

Bohr's Model of an atom

- 1) An atom consists of a small, heavy positively charged
- 2) The electrons revolve only in those orbits which have a fixed value of energy. These orbits are called **energy levels or stationary States**. The energy of the electron revolving in a particular orbit is fixed and does not change with time. The different energy levels are numbered as 1,2,3,4.... or designated as K, L, M, N ,O..... starting from the shells closest to the nucleus.
- 3) Since the electrons revolve only in those orbits which have fixed value of energy ,hence electrons in an atom can have only certain definite or discrete values of energy and not any value of their own. The energy of an electron is quantized.

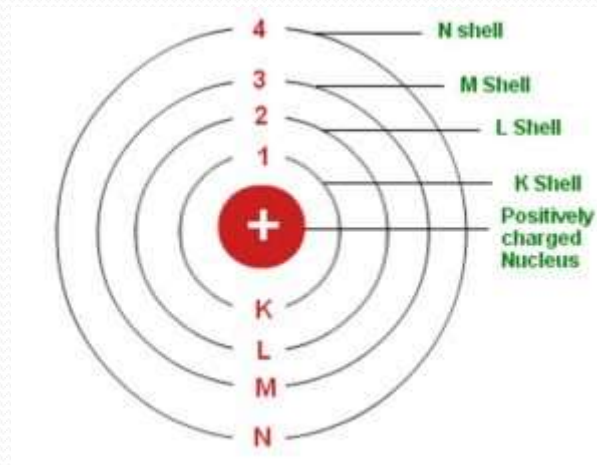
- 4) Like energy, the angular momentum of an electron in an atom can have certain definite or discrete values and not any value of its own. The only permissible values of angular momentum are given by the expression:
$$mvr = nh/2\pi$$
- Where m is the mass of the electron, v is the tangential velocity of the revolving electron, r is the radius of the orbit, h is the Planck's Constant and n is any Integer.
- The angular momentum of an electron in an atom is also quantized.
- 5) When the electrons in an atom are in their lowest energy state, they keep on revolving in the respective orbits without losing energy because energy can neither be lost nor gained continuously. This state of atom is called **normal or ground state**

6) Energy is emitted or absorbed only when the electron jumps from one orbit to the other. When energy is supplied to an atom, an electron in the atom may jump from its normal energy level to some high energy level by absorbing a definite amount of energy. This state of atom is called **excited state**. Since the lifetime of the electron in the excited state is short, it immediately jumps back to the lower energy level by emitting energy in the form of light of suitable frequency or wavelength.

The amount of energy emitted or absorbed is given by the difference of energies of the two energy levels concerned i.e.

$$\Delta E = E_2 - E_1$$

Where E_2 and E_1 are the energy of the electron in the higher and lower energy levels ΔE is the difference in energies of the two levels



Dual character of matter

According to the de Broglie concept of matter waves, the matter has dual nature. It means **when the matter is moving it shows the wave properties (like interference, diffraction etc.) are associated with it and when it is in the state of rest then it shows particle properties.**

De-Broglie's equation

- De Broglie first used Einstein's famous equation relating matter and energy:
- $E=mc^2$ (1)
- with
- E = energy,
- m = mass,
- c = speed of light
- Using Planck's theory which states every quantum of a wave has a discrete amount of energy given by Planck's equation:
- $E=h\nu$ (2)
- with
- E = energy,
- h = Planck's constant (6.62607×10^{-34} J s),
- ν = frequency
- Since de Broglie believed particles and wave have the same traits, he hypothesized that the two energies would be equal:
- $mc^2=h\nu$ (3)
- Because real particles do not travel at the speed of light, De Broglie substituted velocity (v) for the speed of light (c).
- $mv^2=h\nu$ (4)
- Through the equation λ , de Broglie substituted v/λ for ν and arrived at the final expression that relates wavelength and particle with speed.
- $mv^2=hv/\lambda$ (5)
- Hence
- $\lambda=hv/mv^2=h/mv$ (6)

Heisenberg's principle of uncertainty

- Heisenberg's uncertainty principle states **that it is impossible to measure or calculate exactly, both the position and the momentum of an object.**

Heisenberg's Uncertainty Principle

uncertainty
in momentum

↓

$$\Delta x \Delta p \geq \frac{h}{4\pi} = \frac{\hbar}{2}$$

↑

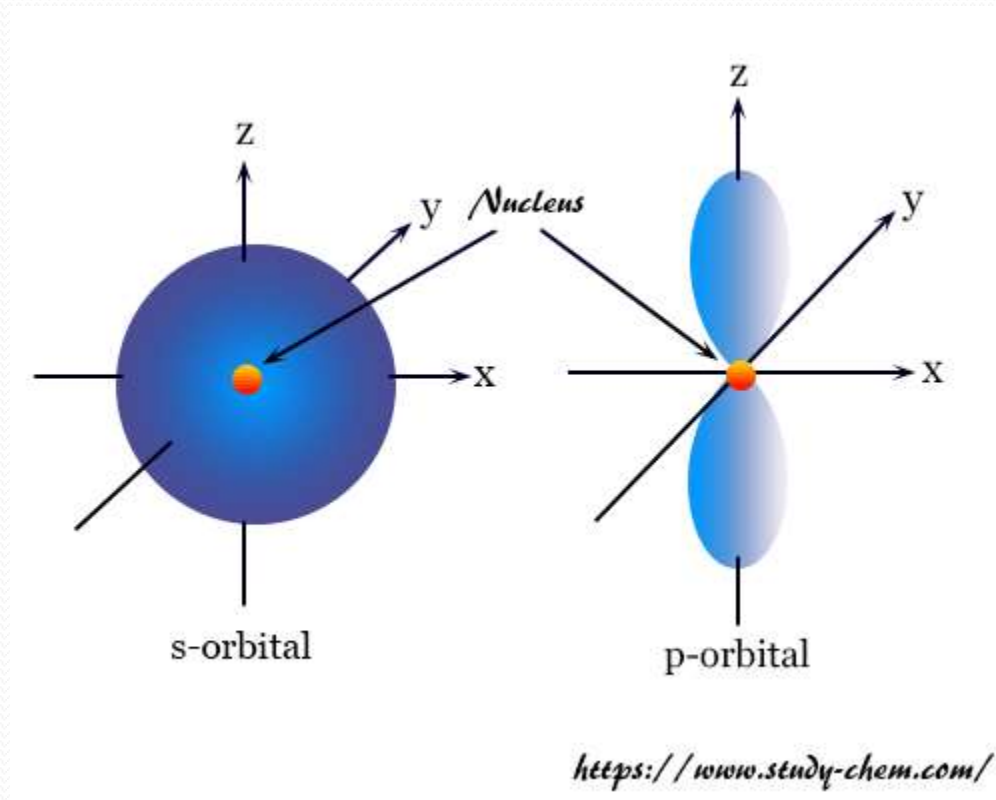
uncertainty
in position

The more accurately you know the position (i.e., the smaller Δx is), the less accurately you know the momentum (i.e., the larger Δp is); and vice versa

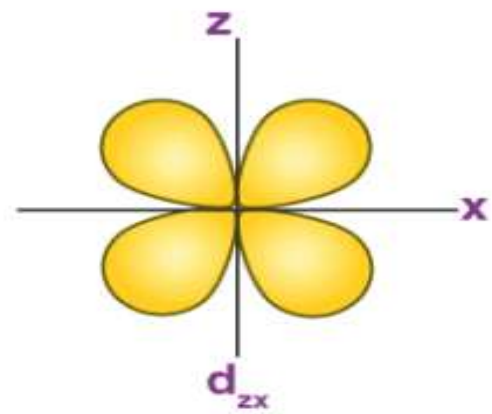
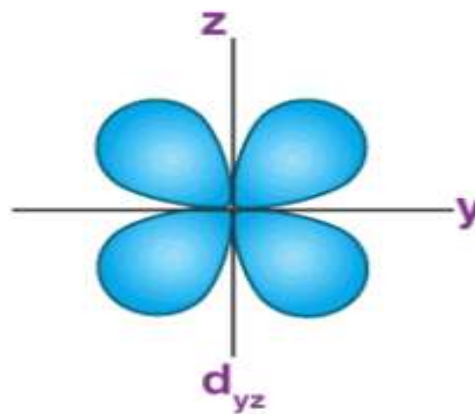
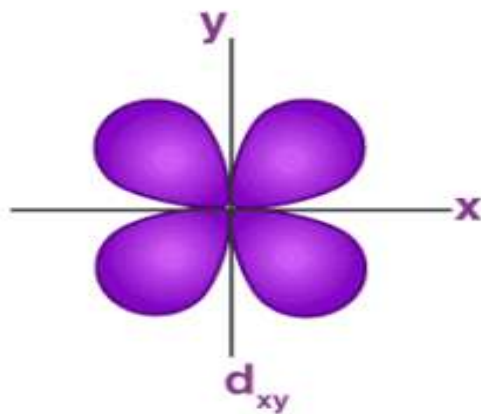
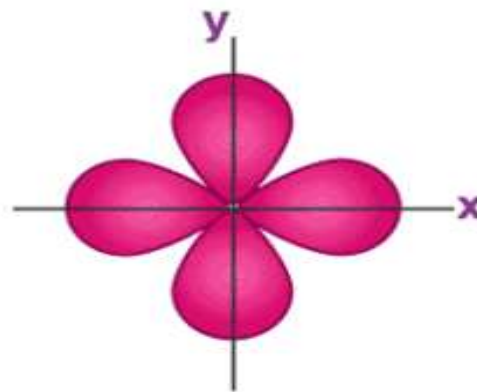
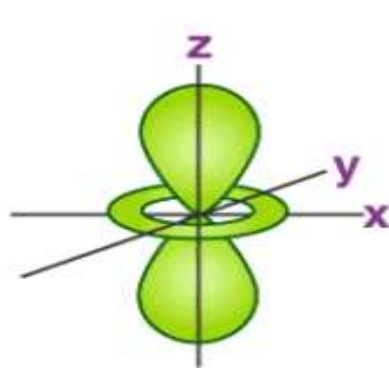
Orbital

- Orbital may be defined as a region in space around the nucleus where probability of finding the electron is maximum

Shape of s & p orbitals



Shape of d orbital



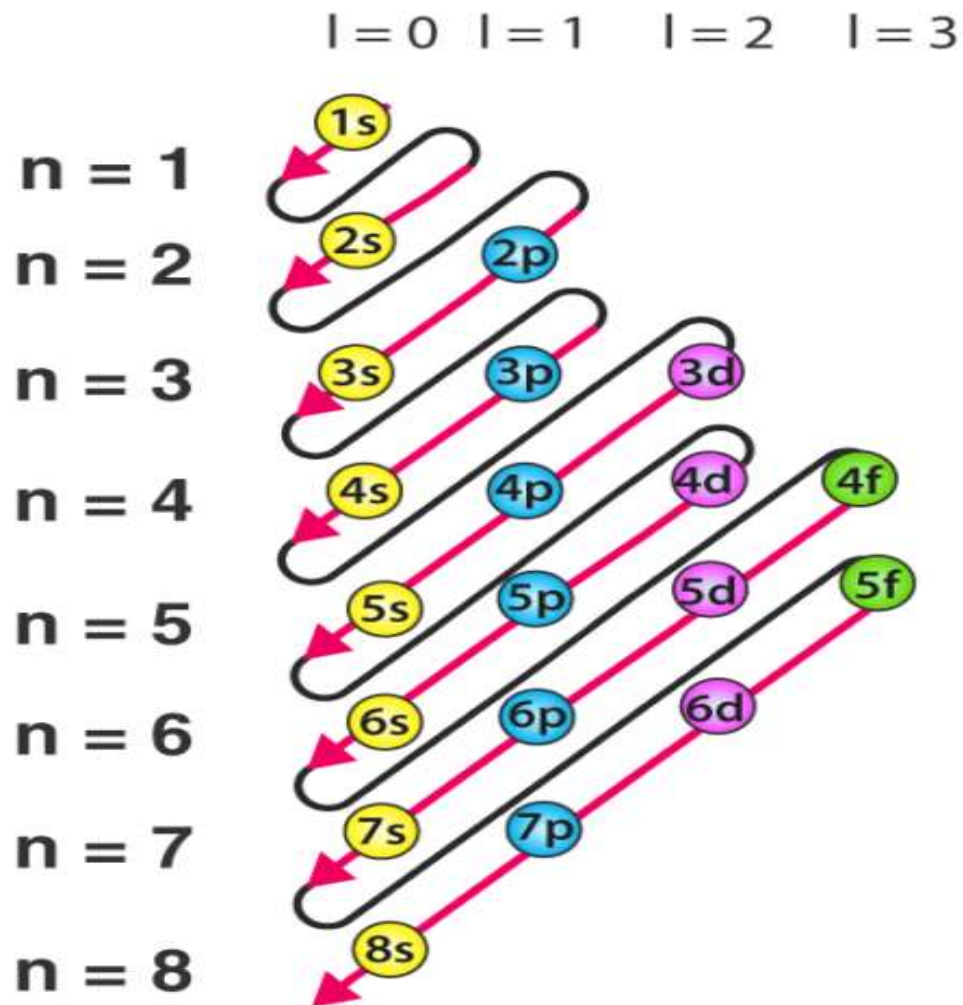
Quantum number

- **The set of numbers used to describe the position and energy of the electron in an atom are called quantum numbers. There are four quantum numbers, namely, principal, azimuthal, magnetic and spin quantum numbers.**

Name	Symbol	Allowed Values	Property
Principal	n	positive integers 1,2,3...	Orbital size and energy level
Secondary (Angular momentum)	l	Integers from 0 to $(n-1)$	Orbital shape (sublevels/subshells)
Magnetic	m_l	Integers $-l$ to $+l$	Orbital orientation
Spin	m_s	$+1/2$ or $-1/2$	Electron spin Direction

Aufbau principle

- The Aufbau principle states that electrons will first fill the lowest energy electron shells in a neutral atom. Electrons fill orbitals from lowest energy orbitals to highest energy orbitals. The Aufbau principle helps to determine the electronic structure of an atom.

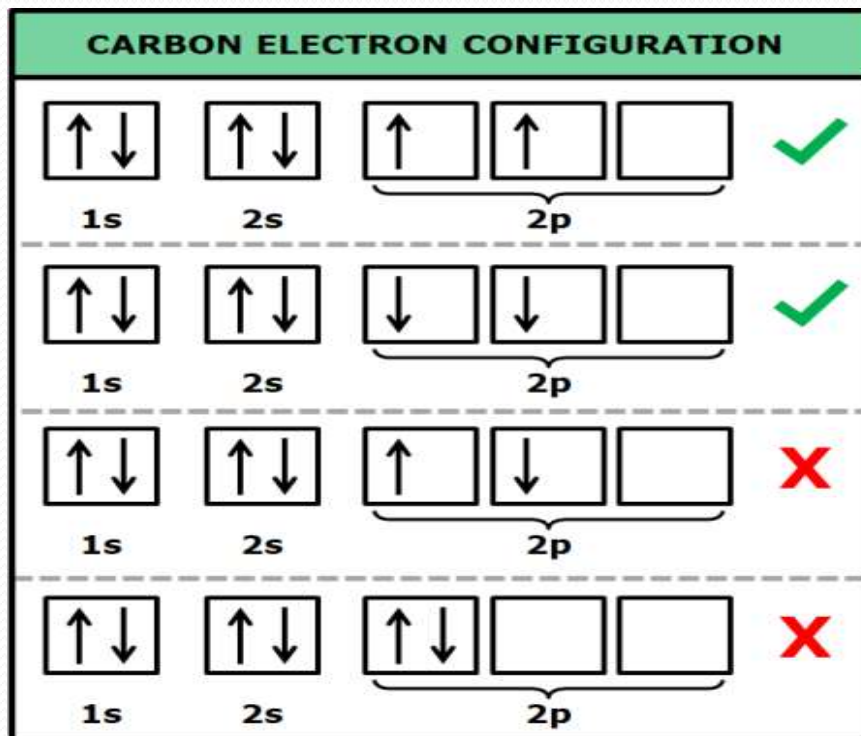


Pauli's exclusion principle

- The Pauli exclusion principle states that in a single atom no two electrons will have an identical set of the same quantum numbers
- Only two electrons can occupy the same orbital.
- The two electrons that are present in the same orbital must have opposite spins or they should be antiparallel.

Hund's rule

- Hund's rule states that: **Every orbital in a sublevel is singly occupied before any orbital is doubly occupied.**



Modern periodic law

- The modern Periodic law can be stated as: **“The physical and chemical properties of the elements are periodic functions of their atomic numbers**

LONG FORM OF PERIODIC TABLE

s-block

or
Light Metals

1 IA	2 IIA
1 H	

IA - Alkali metal
IIA - Alkaline earth metal
- - - Metalloids

p-block

or
Non-Metals

VIIA
or
0

14 IIIA	15 IVA	16 VA	17 VIA	18 VIIA
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Period 1	3	4	Heavy Metals or d-block (Transition Metals)										6	7	8	9	10	11	12	13	14	15	16	17	18
Period 2	Li	Be											B	C	N	O	F	Ne							
Period 3	Na	Mg	VIII										Al	Si	P	S	Cl	Ar							
Period 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr							
Period 5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe							
Period 6	Cs	Ba	57 to 71	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn							
Period 7	Fr	Ra	89 to 103	Rf	Ha	Sg	Ns	Hs	Mt																

Lanthanide series →

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

Actinide series →

89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

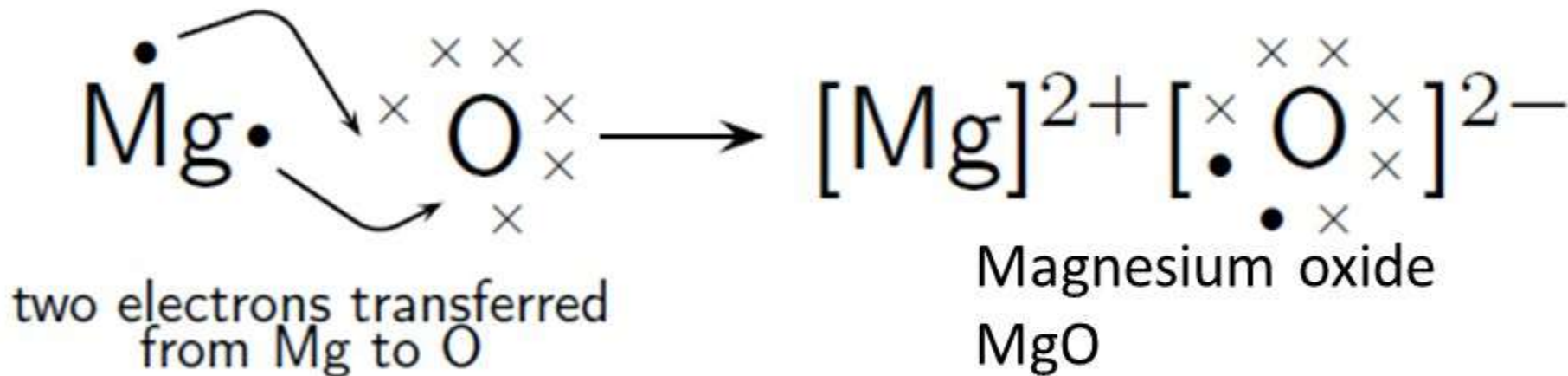
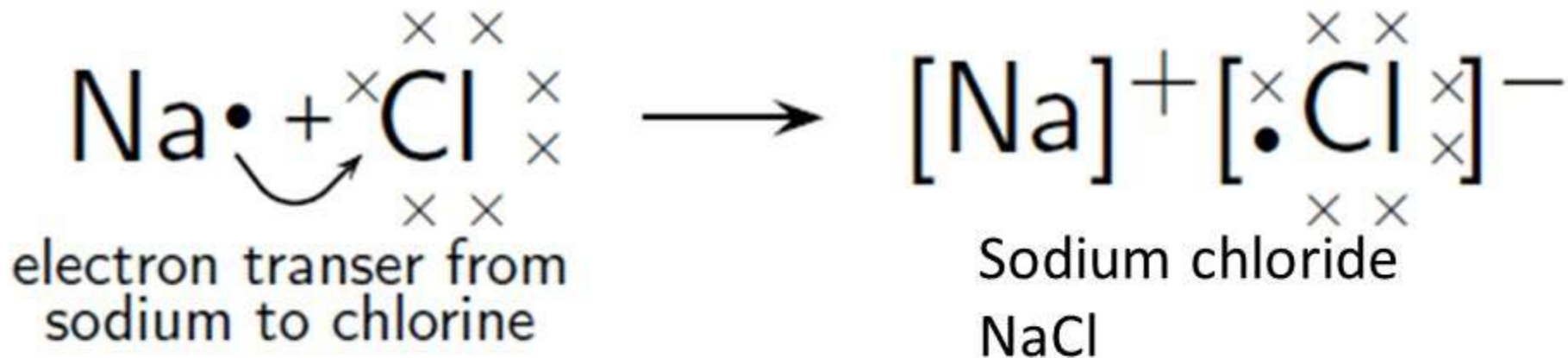
} **f-block**

Chemical bonding

- The main reason why they tend to combine with one another is **to obtain the stable noble gas electron configuration**. This is done by the atoms either **By losing one or more electrons to another atom**. By gaining one or more electrons from another atom. By sharing one or more electrons with another atom.
- Type of bonding
 - 1) Ionic Bond
 - 2) Covalent Bond
 - 3) Metallic Bond

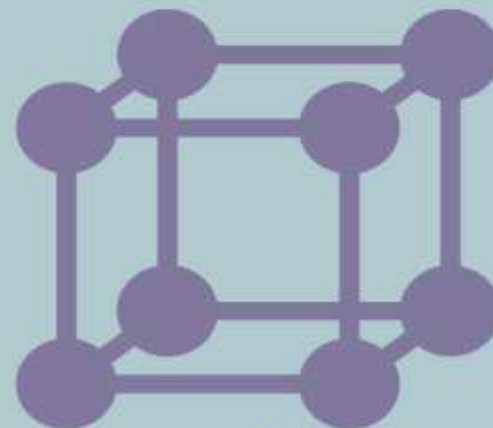
Ionic bond

- A chemical bond is formed between two atoms by the complete transfer of one or more electrons from one atom to the other as a result of which the atoms attain their nearest inert gas configuration.



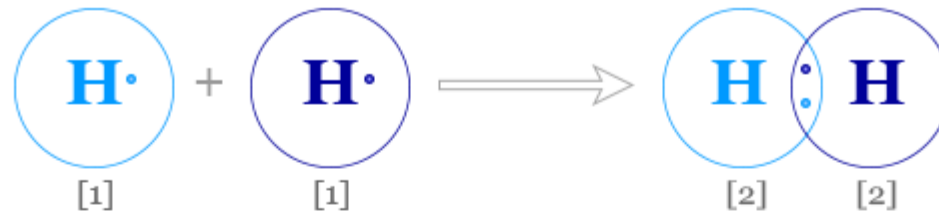
Properties of Ionic Compounds

- Form crystals
- Hard and brittle
- High melting and boiling points
- Don't conduct electricity as solids, but do conduct when molten or dissolved in water
- Often soluble in water and insoluble in nonpolar solvents
- High enthalpies of fusion and vaporization
- Solids are good insulators

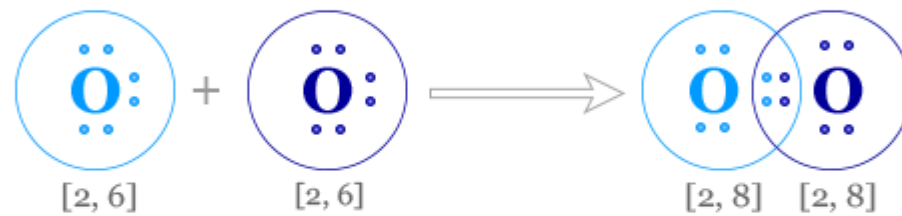


Covalent Bond

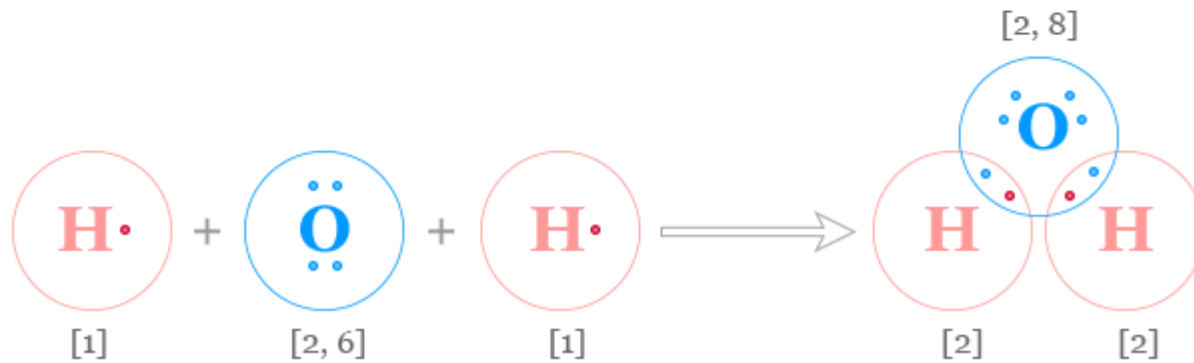
A covalent bond consists of the mutual sharing of one or more pairs of electrons between two atoms.



Hydrogen molecule



Oxygen molecule

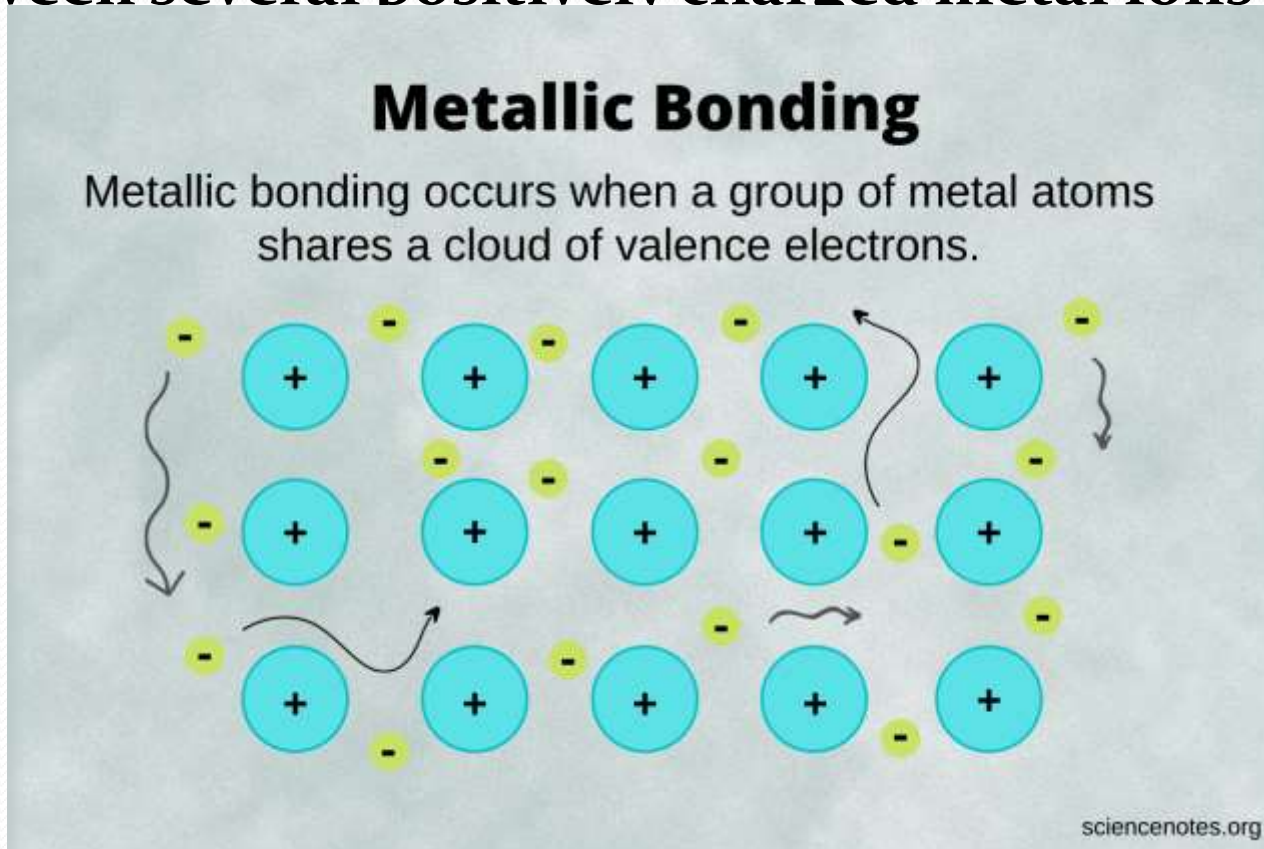


Water molecule

	Covalent Bonds	Ionic Bonds
State at room temperature:	gases, liquids or low-melting solids	Crystalline solids
Polarity:	Low	High
Solubility	Few are soluble in water; Many are soluble in organic liquids	Many are water soluble; Not soluble in organic liquids
Formation:	A covalent bond is formed between two non-metals that have similar electronegativities. Neither atom is "strong" enough to attract electrons from the other. For stabilization, they share their electrons from outer molecular orbit with others	An ionic bond is formed between a metal and a non-metal. Non-metals(-ve ion) are "stronger" than the metal(+ve ion) and can get electrons very easily from the metal. These two opposite ions attract each other and form the ionic bond.
Conductivity:	Do not conduct electricity	Conduct electricity when molten or dissolved in water
Melting point:	Low	High
What is it?:	Covalent bonding is a form of chemical bonding between two non metallic atoms which is characterized by the sharing of pairs of electrons between atoms and other covalent bonds.	Ionic bond, also known as electrovalent bond, is a type of bond formed from the electrostatic attraction between oppositely charged ions in a chemical compound. These kinds of bonds occur mainly between a metallic and a non metallic atom.
Boiling point:	Low	High
Examples:	Methane (CH ₄), Hydrochloric acid (HCl)	Sodium chloride (NaCl), Sulfuric Acid (H ₂ SO ₄)
Occurs between:	Two non-metals or a non-metal and a metalloid	One metal and one non-metal

Metallic Bond

- The collective sharing of a sea of valence electrons between several positively charged metal ions



Metals and Alloys

- **Physical Properties of Metals**
- Metals are lustrous, malleable, ductile, good conductors of heat and electricity. Other properties include:**State:** Metals are solids at room temperature with the exception of mercury, which is liquid at room temperature (Gallium is liquid on hot days).
- **Luster:** Metals have the quality of reflecting light from their surface and can be polished e.g., gold, silver and copper.
- **Malleability:** Metals have the ability to withstand hammering and can be made into thin sheets known as foils. For example, a sugar cube sized chunk of gold can be pounded into a thin sheet that will cover a football field.
- **Ductility:** Metals can be drawn into wires. For example, 100 g of silver can be drawn into a thin wire about 200 meters long. **Metals and Alloys**
- **Hardness:** All metals are hard except sodium and potassium, which are soft and can be cut with a knife.
- **Valency:** Metals typically have 1 to 3 electrons in the outermost shell of their atoms.
- **Conduction:** Metals are good conductors because they have free electrons. Silver and copper are the two best conductors of heat and electricity. Lead is the poorest conductor of heat. Bismuth, mercury and iron are also poor conductors
- **Density:** Metals have high density and are very heavy. Iridium and osmium have the highest densities whereas lithium has the lowest density.
- **Melting and Boiling Points:** Metals have high melting and boiling points. Tungsten has the highest melting and boiling points whereas mercury has the lowest. Sodium and potassium also have low melting points.

Mineral, ore, gangue, flux, slag

- **Minerals are the natural materials in which the metals and their compounds are found in earth**
- Ores are concentrations of minerals in rock that are high enough to be economically extracted for use
- The gangue particles are the **unwanted materials or impurities like sulfide, oxides, silica sand etc which are mixed in minerals**
- Flux is a chemical that is added to molten metal to connect with **impurities that may then be removed.**
- Example: CaO, FeO: Example: CaSiO₃, FeSiO₃
- **When flux is added to an ore, the impurities form a fusible product with flux, it is called slag. Gangue+Flux→Slag (Fusible product)**

Metallurgy of iron

IRON (Fe)

Extraction : Iron is extracted from its oxide ores especially from the **magnetite, haematite and limonite** ores. The extraction involve the following steps given in flow sheet :

IRON ORE

I ↓

CONCENTRATION

Gravity process followed by electromagnetic separation

II ↓

CALCINATION AND ROASTING

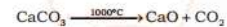
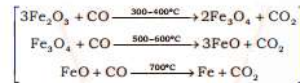
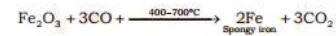
Ore + air $\xrightarrow{\text{Heat}}$ moisture, CO₂, SO₂, As₂O₃ removed

FeO is Oxidised to ferric oxide

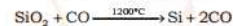
III ↓

REDUCTION

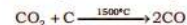
Smelting in a blast furnace (ore + coke + limestone). The following reactions occur



Silicates, phosphates and manganates present as impurities in ore, are reduced to Si, P and Mn, respectively



Spongy iron + C, Mn, Si, etc. \longrightarrow Impure iron



IV ↓

PIG IRON

V ↓

REMETLED AND COOLED : CAST IRON

(Fe = 93%; C = 5% and impurities of Mn, P, Si, etc. = 2%)

FLOW SHEET FOR EXTRACTION OF IRON

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2.1

Mechanical Properties of metals →

The characteristics of materials which describe its behaviour under the action of applied external force are called mechanical properties.

Given as below →

1. Elasticity →

The ability of a material under which it gains a new shape when external force is applied & return to its original shape when force is removed.

2. Plasticity →

The ability of a material to gain a new shape under stress & to retain in its new shape is called plasticity.

3. Strength → The ability of a material to withstand external load without any deformation.

4. Stiffness → The ability of a material to resist deflection or deformation under Applied load.

Teacher's Signature :

5. Toughness → The property of a material which offer resistance to any fracture in the structure of it is called toughness.
6. Luster → The property of a material by which it offer shining to its surface is called luster.
7. Hardness → The property by which a material is resistance to scratch & any crack by beating is called hardness.
8. Ductility → The property of a material by which it can be drawn into wires by applying stress or by beating.
9. Malleability → The property of a material by which it can be converted into sheets by applying stress.
10. Brittleness → The property of a material by which it can crack under load it is opposite to toughness.
11. Impact Resistance → The property of a material by which it offer resistance to any impact on itself when any force is applied.

It can be calculated by energy required to do any fracture in its structure when any load is applied.

ORTH

Experiment No.

2.2 Metallurgy of Iron from Haematite

Iron \rightarrow Fe (Symbol)
ORE \rightarrow Haematite \rightarrow Fe_2O_3
Magnetite \rightarrow Fe_3O_4

Steps of Metallurgy \rightarrow

① Crushing & Grinding

② Pulverisation \rightarrow to convert into powdered ore

③ Concentration \rightarrow to remove impurities by Gravity separation method.

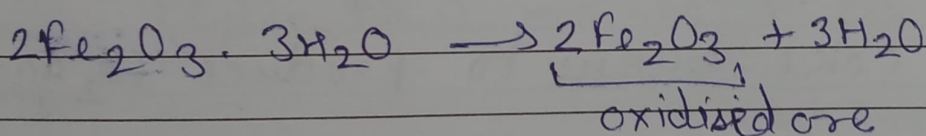
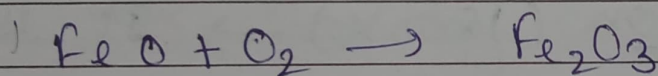
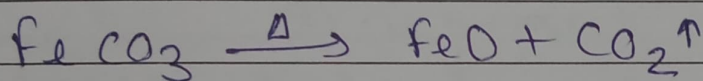
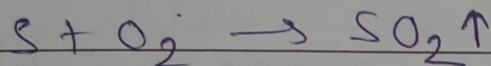
④ Oxidation \rightarrow It is the process of converting the conc. ore into oxidised ore. In case of Iron it is done by the process of calcination.

Teacher's Signature :

Calcination

It is the process of oxidising concentrated ore by heating the ore at high temperature below its mpt, in absence or limited supply of oxygen.

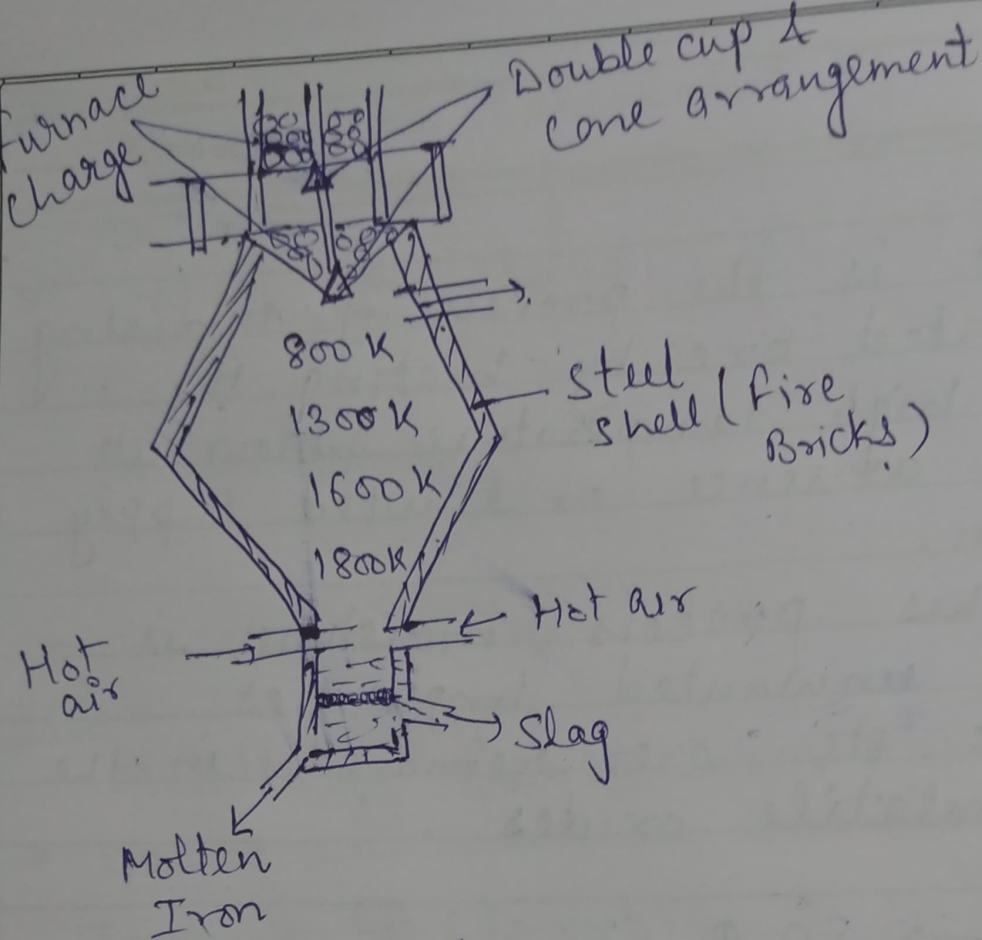
By this process moisture is removed, unwanted impurities like S, As etc are removed in the form of volatile oxides.



5) Reduction → It is done by the process of smelting.

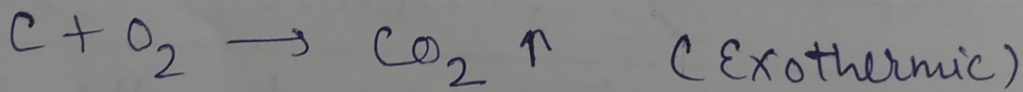
Smelting → The process of reduction of a metal with the addition of coke & flux.

This process is done in Blast furnace. As given below →

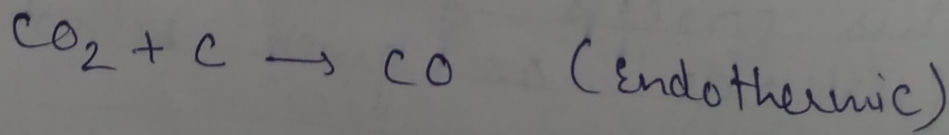


Following reactions takes place in blast furnace

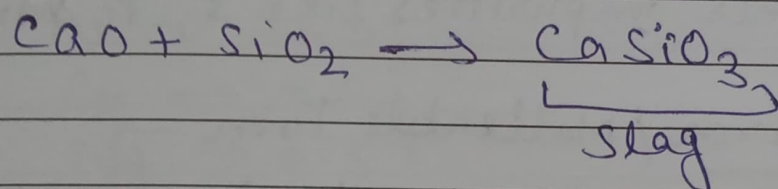
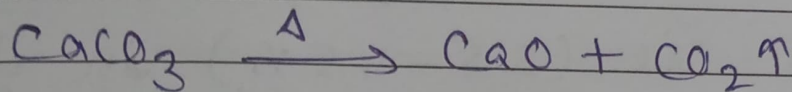
① zone of combustion (1800K) → It is present at the bottom of the furnace, coke burns to produce CO_2 gas



② zone of fusion → (1600K) → It is present just above the zone of combustion, CO_2 combines with hot coke to produce CO .

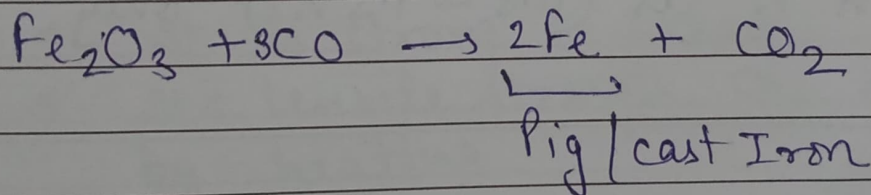


3) Zone of Slag formation (1300K) \rightarrow It is present in the middle of the furnace.



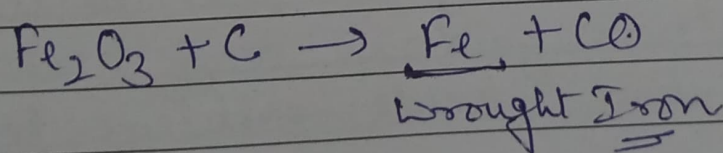
4) Zone of Reduction (800K) \rightarrow

It is present at the top of the furnace. Here Iron oxide is reduced to Iron by CO.



* Then it (Pig Iron) is converted into wrought Iron as wrought Iron is purest form of Iron.

By heating with Carbon as below



What are the three varieties of Iron

- as \rightarrow ① Cast Iron / Pig Iron
most Impure form of Iron
as it contains highest proportion of
Carbon i.e. (2.5-4.5%) in it along
with other impurities like S, P, Mn, Si etc.
- ② wrought Iron / Malleable Iron \rightarrow
It is purest form as Carbon
is only (0.12-0.25%) in it.
- ③ Steel \rightarrow It is most important form of
Iron & ~~are~~ have many applications
Carbon % is (0.5-1.5%) only.

Composition, Properties & Uses of following Alloys →

1. Duralumin → It is light-weight alloy.

Composition →

Al → 95%

Cu → 4%

Mg → 0.5%

Mn → 0.5%

Properties →

① It is strong, tough, highly ductile & corrosion resistant.

2. Good conductor of heat & electricity.

3. Can be easily worked & have high machinability.

4. It is strong & heavy.

5. Its tensile strength can be raised by heating.

Uses →

① Used for making aeroplane, automobile & railway engine parts.

2. Used in making cables, surgical instruments & fluorescent tube caps.

3. Used for making rivets, bars, sheets of building ships, body of vehicles etc.

2. Stainless Steel →

It is also known as corrosion resistant steel.

It is of three types -

- a) Martensitic stainless steel
- b) Ferritic stainless steel
- c) Austenitic " " "

Composition

Cr, Ni, Mo, C

a) Martensitic Stainless Steel → Cr → 0-14%

* Properties

- a) Magnetic in nature
- b) resistant to weathering, acids & other corrosive agents
- c) can be hardened by heat treatment

* USES

- ① Surgical Instruments
- ② For pumps & valve parts
- ③ Turbine brackets

b) Ferritic Stainless steel → Cr → 14-18%

* Properties

- a) Possess ductility.
- b) Excellent corrosion resistance

* USES

- a) For screen & fittings
- b) For decorative work
- c) For heating elements for furnaces.
- d) Petroleum Industry

c) Austenitic Stainless Steel → 15-20%

* Properties

- a) tough, hard, ductile.
- b) Good corrosion resistance

* USES

- ① Cooking utensils,
- ② Kettles, tanks,
- ③ Engine parts of air craft etc.

Teacher's Signature: _____

4

1)

②

③

④

①

②

Heat Treatments

- 1) Annealing
- 2) Normalising
- 3) Hardening or Quenching
- 4) Tempering

① Annealing →

* Definition → The process of heating a metal to a certain high temperature, held at that temperature for sometimes to allow internal changes & then cooled very slowly in a planned manner in a furnace

Purposes

- ① To soften the metal & improve machinability.
- ② To make homogenous
- ③ To relieve internal stress
- ④ To improve magnetic, physical properties.
- ⑤ To produce desired microstructure
- ⑥ To increase ductility
- ⑦ To increase shock-resistance.

② Normalising

* Definition →

The process of heating the metal to a definite temperature & allow to cool gradually in air is called Normalising.

* Purpose / Effect

- ① Homogeneity is recovered or improved.
- ② Grains are refined.
- ③ Internal stress are removed.
- ④ Toughness is increased.

③ Quenching / Hardening

Definition → The process of heating steel beyond critical temperature & then suddenly cooling it either in oil or brine water or any other liquid.

* Purpose / Effect

- ① To Increase hardness
- ② To increase strength
- ③ To Improve toughness & ductility
- ④ Make wear resistant.

④ Tempering → Definition → The process of heating the already hardened steel to a temperature lower than its own hardening temp. & then allow to cool slowly.

* Purpose / Effect

- ① Relieve Internal stress
- ② Improve ductility
- ③ Reduce brittleness & hardness
- ④ Improve toughness
- ⑤ Reheating temp.

Teacher's Signature :

should be between 400-600°C.

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