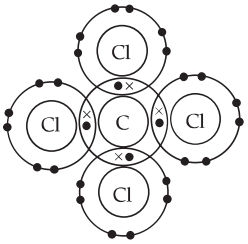

Fig. 9

[One molecule of carbon tetrachloride contains five atoms in all, *i.e.*, one atom of carbon and four atoms of chlorine]

Key Words

- A chemical bond which is formed due to electrostatic force of attraction between a cation and anion or transfer of electrons is known as **electrovalent or ionic bond**.
- **Electrovalent compounds** are those which are formed due to transfer of electrons from one atom of the element to an atom of another element.
- The number of electrons that an atom of an element loses or gains to form an electrovalent bond is called **electrovalency**.
- The symbol of element surrounded by dots representing valence electrons is called as **'Electron dot symbol'** or **'Lewis symbol.'**
- During the formation of electrovalent bond, transfer of electrons is involved. The electropositive atom undergoes oxidation, while the electronegative atom undergoes reduction. This is called as **'Redox process.'**
- **Oxidising agent** is an acceptor of electrons and a **reducing agent** is a donor of electrons.
- The chemical bond that is formed between two combining atoms by mutual sharing of one or more pairs of electrons is called **covalent bond**.
- The molecule formed by sharing of electrons (covalent bond) is called a **covalent molecule**.
- **Single covalent bond** is formed by sharing of one pair of electrons between the atoms, each atom contributes one electron.
- **Double covalent bond** is formed by sharing of two pairs of electrons between the atoms, each atom contributes two electrons.
- **Triple covalent bond** is formed by sharing of three pair of electrons between the atoms, each atom contributes three electrons.
- **Non-polar covalent compounds** are those where shared pair of electrons are equally distributed between two atoms with no charge separation making the molecule symmetrical and electrically neutral.
- **Polar covalent compounds** are those where shared pair of electrons are not at equal distance between the two atoms. Due to which development of fractional positive and negative charges on them and they ionise in water.

CHAPTER-5
THE PERIODIC TABLE

Topic-1 Modern Periodic Table and its Periodicity

Revision Notes

- Elements were classified for studying them in a better way. The reason for classification of elements was to:
  - Study elements in an organized way.
  - To correlate the properties of the elements with some fundamental properties which are characteristics of all the states of matter.

- To reveal relationship between elements.

➢ Earlier classifications were not satisfactory and scientists were searching for properties of elements that never changed.

➢ **William Prout** discovered that the atomic mass of an element did not differ and could form a basis for satisfactory classification of elements.

➢ **Dobereiner** grouped the elements in triads with similar properties such that the atomic weight of the middle element was the arithmetic mean of the other two. For *e.g.*,

$$\text{Ca (40), Sr (88), Ba (137)} : \frac{40 + 137}{2} = 88.5$$

➢ **The law of triad was discarded because:**

- Dobereiner failed to arrange all elements known at that time in the form of triads.
- The law was unable to apply even within the same family.
- Newland's observed that when elements are arranged in increasing order of their atomic mass, every eighth element had properties similar to the properties of the first element.

➢ **Merits of Newland's Law of Octaves:**

- This system worked well for the lighter elements.
- It relates the property of elements to their atomic masses.
- For the first time, this system showed that there is a discrete periodicity in the properties of elements.

➢ **The Law of Octaves was discarded because:**

- This system did not hold good for the heavier elements (for elements beyond calcium) as more and more discovered elements were unable to fit into Newland's Octaves.
- Newland's placed two elements cobalt and nickel in the same slot and placed along with fluorine, chlorine and bromine in the same column, which have different properties compared to cobalt and nickel.
- Whereas iron with similar properties to cobalt and nickel was placed away from these elements.

➢ **Mendeleev's Periodic Table**

➢ A tabular arrangement of elements in groups (vertical columns) and periods (horizontal rows) highlighting the regular trends in properties of elements is called a **periodic table**.

➢ Here '**periodic**' meaning elements with similar properties occur at fixed intervals and '**table**' meaning elements arranged in tabular form.

➢ According to Mendeleev's periodic table, the properties of elements are the periodic functions of their atomic masses.

➢ **Features of Mendeleev's Periodic Table:**

- The periodic table contains vertical columns called 'groups' and horizontal rows called 'periods.'
- There are in all eight groups in which I to VII are divided into sub-groups A, B but VIII has no sub-group.
- All the elements of sub-group have similar characteristics and same valency as the group number or group number minus eight.
- In the period, elements change from metallic to non-metallic character.

➢ **Merits of Mendeleev's Periodic Table:**

- Grouping of elements: He arranged the elements known then, in order in eight groups.
- Gaps for undiscovered elements: Mendeleev's left some gaps in his periodic table for succeeding addition of elements which were unknown at that time.
- Prediction of the properties of undiscovered elements: He predicted the properties of elements lying adjacent to vacant slots (eka –Aluminum & eka – Silicon).
- Incorrect atomic mass corrected: He corrected the atomic mass of elements like gold and platinum and placed them strictly on the basis of their properties.

➢ **Defects in Mendeleev's Periodic Table:**

- There were anomalous pairs which did not follow Mendeleev's principles. *e.g.* Argon with atomic mass 39.9 preceded potassium with atomic mass 39.1, similarly cobalt with atomic mass 58.8 preceded nickel with atomic mass 58.6.

- Position of isotopes in Mendeleev's Periodic table were not given separately. But as per his periodic law, isotopes of an element should be given separate place as they differ in their atomic mass.
- Grouping of chemically dissimilar elements were found. *e.g.* Elements copper and silver were placed together but both had no resemblance with each other.
- Separation of chemically similar elements were found. *e.g.* Gold and platinum being chemically similar were placed separately.
- Electronic configuration was not explained.
- Position of hydrogen was not fixed. It was considered in both I A as well as in VII A as it formed both positive ion and a negative ion.

➢ Magnitude of positive charge present in the nucleus of an atom was revealed by Henry Moseley. He found that when cathode rays hit anodes of different metals, the wavelength of these metals was found to decrease in regular manner of changing the metal of anode in the order of its position in the periodic table.

➢ By this, he determined that the number of positive charges present in the nucleus due to protons (atomic number) is the most fundamental property of the element. Thus, Henry Moseley found that the atomic number is a better fundamental property of an element compared to its atomic mass.

➢ This led to the modern periodic law stating 'Physical and chemical properties of elements are a periodic function of their atomic numbers'.

➢ This law gave explanations for anomalies in Mendeleev's classification of elements such as:

- Position of isotopes with the same atomic number can be placed in the same place as the element in the same group.
- Position of Argon and Potassium were given, based on elements with higher atomic number should be placed later to elements with lower atomic number, which should come first. Thus, argon with atomic number 18 with mass 40 was placed before potassium with atomic number 19 with mass 39.

➢ The number of valence electrons are responsible for periodicity. Chemical properties show subsequent periodicity.

➢ **Salient features of Modern Periodic Table:**

- Vertical columns in the periodic table are called groups and the horizontal rows are called periods.
- The modern periodic table has 18 vertical columns, called groups. Each vertical column accommodates elements with the same number of electrons in the outermost shell.
- The modern periodic table has 7 horizontal rows, called periods. The number of shells present in an atom determines its period.
- Group 1,2, 13,14,15, 16 and 17 are main group or representative elements with their outermost shell incomplete.
- Group 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 are transition elements with their two outermost shell incomplete.
- Group 18 or Zero group are called noble gases with stable electronic configuration (8 electrons in the outermost orbit, except Helium, which has 2 elements.)
- The number of shells present in an atom tells the period of the element.
- First period = 2 elements, shortest period
- Second and third periods = 8 elements each, also short periods.
- Fourth and fifth periods = 18 electrons each, are long periods.
- Sixth period = 32 electrons, longest period.
- Seventh period =incomplete period
- Group 3 of sixth period = Lanthanides
- Group 3 of seventh period = Actinides (radioactive elements)

➢ **Types of Elements**

- Representative elements
- Transition elements
- Inner transition elements
- Inert gases or noble gases

➢ **Representative elements (s and p- block elements)**

- Group 1 – Alkali metals (most reactive metals)
- Group 2 – Alkaline earth metals

- Group 13 – Boron family
- Group 14 – Carbon family
- Group 15 – Nitrogen family
- Group 16 – Oxygen family
- Group 17 – Halogens (most reactive non-metals)

➢ **Characteristics of representative elements:**

- They include both metals and non-metals. Metallic character decreases on moving from left to right across the period.
- They form both electrovalent and covalent compounds with non-metals.
- Metallic nature increases down the groups.
- Metals are good conductors of heat and electricity (groups 1 and 2), Non-metals are poor conductors of heat and electricity (groups 16 and 17).
- Heavier elements tin and lead show variable valencies.

➢ **Transition elements (*d*-block elements):**

They include groups 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12.

➢ **Characteristics:**

- All are metals with high boiling and melting points.
- They are good conductors of heat and electricity.
- Some attract towards magnet
- Most of them are used as catalysts.
- Most of them show variable valencies.
- Most of them form coloured ions and compounds.

➢ **Inner transition elements (*f*- block elements):**

They are Group 3 elements (6^{th} and 7^{th} periods, lanthanides and actinides)

➢ **Characteristics:**

- They are heavy metals with high boiling and melting points.
- They show variable valencies.
- They form coloured ions.
- Actinides are radioactive.

➢ **Inert Gases (Noble gases):**

They are Zero group elements (Group 18th column) with 8 outermost electrons.

➢ **Characteristics:**

They are inactive or they do not react with other elements (inactive).

- **Bridge elements:** Elements of the second period show resemblance in the properties of the elements of the next group of the third period showing a **diagonal relationship**. Such elements are called **bridge elements**. *e.g.* Li and Mg; Be and Al.

Group ⟶	1	2	3	4
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**.

➢ **Merits of Modern Periodic Table:**

- It is based on atomic number, a better fundamental property than atomic mass.
- Position of the element in the table is related to their electronic configuration.
- It shows the variation of properties of elements on moving across the period and down the group.
- Properties that reappear at regular intervals or with gradual variation (increase or decrease) are called **periodic properties**, the phenomenon is called as **periodicity of elements**.
- The periodicity is usually due to recurrence of similar electronic configuration. In a specific group, the number of outermost electrons remains the same, so the valency also remains the same. Thus, the elements of same group have similar properties even though number of shells increase down the group.

- Modern periodic table is easier to memorise, understand and reproduce.

➢ **Drawbacks of Modern Periodic Table**

- The position of hydrogen is not to full satisfaction as its properties belong to both group 1 and 17.
- It fails to give position to inner transition elements (lanthanides and actinides) in the main body of the periodic table.

➢ **General Trends of Modern Periodic Table:**

Groups

- Number of shells increases linearly and the valence electrons remains equal to the number of the group to which the elements belong. Number of electron shells in a given element equals to the number of period to which it belongs.

Element of group 17	No. of shells equates the period number	Electronic configuration
B	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

- Valency of all elements in a given group is the same. It remains equal to the number of the group to which the elements belong.
  Valency of group I A elements is 1
  Valency of group II A elements is 2
  Valency of group III A elements is 3
  (Group number 13; 13 – 10 = 3)
  Valency of group IV A elements is 4
  (Group number 14; 14 – 10 = 4)
  Valency of group V A elements is 3
  (Group number 15; 18 – 15 = 3)
  Valency of group VI A elements is 2
  (Group number 16; 18 – 16 = 2)
  Valency of group VII A elements is 1
  (Group number 17; 18 – 17 = 1)
  Valency of group Zero **(or Group number 18)** elements is 0.
- Elements of a given group show similar electronic configuration, thus similar physical and chemical properties, which change uniformly down the group. For *e.g.*, In alkali metals, reactivity increases down the group.

  Li
  Na
  K
  Rb
  Cs ↓

  In halogens, reactivity decreases down the group.

  $$\underset{\text{Reactivity decreases}}{\underline{\text{I} < \text{Br} < \text{Cl} < \text{F} \rightarrow}}$$

- Atomic size of consecutive element increases down the group due to the increase in the number of shells. For *e.g.*, if we consider alkali metals,

$$\underset{\text{Atomic size increases}}{\underline{\text{Li} < \text{Na} < \text{K} < \text{Rb} < \text{Cs} \rightarrow}}$$

C

- Metallic character increases down the group. For *e.g.*, In Group 15 elements, metallic character increases down the group due to which oxides of elements become increasingly basic in nature.

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

- **Hydrogen** has been placed at the top of alkali metals as it has only one valence electron similar to alkali metals in their electronic configuration.
  But hydrogen atom is very small in size, and thus many of its properties are different from alkali metals. Thus, it has been ignored while discussing group I or alkali metals.
  In some periodic tables, hydrogen has not been placed in any group, it has been treated as a very special element and place at the head of the periodic table.

➢ **Periods**

- On moving across the period from left to right, the number of shells remains the same. In 3rd period, number of shells remains three, which is equal to 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

- Number of electrons in the outermost shell increases from left to right in the given period.
- Valency of elements, with respect to hydrogen, increases linearly from 1 to 4 but again comes down to 1. But valency of elements, with respect to oxygen, increases from 1 to 7.
- Atomic size decreases from left to right along the period. As the number of protons increases along the period there will be an increase in the nuclear pull which results in decrease in the size. Hence, along the period, alkali atoms have the largest size and the halogens have smallest.
  Li > Be > B > C > N > O > F
- Properties of the elements depend on the number of electrons. As the number of electrons vary across the period, properties of elements also vary in a period. Reactivity initially decreases up to Group 14, then increases. Group I elements are most reactive metals while Group 17 elements are most reactive non-metals.
- Metallic character decreases gradually on moving from left to right across the period. Last element in each period is inert.

Li, Be, B, C, N, O, F, Ne
Metal — Metalloid — Non-metal

Oxides of the elements become less basic and finally become acidic. *e.g.*, consider oxides of third period elements.

Oxides of the 3rd period
Na_2O, MgO, Al_2O_3, P_2O_5, SO_3, Cl_2O_7
(Acidic character increases)
⟶

Mnemonics

Concept Name: Different groups/ periods in periodic table
Mnemonics: Sheetal clear 2 exams in 1st attempt, Dhoni has 3 cars and 12 motorcycle, Priya bought 18 oranges to feed 13 people. Lost Apple Found
Interpretations:
s: s - block 1st and 2nd group
d: d - block 3 to 12
p: p - block 13 to 18
LAF: lanthanoids and actinoids-f block

Key Words

➢ **Atomic number** of an element is the number of unit positive charge present in the nucleus of an atom of a particular element.
➢ A tabular arrangement of elements in groups (vertical columns) and periods (horizontal rows) highlighting the regular trends in properties of elements is called a **periodic table**.
➢ **Modern periodic law** states that 'physical and chemical properties of elements are a periodic function of their atomic numbers'.
➢ **Groups** are vertical columns in the periodic table.
➢ **Periods** are the horizontal rows in the periodic table.
➢ **Representative elements** are those elements which belong to Groups 1, 2, 13, 14, 15, 16, 17.
➢ **Transition elements** are those elements which belong to Groups 3 to 12.
➢ Elements of sixth and seventh periods of Group 3 are **called inner-transition elements**.
➢ Elements of the second period show resemblance in the properties of the elements of the next group of the third period showing a **diagonal relationship** are called **bridge 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**.

Know the Facts

➤

PERIODIC TABLE

Metal | Metalloid | Non-metal

Group No.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.0079																	2 He Helium 4.0026
3 Li Lithium 6.941	4 Be Beryllium 9.0122											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminium 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulphur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Kypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.905	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.96	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
55 Cs Caesium 132.91	56 Ba Barium 137.33	57-71 *La-Lu Lanthanide	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.21	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Hercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 209.98	84 Po Polonium 208.98	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radum (226)	89-103 **Ac-Lr Actinide	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (271)	107 Bh Bohrium (272)	108 Hs Hassium (277)	109 Mt Meitnerium (276)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fi Flerovium (289)	115 Mc Moscovium (290)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

* Lanthanide	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97
** Actinide	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No NObelium (259)	103 Lr Lawrencium (262)