell starting from lithium eighth element is the Sodium. And starting from sodium? It is potassium. Properties of all three are similar. Similarly, aluminium is the eighth element from boron it shows properties similar to it.

However, Newland could arrange elements in this manner only up to calcium out of a total of over sixty elements known at his time. Because of this shortcoming his work was not received well by the scientific community. The next break through in classification of elements came in the form of Mendeleev's work.

MENDELEEV'S LAW

A periodic function is the one which repeats itself after a certain interval. Thus, according to the periodic law (given by Mendeleev) the chemical and physical properties of elements repeat themselves after certain intervals when they are arranged in the increasing order of their atomic mass.

A tabular arrangement of the elements based on the periodic law is called periodic table. Mendeleev believed that atomic mass of elements was the most fundamental property and arranged them in its increasing order in horizontal rows till he encountered an element which had properties similar to the first element. He placed this element below the first element and thus started the second row of elements. Proceeding in this manner he could arrange all the known elements according to their properties and thus created the first periodic table.

Dmitri Mendeleev (1834-1907) Periodic Table

	Groups of Elements								
Series	0	I	II	III	IV	V	VI	VII	VIII
1.		Hydrogen H 1.008							
2.	Helium He 4.0	Lithium Li 7.03	Beryllium Be 9.1	Boron B 11.0	Carbon C 12.0	Nitrogen N 14.04	Oxygen O 16.00	Fluorine F 19.0	
3.	Neon Ne 19.9	Sodium Na 23.5	Magnesium Mg 24.3	Aluminium Al 27.0	Silicon Si 28.4	Phosphorus P 31.0	Sulphur S 32.06	Chlorine Cl 35.45	
4.	Argon Ar 38	Potassium K 39.1	Calcium Ca 40.1	Scandium Sc 44.1	Titanium Ti 48.1	Vanadium V 51.4	Chromium Cr 52.1	Manganese Mn 55.0	Iron Fe 55.9 Cobalt Co 59 Nickel Ni 59 (Cu)
5.		Copper Cu 63.6	Zinc Zn 65.4	Gallium Ga 70.0	Germanium Ge 72.3	Arsenic As 75	Selenium Se 79	Bromine Br 79.95	
6.	Krypton Kr 81.8	Rubidium Rb 85.4	Strontium Sr 87.6	Yttrium Y 89.0	Zirconium Zr 90.6	Niobium Nb 94.0	Molybedenum Mo 96.0		Ruthenium Ru 101.7 Rhodium Rh 103.0 Palladium Pd 106.5 (Ag)
7.		Silver Ag 107.9	Cadmium Cd 112.4	Indium In 114.0	Tin Sn 119.0	Antimony Sb 120.0	Tellurium Te 127.6	Iodine I 126.9	
8.	Xenon Xe 128	Caesium Cs 132.9	Barium Ba 137.4	Lanthanum La 139	Cerium Ce 140				
9.	–	–	–	–	–	–	–	–	–
10.				Ytterbium Yb 173		Tantalum Ta 183	Tungsten W 184		Osmium Os 191 Iridium Ir 193 Plantinum Pt 194.9 (Au)
11.		Gold Au 197.2	Mercury Hg 200	Thalium Ti 204.1	Lead Pb 206.9	Bismuth Bi 208			
12.			Radium Ra 224		Thorium Th 232		Uranium U 240		
	R	R_2O	RO	R_2O_3	Higher Saline Oxides RO_2 R_2O_5 RO_3 R_2O_7 Higher Gaseous Hydrogen Compounds RH_4 RH_3 RH_2 RH				RO_4

Main Features of Mendeleev's Periodic Table

In Mendeleev's periodic table elements are arranged in tabular form in rows and columns. Now let us learn more about these rows and columns and the elements present in them.

1. The horizontal rows present in the periodic table are called series. These series are further divided into horizontal columns called periods. You can see that there are seven periods in the periodic table.
2. Properties of elements in a particular period show regular gradation (i.e. increase or decrease) from left to right.
3. The vertical columns present in it are called groups. You must have noticed that these are nine in number and are numbered from I to VIII and Zero (Roman numerals).
4. Groups I to VII are subdivided into A and B subgroups. Groups Zero and VIII don't have any subgroups.

5. All the elements in a particular group are chemically similar in nature. They show regular gradation in their physical properties and chemical reactivities.

After learning about the main features we shall now learn about the main merits of Mendeleev's periodic table.

Merits of Mendeleev's Periodic Classification

1. Classification of all elements : Mendeleev's was the first classification which successfully included all the elements.
2. Prediction of new elements : Mendeleev's periodic table had some blank spaces in it. These vacant spaces were for elements that were yet to be discovered. For example, he proposed the existence of an unknown element that he called eka aluminium. The element gallium was discovered four years later and its properties matched very closely with the predicted properties of eka aluminium.

Defects in Mendeleev's Periodic Classification

In spite of being a historic achievement, Mendeleev's periodic table had some defects in it. The following were the main defects in it:

1. **Position of hydrogen :** Hydrogen resembles alkali metals (forms H^+ ion just like Na^+ ions) as well as halogens (forms H^- ion similar to Cl^- ion). Therefore, it could neither be placed with alkali metals (group I) nor with halogens (group VII).
2. **Position of isotopes :** Different isotopes of same elements have different atomic masses, therefore, each one of them should be given a different position in the periodic table. On the other hand, because they are chemically similar, they had to be given same position.
3. **Anomalous pairs of elements :** At certain places, an element of higher atomic mass has been placed before an element of lower atomic mass. For example, Argon (39.91) is placed before potassium (39.1)

MODERN CLASSIFICATION

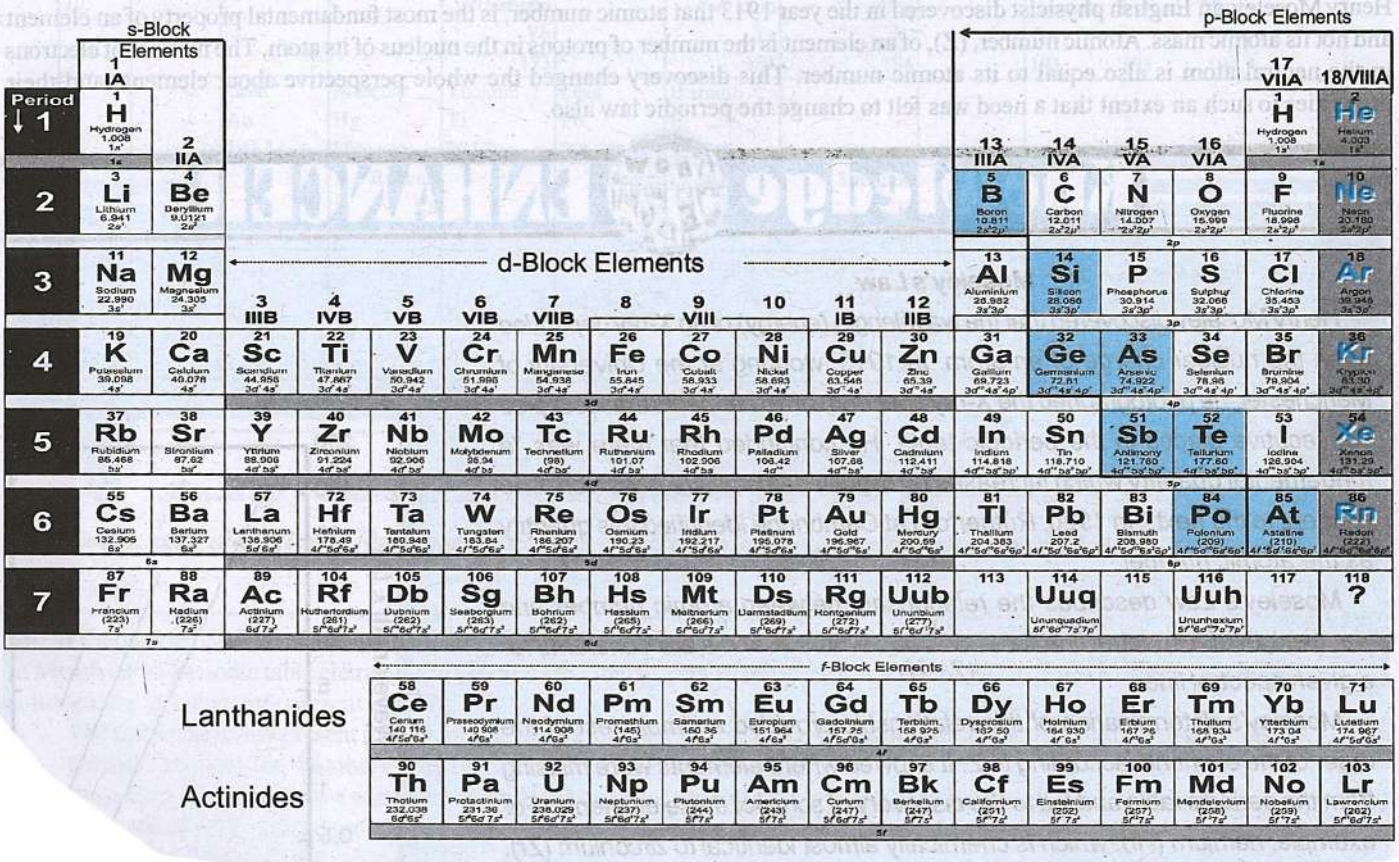
Henry Moseley, an English physicist discovered in the year 1913 that atomic number, is the most fundamental property of an element and not its atomic mass. Atomic number, (Z), of an element is the number of protons in the nucleus of its atom. The number of electrons in the neutral atom is also equal to its atomic number. This discovery changed the whole perspective about elements and their properties to such an extent that a need was felt to change the periodic law also.

MODERN PERIODIC LAW

After discovery of atomic number the periodic law was modified and the new law was based upon atomic numbers in place of atomic masses of elements. After the change in the periodic law many changes were suggested in the periodic table. When the elements are arranged in the increasing order of their atomic number, most of the defects of Mendeleev classification get rectified. **Modern periodic law :** It states that "the properties of the elements are periodic functions of their atomic numbers.

The modern periodic table is also known as the long form of the periodic table or the extended form of the periodic table.

Modern Periodic Table



The Main Features of this Periodic Table

Groups:

There are 18 vertical columns in the periodic table. Each column is called a group. The groups have been numbered from 1 to 18 (in Arabic numerals) from left to right. Group 1 on extreme left position contains alkali metals (Li, Na, K, Rb, Cs and Fr) and group 18 on extreme right side position contains noble gases (He, Ne, Ar, Kr, Xe and Rn).

Elements present in groups 1 and 2 on left side and groups 13 to 17 on the right side of the periodic table are called normal elements or representative elements. Their outermost shells are incomplete. They are also called typical or main group elements. Elements present in groups 3 to 12 in the middle of the periodic table are called transition elements. However, it should be noted here that more and more electrons are added to valence shell only in case of normal elements. In transitions elements, the electrons are added to incomplete inner shells.

Group 18 on extreme right side of the periodic table contains noble gases. Their outermost shells contain 8 electrons and are completely filled that's why they are inert. Inner transition elements: 14 elements with atomic numbers 58 to 71 (Ce to Lu) are called lanthanides and they are placed along with the element lanthanum (La), atomic number 57 in the same position (group 3 in period 6) because of very close resemblance between them. However, for convenience sake they are shown separately below the main periodic table. 14 elements with atomic numbers 90 to103 (Th to Lr) are called actinides and they are placed along with the element actinium (Ac), atomic number 89 in the same position (group 3 in period 7) because of very close resemblance between them. They are shown also separately below the main periodic table along with lanthanides.

Periods :

There are seven rows in the periodic table. Each row is called a period. The periods have been numbered from 1 to 7 (Arabic numerals). In each period a new shell starts filling up. The period number is also the number of shell which starts filling up in it. For example, in elements of 3rd period, the third shell (M shell) starts filling up as we move from left to right . The first element of this period sodium Na (2,8,1) has only one electron in its valence shell (third shell) while the last element of this period, argon Ar (2,8,8) has eight electrons in its valence shell.

The gradual filing of the third shell can be seen below.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Electronic configuration	2,8,1	2,8,2	2,8,3	2,8,4	2,8,5	2,8,6	2,8,7	2,8,8

The first period is the shortest period of all and contains only 2 elements, H and He.

The second and third periods are called short periods and contain 8 elements each.

Fourth and fifth periods are long periods and contain 18 elements each.

Sixth and seventh periods are very long periods containing 32 elements each (including elements up to atomic number 118. Elements 114, 116 and 118 have been reported only recently).

The period of an element signifies the highest energy level an electron in that element occupies in an unexcited state.

CLASSIFICATION OF ELEMENTS

Classification Based on Properties

(i) Elements classified as metalloids :

The 7 elements classified as "Metalloids" are located in Groups 13, 14, 15, 16 and 17 elements of the Periodic Table. Elements classified as Metalloids have properties of both metals and non-metals. Some are semi-conductors and can carry an electrical charge making them useful for electronic appliances like calculators and computers.

The Metalloids in the Periodic Table are : Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium, Polonium,

(ii) Elements classified as alkali metals :

The 6 elements classified as "Alkali Metals" are located in Group 1 elements of the Periodic Table. Elements classified as Alkali Metals are very reactive metals that do not occur freely in nature. Alkali metals are soft, malleable, ductile, and are good conductors of heat and electricity. The Alkali Metals are: Lithium, Sodium, Potassium, Rubidium, Cesium, Francium

(iii) Elements classified as alkaline earth metals :

The 6 elements classified as "Alkaline Earth Metals" are located in Group 2 elements of the Periodic Table. Elements classified as Alkaline Earth Metals are all found in the Earth's crust, but not in the elemental form as they are so reactive (Inspite of being so reactive there reactivity is less than alkali metals). Instead, they are widely distributed in rock structures. The Alkaline Earth Metals on the Periodic Table are : Beryllium, Magnesium, Calcium, Strontium, Barium, Radium.

(iv) Elements classified as transition metals :

The elements classified as "Transition Metals" are located in Groups 3 - 12 of the Periodic Table. Elements classified as Transition Metals are ductile, malleable, and conduct electricity and heat. The Transition Metals on the Periodic Table are: Scandium, Titanium, Vanadium, Chromium, Manganese, Iron, Cobalt, Nickel, Copper, Zinc, Yttrium, Zirconium, Platinum, Gold, Mercury, Rutherfordium, Dubnium, Seaborgium, Bohrium, Hassium, Meitnerium, Ununbium, Niobium, Iridium, Darmstadtium, Molybdenum, Technetium, Ruthenium, Rhodium, Palladium, Silver, Cadmium, Hafnium, Tantalum, Tungsten,

Rhenium, Osmium.

(v) Elements classified as other metals :

The 7 elements classified as "other metals" are located in groups 13, 14, and 15 of the Periodic Table. All of these elements are solid, have a relatively high density and are opaque. The "Other Metals" on the Periodic Table are: Aluminum, Gallium, Indium, Tin, Thallium, Lead, Bismuth

(vi) Elements classified as non-metals :

The 7 elements classified as "Non-metals" are located in Groups 14,15 and 16 of the Periodic Table. Non-metals are not easily able to conduct electricity or heat and do not reflect light . Non-metallic elements are very brittle, and cannot be rolled into wires or pounded into sheets. Non-metallic elements exist, at room temperature, in two of the three states of matter : gases (such as oxygen) and solids (such as carbon). The Non-Metal elements on the Periodic Table are : Carbon, Nitrogen, Oxygen, Phosphorus, Sulfur, Selenium etc.

(vii) Elements classified as halogens :

The 5 elements classified as "halogens" are located in Group 17 of the Periodic Table. Term halogen is derived from Greek words Hals = Sea salt, gennao = producer i.e. sea salt producer

The term "halogen" means "salt-former" and compounds containing halogens are called "salts". The Halogen elements on the Periodic Table are: Fluorine, Chlorine, Bromine, Iodine, Astatine.

(viii) Elements classified as noble gases :

The 6 elements classified as "Noble Gases" are located in Group 18 of the Periodic Table. Six Noble Gases on the Periodic Table are: Helium, Neon, Argon, Krypton, Xenon, Radon

(ix) Elements classified as rare earth elements :

The elements classified as "Rare Earth Elements" are located in Group 3 of the Periodic Table and in the 6th and 7th periods. The Rare Earth Elements consists of the Lanthanide and Actinide series. Most of the elements in the Actinide series are synthetic or man-made. The Lanthanide and Actinide series of Rare Earth Elements on the Periodic Table are:

Lanthanide Elements	Actinide Elements
Lanthanum	Actinium
Cerium	Thorium
Praseodymium	Protactinium
Neodymium	Uranium
Promethium	Neptunium
Samarium	Plutonium
Europium	Americium
Gadolinium	Curium
Terbium	Berkelium
Dysprosium	Californium
Holmium	Einsteinium
Erbium	Fermium
Thulium	Mendelevium
Ytterbium	Nobelium
Lutetium	Lawrencium

Classification Based on Differentiating Electron

This classification divides the elements into four types. i.e., *s*-, *p*-, *d*- and *f*-block elements depending on the type of the atomic shell into which the last electron enters.

(i) **s-block elements :** Those elements of the periodic table in which the last electron enters in *s*–orbital, are called *s*–block elements. s-orbital can accommodate a maximum of two electrons. Their general formulae are ns^1 and ns^2 respectively, where n = (1 to 7). I A group elements are known as alkali metals because they react with water to form alkali. II A group elements are known as alkaline earth metals because their oxides react with water to form alkali and these are found in the soil or earth. *s*-block element are soft and have low melting and boiling points. They mostly form ionic compounds. The total number of *s* block elements are 14. Fr^{87} and Ra^{88} are radioactive elements while H and He are gaseous elements. Cs and Fr are liquid elements belonging to s-block.

(ii) ***p*-block elements** : Those elements of the periodic table in which the last electron gets filled up in the *p*-orbital, called *p*-block elements. A *p*-orbital can accommodate a maximum of six electrons. Therefore, *p*-block elements are divided into six groups which are III A, IV A, V A, VI A, VII A and VIII A groups. They include both metals and non-metals. They form mostly covalent compounds. The general formula of *p* block elements is ns^2np^{1-6} (where n = 2 to 6)

The VIIIA group elements having general formula ns^2np^6 are inert, because their energy levels are fully filled. The total number of *p* block elements in the periodic table is 30 (excluding He). There are nine gaseous elements (Ne, Ar, Kr, Xe, Rn, F_2, Cl_2, O_2 and N_2) belonging to *p*-block. Gallium (Ga) and bromine (Br) are liquids.

(iii) ***d*-block elements :** Those elements of the periodic table in which the last electron gets filled up in the *d* orbital, called *d* block elements. The *d* block elements are placed in groups named IIIB, IV B, V B, VI B, VII B, VIII, I B and II B. In *d* block elements

the electron gets filled up in the *d* orbital of the penultimate shell. Though the total number of *d* block elements is 39 in the periodic table but there are only 36 transition elements. Because only those elements are transition in which *d* orbital is partially filled. The general formula of these elements is $(n-1)d^{1-10}\ ns^{1-2}$ where n = 4 to 7. They are metals having high melting and boiling points. Most of them form coloured compounds and exhibit several oxidation states.

(iv) **f-block elements :** Those elements of the periodic table in which the last electron gets filled up in the *f* orbital, called *f* block elements. There are 28 *f* block elements in the periodic table. The elements from atomic number 58 to 71 are called lanthanides because they come after lanthanum (57). The elements from 90 to 103 are called actinides because they come after actinium (89). They are heavy metals with high melting and boiling points. They form coloured ions. All the actinide elements are radioactive. All the elements after atomic number 92 (i.e. U^{92}) are transuranic elements. The elements which do not occur in nature and are produced in the laboratories artificially are called transuranic or synthetic elements. The general formula of these elements is $(n-2)\ f^{(1-14)}\ (n-1)\ d^{0-1}\ ns^2$ where n = 6 & 7.

Merits of Modern Periodic Table Over Mendeleev's Periodic Table

The modern periodic table is based on atomic number which is more fundamental property of an atom than atomic mass. The long f of modern periodic table is therefore free of main defects of Mendeleev's periodic table.

1. **Position of isotopes :** All isotopes of the same elements have different atomic masses but same atomic number. Therefore, t occupy the same position in the modern periodic table which they should have because all of them are chemically similar.
2. **Anomalous pairs of elements :** When elements are arranged in the periodic table according to their atomic numbers the anon regarding certain pairs of elements in Mendeleev's periodic table disappears. For example, atomic numbers of argon potassium are 18 and 19 respectively. Therefore, argon with smaller atomic number comes before potassium although its ato mass is greater.
3. It explains the periodicity of the properties of the elements and relates them to their electronic configurations.
4. The table is simple, synthetic and easy way for remembering the properties of various elements and moreover lanthanides actinides are placed separately.

TRENDS IN THE MODERN PERIODIC TABLE

In a period the number of valence electrons and the nuclear charge increases from left to right. It increases the force of attrac between them. In a group the number of filled shells increases and valence electrons are present in higher shells. This decreases force of attraction between valence electrons and the nucleus of the atom. These changes affect various properties of elements they show gradual variation in a group and in a period and they repeat themselves after a certain interval of atomic number. S properties are called periodic properties.

Valency

The combining capacity of an atom or radical is known as its valency. It is measured in terms of hydrogen, chlorine and oxygen at Valency of an element is defined as the number of hydrogen, chlorine and double the number of oxygen atom with which atom o element can combine.

For eg. Valency of oxygen in water (H_2O) is 2
Valency of carbon in methane (CH_4) is 4.

(a) **Valency in a period :** You have already learnt in the previous section that the number of valence electrons increases in a period. In normal elements it increases from 1 to 8 in a period from left to right. It reaches 8 in group 18 elements (noble gases) which show practically no chemical activity under ordinary conditions and their valency is taken as zero. Carefully look at the table given below. Valency of normal elements with respect to oxygen increases from 1 to 7 as shown below for elements of third period. This valency is equal to the number of valence electrons or group number for groups 1 and 2, or (group number-10) for groups 13 to 17.

Group	1	2	13	14	15	16	17
Element	Na	Mg	Al	Si	P	S	Cl
No. of valence electrons	1	2	3	4	5	6	7
Valency with respect to oxygen	1	2	3	4	5	6	7
Formula of oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3	Cl_2O_7

In the following table for elements of second period you will observe that valency of elements with respect to hydrogen and chlorine increases from 1 to 4 and then decreases to 1 again.

Group	1	2	13	14	15	16	17
Element	Li	Be	B	C	N	O	F
No. of valence electrons	1	2	3	4	5	6	7
Valency with respect to hydrogen and chlorine	1	2	3	4	3	2	1
Formula of hydride	LiH	BeH_2	BH_3	CH_4	NH_3	H_2O	HF
Formula of chloride	LiCl	$BeCl_2$	BCl_3	CCl_4	NCl_3	Cl_2O	ClF

(b) **Valency in a group :** All the elements of a group have the same number of valence electrons. Therefore, they all have the same valency. Thus valency of all group 1 elements, alkali metals, is 1. Similarly valency of all group 17 elements, halogens, is 1 with respect to hydrogen and 7 with respect to oxygen.

group 1 elements	Formulae of oxides	Valency	Formulae of Hydrides	Valency
Li	Li_2O	1	LiH	1
Na	Na_2O	1	NaH	1
K	K_2O	1	KH	1
Rb	Rb_2O	1	RbH	1
Cs	Cs_2O	1		

Atomic Radii

A number of physical properties like density and melting and boiling points are related to the sizes of atoms. Atomic size is difficult to define. Atomic radius determines the size of an atom. For an isolated atom atomic radius may be taken as the distance between the centre of nucleus of atom and the outermost shell of electrons. Practically, measurement of size of an isolated atom is difficult; therefore, it is measured when an atom is in company of another atom of same element. It is defined as one-half the distance between the nuclei of two atoms when they are linked to each other by a single covalent bond.

Variation of atomic radii in a period :

Atomic radii (in picometer) of 2nd and 3rd period elements are given in the table given below. In a period, atomic radius generally decreases from left to right with increase in atomic number

2nd period	Li	Be	B	C	N	O	F
	152	111	88	77	74	66	42
3rd period	Na	Mg	Al	Si	P	S	Cl
	190	145	118	111	98	88	79

In a period there is a gradual increase in the nuclear charge with increase in atomic number. Since valence electrons are added in the same shell since, the electrons in the same shell do not screen each other from the nucleus, the increase in nuclear charge is not neutralised by the extra valence electron. As a result effective nuclear charge increases therefore valence electrons are more and more strongly attracted towards nucleus. This gradually decreases atomic radii.

Variation of atomic radii in a group :

Atomic radii increases in a group from top to bottom. This can be seen from the data of atomic radii in picometers given for groups 1 and 17 elements below.

Element (group 1)	Atomic radius	Element (group 2)	Atomic radius
Li	155	F	72
Na	190	Cl	99
K	235	Br	114
Rb	248	I	133

On moving down the group the nuclear charge increases with increase in atomic number. However, while going down in a group from one atom to another the number of inner shells also increases, although the number of electrons in the outermost shell remains the same. The effect of increase in the size of the electron cloud (due to increase in number of shells) is more pronounced than the effect of increased nuclear charge. Thus the distance of outermost electron from the nucleus increases as we move down a group. For example, in lithium the valence electron is present in 2nd shell while in sodium it is present in 3rd shell. Also, the number of filled shells between valence electrons and nucleus increases. Thus in group 1 Li (2,1) has one filled shell between its nucleus and valence electron while Na (2,8,1) has two filled shells between them. Both the factors decrease the force of attraction between nucleus and valence electron. Therefore, atomic size increases on moving down a group.

Note : Isoelectronic species are those which have same number of electrons for e.g. K^+ and Ca^{2+}.

Metallic and Non-Metallic Character

You know what are characteristic properties of a metal. They are electropositive in nature (the tendency to lose electrons), have luster, ductility, malleability and electrical conductance.

Variation of metallic character in a group :

You know about the variation of ionization energy in a group. Metallic character of elements increases from top to bottom. As we move down in a group atomic size increases therefore distance between valence electrons and nucleus also increase. Thus electrostatic force of attraction on valence electrons decreases and they can be easily removed. This can best be seen in elements of group 14. Its first element, carbon is a typical non metal, next two elements Si and Ge are metalloids and the remaining elements Sn and Pb, are typical metals as shown below.

Group 14					
Element :	C	Si	Ge	Sn	Pb
Nature :	Non-metal	Metalloid	Metalloid	Metal	Metal

Variation of metallic character in a period :

Metallic character of elements decreases in a period from left to right as shown below for 3rd period elements. As we move from left to right in a period atomic size decreases. Thus electrostatic force of attraction increases for valence electrons thereby decreasing electropositive character.

Element :	Na	Mg	Al	Si	P	S	Cl
Character :	Metal	Metal	Metal	Metalloid	Non-metal	Non-metal	Non-metal

In addition to the properties discussed above we need to understand variation in some other important properties too.

Ionization Energy

Negatively charged electrons in an atom are attracted by the positively charged nucleus. For removing an electron this attractive force must be overcome by spending some energy. The minimum amount of energy required to remove an electron from a gaseous atom in its ground state to form a gaseous ion is called ionization energy. It is measured in unit of kJ mol^{-1}.

It corresponds to the following process : If only one electron is removed, the ionization energy is known as the first ionization energy. If second electron is removed the ionization energy is called the second ionization energy, same goes for third ionization energy and so on. Now we shall study the variation of ionization energy in the periodic table.

Variation of Ionization Energy in a Group

We have already seen earlier, that the force of attraction between valence electrons and nucleus decreases in a group from top to bottom because of increase in atomic size due to addition of inner shells. Moreover there is an increase in shielding effect on outermost (valence) electrons due to increase in the number of inner electrons. As a result, the electron becomes less and less firmly held to nucleus as we move down the group. Therefore Ionization energy decreases in a group from top to bottom. This can be seen from ionization energy values (in kJ mol^{-1}) of groups 1 and 17 elements given below.

Group 1		Group 17	
Element	**Ionization Energy**	**Element**	**Ionization Energy**
Li	520	F	1680
Na	496	Cl	1251
K	419	Br	1143
Rb	403	I	1009

Variation of Ionization Energy in a Period

We know that the force of attraction betweens valence electron and nucleus increases in a period from left to right due to increase in nuclear charge. As a consequence of this, the ionization energy generally increases in a period from left to right. This trend can be seen in ionization energies (in kJ mol^{-1}) of elements belonging to 2nd and 3rd periods.

2nd Period Elements :	Element	Li	Be	B	C	N	O	F	Ne
	Ionization Energy	520	899	801	1086	1400	1314	1680	2080
3rd Period Elements :	Element	Na	Mg	Al	Si	P	S	Cl	Ar
	Ionization Energy	496	738	578	786	1011	1000	1251	1521

ELECTRON AFFINITY

Another important property that determines the chemical properties of an element is the tendency to gain an additional electron. This ability is measured by electron affinity. It is the energy change when an electron is accepted by an atom in the gaseous state. It corresponds to the process : $X(g) + e^- \longrightarrow X^-(g) + E$

Here, X is an atom of an element. The energy change is measured in the unit kJ mol^{-1}. By convention, electron affinity is assigned a positive value when energy is released during the process. Greater the value of electron affinity, more energy is released during the process and greater is the tendency of the atom to gain electron.

Variation of Electron Affinity in a Group

In a group, the electron affinity decreases on moving from top to bottom, that is, less and less amount of energy is released. On moving down a group, the size and nuclear charge increases. The effect of increase in atomic size is much more pronounced than the effect of nuclear charge therefore additional electron feels less attraction by nucleus. Hence lower is electron affinity. Such trends in its values (in kJ mol-1) for group 1 and group 17 elements are given below.

Group 1		Group 17	
Element	**Electron affinity**	**Element**	**Electron affinity**
Li	58	F	333
Na	53	Cl	348
K	48	Br	324
Rb	45	I	295

Variation of Electron Affinity along a Period

On moving across a period, the size of atom decreases and nuclear charge increases. Both of these factors result into greater attraction for incoming electron. Thus electron affinity increases in a period from left to right. However certain irregularities are due to stable electronic configurations of certain atoms.

Electronegativity

You have learnt in the previous section that electron affinity of an element is a measure of an isolated atom to attract electrons towards itself. We normally do not deal with isolated atoms. Mostly we come across atoms which are bonded to other atoms. There is another property which deals with the power of bonded atoms to attract electrons. This property is known as electronegativity. Electronegativity is relative tendency of a bonded atom to attract the bond-electrons towards itself. Electronegativity is a dimensionless quantity and does not have any units. It just compares the tendency of various elements to attract the bond-electrons towards themselves. The most widely used scale of electronegativity was devised by Linus Pauling. Now let us learn about its variation in groups 1 and 17.

Group 1		Group 17	
Element	**Electronegativity**	**Element**	**Electronegativity**
Li	1.0	F	4.0
Na	0.9	Cl	3.0
K	0.8	Br	2.8
Rb	0.8	I	2.5

Electronegativity generally decreases in a group from top to bottom. As we move in a group from top to bottom the atomic size increases as a result bonding electrons become away from the nucleus. Now let us see its variation in 2nd and 3rd period elements. Electronegativity generally increases in a period from left to right. This is due to decrease in atomic size and increase in effective nuclear charge. Now as a result of increase in effective nuclear charge, the attraction for the outermost electrons increases.

2nd Period Elements :

Element	Li	Be	B	C	N	O	F
Electronegativity	1.0	1.5	2.0	2.5	3.0	3.5	4.0

3rd Period Elements :

Element	Na	Mg	Al	Si	P	S	Cl
Electronegativity	0.9	1.2	1.5	1.8	2.1	2.5	3.0

1 EXERCISE

Fill in the Blanks :

DIRECTIONS : *Complete the following statements with an appropriate word / term to be filled in the blank space(s).*

1. The law of triads was given by .....
2. According to Modern periodic law, the elements are arranged in the periodic table in the order of their increasing .....
3. Elements with eight electrons in their outermost energy shell are called .....
4. If two elements have the same number of valence electrons, then they belong to the same ..... of the periodic table.
5. The elements in groups 1, 2 and 13 to 18 are known as ..... elements.
6. The valency of an atom is equal to its .....
7. The atomic size in a period .....
8. Dobereiner grouped the elements into triads and Newlands gave the .....
9. Mendeleev arranged the elements in increasing order of their ..... and according to their ..... properties.
10. Mendeleev predicted the existence of some yet to be discovered elements on the basis of ..... in his Periodic Table.
11. Elements in the Modern Periodic Table are arranged in ..... vertical columns called ..... and ..... horizontal rows called .....

True / False :

DIRECTIONS : *Read the following statements and write your answer as true or false.*

1. As nuclear charge increases, atomic orbitals become smaller and more stable.
2. As number of shells increases, atomic orbitals become larger and less stable.
3. Atomic radii decrease from left to right across a row of the periodic table.
4. Atomic radii increase from top to bottom down a column of the periodic table.
5. Fluorine has highest electron affinity in the periodic table.
6. Noble gases are placed extremely left in the periodic table.
7. Magnesium is more metallic in nature than sodium.
8. The number of shells increases in a given period from left to right in the periodic table.
9. The elements silicon, germanium and arsenic are called metalloids.
10. Elements are classified on the basis of similarities in their properties.
11. Rows in the periodic table are called periods.
12. The columns of the periodic table are called groups.
13. You will find metals on the extreme right side of the periodic table.
14. Although the order of elements is based on atomic number, vertical families share similar chemical properties.

Match the Following :

DIRECTIONS : *Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in column I have to be matched with statements (p, q, r, s) in column II.*

1. Column II give group to which element in column I belong match them correctly.

Column I	Column II
(A) Nitrogen	(p) 15
(B) Aluminium	(q) 16
(C) Chlorine	(r) 17
(D) oxygen	(s) 13

2. Column II give period to which element in column I match them correctly.

Column I	Column II
(A) Hydrogen	(p) 3
(B) Sodium	(q) 4
(C) Calcium	(r) 6
(D) Barium	(s) 1

3. Match the column –

Column I	Column II
(A) Element with largest size in second period	(p) boron
(B) Element with smallest size in group 13	(q) fluorine
(C) Element with maximum non-metallic character.	(r) bromine
(D) Element with smallest size in fourth period	(s) lithium

Very Short Answer Questions:

DIRECTIONS : *Give answer in one word or one sentence.*

1. What is the basis of the modern periodic table ?
2. In how many blocks has the modern periodic table been divided ?
3. Why elements in any given group have similar properties?
4. Why some gaps were left in Mendeleev's periodic table ?
5. Why are the group 2 elements called alkaline earth metals?
6. What was Dobereiner's basis of classifying elements ?
7. Out of Li, Ge and N, which forms the most basic oxide and which forms the most acidic oxide ?
8. Define group.
9. Name the scientist who proposed Modern Periodic table.
10. Predict the location in the periodic table (row and column) of element with atomic number 111.
11. What element immediately follows xenon in the periodic table?
12. Name two metals that react with bromine to give compounds with the chemical formula MBr.
13. Write the names and symbols of all elements that occupy the same row of the periodic table as nitrogen.
14. Which is the smallest atom in group VIIA ?
15. Use the second period of the periodic table as an example to show that the size of atoms decreases as we move from left to right. Explain the trend.
16. What is the atomic number of the element that would occupy, the position in row 7, column 17 of the periodic table

Short Answer Questions :

DIRECTIONS : *Give answer in 2-3 sentences.*

1. Arrange these atoms and ions in order of decreasing size : Mg^{2+}, Ca^{2+} and Ca.
2. What were the limitations of Newlands' Law of Octaves?
3. (a) Lithium, sodium, potassium are all metals that react with water to liberate hydrogen gas. Is there any similarity in the atoms of these elements ?

   (b) Helium is an unreactive gas and neon is a gas of extremely low reactivity. What, if anything, do their atoms have in common ?
4. What do you understand by the term periodicity ? Are the properties of the elements placed in a group, same ? Illustrate.
5. Why does the size of the atom increases down the group ?
6. Define and explain Mendeleev's Periodic law ?
7. (a) Which elements or ions from among Ar, S^{2-}, Si^{-} and Cl^{3+} are isoelectronic with P^{+} ?

   (b) Which ions from among Fe^{3+}, Ni^{3+}, and Co^{3+} are isoelectronic with Mn^{2+}?
8. Explain why the first ionization energy of lithium is less than that for beryllium, but the second ionization energy of beryllium is less than that for lithium.
9. What is the general electron configuration for the valence electrons in

   (a) group IA (b) group IV A (c) group VIIA?
10. Write the symbol for a cation with a 1+ charge that has the electron configuration

    (a) $1s^2 2s^2 2p^6 3s^2 3p^1$ (b) $1s^2 2s^2 2p^6 3s^1$

    (c) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^6$
11. Which species in each of the following pairs is larger ? Give an explanation for your answer.

    (a) Na or Na^{+} (b) O^{2-} or F^{-} (c) Ni^{2+} or Ni^{3+}
12. Using only a periodic table as a guide, arrange each of the following series of atoms in order of increasing size.

    (a) B, O, Li (b) C, N, Si (c) S, As, Sn
13. Using only a periodic table as a guide, arrange each of the following series of species in order of increasing size.

    (a) Li, Be^{2+}, Be (b) Cl, S, S^{2-} (c) N, C, Si
14. Indicate which species in each pair has the higher ionization energy. Explain the reason for your answer.

    (a) Na and Rb (b) O^{2-} and F^{-}
15. Which will be greater, the second ionization energy of boron or that of beryllium ? Explain your answer.
16. What are the names and chemical symbols of the elements that are vertical and horizontal neighbors of sulfur in the periodic table? Which of these have chemical properties similar to those of sulfur?
17. Why does the metallic character increase down the group?
18. Arrange the following atoms in order of decreasing atomic radius : Na, Al, P, Cl, Mg.
19. Arrange the following atoms in order of increasing radius: P, Si, N.

Long Answer Questions :

DIRECTIONS : *Give answer in four to five sentences.*

1. Identify the larger species of each of the following pairs:

   (a) K or K^{+} (b) S^{2-} or Cl^{-} (c) Co^{2+} or Co^{3+}

2. Predict which species in each of the following pairs has the higher ionization energy:

(a) Mg or P (b) B or Cl (c) K^+ or Ca^{2+}.

(d) Indicate which species in each pair has the higher ionization energy.

(I) Ge and Cl (II) B and F

(III) Al^{3+} and Na^+

3. (a) Which atom in Group VIA should have a smaller first ionization energy : oxygen or sulfur?

(b) Which atom in the second period should have a higher second ionization energy : lithium or beryllium?

(c) Specify the group of the periods table in which each of the following elements is found :

(I) [Ne] $3s^1$, (II) [Ne] $3s^2 3p^3$, (III) [Ar] $4s^2 3d^8$

4. An atom has electronic configuration 2, 8, 7.

(a) What is the atomic number of this element ?

(b) To which of the following elements would it be chemically similar ? (Atomic numbers are given in parentheses)

N (7) F (9) P (15) Ar (18) .

2 EXERCISE

Text - Book Questions :

1. Did Dobereiner's triads also exist in the columns of Newland's Octaves? Compare and find out
2. What were the limitations of Dobereiner's classification?
3. What were the limitations of Newland's Law of Octaves?
4. Use Mendeleev's periodic table to predict the formulae for the oxides of following elements :
   K, C, Al, Si, Ba
5. Besides Galium, which other elements have since been discovered to fill the gaps left by Mendeleev in his periodic table? (any two)
6. What were the criteria used by Mendeleev in creating his periodic table?
7. Why do you think the noble gases are placed in a separate group?
8. How could the modern periodic table remove various anomalies of Mendeleev's periodic table?
9. Name two elements you would expect to show same kind of chemical reactivity as magnesium. What is the basis for your choice?
10. Name :
    (a) three elements that have only a single electron in their outermost shells.
    (b) two elements that have two electrons in their outermost shells.
    (c) three elements with filled outermost shells.
11. (a) Lithium, Sodium, Potassium are all metals that react with water to liberate hydrogen gas. Is there any similarity in the atoms of these elements?
    (b) Helium is an unreactive gas and neon is a gas of extremely low reactivity. What, if anything, do their atoms have in common?
12. In the modern periodic table, of the first ten elements, which are metals?
13. By considering their position in the periodic table, which one of the following elements would you expect to have the most metallic characteristics?
    Ga Ge As Se Be

Text - Book Exercise :

1. Which of the following statements is not a correct statement about the trends when going from left to right across the periods of periodic table.
   (a) The elements become less metallic in nature
   (b) The number of valence electrons increases
   (c) The atoms lose their electrons more easily
   (d) The oxides become more acidic
2. Element X forms a chloride with the formula XCl_2, which is a solid with a high melting point. X would most likely be in the same group of the periodic table as :
   (a) Na (b) Mg
   (c) Al (d) Si
3. Which elements has :
   (a) two shells, both of which are completely filled with electrons?
   (b) the electronic configuration 2, 8, 2?
   (c) a total of three shells, with four electrons in its valence shell?
   (d) a total of two shells, with three electrons in its valence shell?
   (e) twice as many electrons in its second shell as in its first shell?
4. (a) What property do all elements in the same column of the periodic table as boron have in common?
   (b) What property do all elements in the same column of the periodic table as fluorine have in common?
5. An atom has electronic configuration 2, 8, 7.
   (a) What is the atomic number of this element?
   (b) To which of the following elements would it be chemically similar? (Atomic numbers are given in parentheses).
   N (7) F(9) P (15) Ar(18)
6. The position of three elements A, B and C in the periodic table are shown below :

Group 16	Group 17
—	—
—	A
—	—
B	C

   (a) State whether A is a metal or non-metal.
   (b) State whether C is more reactive or less reactive than A.
   (c) Will C be larger or smaller in size than B?
   (d) Which type of ion, cation or anion will be formed by an element A?
7. Nitrogen (atomic number 7) and phosphorus (atomic number 15) belong to group 15 of the periodic table. Write the electronic configuration of these two elements. Which of these will be more electronegative? Why?
8. How does the electronic configurations of an atom relate to its position in the modern periodic table?
9. In the, modern periodic table, calcium (atomic number 20) is surrounded by elements with atomic numbers 12, 19, 21 and 28. Which of these have physical and chemical properties resembling calcium.?

10. Compare and contrast the arrangement of elements in Mendeleev's Periodic Table and the Modern Periodic Table.

Exemplar Questions :

1. If an element X is placed in group 14, what will be the formula and the nature of bonding of its chloride?
2. Compare the radii of two species X and Y. Give reasons for your answer.
   (a) X has 12 protons and 12 electrons
   (b) Y has 12 protons and 10 electrons
3. An element is placed in 2nd Group and 3rd Period of the Periodic Table, burns in presence of oxygen to form a basic oxide.
   (a) Identify the element
   (b) Write the electronic configuration
   (c) Write the balanced equation when it burns in the presence of air
   (d) Write a balanced equation when this oxide is dissolved in water
   (e) Draw the electron dot structure for the formation of this oxide
4. An element X of group 15 exists as diatomic molecule and combines with hydrogen at 773 K in presence of the catalyst to form a compound, ammonia which has a characteristic pungent smell.
   (a) Identify the element X. How many valence electrons does it have?
   (b) Draw the electron dot structure of the diatomic molecule of X. What type of bond is formed in it?
   (c) Draw the electron dot structure for ammonia and what type of bond is formed in it?
5. Which group of elements could be placed in Mendeleev's Periodic Table without disturbing the original order? Give reason.

HOTS Questions :

1. Referring to a periodic table, arrange the following atoms in order of increasing first ionization energy : Ne, Na, P, Ar, K.
2. For each of the following pairs, indicate which one of the two species is larger:
   (a) N^{3-} or F^-; (b) Mg^{2+} or Ca^{2+}; (c) Fe^{2+} or Fe^{3+}
3. Using only a periodic table as a guide, arrange each of the following series of species in order of increasing first ionization energy.
   (a) O, O^{2-}, F (b) C, Si, N (c) Te, Ru, Sr
4. Predict which element of the following pairs will have the higher density and support your prediction using periodic trends :
   (a) Cr or W; (b) W or Os; (c) Pd or Ag; and (d) Y or Nb.
5. Group the following electron configurations in pairs that would represent similar chemical properties of their atoms:
   (a) $1s^2 2s^2 2p^5$
   (b) $1s^2 2s^1$
   (c) $1s^2 2s^2 2p^6$
   (d) $1s^2 2s^2 2p^6 3s^2 3p^5$
   (e) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
   (f) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$
6. Why are the elements of group 18 called zero valent ?
7. List the following series of elements in order of increasing atomic radius : (a) Be, C, Mg (b) Rb, I, Br.
8. Arrange the ions S^{2-}, Cl^-, K^+ and Ca^{2+} in order of decreasing order.
9. List the following ions in order of increasing ionic radius : N^{3-}, Na^+, F^-, Mg^{2+}, O^{2-}.
10. Why are the electron affinities of the alkaline earth metals, either negative or small positive values?

3 EXERCISE

Multiple Choice Questions :

DIRECTIONS : *This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.*

1. Cl, Br, I, if this is Dobereiner's triad and the atomic masses of Cl and I are 35.5 and 127 respectively the atomic mass of Br is –
   (a) 162.5 (b) 91.5
   (c) 81.25 (d) 45.625
2. Newlands could classify elements only upto –
   (a) copper (b) chlorine
   (c) calcium (d) chromium
3. Mendeleev classified elements in –
   (a) increasing order of atomic groups
   (b) eight periods and eight groups
   (c) seven periods and nine groups
   (d) eight periods and seven groups
4. Noble gases were included in Mendeleev's periodic table in the –
   (a) 1st group (b) 7th group
   (c) 8th group (d) none of these
5. 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
6. In the modern periodic table one of the following does not have appropriate position –
   (a) transition elements
   (b) inert gases
   (c) inner transition elements
   (d) halogens
7. An element M has an atomic number 9 and atomic mass 17. Its ion will be represented by –
   (a) M (b) M^{+2}
   (c) M^{-} (d) M^{-2}
8. The correct order of first IE of C, N, O, F is –
   (a) F > O > N > C (b) C > N > O > F
   (c) O > N > F > C (d) F > N > O > C
9. Elements belonging to the same group have similar properties because –
   (a) they have similar electronic configuration of the outermost shell
   (b) their atomic numbers go on increasing as we move down the group
   (c) all of them are metallic elements.
   (d) none of the above
10. The atoms of elements belonging to the same group of periodic table have the same –
    (a) number of protons
    (b) number of electrons
    (c) number of neutrons
    (d) number of electrons in the outermost shell
11. Which of the following is the correct order of relative size
    (a) $I^{-} > I^{+} > I$ (b) $I^{-} > I > I^{+}$
    (c) $I > I^{+} > I^{-}$ (d) $I^{+} > I^{-} > I$
12. The element with the smallest size in the group 13 is –
    (a) beryllium (b) carbon
    (c) aluminium (d) boron
13. The element with smallest size in the 4th period is –
    (a) chlorine (b) iodine
    (c) fluorine (d) bromine
14. The most metallic element in the fifth period is –
    (a) silver (b) rubidium
    (c) gold (d) rhodium
15. If the two members of a Dobereiner triad are chlorine and iodine, the third member of this triad is –
    (a) fluorine (b) bromine
    (c) sodium (d) calcium
16. 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
17. According to Mendeleef periodic law, the properties of elements are periodic function of their –
    (a) atomic masses (b) atomic numbers
    (c) atomic volumes (d) densities
18. The elements with atomic numbers 2, 10, 18, 36, 54 and 86 are all –
    (a) halogens (b) noble gases
    (c) noble metals (d) light metals
19. How many periods are there in the long form of the periodic table –
    (a) 6 (b) 7
    (c) 8 (d) 9
20. The elements with atomic numbers 3, 11, 19, 37 and 55 belong to
    (a) alkali metals (b) alkaline earth metals
    (c) halogens (d) noble gases
21. The elements with atomic numbers 9, 17, 35, 53 and 85 belong to
    (a) alkali metals (b) alkaline earth metals
    (c) halogens (d) noble gases
22. Each transition series contains a total of –
    (a) 2 elements (b) 8 elements
    (c) 10 elements (d) 18 elements
23. The number of elements in each of the inner transition series are –
    (a) 2 (b) 8
    (c) 10 (d) 14

24. The number of elements in the third period of the periodic table are –
(a) 2 (b) 8
(c) 18 (d) 32

25. The total number of elements in VII group of the periodic table are –
(a) 3 (b) 5
(c) 7 (d) 9

26. The total number of elements in the group IB are –
(a) 3 (b) 5
(c) 7 (d) 9

27. Which of the following elements has the least nonmetallic character –
(a) fluorine (b) chlorine
(c) bromine (d) iodine

28. Element X forms a chloride with the formula XCl_2, which is a solid with a high melting point. X would most likely be in the same group of the Periodic Table as –
(a) Na (b) Mg
(c) Al (d) Si

29. About how many known elements are there –
(a) 10 (b) 50
(c) 110 (d) 200

30. Elements in the periodic table are arranged by –
(a) atomic number (b) atomic weight
(c) number of neutrons (d) chemical reactivity

31. Which of these things you will not find in the periodic table on the wall –
(a) element name and symbol
(b) atomic weight
(c) atomic orbital radius
(d) atomic number

32. 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

33. The alkali metals are in which group of the periodic table?
(a) Group 1 (b) Group 2
(c) Group 3 (d) Group 4

34. As you go down the group, the alkali metals become –
(a) brighter (b) hotter
(c) more reactive (d) less reactive

35. Where are the transition metals in the periodic table –
(a) In group 0
(b) In group 1
(c) In group 2
(d) In a central block with no group number

36. 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

37. Which of the following element is not in the liquid state
(a) Hg (b) Li
(c) Ga (d) Br

38. The long form of periodic table has –
(a) eight horizontal rows and seven vertical columns
(b) seven horizontal rows and eighteen vertical columns
(c) seven horizontal rows and seven vertical columns
(d) eight horizontal rows and eight vertical columns

39. Which of the following elements are analogous to the lanthanides –
(a) actinides (b) borides
(c) carbides (d) hydrides

40. Arrange the following in increasing order of their atomic radius : Na, K, Mg, Rb –
(a) Mg < K < Na < Rb (b) Mg < Na < K < Rb
(c) Mg < Na < Rb < K (d) Na < K < Rb < Mg

41. Which is metalloid –
(a) Pb (b) Sb
(c) Si (d) Zn

42. Which shows variable valency –
(a) s–block elements (b) p–block elements
(c) d–block elements (d) Radioactive elements

43. Dobereiner traids is –
(a) Na, K, Rb (b) Mg, S, As
(c) Cl, Br, I (d) P, S, As

44. Elements in which 4f orbitals are progressively filled are called as –
(a) transition elements (b) lanthanides
(c) actinides (d) inert gases

45. 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

46. Which of the following elements is a lanthanide (Rare–earth element) –
(a) cadmium (b) californium
(c) cerium (d) cesium

47. If the valene shell electronic conjiguration for an element is ns^2np^5, this element will belong to the group of –
(a) alkali metals (b) inert metals
(c) noble gases (d) halogens

48. If an atom has electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$, it will be placed in –
(a) second group (b) third group
(c) fifth group (d) sixth group

49. On moving from left to right across a period in the table the metallic character –
(a) increases
(b) decreases
(c) remains constant
(d) first increases and then decreases

50. Which of the following is the atomic number of a metal –
(a) 32 (b) 34
(c) 36 (d) 38

51. All the elements in a group in the periodic table have the same –
(a) atomic number
(b) electronic configuration
(c) atomic weight
(d) number of electrons in the outermost shell or number of electrons for bonding

52. Which has the maximum atomic radius –
(a) Al (b) Si
(c) P (d) Mg

53. Which one of the following ions has the highest value of ionic radius –
(a) O^{2-} (b) B^{3+}
(c) Li^{+} (d) F^{-}

54. Which one of the following is the smallest in size –
(a) N^{3-} (b) O^{2-}
(c) F^{-} (d) Na^{+}

55. The size of the following species increases in the order –
(a) $Mg^{2+} < Na^{+} < F^{-} < Al$ (b) $F^{-} < Al < Na^{+} > Mg^{2+}$
(c) $Al < Mg < F^{-} < Na^{+}$ (d) $Na^{+} < Al < F^{-} < Mg^{2+}$

56. Elements of which group form anions most readily –
(a) oxygen family (b) nitrogen group
(c) halogens (d) alkali metals

57. The correct order of radii is –
(a) N < Be < B (b) $F^{-} < O^{2-} < N^{3-}$
(c) Na < Li < K (d) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

58. Which of the following is correct regarding ionic radii
(a) $Ti^{4+} < Mn^{+7}$ (b) $^{35}Cl^{-} < ^{37}Cl^{-}$
(c) $K^{+} > Cl^{-}$ (d) $P^{3+} > P^{5+}$

More than One Option Correct :

DIRECTIONS : *This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which ONE OR MORE may be correct.*

1. Which of the following are representative element –
(a) Fe (b) K
(c) Ba (d) N

2. Which one of the following are electropositive element –
(a) sodium (b) calcium
(c) oxygen (d) chlorine

3. Which of the following pair of element has same property
(a) 10, 12 (b) 11, 20
(c) 20, 38 (d) 13, 31

4. All the members in a group of a long form of periodic table have the same –
(a) valency
(b) number of valence electrons
(c) chemical properties
(d) Physical characteristics

5. Metals are included in the long form of periodic table in the
(a) s-block only (b) p-block only
(c) d-block only (d) f-block only

6. Important merits of modern periodic table is –
(a) it explains why element in the same group have the same chemical properties
(b) hydrogen has been placed accurately
(c) isotopes have been placed of same position
(d) it is based on classifying elements according to their atomic number

7. The difference between ions and atoms is of –
(a) relative size (b) configuration
(c) presence of charge (d) mass of nucleus

8. Which of the following properties generally decrease along a period –
(a) atomic size (b) non-metallic character
(c) metallic character (d) ionic size

9. Which of the following elements will form acidic oxide –
(a) Na (b) Si
(c) Mg (d) P

10. In the periodic table, the metallic character of elements –
(a) increases, (i) from left to right across a period and (ii) on descending a group
(b) decreases, (i) from left to right across a period and (ii) on moving up group from bottom to top
(c) increases from left to right across a period and decreases on descending a group
(d) increases from right to left across a period and increases on descending a group

11. Which of the following statements is (are) correct statement about the trends when going from left to right across the periods of periodic Table.
(a) the elements become less metallic in nature.
(b) the number of valence electrons increases.
(c) the atoms lose their electrons more easily.
(d) the oxides become more acidic.

12. Which of these choices is not a family of elements?
(a) halogen (b) metal
(c) inert Gas (d) fire extinguishers

13. Transition metals can –
(a) show variable oxidation states
(b) form coloured compounds
(c) float in air
(d) create oxygen

14. The statement that is true for the long form of the periodic table is –
(a) if reflects the sequence of filling the electrons in the order of sub-energy levels *s*, *p*, *d* and *f*.
(b) it helps to predict the stable valency states of the elements
(c) if reflects trends in physical and chemical properties of the elements.
(d) it helps to predict the relative atomicity of the bonds between any two elements.

15. The statement that is correct for the period classification of elements is –
(a) the properties of elements are the periodic functions of their atomic numbers.
(b) non-metallic elements are lesser in number than metallic elements
(c) the first ionisation energies along a period do not vary in a regular manner with increase in atomic number
(d) for transition elements the d-sub-shells are filled with electrons monotonically with increases in atomic number

Passage Based Questions :

DIRECTIONS : *Study the given paragraph(s) and answer the following questions.*

Passage - 1

The table given below refers to the elements of the periodic table with atomic number from 3 to 18. These elements are shown by letters. (not the usual symbols of the elements).

3	4	5	6	7	8	9	10
A	B	C	D	E	F	G	H
11	12	13	14	15	16	17	18
I	J	K	L	M	N	O	P

1. Which of the following are noble gases?
   (a) H and P (b) G and O
   (c) D and L (d) A and I
2. Which are Halogens?
   (a) H and L (b) C and M
   (c) G and O (d) E and P
3. Which of the following elements have valency 4?
   (a) F and N (b) C and K
   (c) D and L (d) H and P

Passage - 2

Group VII elements are strong non-metals because they can easily accept an electron to form an anion where as group 1 element are strong metals because they can very easily lose one electron to form cation.

Metals have the tendency to loose their valence electrons and form positive ions, so metallic character is related to the ionisation potential. Elements having low ionisation potential, lose electrons easily. Thus, metallic character generally decreases across a period and increases down a group.

1. The non metallic character On moving along a period.
   (a) increases (b) decreases
   (c) depends on the period (d) remains the same
2. Group 1 and Group 2 elements are considered as strong metals because
   (a) they have incomplete octet.
   (b) they can easily gain electrons.
   (c) they can easily loose electrons.
   (d) they form anions.
3. Which of the following is the correct decreasing order of metallic character?
   (a) Ca > Sc > Ti > K (b) K > Ca > Sc > Ti
   (c) K > Sc > Ca > Ti (d) Ti > Sc > Ca > K

Assertion & Reason :

DIRECTIONS : *Each of these questions contains an Assertion followed by reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.*

(a) If both **Assertion** and **Reason** are **correct** and Reason is the **correct explanation** of Assertion.
(b) If both **Assertion** and **Reason** are correct, but Reason is **not the correct explanation** of Assertion.
(c) If **Assertion** is **correct** but **Reason** is **incorrect**.
(d) If **Assertion** is **incorrect** but **Reason** is **correct**.

1. **Assertion :** Group 1 (1*s*) elements are known as the alkali elements.
   Reason : *s*-orbital can accommodate only two electrons.
2. **Assertion :** Nitrogen has higher ionization energy than that of oxygen.
   Reason : Nitrogen has smaller atomic size than that of oxygen.
3. **Assertion :** According to Mendeleev, periodic properties of elements is a function of their atomic number.
   Reason : Atomic number is equal to the number of protons.
4. **Assertion :** Elements in the same vertical column have similar properties.
   Reason : Elements have periodic dependence upon the atomic number.

Multiple Matching Questions :

DIRECTIONS : *Following question has four statements (A, B, C and D) given in Column I and four statements (p, q, r and s) in Column II. Any given statement in Column I can have correct matching with one or more statement(s) given in Column II. Match the entries in column I with entries in column II.*

1.

Column I	Column II
(A) *s*-block elements	(p) Alkali metals
(B) *p*-block elements	(q) Alkaline earth metals
(C) Representative elements	(r) Halogens
(D) High ionisation energy	(s) Noble gases

	A	B	C	D
(a)	p,q	r,s	p,q,r	r,s
(b)	p,q	q	s,r	r,p
(c)	s	q,r	p,q	r
(d)	r,q	q	s,q	p,q,r

Integer Type Questions :

DIRECTIONS : *Following are integer based questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive).*

1. The period to which element with atomic number 47 belongs is
2. The element with atomic number 26 will be found in group

4 ADVANCED EXERCISE
BASED ON CONNECTING TOPICS

DIRECTIONS (Qs. 1-19) : *This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.*

1. Which of the following element has most ionisation energy
(a) Al (b) In
(c) Ga (d) B

2. Which sequence of ionisation potential is correct –
(a) B < Be (b) Be < B
(c) Be = B (d) None

3. In which of the following process highest energy is required
(a) $Cu \rightarrow Cu^+$ (b) $Al \rightarrow Al^+$
(c) $Zn \rightarrow Zn^+$ (d) $Li \rightarrow Li^+$

4. Arrange F, Cl, O, N in the decreasing order of electronegativity –
(a) O > F > N > Cl (b) F > N > Cl > O
(c) Cl > F > N > O (d) F > O > N ≈ Cl

5. Which of the following is most electronegative –
(a) carbon (b) silicon
(c) lead (d) tin

6. The electron affinity for the inert gases is –
(a) zero (b) high
(c) begative (d) positive

7. Which element has the highest electronegativity –
(a) C (b) Mg
(c) O (d) S

8. In the following, the element with the highest electropositivity is –
(a) copper (b) caesium
(c) barium (d) chromium

9. Which of the following element has maximum, first ionisation potential –
(a) V (b) Ti
(c) Cr (d) Mn

10. Which one of the following arrangements represents the correct order of electron gain enthalpy (with negative sign) of the given atomic species –
(a) Cl < F < S < O (b) O < S < F < Cl
(c) S < O < Cl < F (d) F < Cl < O < S

11. Arrange S, O and Se in ascending order of electron affinity
(a) Se < S < O (b) Se < O < S
(c) S < O < Se (d) S < Se < O

12 Which transition involves maximum amount of energy?
(a) $M^-(g) \longrightarrow M(g) + e$
(b) $M^-(g) \longrightarrow M^+(g) + 2e$
(c) $M^+(g) \longrightarrow M^{2+}(g) + e$
(d) $M^{2+}(g) \longrightarrow M^{3+}(g) + e$

13. Consider the following changes
$A \rightarrow A^+ + e^- : E_1$ and $A^+ \rightarrow A^{2+} + e^- : E_2$
The energy required to pull out the two electrons are E_1 and E_2 respectively. The correct relationship between two energies would be
(a) $E_1 < E_2$ (b) $E_1 = E_2$
(c) $E_1 > E_2$ (d) $E_1 \geq E_2$

14. Which of the following electronic configuration an atom has the lowest ionisation enthalpy?
(a) $1s^2\ 2s^2\ sp^3$ (b) $1s^2\ 2s^2\ 2p^5\ 3s^1$
(c) $1s^2\ 2s^2\ 2p^6$ (d) $1s^2\ 2s^2\ 2p^5$

15. 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

16. Ionisation energy decreases down the group due to
(a) increase in charge
(b) increase in atomic size
(c) decrease in size
(d) decreasing in shielding effect

17. Which form coloured salts?
(a) Non-metals
(b) Metals
(c) *p*-block elements
(d) Transitional elements

18. Consider the following statements
I. The radius of an anion is larger than that of the parent atom.
II. The ionization energy generally increases with increasing atomic number in a period.
III. The electronegativity of elements increases on moving down across a group.
Which of the above statements is/are correct?
(a) I alone (b) II alone
(c) I and II (d) II and III

19. Elements of which of the following groups will form anions most readily ?
(a) Oxygen family (b) Nitrogen family
(c) Halogens (d) Alkali metals

DIRECTIONS (Qs. 20-26) : *This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which ONE OR MORE may be correct.*

20. I.E. increases with –
(a) decrease in atomic size
(b) increase in nuclear charge
(c) increase in penetration effect of electrons
(d) decrease in nuclear charge

21. While moving in a period left to right –
(a) atomic size decrease (b) nuclear charge increase
(c) I.E. increases (d) I.E. decreases

22. Which of the following factors influence electron affinity.
(a) Atomic size
(b) Magnitude of nuclear charge
(c) Electronic configuration
(d) Ionization enthalpy

23. Which of the following have no unit?
(a) Electronegativity (b) Electron gain enthalpy
(c) Ionisation enthalpy (d) Metallic character

24. Ionsiation enthalpy depends upon
(a) effective nuclear charge.
(b) electronegativity
(c) atomic size
(d) electron affinity

25. Which of the following properties increases on moving down in the group?
(a) Atomic size (b) Ionization potential
(c) Metallic character (d) Electron affinity

26. Which of the following properties depends upon atomic size ?
(a) Electron affinity (b) Ionization enthalpy
(c) Valency (d) Metallic character

DIRECTIONS (Qs. 27-32) : *Study the given paragraph(s) and answer the following questions.*

Passage-1

In the modern periodic table, elements are arranged in order of increasing atomic numbers which is related to the electronic configuration. Depending upon the type of orbitals receiving the last electron, the elements in the periodic table have been divided into four blocks, viz, *s*, *p*, *d* and *f*. The modern periodic table consists of 7 periods and 18 groups. Each period begins with the filling of a new energy shell. In accordance with the Arfbau principle, the seven periods (1 to 7) have 2, 8, 8, 18, 18, 32 and 32 elements respectively. The seventh period is still incomplete. To avoid the periodic table being too long, the two series of *f*-block elements, called lanthanoids and actinoids are placed at the bottom of the main body of the periodic table.

27. The element with atomic number 57 belongs to
(a) s-block (b) p-block
(c) d-block (d) f-block

28. The last element of the p-block in 6th period is
(a) Pb (b) Bi
(c) At (d) Rn

29. The elements with atomic numbers 35, 53 and 85 are all _____.
(a) noble gases (b) halogens
(c) heavy metals (d) light metals

Passage-2

The way atomic radius varies with increasing atomic number can be explained by the arrangement of electrons in shells of fixed capacity. Shells closer to the nucleus-those with a smaller radius-are generally filled first, since the negatively charged electrons are attracted by the positively charged protons in the nucleus. As the atomic number increases along a row of the periodic table, additional electrons are added to the same, outermost shell. The radius of this shell gradually contracts as the attraction between the additional electrons and the nucleus increases. One moving down in group atomic radius increases dur to increase in the number of shells. As the no of shells increases the force of attraction netween the nucleus and the outermost electron decreases and hence the size increases.

30. In period 3 of the periodic table the atom with the largest atomic radius is located in group
(a) 1 (b) 3
(c) 13 (d) 17

31. Which of the following would have the largest atomic radii?
(a) Sr (b) Sn
(c) Rb (d) In

32. Which of the following would have the smallest atomic radii?
(a) K (b) Rb
(c) Li (d) Fr

DIRECTIONS (Qs. 33-35) : *Each of these questions contains an Assertion followed by reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.*

(a) If both **Assertion** and **Reason** are **correct** and Reason is the **correct explanation** of Assertion.
(b) If both **Assertion** and **Reason** are correct, but Reason is **not the correct explanation** of Assertion.
(c) If **Assertion** is **correct** but **Reason** is **incorrect**.
(d) If **Assertion** is **incorrect** but **Reason** is **correct**.

33. **Assertion :** Ionization enthalpy is the energy released to remove an electron from an isolated gaseous atom in its ground state.
Reason : Element has a tendency to lose of gain the electrons to attain the stable configuration.

34. **Assertion :** The highest I.E. in a period is shown by noble gas.
Reason : Noble gases are at the extreme right of the period.

35. **Assertion :** Smaller the size of an atom greater is the electronegativity.
Reason : Electronegativity refers to the tendency of atom to share electrons with other atom.

DIRECTIONS (Qs. 36-37) : *Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in column I have to be matched with statements (p, q, r, s) in column II.*

36.

Column I	Column II
(A) He	(p) P-block
(B) Cl	(q) Metal
(C) Cu	(r) Noble gas
(D) Sn	(s) Non-metal

	A	B	C	D
(a)	p,s	q	r,p	s
(b)	r	q,r	s	p,s
(c)	r	p,s	q	p,q
(d)	r,p	q,r	p,q	s

37.

Column I	Column II
(A) Metals	(p) High I.E.
(B) Non-metals	(q) Low I.E.
(C) Transition Metal	(r) High E.A
(D) Noble gases	(s) Low E.A.

	A	B	C	D
(a)	q,r	p,s	q	p,r
(b)	p	q,s	s	r
(c)	q,r	s	p	p,r
(d)	r	q	q,s	p

DIRECTIONS (Qs. 38-41) : *Following are integer based questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive).*

38. The atomic number of an element is 17. What will be its valency

39. An element 'X' belongs to group VA of the periodic table. What is its valency.

40. An element 'X' have atomic number 56. What will its group no?

41. How many metalloids are there in Periodic table.