5 THE PERIODIC TABLE

SYLLABUS

Dobereiner's Triads, Newland's law of Octaves, Mendeleev's contributions; Modern Periodic Law, the Modern Periodic Table. (Groups and periods)

- *General idea of Dobereiner's triads, Newland's law of Octaves, Mendeleev's periodic law.*
- *Discovery of Atomic Number and its use as a basis for Modern Periodic law.*
- *Modern Periodic Table (Groups 1 to 18 and periods 1 to 7).*
- *Special reference to Alkali metals (Group 1), Alkaline Earth metals (Group 2) Halogens (Group 17) and Zero Group (Group 18)*

INTRODUCTION

It is a human instinct to classify, *i.e.* to put things of one kind in one group and of another kind in another group.

Towards the end of the 18^{th} and the beginning of the 19^{th} centuries, more and more elements began to be discovered, and their individual properties and compounds had begun to be studied. Soon, the need arose for classifying them so as to make their comparative study easier.

5.1 REASONS FOR CLASSIFICATION OF ELEMENTS

1. It helps in studying the elements in an organized manner.
2. It helps in correlating the properties of elements with the fundamental properties of all states of matter.
3. It helps in defining the relationship of one element with another.

In the beginning, attempts were made by chemists to classify elements on the basis of factors such as density, malleability, ductility, etc., and also to consider whether they were **metals** or **non-metals**. But none of these early classifications proved satisfactory because :

(i) the number of elements falling in a particular group were so large that it did not serve the purpose of generalization.

(ii) some of the characteristics being considered varied under differing conditions.

(iii) certain elements showed metallic as well as non-metallic characteristics.

Obviously, scientists were in search of characteristics of an element that would never change. It was ***William Prout*** *who discovered that the atomic mass of an element never differs and that it could therefore, form a truly scientific basis for a satisfactory scheme of classification.*

5.2 DOBEREINER'S TRIADS

J. W. Dobereiner a German chemist observed that certain elements displayed similar properties and that they could be placed in groups of three elements each. These groups of three elements each were called **triads**.

The three elements of a particular triad had similar chemical properties. In fact, Dobereiner was the first scientist to show the clear relationship between properties of an element and its atomic mass.

The atomic mass of the middle element of a triad was approximately equal to the arithmetic mean *(average)* of the atomic masses of the other two elements of that triad.

The following examples will make this point clear.

(a) Take three elements, **calcium, strontium and barium**. These elements have following similarities:

(i) All are metals;

(ii) Each has an oxide that is alkaline in nature;

(iii) Each has valency 2.

Since these elements have similar chemical properties, they were put together in one group (or family) to form a triad called Dobereiner's triad.

The atomic mass of calcium is 40, strontium is 88 and barium is 137. It is noticed that the middle element, strontium, has atomic mass approximately equal to the average *i.e.*, mean value of the atomic masses of calcium and barium.

The mean of the atomic masses of calcium and barium $= \frac{40+137}{2} = \frac{177}{2} = 88{\cdot}5$.

This is nearly the same as the atomic mass of strontium (88).

(b) **Take three elements chlorine (35·5), bromine (80) and iodine (127);** they also form a triad because:

(i) all are non-metals;

(ii) all react with water to form acids

(iii) all have valency 1.

The mean of the atomic masses of Cl and I $= \frac{35{\cdot}5+127}{2} = \frac{162{\cdot}5}{2} = 81{\cdot}25$, which is approximataly the same as the atomic mass of bromine.

Reasons for discarding the law of triad

(i) *Dobereiner failed to arrange all the then known elements in the form of triads.*

(ii) *The law did not fully apply even within the same family.*

For example, taking halogens, viz. the first three members, Fluorine (19), Chlorine (35·5) and Bromine (80), it is observed that the mean of the atomic masses of Fluorine and Bromine is $\frac{1}{2}(19 + 80) = 49{\cdot}5$, not 35·5.

So, Dobereiner's scheme of classification of elements was not very successful, though it did contain important insights and principles.

5.3 NEWLAND'S LAW OF OCTAVES

John Newland (a scientist and a lover of music) arranged elements in ascending order of atomic mass and found that every eighth element had properties similar to the properties of the first element, *just as the eighth note of a musical octave is the same as its first note.* Based on this observation, Newland gave his law of octaves for classification of elements.

According to Newland's law of octaves, *when elements are arranged by increasing atomic mass, the properties of every eighth element starting from any element are a repetition of the properties of the starting element.*

Western Music Do	Re	Me	Fa	So	La	Ti
Indian Music Sa	Re	Ga	Ma	Pa	Dha	Nee
1	2	3	4	5	6	7
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Tl	Mn	Fe
Co and Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce & La	Zr	—	—

Newland divided the elements into horizontal rows of seven elements each, as shown above [the noble, *i.e.* inert, gases were not known at that time].

Merits of Newland's classification

1. This system worked quite well for the lighter elements. *For example*, lithium, sodium and potassium were brought together.
2. It relates the properties of the elements to their atomic masses.
3. For the first time, it was shown that there is a distinct periodicity in the properties of elements.

Newland was honoured in 1887

The Royal Society presented the Davy Medal to Newland in 1887 for his work on classification of elements.

Reasons for discarding the law of octaves

- This classification did not work with heavier elements, *i.e.* those lying beyond calcium. As more and more elements were discovered, they could not be fitted into Newland's Octaves.
- Newland adjusted two elements cobalt (Co) and nickel (Ni) in the same slot and these were placed in the same column as fluorine, chlorine and

bromine which have very different properties than these elements.

- Iron, which resembles cobalt and nickel in properties, has been placed far away from these elements.

5.4 MENDELEEV'S PERIODIC TABLE

In 1869, Dmitri Ivanovich Mendeleev, a Russian chemist, arranged all the 63 elements known at that time in increasing order of their atomic mass. Elements with similar properties were put one after the other in the same vertical column (group), with blank spaces where the expected periodicity of the properties was disrupted, *i.e.*, where the properties of an element did not tally with the properties of the element placed above it. He observed that elements with similar properties occurred at regular intervals. This he called as *periodicity of properties of elements.*

Based on this, he propounded a law that is called *Mendeleev's Periodic Law.*

Mendeleev's Periodic Law

Physical and chemical properties of elements are a periodic function of their atomic masses.

***Periodic table** is a chart of elements prepared in such a way that elements with similar properties occur in the same vertical column (or group).* It is called periodic because elements with similar properties occur at fixed intervals (or periods); and it is called a table because elements are arranged in tabular form.

Essential features of Mendeleev's periodic table :

Mendeleev's Periodic table contains vertical columns, called '**groups**' and horizontal rows called '**periods**'.

- There are in all eight ***groups,*** *i.e.* Group I to Group VIII. Each of these groups from I to VII is divided into two sub-groups : A and B. Group VIII has no sub group. Inert gases were not known at that time.
- All elements of a sub-group (or of Group VIII, which has no sub-group) have similar properties and show the same valency, which is equal to the group number (for upto Group IV) or group number subtracted from eight (for Groups V-VII).
- In a period, elements gradually change from metallic to a non-metallic character or metallic character decreases as one moves from left to right across the horizontal row.

Table 5.1. Mendeleev's periodic table

Groups	I	II	III	IV	V	VI	VII	VIII
Oxide :	R_2O	RO	R_2O_3	RO_2	R_2O_5	RO_3	R_2O_7	RO_4
Hydride :	RH	RH_2	RH_3	RH_4	RH_3	RH_2	RH	
Periods ↓	A B	A B	A B	A B	A B	A B	A B	Transition series
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First series	K 39.102	Ca 40.08	Sc 44.96	Ti 47.90	V 50.94	Cr 50.20	Mn 54.94	Fe 55.85 Co 58.93 Ni 58.71
Second series	Cu 63.54	Zn 65.37	Ga 69·72	Ge 72·59	As 74.92	Se 78.96	Br 79.909	
5 First series	Rb 85.47	Sr 87.62	Y 88·41	Zr 91.22	Nb 92.91	Mo 95.94	Tc 99	Ru 101.07 Rh 102.91 Pd 106.4
Second series	Ag 107.87	Cd 112.40	In 114.82	Sn 118.69	Sb 121.75	Te 127.60	I 126.90	
6 First series	Cs 132.90	Ba 137.34	La 138.91	Hf 178.49	Ta 180.95	W 183.85		Os 190.2 Ir 192.2 Pt 195.2
Second series	Au 196.97	Hg 200.59	Tl 204.37	Pb 207.19	Bi 208.98			

Mendeleev's Periodic Table was published in a German journal in 1872. He used letter 'R' to represent the element of that particular group. Hydride of any element of group IV is written as RH_4. For example hydride of carbon is CH_4. Oxide of any element of the same group is RO_2 (CO_2).

Merits of Mendeleev's table

(1) **Grouping of elements.** He generalized the study of the elements then known to a study of mere eight groups.

(2) **Gaps for undiscovered elements.** In order to make sure that elements having similar properties fell in the same vertical column or group, Mendeleev left some gaps in his periodic table. These gaps were left for subsequent inclusion of elements not known at that time. Mendeleev correctly thought that such elements would be discovered later.

(3) **Prediction of properties of undiscovered elements.** He predicted the properties of the then unknown elements on the basis of properties of elements lying adjacent to the vacant slots. He actually predicted the properties of some undiscovered elements in 1871.

For example :

(i) Eka aluminium (means one place below aluminium in the group); its atomic mass and chemical properties are quite similar to those of the element gallium discovered in 1876.

(ii) Properties of eka-silicon are the properties of germanium.

Property	Eka-aluminium	Gallium	Eka-silicon	Germanium
Atomic mass	68	69.7	72	72.6
Density	5.9 g/cc	5.91 g/cc	5.5 g/cc	5.36 g/cc
Melting point	Low	302 K	High	1231 K
Valency	3	3	4	4
Formula of oxide	M_2O_3	Ga_2O_3	MO_2	GeO_2

(4) **Incorrect atomic mass corrected.** He was able to *correct the values of atomic mass of elements like gold and platinum* by placing these elements strictly on the basis of similarities in their properties.

Defects in Mendeleev's periodic table

(1) Anomalous pairs :

The following pairs of elements did not follow *Mendeleev's principles :*

(i) Argon with atomic mass 39·9 preceeds potassium with atomic mass 39·1.

(ii) Cobalt with atomic mass 58·9 preceeds nickel with atomic mass 58·6.

(iii) Tellurium with atomic mass 127·6 preceeds iodine with atomic mass 126·9.

(2) Position of isotopes :

Isotopes of an element are atoms of that element having similar chemical properties but different atomic masses.

According to Mendeleev's periodic law, isotopes of an element must be given separate places in the periodic table since they have different atomic masses. But they were not assigned separate places.

(3) Grouping of chemically dissimilar elements:

Elements such as copper and silver bear no resemblance to alkali metals (lithium, sodium, etc.) but they have been placed together in the first group.

(4) Separation of chemically similar elements :

Elements that are chemically similar, such as gold and platinum have been placed in separate groups.

(5) Electron arrangement :

It does not explain the electron arrangement of elements.

(6) Position of hydrogen :

Hydrogen was not given a fixed position. It was considered in Group IA as well as in Group VIIA because it forms both a positive ion, *viz.* in HCl, and a negative ion, *viz.* in NaH.

5.5 ATOMIC NUMBER AS BASIS FOR MODERN PERIODIC LAW

The magnitude of positive charge present in the nucleus of an atom was determined by Henry Moseley, an English physicist.

In 1913. Moseley used anodes of different metals in a discharge tube and subjected them to attack by cathode rays. He found, that when cathode rays struck anodes of different metals, the wavelength of the rays produced change. *The wavelength of these rays was found to decrease in a regular manner on changing the metal of the anode in order of their position in the periodic table.* By this, he concluded that the number of positive charge present in the nucleus of an atom is the most fundamental property of an atom.

The *number of unit positive charge present in the nucleus of an atom of a particular element is called the atomic number of that element.*

Some of the positive charge present in the nucleus is due to protons, the number of protons is equal to the atomic number of that element.

Thus, **Henry Moseley** found that ***atomic number*** *is a better fundamental property of elements compared to atomic mass.* This led to the modern periodic law.

> **Modern periodic law :** *Physical and chemical properties of elements are a periodic function of their atomic numbers.*

If elements are arranged in order of their increasing atomic number, those with similar properties are repeated after regular intervals, *i.e.* periodicity in the periodic table occurs based on the atomic numbers (number of protons)

Explanations for anomalies in Mendeleev's classification of elements

1. Position of isotopes

Since all isotopes of an element have the same number of protons, their atomic number is also the same. And since all isotopes of an element have the same atomic number, they can be put at the same position in the periodic table.

2. Position of argon and potassium

The atomic number of argon is 18 and its mass number is 40 while the atomic number of potassium is 19 and its mass number is 39. Now, according to the Modern periodic law, elements are arranged in increasing order of their atomic number. So argon, with its lower atomic number, should come first, and potassium, with its higher atomic number, should come later.

EXCERCISE 5(A)

1. What is the need for classification of elements?
2. What was the basis of the earliest attempts made for classification and grouping of elements ?
3. (a) A, B and C are the elements of a Dobereiner's triad. If the atomic mass of A is 7 and that of C is 39, what should be the atomic mass of B?
   (b) Why was Dobereiner's triad discarded ?
4. Explain 'Newland's law of Octaves.' Why was the law discarded ?
5. Did Dobereiners triads also exist in the columns of Newland's Octaves ? Compare and find out.
6. (a) Lithium, sodium and potassium elements were put in one group on the basis of their similar properties. What are those similar properties ?
   (b) The elements calcium, strontium and barium were put in one group or family on the basis of their similar properties. What were those similar properties ?
7. (a) What was Mendeleev's basis for classification of elements ?
   (b) Mendeleev's contributions to the concept of periodic table laid the foundation for the Modern Periodic Table. Give reasons.
8. State Mendeleev's periodic law.
9. Use Mendeleev's Peridic Table to predict the formula of
   (a) hydrides of carbon and silicon
   (b) oxides of potassium, aluminium and barium.
10. Which group of elements was missing from Mendeleev's original periodic table ?
11. State the merits of Mendeleev's classification of elements.
12. Why did Mendeleev leave some gaps in his periodic table of elements ? Explain your answer with an example.
13. The atomic number of an element is more important to the chemist than its relative atomic mass. Why ?
14. Consider the following elements : Be, Li, Na, Ca, K. Name the elements of (a) same group (b) same period.
15. (a) Name an element whose properties were predicted on the basis of its position in Mendeleev's periodic table.
    (b) Name two elements whose atomic weights were corrected on the basis of their positions in Mendeleev's periodic table.
    (c) How many elements were known at the time of Mendeleev's classification of elements ?

THE LONG FORM OF PERIODIC TABLE OF ELEMENTS

GROUPS

Representative Elements (s - block: groups 1–2) · **Transition Metals** (d - block: groups 3–12) · **Representative Elements** (p - block: groups 13–17) · **Noble gases** (p - block: group 18)

Atomic number — ^{6}C — Symbol

Solid · Liquid · Gas

Active metals (Alkali metals & Alkaline earth metals)
Heavy metals
Metalloids
Non-metals
Non-metals (Halogens)
Non-metals (Inert gas)

Periods	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	Zero
1	1 H Hydrogen																	2 He Helium
2	3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
3	11 Na Sodium	12 Mg Magnesium											13 Al Aluminium	14 Si Silicon	15 P Phosphorus	16 S Sulphur	17 Cl Chlorine	18 Ar Argon
4	19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
5	37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
6	55 Cs Caesium	56 Ba Barium	57-71 Lanthanide Series	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
7	87 Fr Francium	88 Ra Radium	89-103 Actinide Series	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborguim	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Damstacium	111 Rg Roentgentium	112 Cn Copernicium	113 Uut Ununtrium	114 Fl Flerovium	115 Uup Unumpentium	116 Lv Livermorium	117 Uus Ununseptium	118 UuO Un-Un Octium

INNER TRANSITION METALS f-block															
Lanthanide Series	57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
Actinide Series	89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einstenium	100 Fm Fermium	101 Md Mendelevium	102 No Noblium	103 Lr Lawrencium

5.6 PERIODICITY IN THE MODERN PERIODIC TABLE

When elements are arranged according to increasing atomic number, those having an equal number of valence electrons occur at regular intervals (or periods). And, *since the numbers of valence electrons of elements show periodicity (regular repetition), chemical properties show corresponding periodicity.*

Consider a group of the periodic table, for example, the first group of elements. Lithium, sodium, potassium, rubidium, caesium and francium, respectively. They have atomic numbers 3, 11, 19, 37, 55 and 87.

They :

(i) are good reducing agents.
(ii) form unipositive ions.
(iii) are soft metals.
(iv) are very reactive and are thus found mainly in combined state.
(v) impart colour to the flame when they burn.
(vi) form hydrides with hydrogen.
(vii) form basic oxides with oxygen.
(viii) react with water to form metal hydroxides and hydrogen.

All these elements have one electron each in their outermost shell (Refer 5.14), and so they have similar properties.

It is noticed that elements with similar electronic configurations have similar properties. ***Thus, the cause of periodicity is same number of electron(s) in outermost orbit i.e., recurrence of similar electronic configuration.***

Salient features of the modern periodic table

Vertical columns in the periodic table are called ***groups*** and the horizontal rows are called **periods**.

GROUPS

(1) The modern periodic table has **eighteen vertical columns**, comprising of groups (I to VIII and zero). Note that groups, I to VII are divided into sub-groups thereby making a total of eighteen groups.

(2) Elements of sub-group A, *i.e.* of IA, IIA, IIIA, IVA, VA, VIA and VIIA, (Group number 1, 2,

According to the recommendation of International Union of Pure and Applied Chemistry (IUPAC), *the groups are numbered from 1 to 18 replacing the older notation of GROUPS IA.. VIIA, VIII, IB... VIIB and 0.* However, for the examination, both notations will be accepted.

Old notation	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
New notation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Table 5.2 : Salient features of periods

Period	Type of period	Number of elements	Atomic no. of elements	No. of shell (s)	Elements in Group IA 1	IIA 2	IIIA 13	IVA 14	VA 15	VIA 16	VIIA 17	0 18
1	Shortest period	2	1 – 2	1	**H** 1							**He** 2
2	Short period	8	3 – 10	2	**Li** 3	**Be** 4	**B** 5	**C** 6	**N** 7	**O** 8	**F** 9	**Ne** 10
3	Short period	8	11 –18	3	**Na** 11	**Mg** 12	**Al** 13	**Si** 14	**P** 15	**S** 16	**Cl** 17	**Ar** 18
4	Long period	18	19 – 36	4	**K** 19						**Br** 35	**Kr** 36
5	Long period	18	37 – 54	5	**Rb** 37						**I** 53	**Xe** 54
6	Longest period	32	55 – 86	6	**Cs** 55		**La** 57 ← →		**Hg** 80			**Rn** 86
7	Incomplete period	32	87 – 118	7	**Fr** 87		**Ac** 89 ← →		**Cn** 112		**UuS** 117	**UuO** 118

13, 14, 15, 16 and 17) are known as **main group elements** or **representative elements** or the **normal elements.** *These elements have their outermost shells incomplete.*

(3) Elements of Group number 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 are known as **transition elements.** *They have their two outermost shells incomplete.*

(4) Elements in the Zero group (Group number 18) are called *noble gases* because owing to their stable electronic configurations, they hardly react with other elements. (Eight electrons in the outermost orbit, except in the case of Helium which has 2 electrons).

PERIODS

There are **seven horizontal rows** in the modern periodic table, each called a **period.** *The number of shells present in an atom determines its period, as is clear from Table 8.2.*

(1) Elements with electrons increasing arithmetically in their outermost shell, *i.e.* one by one, till an octet is attained, are placed in the same period. The last element of each period has eight electrons, except the first period He (2 electrons).

(2) **The first period** contains only two elements, (atomic nos. 1 and 2). It is the **shortest period.**

(3) **The second and third periods** contain eight elements each (atomic nos. 3-10 in the second and atomic nos. 11-18 in the third period). These are **short periods.**

(4) **The fourth and fifth periods** contain eighteen elements each (atomic nos. 19-36 in the fourth and atomic nos. 37-54 in the fifth period). These are **long periods.**

(5) **The sixth period** contains 32 elements (atomic nos. 55-86). It is the **longest period.**

(6) **The seventh period** (atomic nos. 87 and onward) is as yet an incomplete period.

(7) **In Group IIIB (Group number 3) of the sixth period,** there is a set of elements with atomic numbers 57 to 71 (La - Lu), beginning with lanthanum (La-57). These element are known as **lanthanides** (rare earths).

(8) **In Group IIIB (Group number 3) of the seventh period,** there is a set of elements with atomic numbers 89 to 103 (Th – Lr), beginning with actinium (Ac-89). These elements are known as **actinides** (radioactive elements).

> Lanthanides and actinides have similar properties because they belong to the same group, Group III B. But they are shown at the bottom of the periodic table because they are large in number, and showing them in the main body of the table will distort its shape.

5.7 TYPES OF ELEMENTS

Elements can also be classified in the following four types :

1. Representative elements
2. Transition elements
3. Inner transition elements
4. Inert gases or noble gases

Classification according to *s, p, d* and *f* blocks is based on electronic configuration, which you will study in higher classes.

5.7.1 Representative elements

(***s and p-block elements***) **:** They include all elements of :

Group 1 : Alkali metals – form strong alkalis with water;

Group 2 : Alkaline earth metals – form weaker alkalis compared to IA group elements;

Group 13 : Boron family – boron is the first member of the group;

Group 14 : Carbon family – carbon being the first member;

Group 15 : Nitrogen family, nitrogen being the first member;

Group 16 : Oxygen family, oxygen being the first member;

Group 17 : Halogens, they are salt formers.

> The alkali metals (Group I) are the most reactive metals that occur. They are known as the alkali metals because they react vigorously with water to produce hydrogen and an alkali solution.
> Halogens (Group 17) are most reactive non-metals. They form salts on reacting with metals.

Main characteristics of representative elements:

(a) They include both metals and non-metals. There is a regular gradation from metallic to non-metallic character as one moves from left to right across the period.

(b) They form electrovalent as well as covalent compounds with non-metals.

(c) Metallic nature increases, moving down any of these seven groups.

(d) Metals, which are good conductors of heat and electricity, are present in groups 1 and 2. Non-metals, which are present in groups 16 and 17, are poor conductors of heat and electricity.

(e) Some heavier elements, like tin and lead, exhibit variable valencies.

5.7.2. Transition elements *(d-block elements)* :

They are included in Groups 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12

Main characteristics of transition elements :

(a) All these elements are metals with high melting and boiling points.

(b) They are good conductors of heat and electricity.

(c) Some of these elements are attracted towards a magnet.

(d) Most of these elements are used as catalysts.

(e) Most of these elements exhibit variable valencies.

(f) Most of these elements form coloured ions and coloured compounds.

5.7.3. Inner transition elements *(f-block elements)* :

The elements of the sixth and seventh periods of Group 3, *i.e.* the lanthanides and the actinides, are collectively known as inner transition elements.

Main characteristics of inner transition elements :

(a) They are heavy metals with high melting and boiling points.

(b) They show variable valencies.

(c) They form coloured ions.

(d) Actinides are all radioactive by nature.

5.7.4. Inert gases (or noble gases)

Elements of the Zero group, which is the 18^{th} vertical column, are known as inert gases or noble gases.

They have 8 electrons in their outermost orbits (except He, which has only 2). They do not react with other elements and are, therefore, inert. (Refer 5.11.4.)

Bridge elements : Elements of the second period show resemblance in properties with elements of the next group of the third period, leading to a **diagonal relationship.** Such elements are called **bridge elements**, *viz.* Li and Mg; Be and Al; B and Si.

Group →	**1**	**2**	**13**	**14**
Period 2	Li	Be	B	C
Period 3	Na	Mg	Al	Si

Typical elements

The third period elements, Na, Mg, Al, Si, P, S and Cl, summarize the properties of their respective groups and are called **typical elements.**

5.8 MERITS OF THE MODERN PERIODIC TABLE

(1) It is based on atomic number, which is an even better fundamental property compared to atomic mass.

(2) Position of an element in the table is related to its electronic configuration.

(3) It shows regular changes in properties of elements on moving across a **period** or down a **group**.

Properties that reappear at regular intervals, or in which there is gradual variation, *i.e.* increase or decrease at regular intervals, are called ***periodic properties*** and the phenomenon is known as ***periodicity of elements.***

Cause of periodicity is recurrence of similar electronic configuration.

In a particular group, **the number of electrons in the outermost orbit** remains the same, *i.e.* electronic configuration is similar. **Valency** also remains the same. So elements of the same group have similar properties, though the number of shells increases down a group.

(4) Modern periodic table is easier to remember, understand and reproduce.

5.9 DEFECTS OF THE MODERN PERIODIC TABLE

1. *Position of hydrogen* is still not satisfactory, as its properties relate to both Group 1 and Group 17.

2. It fails to accommodate the inner transition elements, *i.e.* the lanthanides and the actinides, into the main body of the periodic table.

5.10 GENERAL TRENDS OF THE MODERN PERIODIC TABLE

GROUPS

(1) Numbers of shells and valence electrons :

Number of shells increases arithmetically and number of valence electrons remains *equal to the number* of the *group* to which the element belongs. Also, number of electron shells in a given element

equals the number of the period to which it belongs.
Consider halogens (Group 17), as shown below.

Element of group 17	No. of shells equals the period number	Electronic configuration
F	2	2, 7
Cl	3	2, 8, 7
Br	4	2, 8, 18, 7
I	5	2, 8, 18, 18, 7
At	6	2, 8, 18, 32, 18, 7

(2) Valency :

Valency of an element equals the number of electrons present in its valence shell. Since elements in a particular group have an equal number of electrons in their respective valence shells, valency of all elements in a given group is the same. *For example*, valency of any alkali metal is 1, as shown in the table below.

Element	Group 1	Electronic configuration	No. of valence electrons
Lithium	Li	2, 1	1
Sodium	Na	2, 8, 1	1
Potassium	K	2, 8, 8. 1	1

Valency of group IA elements is 1

Valency of group IIA elements is 2

Valency of group IIIA elements is 3

(**Group number 13**; 13 – 10 = 3)

Valency of group IVA elements is 4

(**Group number 14**; 14 – 10 = 4)

Valency of group VA elements is 3

(**Group number 15**; 18 – 15 = 3)

Valency of group VIA elements is 2

(**Group number 16**; 18 – 16 = 2)

Valency of group VIIA elements is 1

(**Group number 17**; 18 – 17 = 1)

Valency of group Zero (or Group number 18) elements is 0.

(3) Properties of elements :

Elements in a given group possess similar electronic configurations. Because the number of electrons in their respective outermost shells is the same hence, they have very *similar physical and chemical properties, which change uniformly down that group.*

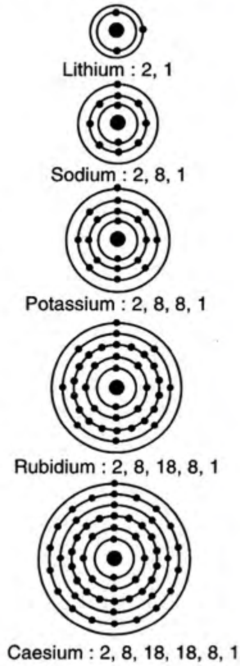
Examples :

(a) *Alkali metals* (Group 1) are all very reactive, and degree of reactivity further **increases** down the group.

$$\xrightarrow[\text{Reactivity increases}]{\text{Li<Na <K<Rb<Cs}}$$

(b) *Halogen atoms* also are very reactive. But there degree of reactivity **decreases** as we move from fluorine to iodine.

$$\xrightarrow[\text{Reactivity decreases}]{\text{F>Cl >Br>I}}$$



(4) Atomic size :

As one moves down a group, size of atoms of successive elements increases. This is because of progressive increase in the number of shells. *For example*, in Group 1, atomic size increases as one moves from lithium to caesium.

$$\xrightarrow[\text{Atomic size increases}]{\text{Li<Na<K<Rb<Cs}}$$

(5) Metallic character :

Metallic character increases as one moves down a group. For example, in Group 15, nitrogen and phosphorus are non-metals, arsenic and antimony are metalloids, and bismuth is a typical metal.

Elements of Group 15 :	N; P	As; Sb	Bi
Character :	non–metals	metalloids	metal

It is on account of gradual increase in metallic character of elements from top to bottom that *oxides of elements become increasingly basic in character* moving in the same direction.

The oxides of the elements of Group 15 :	NO_2; P_2O_5	As_2O_3; Sb_2O_3	Bi_2O_3
Oxide character :	acidic	amphoteric	basic

Note : Hydrogen has been placed at the top of Group 1, above the alkali metals of that group, because the electronic configuration of hydrogen is similar to those of the alkali metals. Both hydrogen and alkali metals have 1 valence electron. However, hydrogen atom is very small in size, and therefore, many of its properties are different from those of alkali metals. As such, while discussing the alkali metals of group 1, hydrogen is ignored. However, in some periodic tables, hydrogen is not placed in any group. It is treated as a very special element, and thus placed alone at the head of the periodic table.

PERIODS

(1) Number of shells :

On moving from left to right in a given period, number of shells remains the same.

For example, in the 3rd period, number of shells remains three, *i.e.* equal to the number of period.

Elements of the 3rd period	Na	Mg	Al	Si	P	S	Cl	Ar
Atomic No.	11	12	13	14	15	16	17	18
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

(2) Number of electrons in valence shell :

In a given period, number of electrons in valence shell increases from left to right.

(3) Valency :

Valency of elements, with respect to hydrogen, increases arithmetically from 1 to 4 and back to 1.

Elements of the 2nd period	Li	Be	B	C	N	O	F
Hydrides of elements	LiH	BeH_2	BH_3	CH_4	NH_3	H_2O	HF
Valency with respect to hydrogen	1	2	3	4	3	2	1

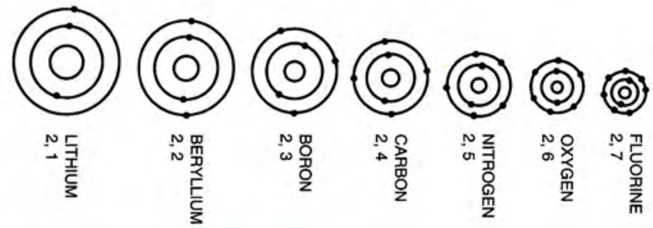
But valency of elements, with respect to oxygen, increases from 1 to 7.

Elements of the 3rd period	Na	Mg	Al	Si	P	S	Cl
Oxides of elements	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl_2O_7
Valency with respect to oxygen	1	2	3	4	5	6	7

(4) Size of atoms :

Size of atom decreases when moving left to right in a period (increase in the number of protons increases nuclear pull which decreases the size). Thus, in a particular period, alkali atoms have the largest size and halogen atoms are the smallest.

$$Li > Be > B > C > N > O > F$$



(5) Properties of elements :

Properties of an element *depend upon the number of electrons in its outermost orbit.* Since in a period, number of electrons in valence shell changes, properties of elements in a period differ significantly. **Reactivity first decreases up to Group 14 and then increases.** Thus Group 1 elements are the most reactive metals while those of Group 17 are the most reactive non-metals.

(6) Metallic character :

On moving from left to right in a given period, *metallic character gradually decreases, i.e.* it changes from metallic to non-metallic. The last element of each period is inert.

Elements of the 2nd period

$$\underbrace{Li, \; Be,}_{\text{Metal}} \; \underbrace{B,}_{\text{Metalloid}} \; \underbrace{C, \; N, \; O, \; F,}_{\text{Non-metal}} \; Ne$$

Oxides of elements : Oxides of elements in a particular period become progressively less basic and finally change to an acidic character. *For example*, consider the oxides of the third period elements.

Oxides of the 3rd period

$$Na_2O, \; MgO, \; Al_2O_3, \; SiO_2, \; P_2O_5, \; SO_3, \; Cl_2O_7$$

(Acidic character increases)

$$\longrightarrow$$

EXCERCISE 5(B)

1. (a) State the modern periodic law.
   (b) How many periods and groups are there in the modern periodic table ?
2. What is the main characteristic of the last elements in the periods of a periodic table ? What is the general name of such elements ?
3. What is meant in the periodic table by :
   (a) a group, and
   (b) a period ?
4. From the standpoint of atomic structure, what determines which element will be the first and which the last in a period of the periodic table ?
5. (a) What are the following groups known as ?
   (i) Group 1 (ii) Group 17 (iii) Group 18
   (b) Name two elements of each group.
6. What is the number of elements in the :
   (a) Ist period, and
   (b) 3rd period, of the modern periodic table ?
7. How does number of (i) valence electrons (ii) valency; vary on moving from left to right :
   (a) in the second period of a periodic table ?
   (b) in the third period of a periodic table ?
8. How do atomic structures (electron arrangements) change in a period with increase in atomic numbers moving left to right ?
9. This question refers to elements of the periodic table with atomic numbers from 3 to 18. In the table below, some elements are shown by letters, even though the letters are 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

   (a) Which of these is :
   (i) a noble gas ?
   (ii) a halogen ?
   (iii) an alkali metal ?
   (iv) an element with valency 4 ?
   (b) If A combines with F, what would be the formula of the resulting compound ?
   (c) What is the electronic arrangement of G ?
10. Sodium and aluminium have atomic numbers 11 and 13, respectively. They are separated by one element in the periodic table, and have valencies 1 and 3 respectively. Chlorine and potassium are also separated by one element in the periodic table (their atomic numbers being 17 and 19, respectively) and yet both have valency 1. Explain.
11. 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 which part of a group would you separately expect the elements to have :
   (a) the greatest metallic character ?
   (b) the largest atomic size ?
13. What happens to number of valence electrons in atoms of elements as we go down a group of the periodic table ?
14. The position of elements A, B, C, D and E in the periodic table are shown below :

Group 1	Group 2	Group 17	Group 18
—	—	—	D
—	B	C	—
A	—	—	E

   (a) State which are metals, non-metals and noble gas in this table.
   (b) State which is most reactive (i) metal (ii) non-metal
   (c) Which type of ion will be formed by element A, B and C.
   (d) Which is larger in size (i) D or E (ii) B or C.
15. Write electronic configuration of element $_{17}T^{35}$.
   (a) What is the group number of T ?
   (b) What is the period number of T ?
   (c) How many valence electrons are there in an atom of T ?
   (d) What is the valency of T ?
   (e) Is it a metal or a non-metal ?
   (f) State number of protons and neutrons in T.

7.11 STUDY OF SPECIFIC GROUPS

7.11.1 Group I (Alkali Metals)

The elements such as lithium (Li), sodium (Na), potassium (K), rubidium (Rb), caesium (Cs) and francium (Fr) have one electron in their outermost orbit and therefore show one valency. So they are placed in IA group (the first column on the left) of the Periodic Table. They are known as alkali metals, as *they react with water to form their hydroxides which are strong alkalies (bases soluble in water).*

$$2M + 2H_2O \rightarrow 2MOH + H_2$$
(Alkali metal) (Alkali)

Where M is any metal of IA group.

Characteristics

1. **Electronic configuration**

Element	K	L	M	N	O	P	Q
$_3Li$	2	1					
$_{11}Na$	2	8	1				
$_{19}K$	2	8	8	1			
$_{37}Rb$	2	8	18	8	1		
Cs_{55}	2	8	18	18	8	1	
Fr_{87}	2	8	18	32	18	8	1

2. **Occurrence :** All of them are very reactive and do not occur in free state.
3. **Nature :** They are soft (can be cut with a knife) and have low melting and boiling points.
4. **Bonding :** All alkali metal salts (except some salts of lithium) are ionic in nature.
5. **Action of air :** They react rapidly with oxygen and water vapour in the air.

$$4Na + O_2 \rightarrow 2Na_2O$$
$$Na_2O + H_2O \rightarrow 2NaOH$$
$$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$$

Reactivity of these metals increases down the group.

6. **Action of water :** They react violently with water and produce hydrogen.

$$2M + 2H_2O \rightarrow 2MOH + H_2$$
(Any Alkali metal)

7. **Action of acids :** They react violently with dil HCl and dil. H_2SO_4, to produce hydrogen

$$2M + 2HCl \rightarrow 2MCl + H_2$$
(Any Alkali metal)

8. They form unipositive ion easily.

$$M(g) - e^- \rightarrow M^{1+}(g)$$

They are strong *reducing agents*.

9. When freshly cut, they show typical silvery white metallic lustre but soon they turn dull (tarnish) because of their reaction with air.
10. All alkali metal salts impart colour to the flame, *e.g.*, lithium (*crimson red*), sodium (*golden yellow*), potassium (*pale violet*).
11. Alkali metals are obtained by electrolysis of their molten salts.

5.11.2 Group II (Alkaline Earth Metals)

The elements such as beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba) and radium (Ra) are known as alkaline earth metals, because their oxides occur in the earth's crust and their hydroxides are weak alkalies.

All the elements of this group have two electrons in their outermost orbit and show the valency two, so they are placed in **IIA group** of the Periodic Table.

Characterstics

1. **Electronic configuration**

Element	K	L	M	N	O	P	Q
$_4Be$	2	2					
$_{12}Mg$	2	8	2				
$_{20}Ca$	2	8	8	2			
$_{38}Sr$	2	8	18	8	2		
Ba_{56}	2	8	18	18	8	2	
Ra_{88}	2	8	18	32	18	8	2

2. **Occurrence :** They are reactive metals (less reactive than alkali metals); hence they do not occur in free state in nature.
3. **Nature :** They are greyish white in colour and harder than the alkali metals.
4. **Bonding :** All the alkaline earth metal salts except beryllium are ionic compounds.
5. **Action of air :** They are less reactive than alkali metals.

Their reactivity increases on moving down the group.

6. **Action of water :** They react with water to produce hydrogen.

$$M + 2H_2O \rightarrow M(OH)_2 + H_2$$
(Any alkaline metal) (Alkali)

7. **Action of acids :** They react with dil HCl and dil H_2SO_4 to produce hydrogen.

$$M + 2HCl \rightarrow MCl_2 + H_2$$
$$M + H_2SO_4 \rightarrow MSO_4 + H_2$$

8. They form dipositive ion.

$$M - 2e^- \rightarrow M^{2+}$$

They are also strong **reducing agents**.

9. Melting points and boiling points are comparatively low but these are higher than the alkali metals.

10. Except beryllium and magnesium, all other alkaline earth metals impart colour to the flame like Calcium – *brick red*, Strontium – *Crimson*, Barium – *Apple green*, Radium – *Crimson*.
11. They are obtained by the electrolysis of their molten salts.

5.11.3 Group VIIA or Group 17 (The hologens)

Group VIIA or Group 17 elements are known as halogens. The name halogens (Greek halo = Sea saltogens = producing, meaning sea salt former).

Characterstics

1. These elements have 7 electrons in their outermost orbit.

Element	K	L	M	N	O	P	Q
$_{9}F$	2	7					
$_{17}Cl$	2	8	7				
$_{35}Br$	2	8	18	7			
$_{53}I$	2	8	18	18	7		
$_{85}At$	2	8	18	32	18	7	

2. They are the most reactive non-metals. Their reactivity decreases down the group. *For example*, Fluorine is the most reactive and iodine the least reactive halogen.
3. There is a steady increase in melting points and boiling points as we go down the group. Fluorine is a gas, chlorine is a gas, Bromine is liquid and iodine is solid.

   Astatine is highly radioactive and a rare element.

   The intensity of the colour of the element also increases from pale to dark.

   Fluorine is a pale yellow gas, chlorine is a greenish yellow gas, Bromine is a reddish brown liquid and iodine is a violet solid.
4. They are all poisonous and have a similar strong pungent and unpleasant odour.
5. They all form diatomic molecules F_2, Cl_2, I_2, Br_2.
6. They all have a valency 1 and form compounds with similar formulae, *for example*, hydrogen chloride (HCl), hydrogen bromide (HBr), Hydrogen iodide (HI).
7. They produce a series of compounds with other elements chloride, bromides and iodides, together they are known as **halides**.
8. The halogens themselves can react directly with metals to form metal halides (or salts).
9. They all form negative ions carrying a single charge [Fluoride ions F^-, Chloride ions Cl^-, Bromide ions Br^-, Iodide ions 1^-].

5.11.4 Group Zero or 18 group (Noble gases)

When Mendeleev first constructed his table, there was no indication that a whole group of elements (Group zero) remained to be discovered. Because of their lack of reactivity. There was no clear sign of their existence. However,analysis of the gases in air led to the discovery of argon. Helium was first detected by spectroscopy of light from the sun during an eclipse and the other noble gases were isolated. **William Ramsay isolated these gases**. He was awarded the Nobel prize for this major contribution.

These gases (Helium, neon, argon, krypton, xenon and radon) are refered to as **inert gases** meaning they do not react at all. In 1960s some compounds of xenon and krypton have been made and their name was changed to **noble gases**.

Characterstics

1. Electronic configuration

Element	K	L	M	N	O	P	Q
$_{2}He$	2						
$_{10}Ne$	2	8					
$_{18}Ar$	2	8	8				
$_{36}Kr$	2	8	18	8			
$_{54}Xe$	2	8	18	18	8		
$_{54}Rn$	2	8	18	32	18	8	

   Helium has 2 electrons in its shell, all the other members have eight electrons in outermost orbit *i.e.*, their electronic arrangment is very stable, so that they are unreactive.
2. All are colourless, tasteless, odourless gases. They are neither inflammable nor supporter of combustion.
3. They are monoatomic because their electronic configuration is stable.
4. Noble gases are liquified with great difficulty.
5. These gases are slightly soluble in water and on moving from He to Rn solubility increases.
6. These gases emit coloured light when an electrical discharge is passed through them.
7. Their melting points and boiling points are extremely low. Helium has the lowest melting point of any element, and cannot be solidified

by cooling alone (pressure is needed also). All these properties point to the atoms of the noble gases being particularly stable.

8. The uses of noble gases depend on their unreactive nature. Helium is used in airships and balloons because it is both light and unreactive. Argon is used to fill light bulbs because it will not react with the filament even at high temperatures. The best known use of the noble gases is, perhaps, its use in 'neon' lights. The brightly coloured advertising light works, when an electric discharge is passed in a tube containing a little of a noble gas. Different gases impart different colours.

   Note : The elements of Group zero (18) are between the two most reactive groups of elements [Groups I and VIIA (17)]. Indeed, it is their closeness to these groups with stable electron arrangments that makes the alkali metals and the halogens so reactive. They can easily achieve a noble gas electron structure. The Group VIIA (17) elements **gain** or **share** an electron while group IA lose an electron to achieve a noble gas electron arrangment.

5.12 USES OF PERIODIC TABLE

1. Periodic table has been useful in predicting the existence of new elements.
2. It has been useful in the past in correcting the properties of elements.
3. Study of elements and their compounds has become systematic and easier to remember.
4. Position of an element in the periodic table reveals its
   (i) atomic number (ii) electronic configuration
   (iii) number of valence electrons
   (iv) properties
5. Nature of chemical bond, formula of compound formed and properties of that compound can all be predicted from the periodic table.

   For example : Elements present in groups 1, 2 and 3 (metals) lose electrons to form positive ions, while elements of groups 15, 16 and 17 (non-metals) gain electrons to form negative ions. When these positive and negative ions combine, they form a compound, that is electrovalent in nature.

   If elements of groups 14, 15, 16 and 17 combine with those of 15, 16 and 17, *i.e.* non-metals with non-metals, they form covalent compounds.
6. Position of an element in the periodic table reveals
   (i) Valency of an element.
   (ii) whether the element is a metal or a non-metal — metals occupy the extreme left positions at the bottom of the periodic table while non-metals are at the extreme right of the periodic table.

CHAPTER AT A GLANCE

Doberiener grouped the elements in *triads* (groups of three elements) such that the middle element of the triad had both atomic mass and properties roughly equal to the average equivalent figures for the other two elements of the triad.

Examples :

(i) Ca (40), Sr (88), Ba (137) : $\frac{40+137}{2} = 88{\cdot}5$ (ii) Li (7), Na (23), K (39) : $\frac{7+39}{2} = 23$

However, *this method was soon discarded since only a few elements then known could be arranged in such triads.*

Newland gave the ***law of octaves***. According to it, when elements are arranged in increasing order of atomic mass, every *eighth element beginning from any element resembles the first* in its physical and chemical properties. [Like the eighth note on a musical scale resembling the first note].

This method too was soon discarded since *it failed to accommodate the heavier elements and left no space for elements that were discovered later.* Moreover, after the discovery of the noble gases, the idea of octaves simply did not work.

In 1871, Russian chemist **Dmitri Mendeleev** published a table of elements, and proposed a periodic law. It states that "*the properties of elements are the periodic functions of their atomic masses.*" He arranged the elements in increasing order of their *atomic mass*. This arrangement enabled Mendeleev to place elements in vertical columns known as ***groups*** and horizontal rows known as ***periods***. He even predicted the existence of some yet to be discovered elements. But even this method could not explain the positions of certain elements like the rare earth metals and existence of isotopes.

These defects were removed when **Moseley** found that atomic numbers are the fundamental property that best explained the periodic properties of elements. He then put forward the idea of the **modern periodic table**.

1. MODERN PERIODIC LAW

Physical and chemical properties of elements are periodic functions of their ***'atomic numbers.'***

Period No.	Type of period	No. of elements	Atomic number	1 IA	2 IIA	3	4	5	6	7	8	9	10	11	12	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 0
1	Shortest	2	1 and 2	H_1 1																	He_2 2
2.	Short	8	3 to 10	Li_3 2,1	Be_4 2,2											B_5 2,3	C_6 2,4	N_7 2,5	O_8 2,6	F_9 2,7	Ne_{10} 2,8
3.	Short	8	11 to 18	Na_{11} 2,8,1	Mg_{12} 2,8,2	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	11 IB	12 IIB	Al_{13} 2,8,3	Si_{14} 2,8,4	P_{15} 2,8,5	S_{16} 2,8,6	Cl_{17} 2,8,7	Ar_{18} 2,8,8
4.	Long	18	19 to 36	K_{19} 2,8,8,1	Ca_{20} 2,8,8,2	TRANSITION ELEMENTS														Br_{35}	Kr_{36}
5.	Long	18	37 to 54	Rb_{37}																I_{53}	Xe_{54}
6.	Longest	32	55 to 86	Cs_{55}		La_{57}														At_{85}	Rn_{86}
7.	Incomplete		87 to	Fr_{87}		AC_{89}														Uus_{117}	Uuo_{118}

Lanthanide series	Ce_{58}	INNER TRANSITION ELEMENTS	Lu_{71}
Actinide series	Th_{90}		Lr_{103}

Group 1 are Alkali metals (except hydrogen)
Group 2 Alkaline earth metals
Group 3 to 12 Transition elements
Group 17 Halogens
Group 18 Inert gases
Group IIIB 6th period Lanthanides
Group IIIB 7th period Actinides
] Inner Transition Elements

2. FEATURES OF THE MODERN PERIODIC TABLE

Periods :

Period – 1 : Shortest period – consists of 2 elements – $_1H$ and $_2He$.

Period – 2 : Short period – contains 8 elements – $_3Li$, $_4Be$, $_5B$, $_6C$, $_7N$, $_8O$, $_9F$, $_{10}Ne$.

Period – 3 : Short period – contains 8 elements – $_{11}Na$, $_{12}Mg$, $_{13}Al$, $_{14}Si$, $_{15}P$, $_{16}S$, $_{17}C$, $_{18}Ar$.

Periods – 4 & 5 : Long periods – contain 18 elements each.

Period – 6 : Longest period – contains 32 elements.

Period – 7 : Incomplete period.

Characteristics of periods :

There are seven horizontal periods.

1. Elements of the same period have the *same number of electron shells.*
2. Electrons in the outermost shell *increase progressively* for elements of the same period.

Groups :

There are 18 vertical columns numbered 1 to 18.

- Group 0 [zero] or group 18 – contains *noble gases* : He, Ne, Ar, Kr, Xe and Rn.
- Group 1 – contains hydrogen and *alkali metals* Li, Na, K, Rb, Cs and Fr.
- Group 2 – contains *alkaline earth metals.*
- Group 3 to group 12 – contain *transition metals*. In Group 3, period 6 and period 7 are known as Inner Transition metals (**Lanthanides** and **Actinides**)
- Group 17 – contains *halogens* : F, Cl, Br, I and At.

Characteristics of groups :

(i) Elements of the same group have the *same number of valence electrons, i.e.* they have the same valency and thus show similar chemical properties.

(ii) Electron shells increase down a group.

Metallic and non-metallic character

Metallic character decreases across a period (left to right) and increases down a group (top to bottom).

Non-metallic character increases across a period (left to right) and decreases down a group (top to bottom).

- Uses of the periodic table : position of elements, their properties, nature of compounds formed can be determined.

EXCERCISE 5(C)

1. Element P has atomic number 19. To which group and period, does P belong ? Is it a metal or a non- metal ? Why ?
2. An element belongs to the 3rd period and Group IIIA (13) of the periodic table. State :
   (a) the number of valence electrons,
   (b) the valency,
   (c) if it is a metal or non-metal ?
   (d) the name of the element.
3. Name or state the following with reference to the elements of the first three periods of the periodic table.
   (a) Noble gas with duplet arrangement of electrons.
   (b) Metalloid in Period 3.
   (c) Valency of elements in Group 14 and 15.
   (d) Noble gas having electronic configuration : 2, 8, 8.
   (e) Group whose elements have zero valency.
   (f) A covalent compound formed by an element in Period 2 and a halogen.
   (g) Non-metallic element present in Period 3 of Groups 15 and 16.
   (h) An electrovalent compound formed by an alkaline earth metal and a halogen.
   (i) Bridge elements of Period 3 of Group 1, 2 and 3.
   (j) Alkali metal in Period 3 that dissolves in water giving a strong alkali.
   (k) Typical elements of Groups 14 and 15.
   (l) Alkaline earth metal in Period 3.
4. Match column A with column B

Column A	*Column B*
(a) Elements short by 1 electron in octet	(i) Transition elements
(b) Highly reactive metals	(ii) Noble gases
(c) Non-reactive elements	(iii) Alkali metals
(d) Elements of groups 3 to 12	(iv) Alkaline earth metals
(e) Radioactive elements	(v) Halogens
(f) Elements with 2 electrons in the outermost orbit	(vi) Actinides

5. Complete the table

Atomic No.	Element	Electronic configuration	Select element of the same group
11	Sodium	....	(Ca / N / K) ....
15	Phosphorus	....	(Ba / N / Rb) ....
16	Sulphur	....	(F / Cl / O) ....
9	Fluorine	....	(Ca / Cl / K) ....

6. Write down the word that will correctly complete the following sentences :
   (a) Relative atomic mass of a light element up to calcium is approximately .... its atomic number.
   (b) The horizontal rows in a periodic table are called ....
   (c) Going across a period left to right, atomic size ....
   (d) Moving left to right in the second period, number of valence electrons ....
   (e) Moving down in the second group number of valence electrons ....
7. (a) Name the alkali metals. How many electrons(s) they have in their outermost orbit.
   (b) Take any one alkali metal and write its reaction with (i) oxygen (ii) water (iii) acid.

8. (a) Name the method by which alkali metals can be extracted.
   (b) What is the colour of the flame of sodium and potassium ?
9. (a) Name the first three alkaline earth metals.
   (b) Write their reactions with dil hydrochloric acid.
10. (a) How do alkaline earth metals occur in nature ?
   (b) Write the electronic configuratrion of the first two alkaline earth metals.
11. (a) What is the name given to group 17 elements ? Why are they called so ?
   (b) Comment on the (i) reactivity (ii) colour (iii) physical state of group 17 elements.
12. (a) State the nature of compounds formed when group 17 elements combine with (i) metals (ii) non-metals.
   (b) Why group 17 elements are highly reactive ?
13. (a) How many electrons do inert gases have in their valence shells ?
   (b) Name an element of group 18 which can form compounds.
14. Give use of (i) helium gas (ii) neon gas.
15. An element A has 2 electrons in its fourth shell. State :
   (a) its atomic number
   (b) its electronic configuration
   (c) its valency
   (d) position in the periodic table
   (e) is it a metal or non metal
   (f) is it an oxidising or reducing agent