

CLASS NOTES OF “APPLIED CHEMISTRY-B”



Technical Classes

✓ Technical Classes के Course में उपलब्ध फीचर्स

1. सभी कक्षाएं स्मार्ट बोर्ड पर Live
2. विशेषज्ञ शिक्षको द्वारा पठन पाठन
3. Lecture के दौरान डाउट सॉल्विंग
4. Recorded Lecture (VOD)
5. प्रत्येक क्लास का PDF नोट्स
6. SBTE Exam की तैयारी के लिए ब्रह्मास्त्र क्लास
7. Laptop में क्लास देखने की सुविधा

Call/WhatsApp - 93347 89450 / 91555 63777

नोट :-

1. सभी ऑफलाइन कक्षाएं Technical Classes के कैंपस तथा सभी ऑनलाइन कक्षाएं Technical Classes के एप्लीकेशन पर चलेगी।
2. यह नोट्स टेक्निकल क्लासेस के स्टूडेंट्स के लिए है, तथा क्लास करने के बाद अधिक प्रभावी होगा।

By Er. Amardeep Sir

Since 2011



Technical Classes

तकनीकी शिक्षा के लिए No.1 संस्थान

Online -- Download
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App from PlayStore



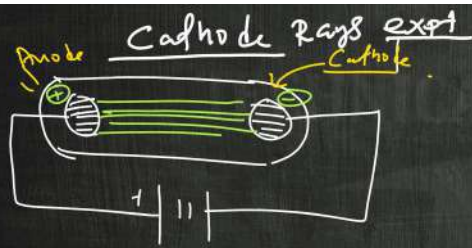
Offline & Online

- Polytechnic + B.Tech Semester
- For ME, CE, EE, ECE, CSE
- BCECE LEET Entrance Exam
- Polytechnic Entrance Exam
- SSC, RRB & All J.E. Exams

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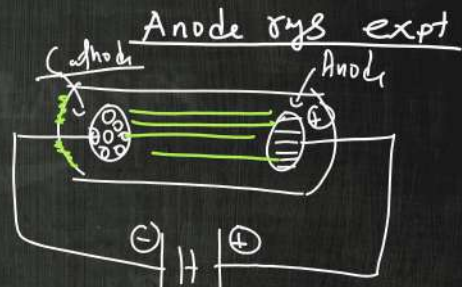
Offline -- Technical Classes, Rajiv Nagar, Patna-24



J. J Thomson

Cathode rays = e^-

Anode rays = $ions$



Goldstein

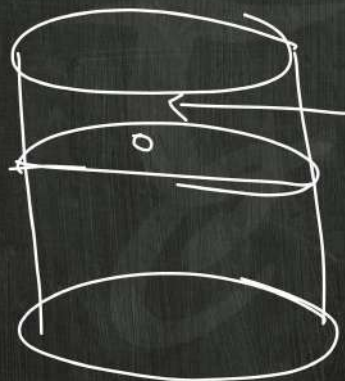
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mass of e^- & Proton
charge of e^- & Proton

??

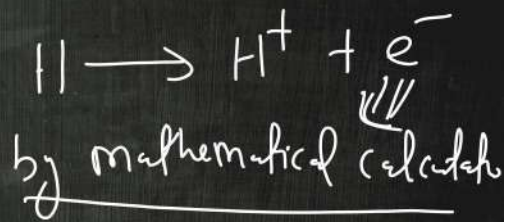
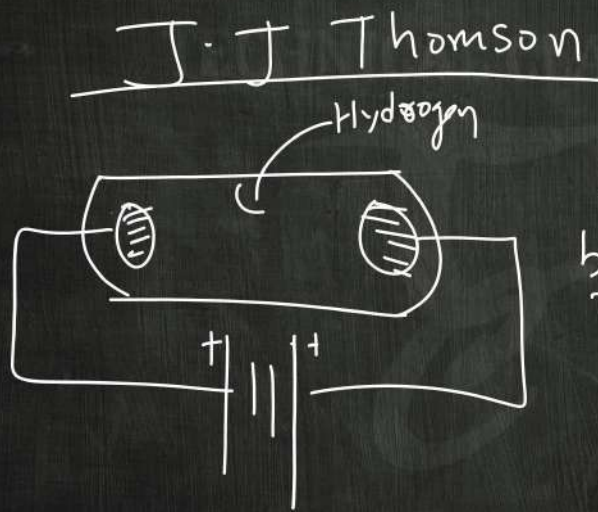
Technical Classes || Cont. - 91555 63777 / 9334789450

Millikan oil drop experiment



Conclusion
Charge on electron
 $= -1.6 \times 10^{-19} C$

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Charge by mass ratio

$$\Rightarrow \frac{e}{m} \in \text{charge}$$

$$\frac{e}{m} \in \text{mass}$$

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charge $\Rightarrow \frac{e}{m} = -1.76 \times 10^{11} \text{ C/kg}$

from m. liken oil drop experiment

Charge on electron = $-1.6 \times 10^{-19} \text{ C}$

$$\frac{-1.6 \times 10^{-19} \text{ C}}{m} = -1.76 \times 10^{11}$$

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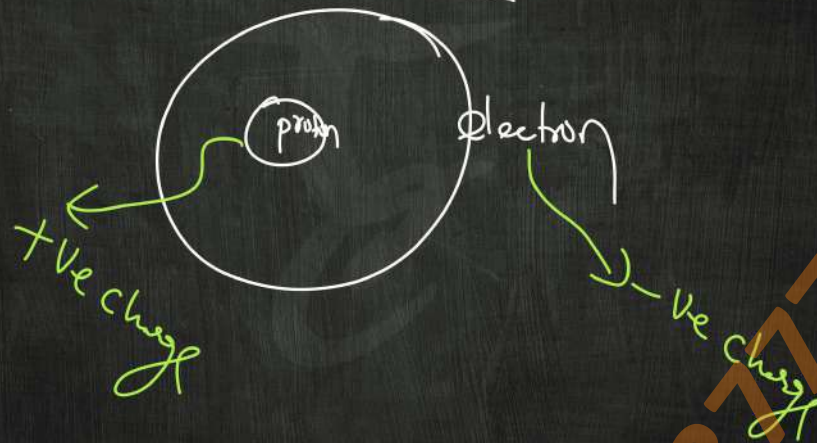
$$m = \frac{1.6 \times 10^{-19} \text{ C}}{1.76 \times 10^{11} \text{ C/kg}}$$

$$= 9.1 \times 10^{-31} \text{ kg}$$

mass of e^-

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Mass of Proton



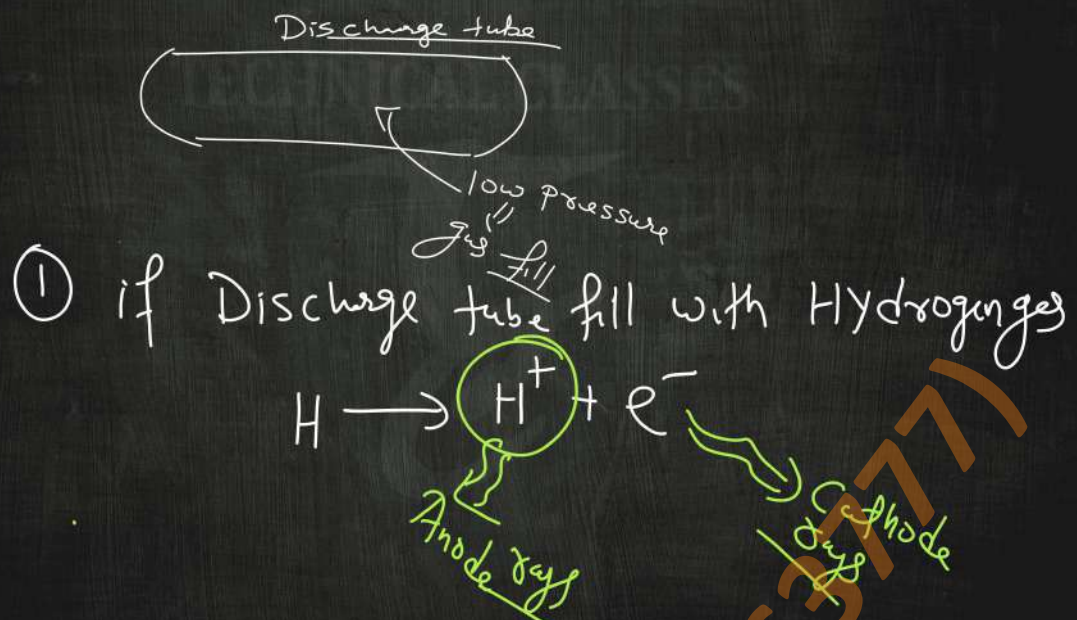
Technical Classes || Cont. - 91555 63777 / 9334789450

$$\begin{aligned} 26.28 \times 10^4 \\ 262.8 \times 10^3 \\ 2.628 \times 10^5 \end{aligned}$$

Technical Classes || Cont. - 91555 63777 / 9334789450

$$\begin{aligned} 2.68 \times 10^{-4} \\ 26.8 \times 10^{-5} \\ 0.268 \times 10^{-3} \end{aligned}$$

Technical Classes || Cont. - 91555 63777 / 9334789450



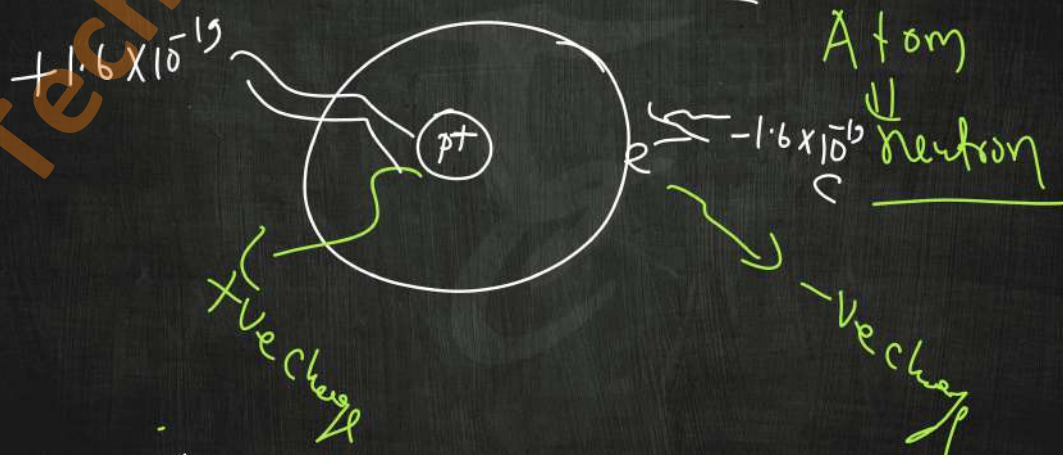
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if discharged tube filled with He gas



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mass of proton



Technical Classes || Cont. - 91555 63777 / 9334789450

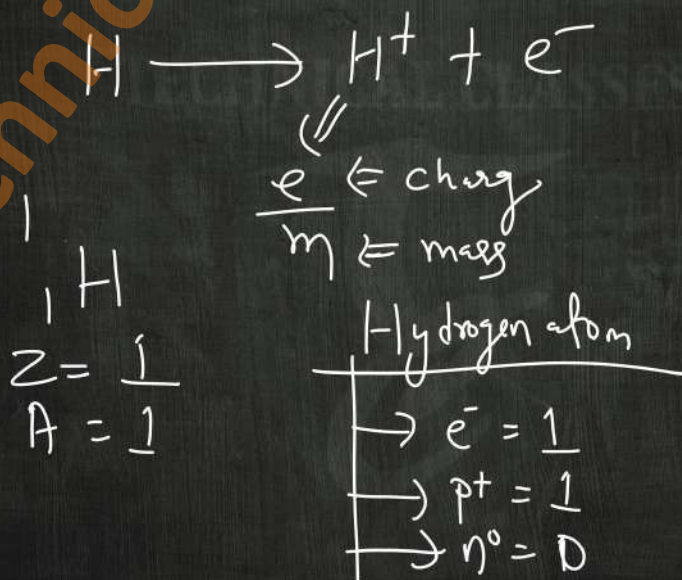
Charge on $e^- = -1.6 \times 10^{-19} \text{ C}$
atom neutral in nature So

Charge on Proton = $+1.6 \times 10^{-19} \text{ C}$

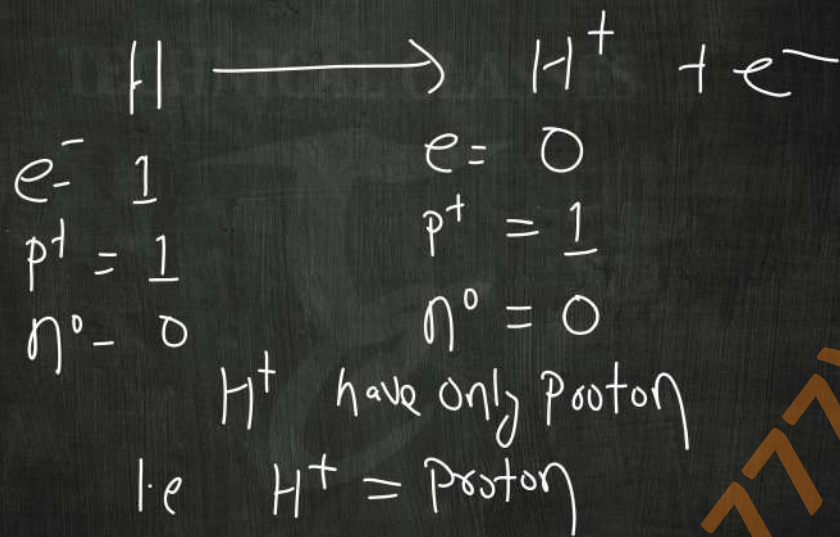
Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450

Charge

Gold Stein

$\frac{e}{m}$ ratio of proton

$\frac{e}{m} = 9.58 \times 10^7 \text{ C/kg}$

$e = +1.6 \times 10^{-19} \text{ C}$

mass

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$$\frac{+1.6 \times 10^{-19}}{m} = 9.58 \times 10^7 \text{ C/kg}$$

$$\frac{+1.6 \times 10^{-19}}{9.58 \times 10^7} = m$$

$$\Rightarrow \frac{1.67}{9.58} \times 10^{-20} = m$$

$$= 1.67 \times 10^{-27} \text{ kg}$$

$$= 1.672 \times 10^{-27} \text{ kg}$$

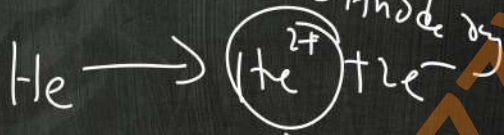
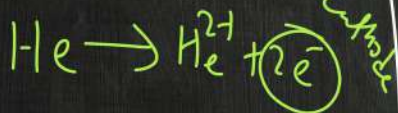
$$= 1.672 \times 10^{-24} \text{ g}$$

10^3

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Note $\frac{e}{m}$ ratio in case of electron not depends upon gas $\Rightarrow$ not variable

$\frac{e}{m}$ ratio of proton depends upon gas $\Rightarrow$ variable



$\Rightarrow$ Anode ray

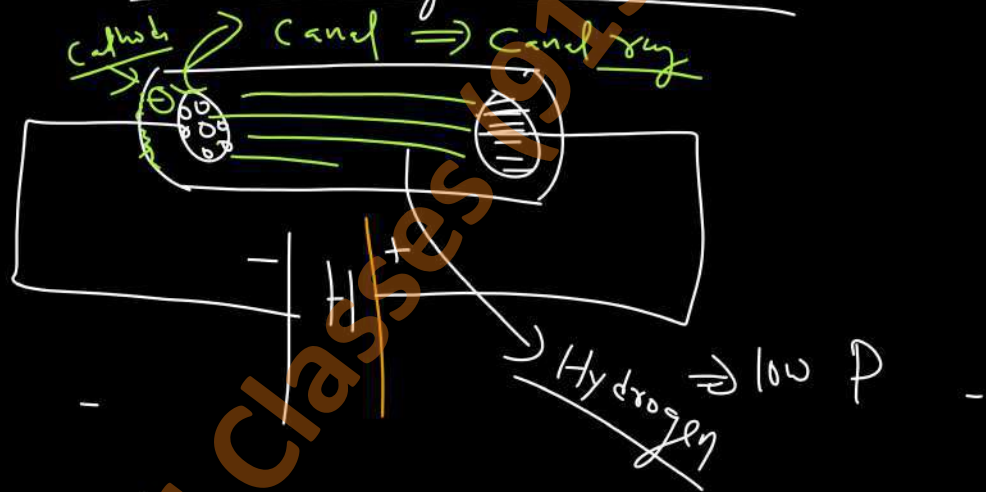
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Technical Classes (91555 63777)

Discovery of Proton

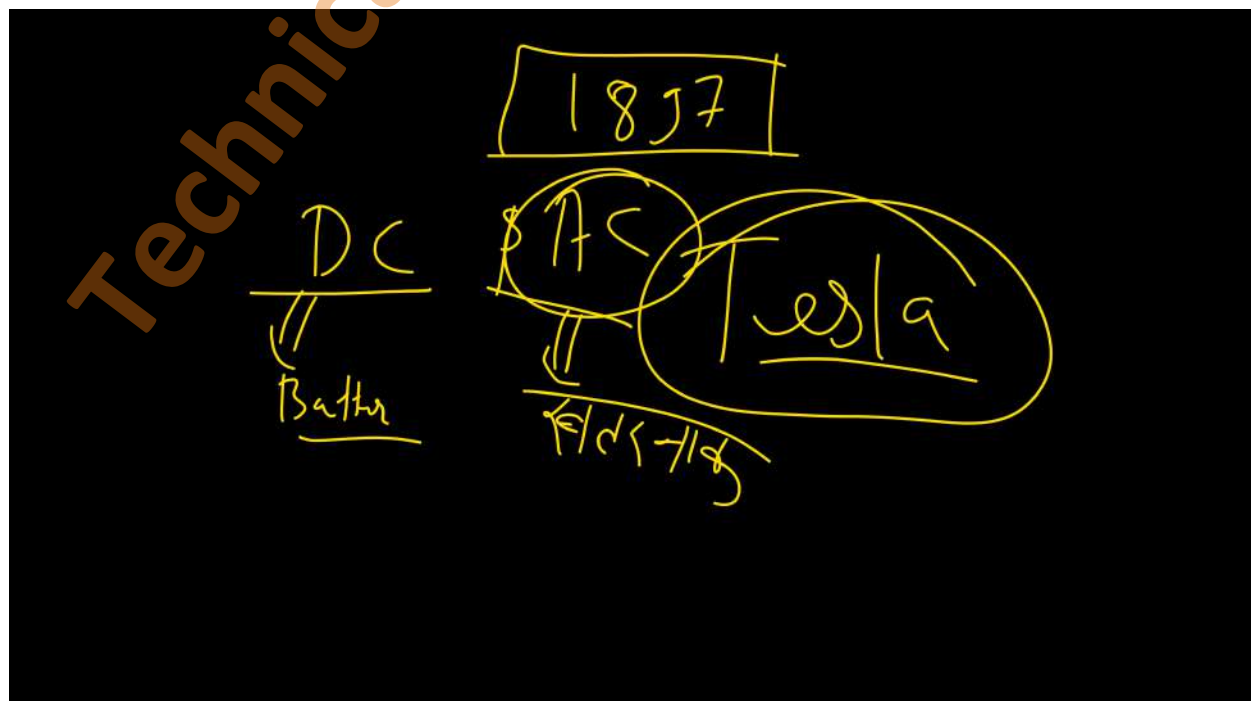
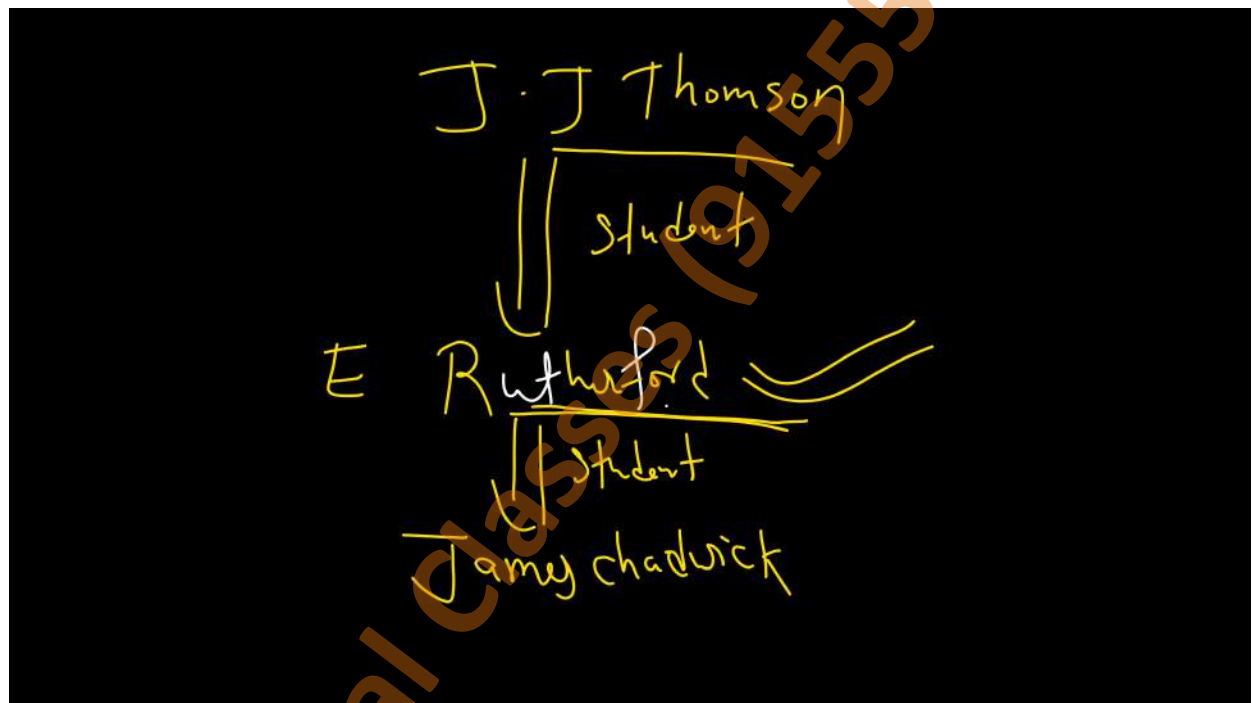
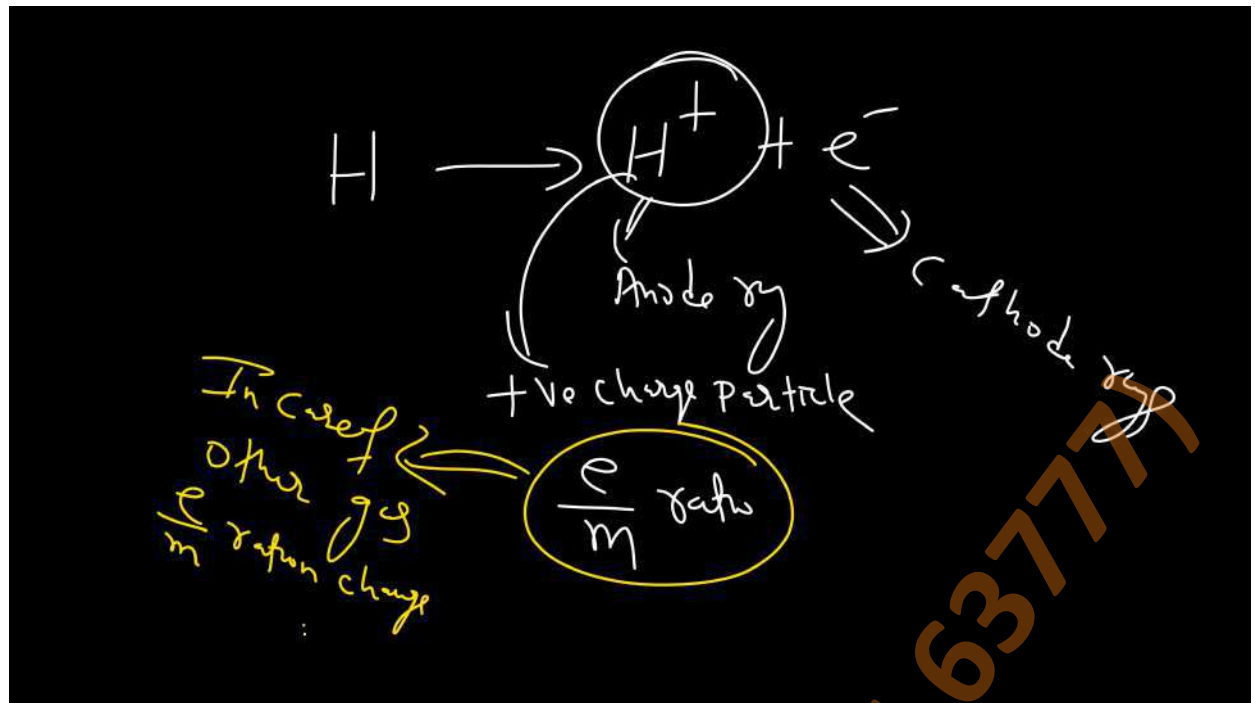
Goldstein
Rutherford

Anode rays experiment



##

Anode rays are also known as Cathode rays, because it passed through Cathode



1897 — e^-
11
 1898



Thomson atomic model

A/c to Thomson, atoms are
 Positive charged sphere
 and negative charge particles
 present in it, like seeds present
 in watermelon

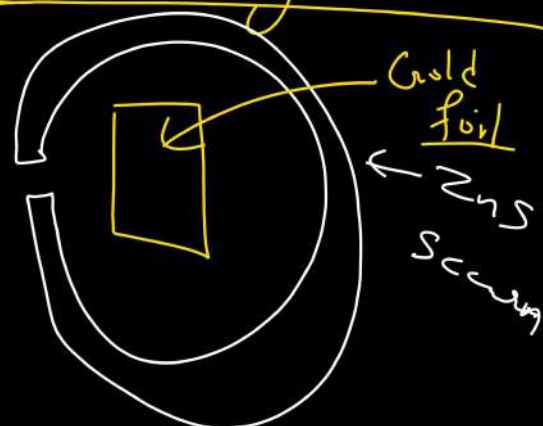
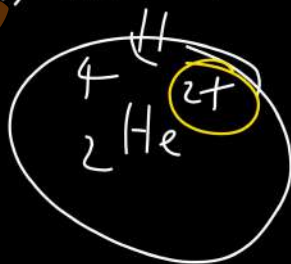
Positive charge sphere

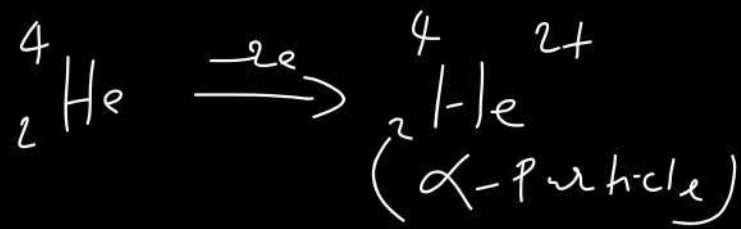


atoms become neutral to presence of
 positive & negative charge in equal magnitude

Rutherford alpha scattering experiment

(α) Alpha Particle





$$e^- = 0 \quad Z = e^- = p^+ = 2$$

$$p^+ = 2$$

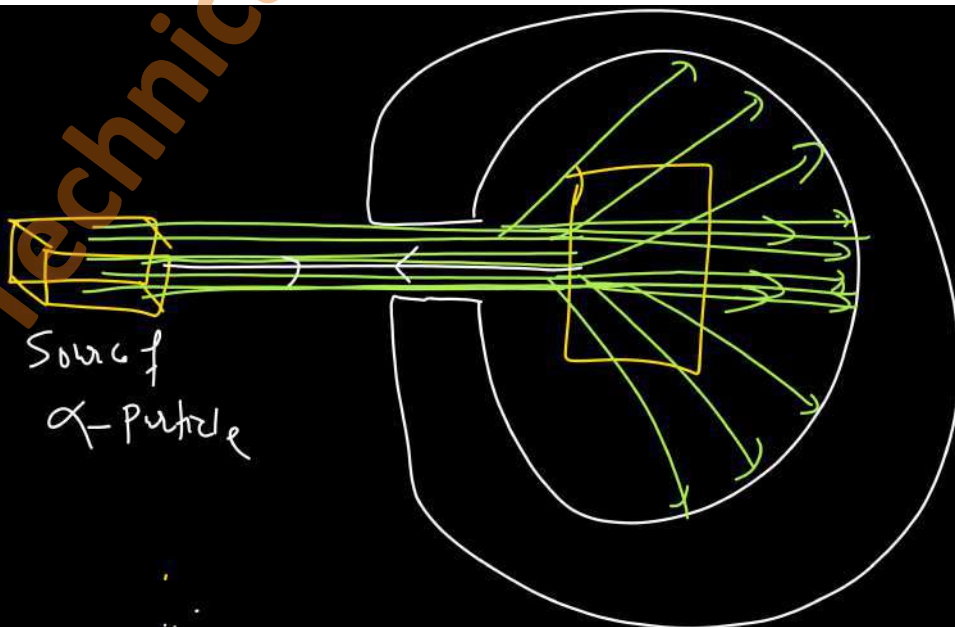
$${}^4_2\text{He}$$

$$e^- = 2$$

$$p^+ = 2$$



It made by layer of single atom



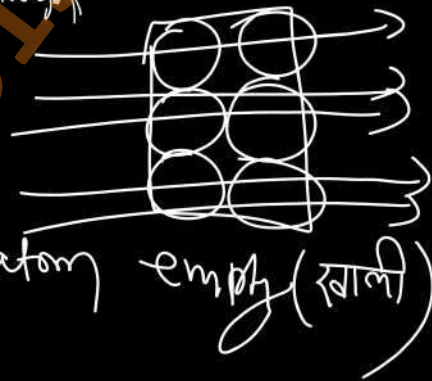
Rutherford take ZnS Screen,
Gold foil and source of
alpha particle.

Observation-①

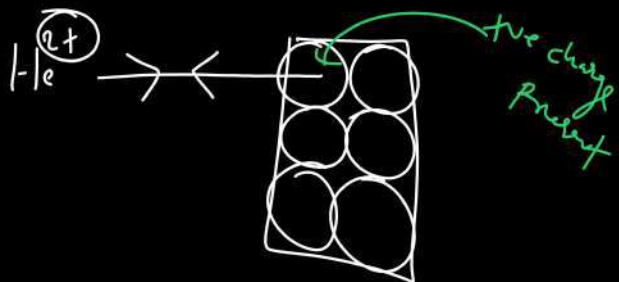
lots of α -Particle passed through
gold foil with any
deflection

Conclusion

almost part of an atom empty (खाली)



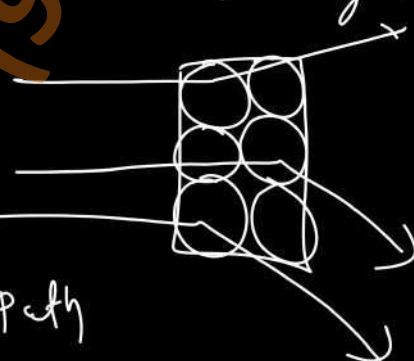
①① Observation — Very few alpha particle
(1 in 8000)
Come back on its path



Conclusion — Whole mass of an atom
present in its center
that center carry positive charge
which is known as nucleus.

Observation — (ii)
few alpha particle deflected (change path)
from its path

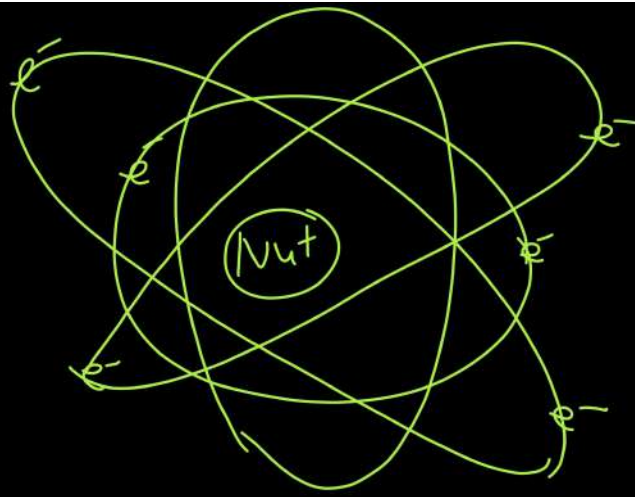
Conclusion — negative charge
particle move around
Nucleus on circular path



The diagram illustrates the deflection of alpha particles. A central region is represented by a grid of circles, indicating a positive charge. Three horizontal lines represent the initial paths of alpha particles. The top line is deflected upwards, the middle line is deflected downwards, and the bottom line is deflected significantly downwards. Arrows indicate the direction of deflection.

Rutherford atomic model

A/c to Rutherford whole mass of an
atom consist in its center i.e. nucleus and
negative charge particle move around
Nucleus on circular path



Limitation of Rutherford atomic model

Some other informations for Rutherford atomic model

Diameter of nucleus = $1 \text{ fm} = 10^{-15} \text{ m}$

Diameter of atom = $1 \text{ \AA} = 10^{-10} \text{ m}$

Nucleus is 10^5 times smaller than atom

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Limitations of Rutherford atomic model

Stability of an atom



A/c to Maxwell theory of radiation
When a charge particle moves on circular path they emit energy and fall in center

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as we know A/c to Rutherford atomic model electrons moves on circular path ^{around the nucleus}, which is not possible for long time according to Maxwell because when electron moves on circular path they emit energy and fall in nucleus



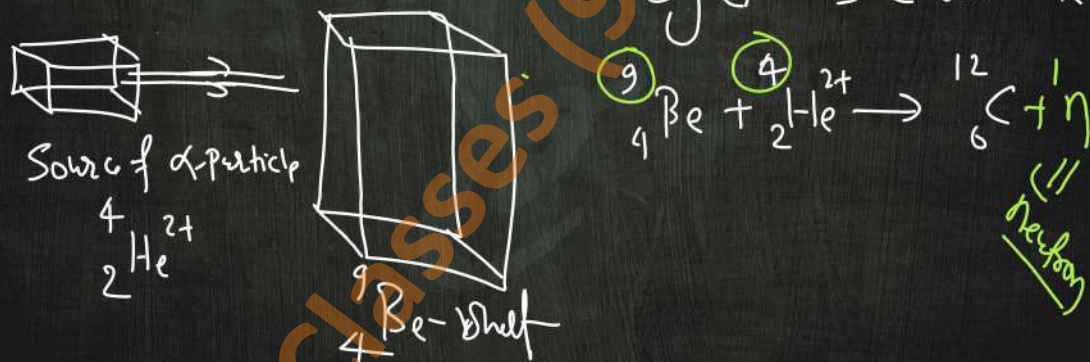
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Rutherford atomic model can't explain distribution of an electron in atom

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Discovery of neutron

by James Chadwick



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Neutrons Discover by James Chadwick
by Attack of Alpha (α) Particle on Be shield

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Some important terms

Atomic number (Z) - The number of protons present in nucleus of an atom

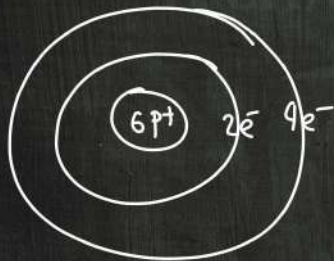
for example

Hydrogen (${}^1\text{H}$)



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Carbon (${}_6\text{C}$)



atoms of every elements have a unique no. of Proton
So every elements have a specific atomic number
which is not same to other

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H.W Atomic no (1 - 30)

${}_{79}\text{Au}$ Ag W , Og , U , I

mass number / Atomic mass number (A)

It is Sum of number of Protons and neutrons present in Nucleus of an atom

$$A = p^+ + n^0$$

(अणु)

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+

Relation between Atomic number, mass no

Number e^- , p^+ & neutron

A = mass number / Atomic mass number

Z = Atomic number

e^- - electron

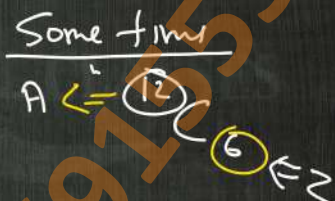
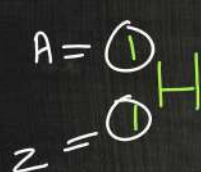
p^+ - Proton

n^0 - neutron

if symbol of an element



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ions - charge species are called ions

eg Ammonium ion (NH_4^+)
Sulphate ion (SO_4^{2-})
Chloride ions (Cl^-)

Sodium ion - Na^+
Magnesium ions - Mg^{2+}

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Types of ions

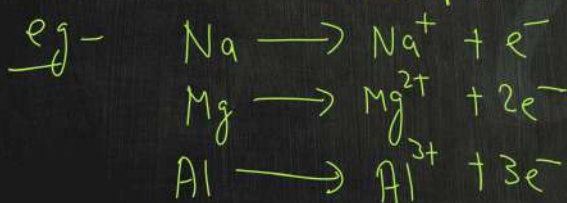
ions

Cation

It is positive charge ions

eg Na^+ , Mg^{2+} , Al^{3+}

formation of cation - It is form by loss of e^-

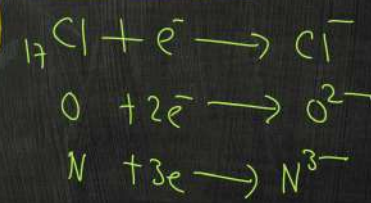


Anion

It is negative charge ions

eg Cl^- , Br^- , OH^- etc
 O^{2-} , N^{3-}

formation of Anion - due to gain of e^-



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Cation
Cations are generally formed by metal
Na, K, Ca, Al

Anion
Anions are generally formed by nonmetals
eg Cl, O, N, Br, F etc

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TRIC for Relation b/w Z, A, e^-, p^+ & n^0
for neutral atom
 $Z = e^- = p^+$
 $n^0 = A - Z$ ($Z = p^+$)
 $A = p^+ + n^0$
eg ${}_{11}^{23}\text{Na}$
 $Z = e^- = p^+$
 $n^0 = A - Z = 23 - 11 = 12$
Q if an element X have Atomic no 12 and no of neutron 12 then its mass number will be
 $Z = 12 = p^+ \quad n^0 = 12$
 $A = p^+ + n^0 = 12 + 12 = 24$

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Question 8 - Calculate number of electron, protons and neutrons in following

(i) ${}_{13}^{24}\text{Al}$

(iv) Sodium ion

(vii) carbonate ion

(ii) ${}_{12}^{24}\text{Mg}$

(v) chloride ion

(viii) hydroxy ion

(iii) ${}_{18}^{40}\text{Ar}$

(vi) Sulphate ion

(ix) Phosphate ion

(xi) water molecule

(x) Carbon dioxide

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Welcome
to
Technical Classes

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Applied Chemistry-B

2nd Semester Electrical, CSE

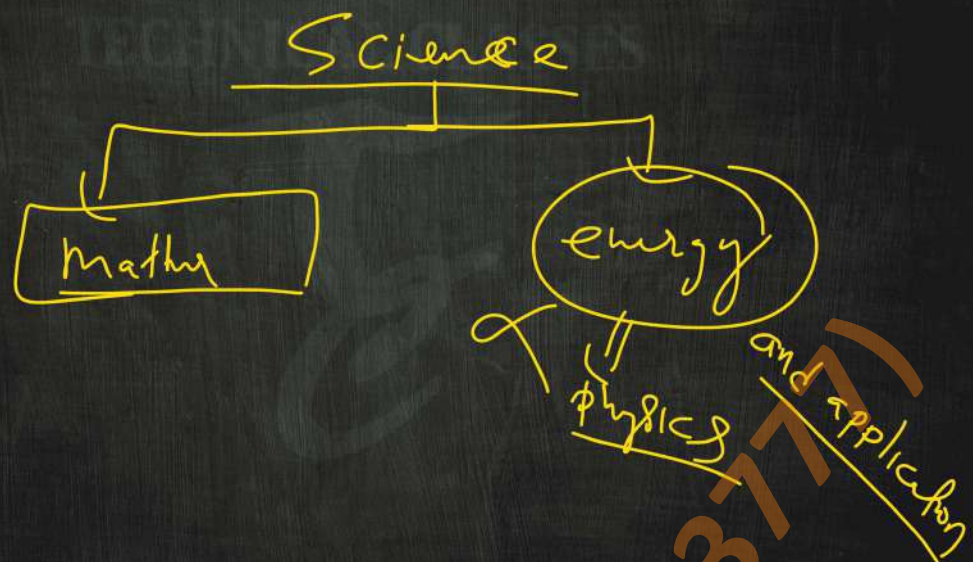
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Chemistry

vs

Applied Chemistry

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Study of matter

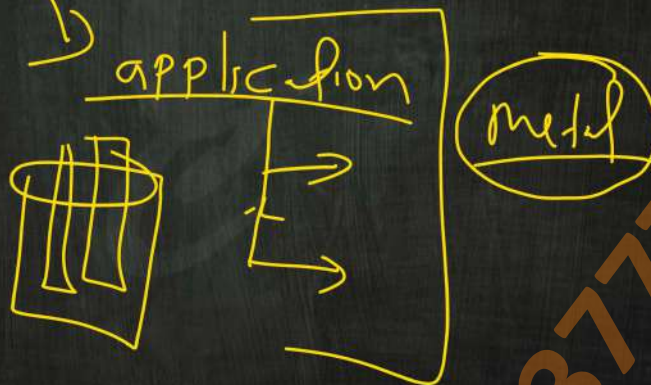


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Chemistry

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Applied Chemistry



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Unit-1.0 Atomic Structure and Chemical Bonding and Solutions

Unit-2.0 Water

Unit-3.0 Engineering Materials

Unit-4.0 Solid State

Unit-5.0 Electrochemistry

Butlers

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1.1 Atoms and its fundamental particles,

1.2. Rutherford Model of Atom,

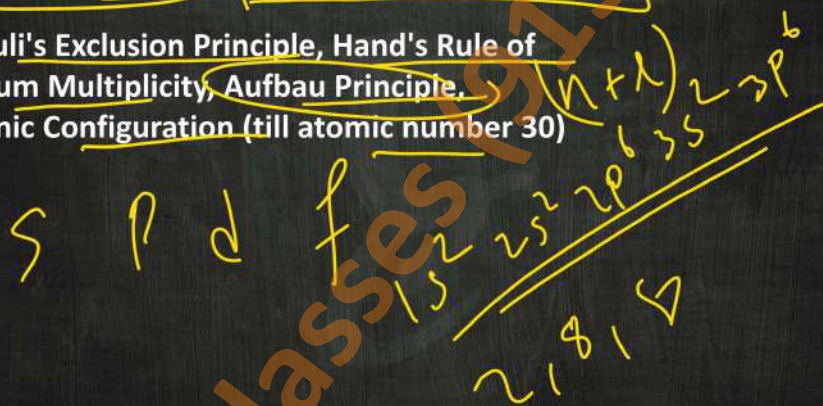
1.3. Bohr's Theory, Hydrogen spectrum explanation based on Bohr's Model of Atom,

1.4. Wave Mechanical model of atom, de Broglie relationship, Heisenberg Uncertainty Principle

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1.5. Quantum Numbers, Shapes of Atomic Orbitals,

1.6. Pauli's Exclusion Principle, Hund's Rule of Maximum Multiplicity, Aufbau Principle,
Electronic Configuration (till atomic number 30)



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Unit-1.0 | Atomic Structure and Chemical Bonding and Solutions

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Atoms and its fundamental particles

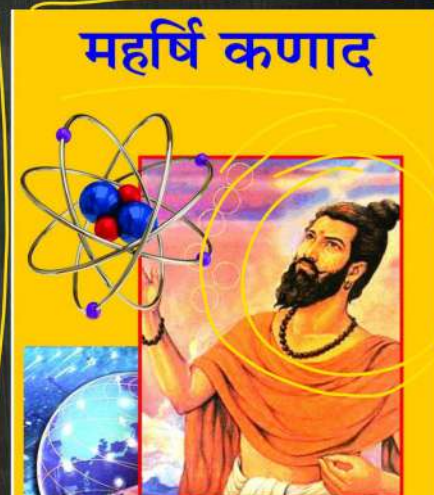
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Technical Classes || Cont. - 91555 63777 / 9334789450

Atom

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Parmanu

परमाणु



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John Dalton



Handwritten notes on a chalkboard:

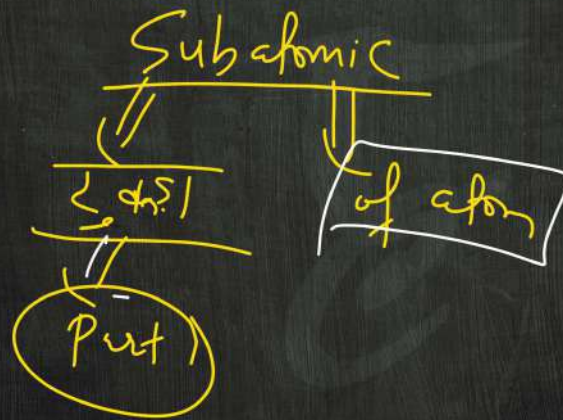
- A vertical line with a double arrow pointing down, labeled 'A'.
- Text: "not to"
- A rectangular box containing the text "Smallest individual particle".

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Handwritten notes on a chalkboard:

- A vertical line with a double arrow pointing down, labeled 'A'.
- Text: "not to cut"
- A circle containing the number '31'.
- Text: "not to cut"

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Amardeep Bhardwaj

Atoms are made by small

Particles. Those particles are

called Subatomic Particle

- (i) Electron
- (ii) Proton
- (iii) Neutron

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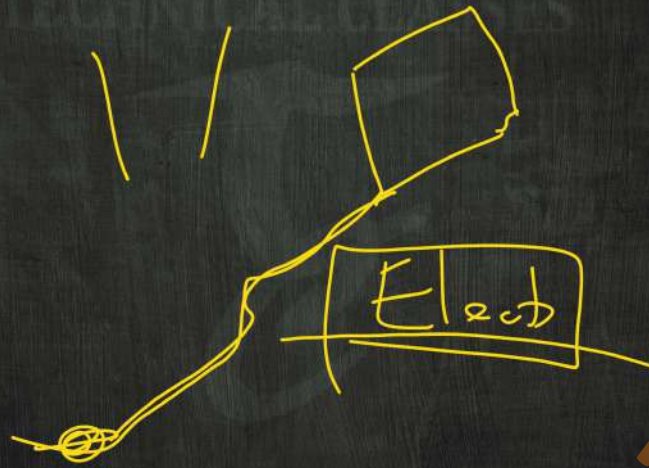
Benjamin Franklin was an American polymath: a writer, scientist, inventor, statesman, diplomat, printer, publisher and political philosopher.

Year 1752

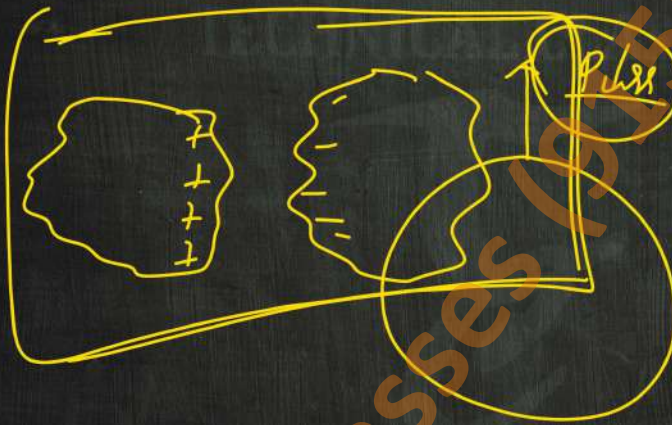
(i) Electron



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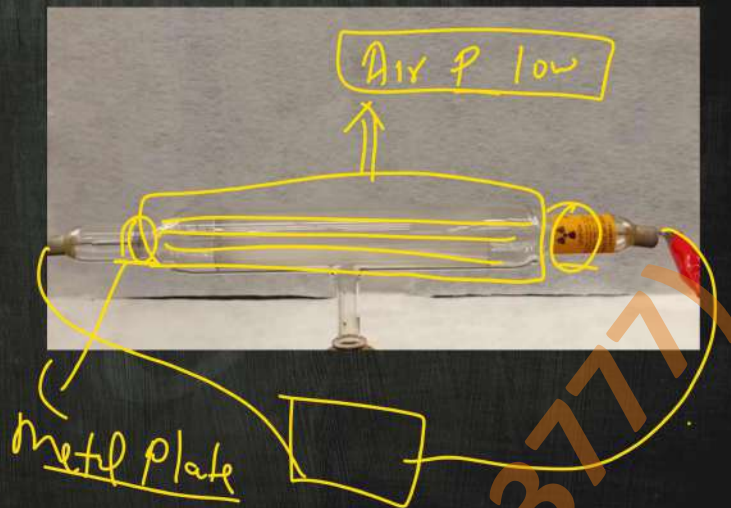
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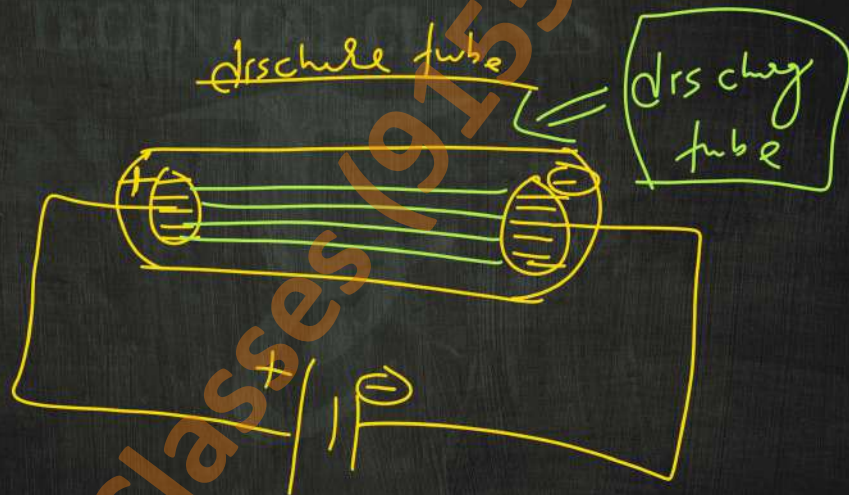
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Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450

Discovery of an electron
by J.J Thomson

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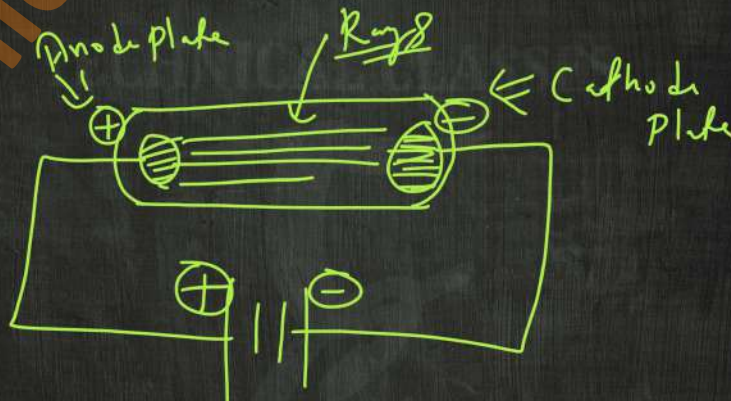
Sir Joseph John Thomson in 1897



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- 1800
- # Requirements
- (I) Discharge tube
↳ Glass
 - (II) Battery
 - (III) Wire
 - (IV) metal plate

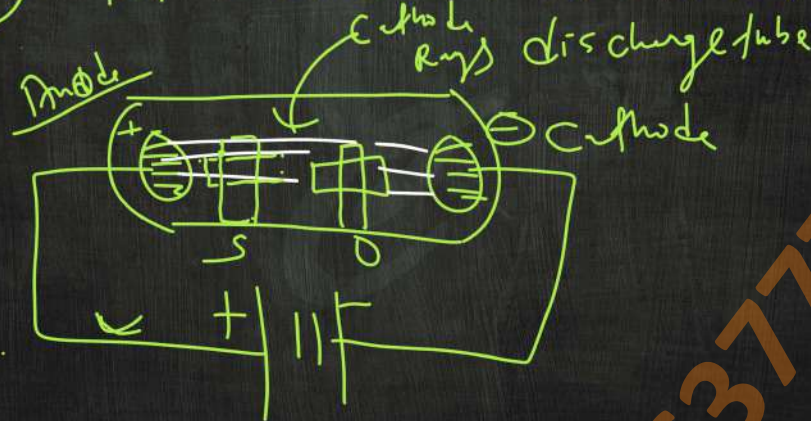
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Experiment

- ① Put a solid object inside the

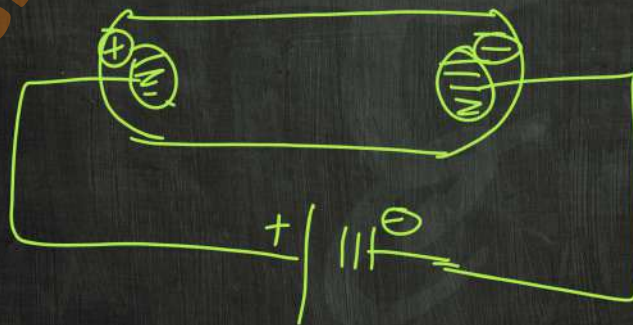


Technical Classes || Cont. - 91555 63777 / 9334789450

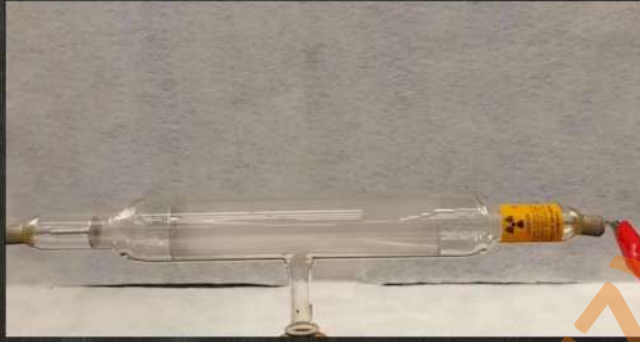
Conclusion

- # Rays comes from Cathode plate
- # Discovery of an electron also known as Cathode Ray experiment

Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450



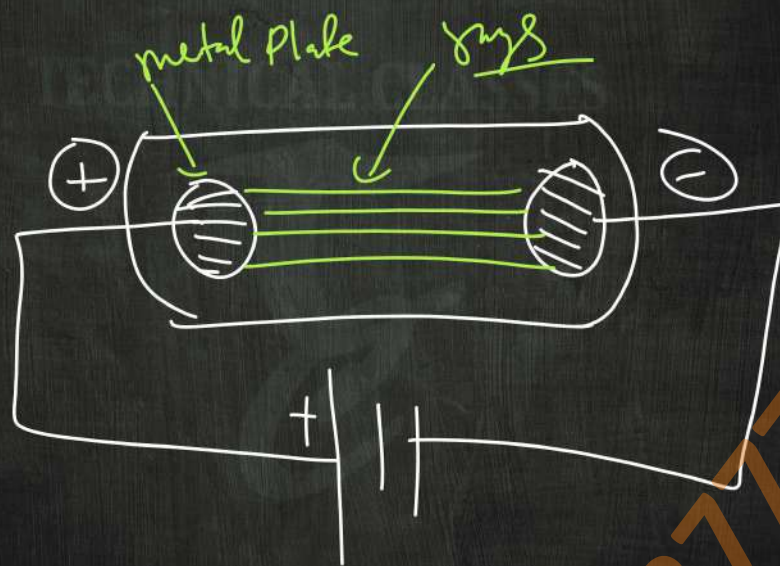
Technical Classes || Cont. - 91555 63777 / 9334789450



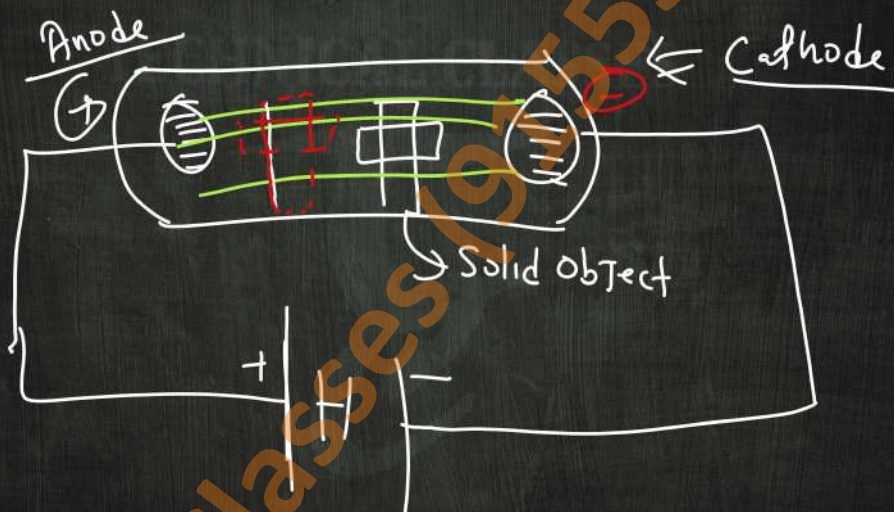
Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450



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Technical Classes || Cont. - 91555 63777 / 9334789450

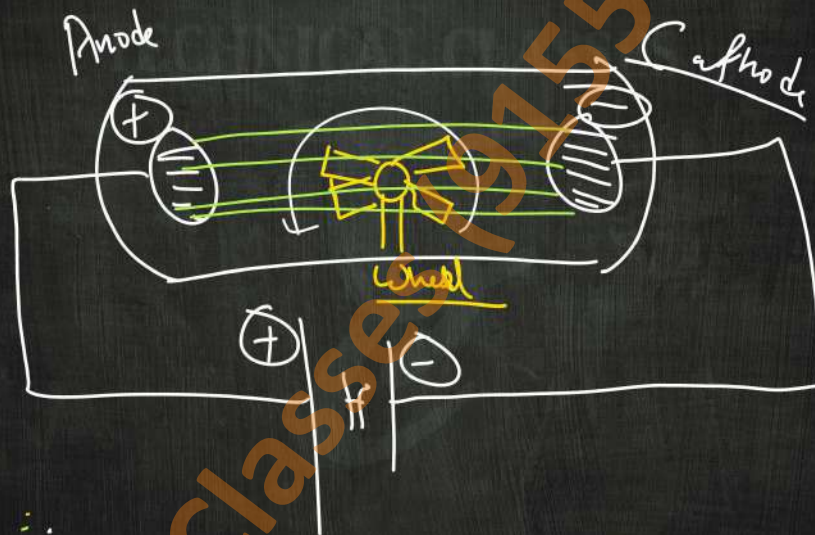
##

Rays are known as
Cathode Rays and
this experiment is known
as Cathode Ray experiment

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Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450

Cathode rays are made
by small particles
100%

Technical Classes || Cont. - 91555 63777 / 9334789450

Conclusion (Cathode rays experiment)

Cathode rays are made by small particles. those particles carry negative charge

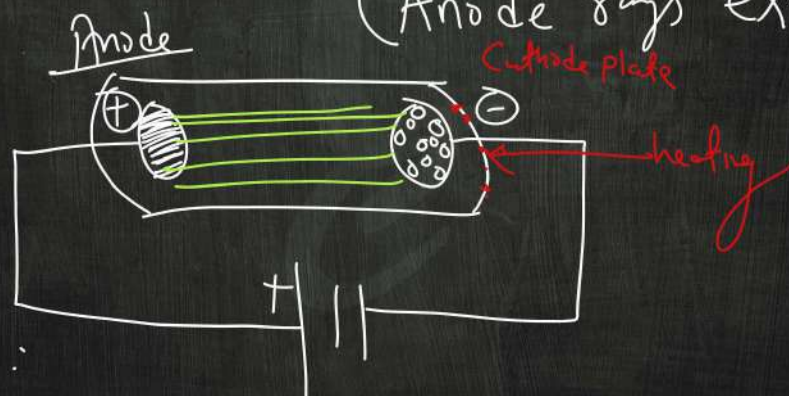
Technical Classes || Cont. - 91555 63777 / 9334789450

those particles are known as electron.

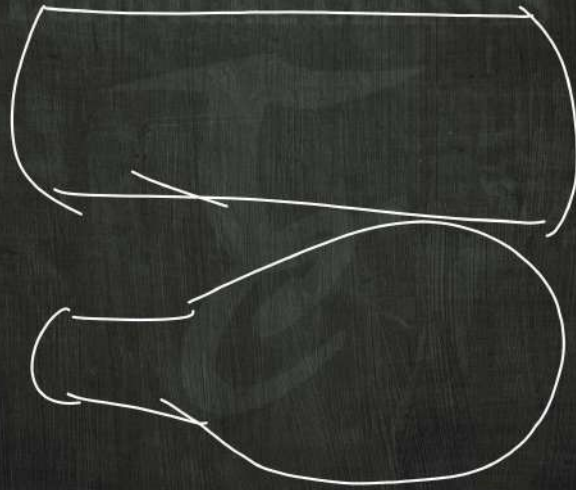
Technical Classes || Cont. - 91555 63777 / 9334789450

Discovery of Proton

(Anode rays experiment)

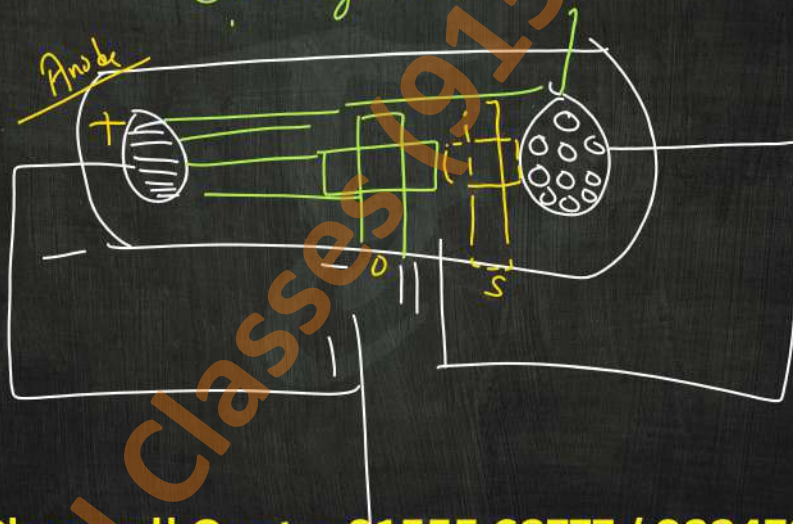


Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450

(1) Put a Solid object inside the discharge tube



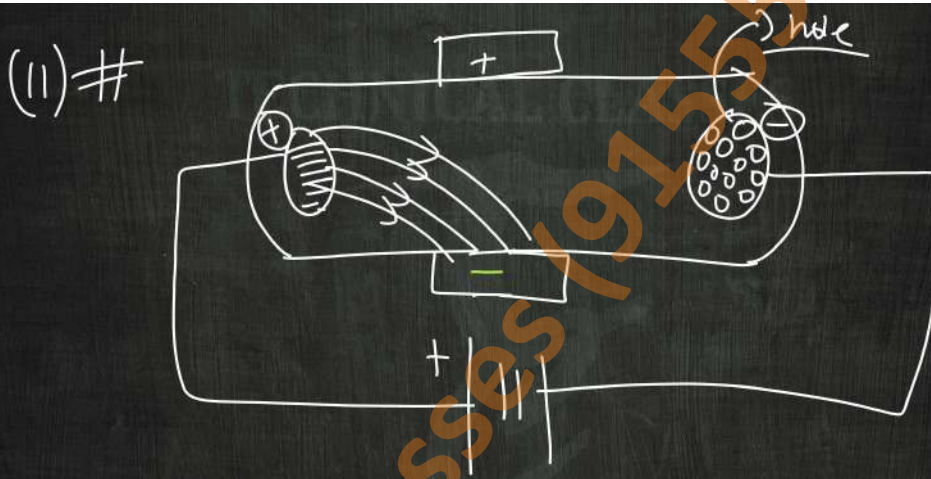
Technical Classes || Cont. - 91555 63777 / 9334789450

Rays are comes from Anode Plate so these rays are known as anode rays and this experiment is known as anode ray experiment

Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450



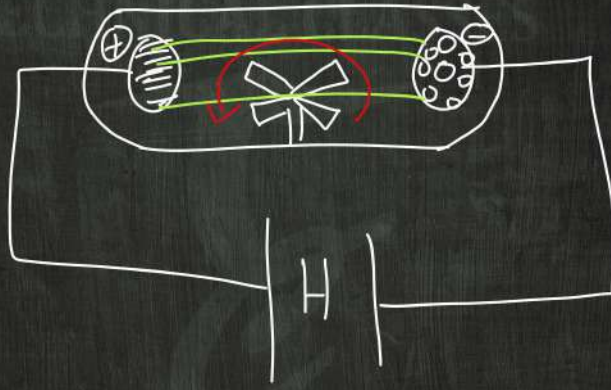
Technical Classes || Cont. - 91555 63777 / 9334789450

Conclusion

Anode rays carry positive charge

Technical Classes || Cont. - 91555 63777 / 9334789450

(III)

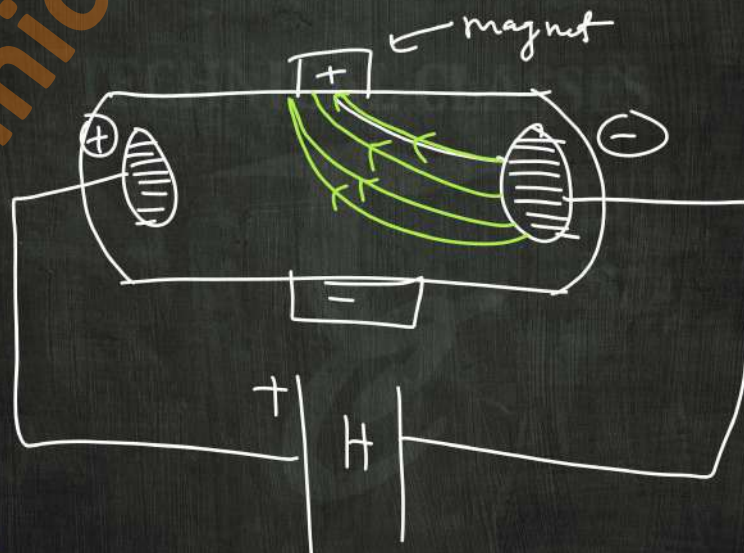


Technical Classes || Cont. - 91555 63777 / 9334789450

Conclusion

Anode rays are made by
Small particles

Technical Classes || Cont. - 91555 63777 / 9334789450



Technical Classes || Cont. - 91555 63777 / 9334789450

Cathode ray carry
negative charge

Technical Classes || Cont. - 91555 63777 / 9334789450

electron

$$\begin{aligned} \text{Charge} &= -1.6 \times 10^{-19} \text{ C (SI unit)} \\ \text{CGS} &= -4.8 \times 10^{-10} \text{ ESU (Electrostatic unit)} \\ \text{mass} &= 9.1 \times 10^{-31} \text{ kg} \\ &= 9.1 \times 10^{-31} \times 10^3 = 9.1 \times 10^{-28} \text{ g} \end{aligned}$$

Technical Classes || Cont. - 91555 63777 / 9334789450

Neutron

$e^- \quad p^+ \quad n^0$

Technical Classes || Cont. - 91555 63777 / 9334789450

$$9.1 \times 10^{-31} \text{ kg} \times 10^3$$

$$(10^{-31} \times 10^3)$$

$$9.1 \times 10^{-28} \text{ g}$$

$$\begin{array}{r} -31 + 3 \\ -28 \end{array}$$

$$\frac{1000}{2.45} \text{ इकाई}$$

Technical Classes || Cont. - 91555 63777 / 9334789450

Proton

$$\text{Charge} = +1.6 \times 10^{-19} \text{ C (SI unit)}$$

$$= +4.8 \times 10^{-10} \text{ ESU (Electrostatic unit)}$$

$$\text{mass} = 1.672 \times 10^{-27} \text{ kg}$$

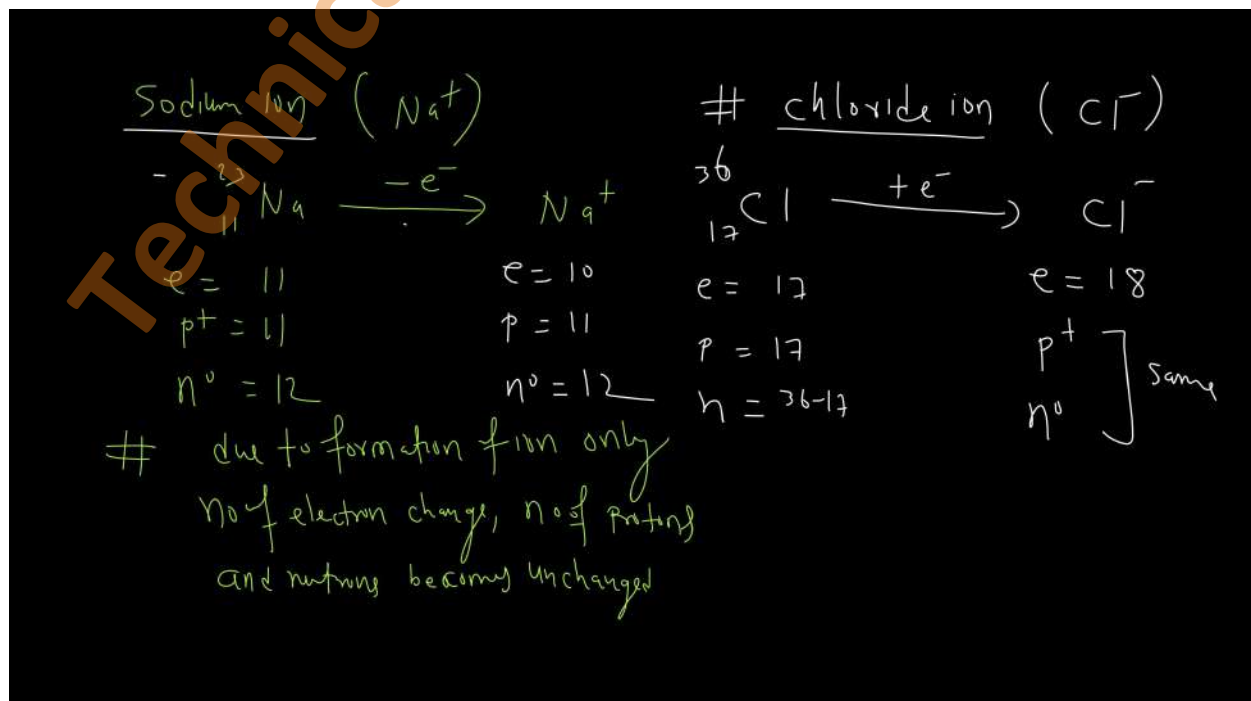
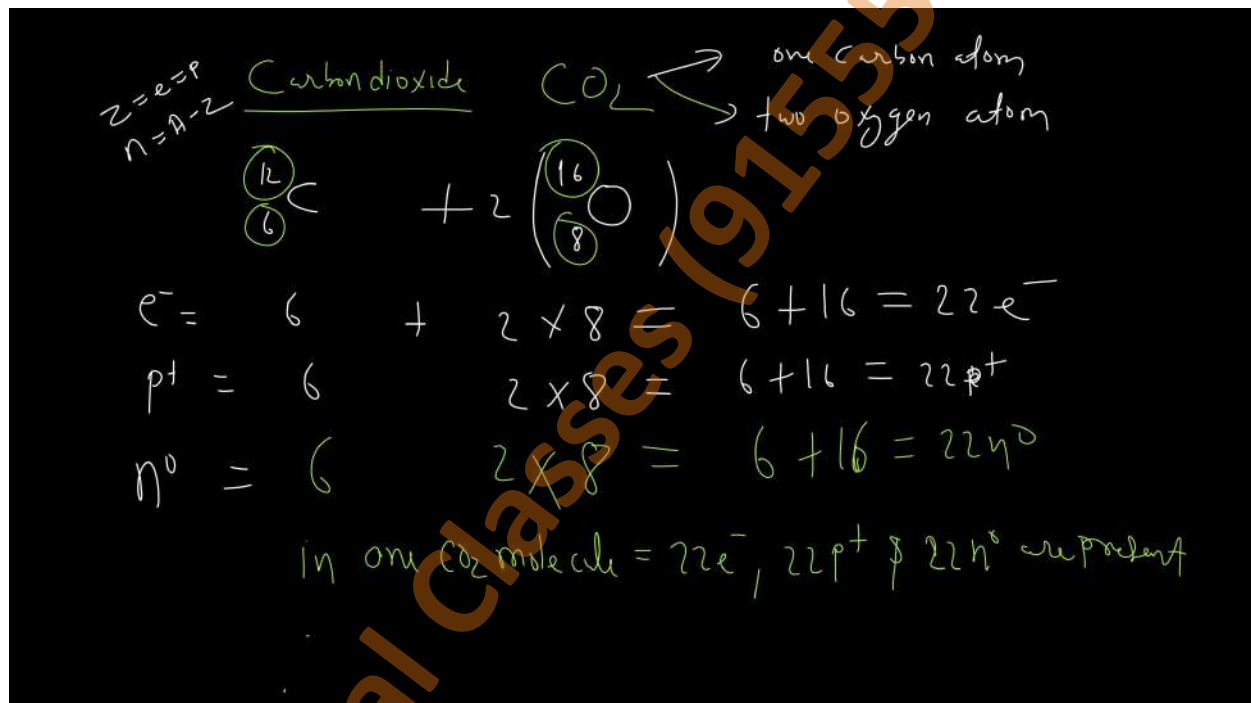
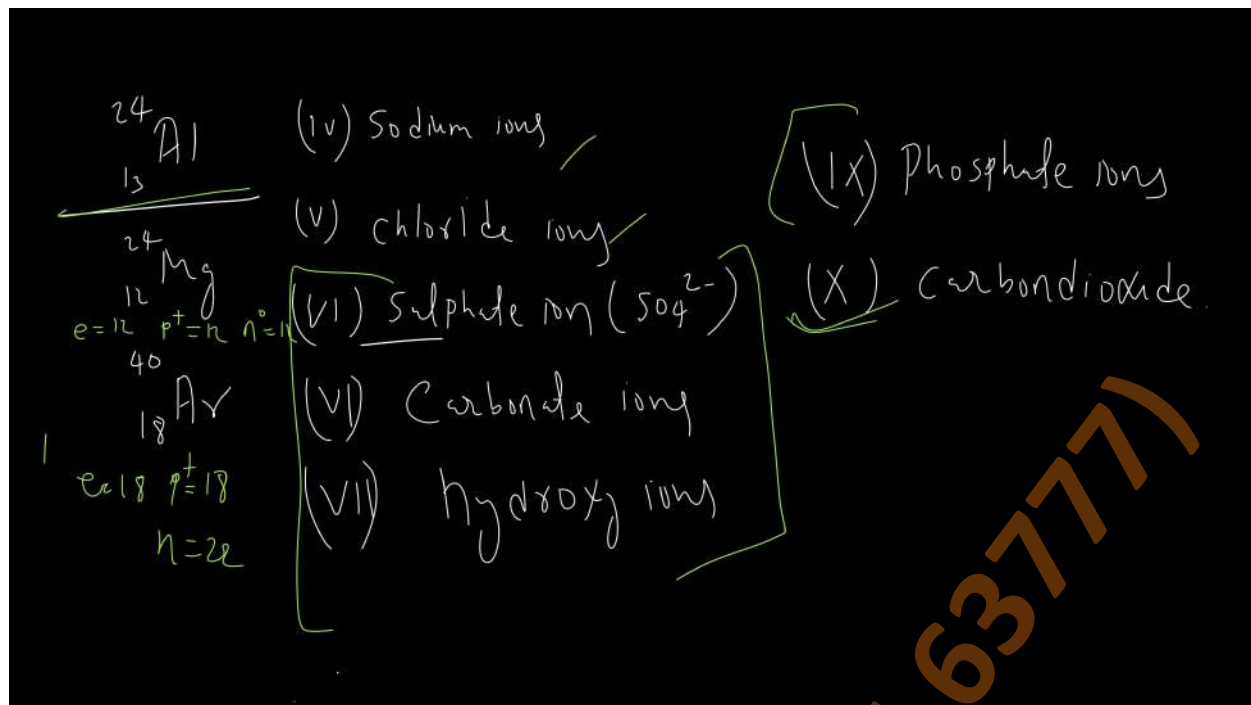
$$1.672 \times 10^{-24} \text{ g}$$

Technical Classes || Cont. - 91555 63777 / 9334789450

Proton

$$\text{Charge} = +1.6$$

Technical Classes || Cont. - 91555 63777 / 9334789450



$$A = 24$$

$$Z = 13$$

$$e^- = 13$$

$$p^+ = 13$$

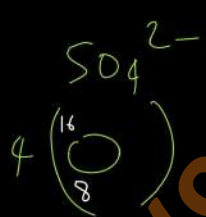
$$n^0$$

$$Z = e^- = p^+$$

$$n^0 = A - Z$$

$$= 24 - 13$$

Sulphate ion



one S-atom
four oxygen atom

$$e^- = 16 + 4 \times 8 = 16 + 32 + 2e^- = 50e^-$$

$$p^+ = 16 + 4 \times 8 = 16 + 32 = 48p^+$$

$$n^0 = 16 + 4 \times 8 = 16 + 32 = 48n^0$$

In one SO_4^{2-} there are $50e^-$, $48p^+$ & $48n^0$ are present



one carbon atom
three oxygen atom



$$e^- = 6 + 3 \times 8 + 2 =$$

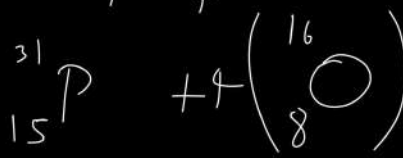
$$p^+ = 6 + 3 \times 8 =$$

$$n^0 = 6 + 3 \times 8 =$$

Hydroxy (OH^-)



PO_4^{3-}



H.W

(I) Benzene (C_6H_6)

(II) Methanol / Methyl Alcohol - CH_3OH

(III) Methoxy methane / dimethylether - CH_3OCH_3

Relations between atoms & ions

TRICK

	Z	A	n
Isotopes	Same	diff	diff
Isobars	different	Same	diff
Isotones	diff	diff	Same

Z = Atomic no

A - mass no / Atomic mass

n - no of neutron

Isotopes = Iso + topes

Same

(position) in Periodic Table

||

Same atomic no

atoms having same atomic number but different atomic mass and number of neutron

example Isotopes of hydrogen

	e^-	p^+	n^0
Protium	1	1	0
Deuterium	1	1	1
Tritium	1	1	2

Oxide of deuterium (${}^3\text{H}$ or ${}^3\text{D}$) which is D_2O used in nuclear reactor to stop nuclear reaction

(11) Isobar = Is + bar
 Same mass

atoms having same atomic mass but different atomic number and number of neutron

${}^{40}_{18}\text{Ar}$	${}^{40}_{20}\text{Ca}$
$Z = 18$	20 (different)
$n^{\circ} = 22$	20 (same)
$A = 40$	40 (same)

So ${}^{40}_{18}\text{Ar}$ and ${}^{40}_{20}\text{Ca}$ are Isobars of each other

Isotones = Is + tones
 Same neutron

atoms having same number of neutrons but different atomic number and atomic mass

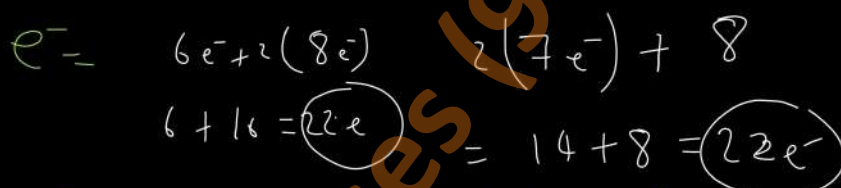
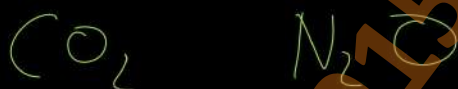
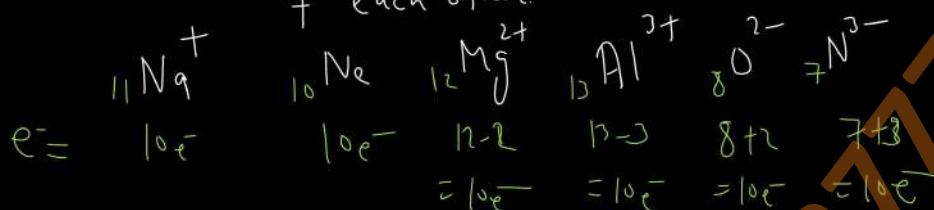
for example

${}^{15}_7\text{N}$	${}^{16}_8\text{O}$
$Z = 7$	8 (diff)
$n^{\circ} = 8$	8 (same)
$A = 15$	16 (diff)

${}^{15}_7\text{N}$ & ${}^{16}_8\text{O}$ are Isotones of each other

Isoelectronic = Iso + electronic
 (// same) (↓ electron)

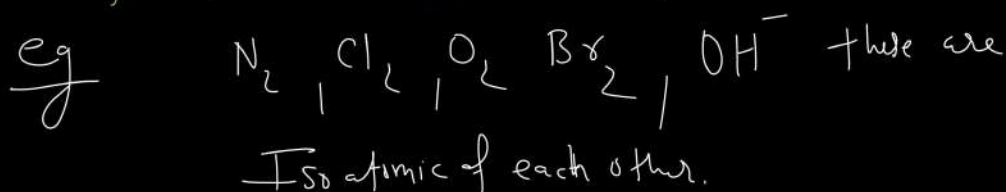
atoms, molecules or ions which have same number of electrons are called Iseoelectronic of each other.



CO_2 & N_2O are Iseoelectronic of each other.

Isoatomic = Iso + atomic
 (// same) (↓ atoms)

molecules or ions which have same number of atoms are Isoatomic of each other.



(i) N_2O & CO_2 , SO_2 , NO_2^- , O_3 (Ozone)

(ii) PCl_3 , NCl_3

these are Iso atomic of each other

Isoe-steris = Iso atomic + Isoelectronic

molecules of ions which have same number of atoms and electron are called Isoe-steris of each other.

CO_2 & N_2O

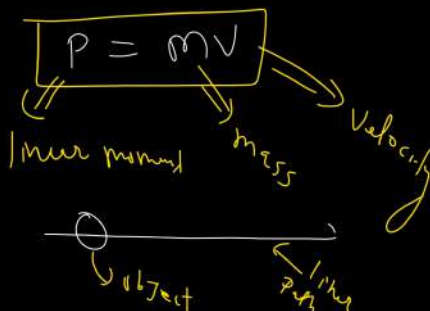
e- $22e^-$ $22e^-$

No. of atom (3) (3)

Some Important terms

Momentum

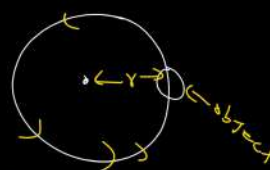
Linear momentum ($\vec{p}$)



$$J = p \times r$$

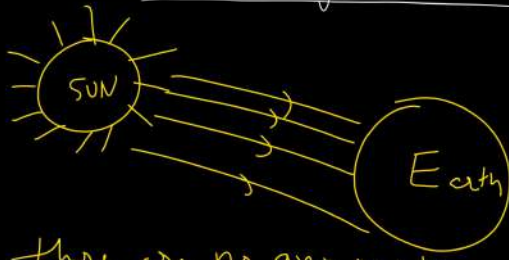
$$J = mv \times r$$

Angular momentum ($\vec{J}$)



When an object moves in circular path

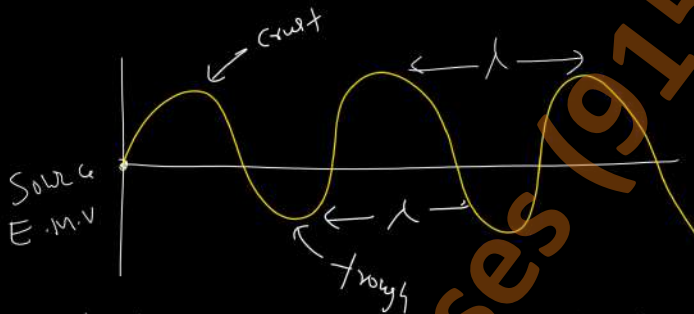
Electromagnetic waves/radiation



there are no any medium
Present to transfer energy
from sun to earth

When energy transfer
from one object to
another without an medium
it transfer in form of
electromagnetic waves
for example light

Properties



Wavelength - The distance between two nearest crest or trough
(λ) is called wavelength

Frequency (ν) - The number of waves passed through a
Point per second

Electromagnetic waves are travels with speed
of light (c)

$$c = 3 \times 10^8 \text{ m/s}$$

Relation between λ & ν

$$C = \nu \lambda$$

Speed of light $\downarrow$ frequency $\downarrow$ wave length

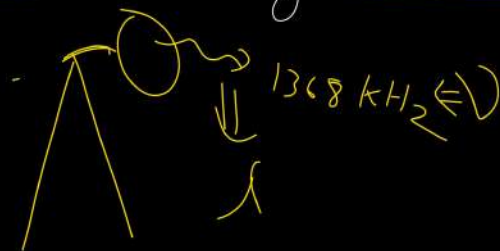
$$\lambda = \frac{C}{\nu}$$

$$\nu = \frac{C}{\lambda}$$

Wave Number ($\bar{\nu}$) - It is reciprocal of wave length

$$\bar{\nu} = \frac{1}{\lambda}$$

Q The Vividh Bharti station of all India radio broadcasts on frequency of 1368 kilohertz. Calculate the wavelength of the electromagnetic waves emitted by the transmitter.



$$\nu = 1368 \text{ kHz}$$

$$= 1368 \times 10^3 \text{ Hz}$$

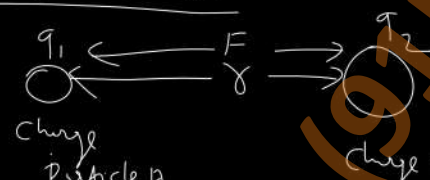
$$c = \nu \lambda$$

$$\boxed{\text{Hz}} \quad \lambda = \frac{c}{\nu}$$

$$\frac{3000 \times 10^8}{1368} = \frac{3 \times 10^8 \text{ m/s}}{1368 \times 10^3} = \frac{3000 \times 10^5}{1368 \times 10^3}$$

$$= \frac{3000}{1368} \times 10^2$$

Coulomb's law



charge particle A charge particle B

force

$F \propto q_1 q_2$

$F \propto \frac{1}{r^2}$

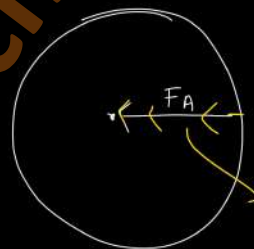
Where q_1 and q_2 are magnitude of charge particle

$r = \text{distance b/w charge particle}$

$F \propto \frac{q_1 q_2}{r^2} \Rightarrow F = k \frac{q_1 q_2}{r^2}$

k - Coulomb's constant in C.G.S unit system Value 1

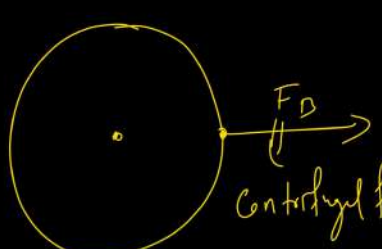
Centripetal force



Centripetal force

The force which applied towards the center.

Centrifugal force

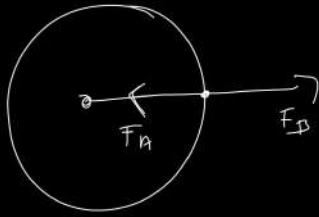


Centrifugal force

The force which applied away from center

When an object moves on circular path

in this situation



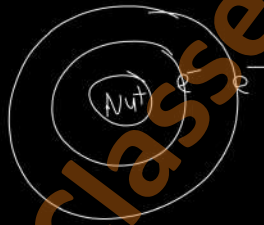
$$\text{Centripetal force} = \text{Centrifugal force}$$

$$F_A = F_B$$

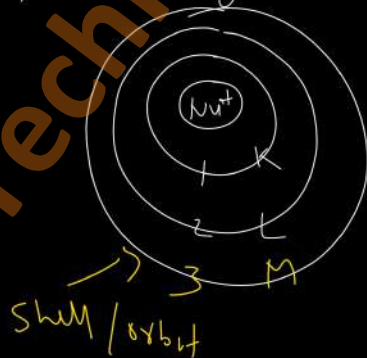
Bohr's atomic model

Postulates

- (i) A/c to Bohr electrons move around nucleus on definite circular path without emits energy

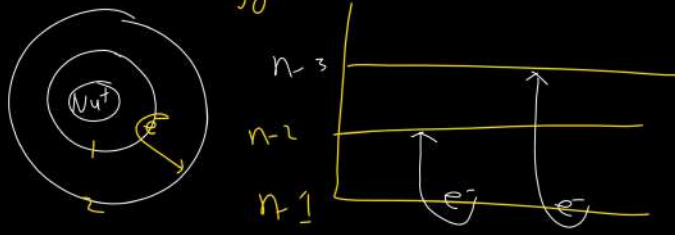


- (ii) energy of orbits increases with increase in orbit number



$$\text{energy} = 1^{\text{st}} \text{ shell} < 2^{\text{nd}} \text{ shell} < 3^{\text{rd}} \text{ shell} < 4^{\text{th}} \text{ shell}$$

(III) When electron transfer from lower orbit to higher orbit energy absorb.



(IV) When electron transfer from higher orbit to lower orbit energy release



Bohr atomic model

In last class

- (i) definite circular path
- (ii) shell / orbit $\propto$ energy
- (iii) if electron transfer lower to higher $\Rightarrow$ energy absorb
- (iv) " " " higher to lower $\Rightarrow$ energy release

(v) only those electrons are moved on circular path which angular momentum is integer multiple of $\frac{h}{2\pi}$

$$J = n \frac{h}{2\pi}$$

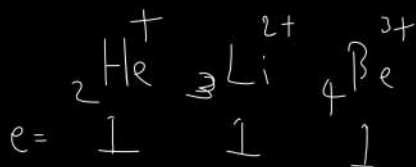
$n = 0, 1, 2, 3$

h - Planck's constant

Condition / Limitation of Bohr's atomic model

Bohr's atomic model only applicable on single electron species

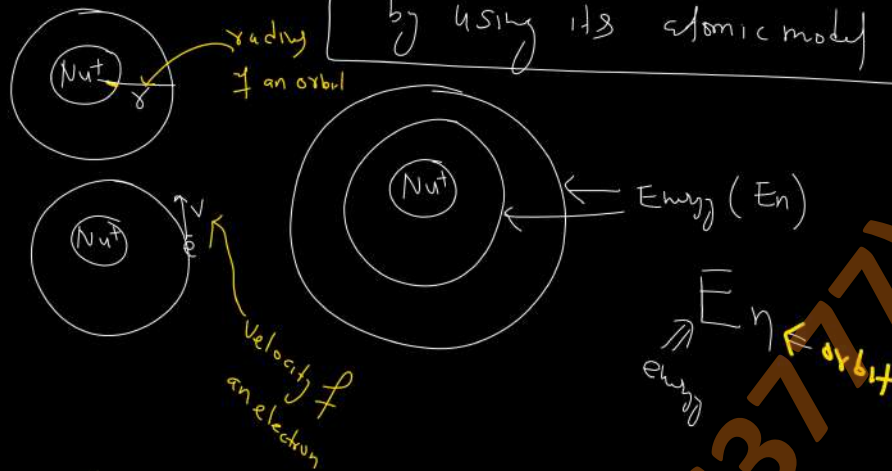
for example - Hydrogen, ${}^1\text{H}$



$$Z = e = 1$$
$$\textcircled{1} \quad \textcircled{1}$$

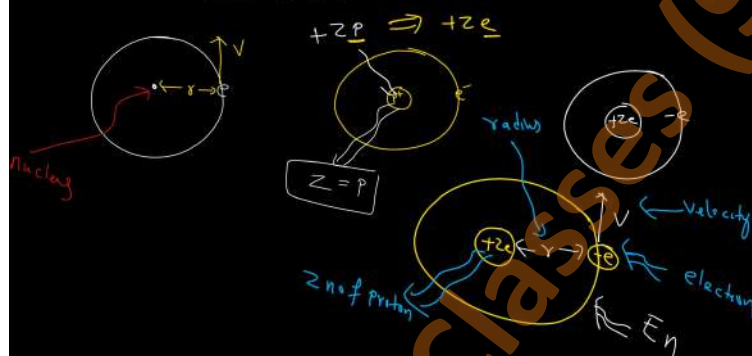
$$\left[Z X^{Z-1} \right]$$

Bohr also calculate radius(r), Energy(E) and velocity(v) by using its atomic model

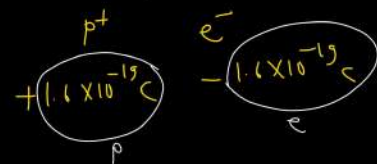


Application of Bohr's atomic theory

Bohr's consider an atom in which an electron moves around circular path which have radius r with velocity v

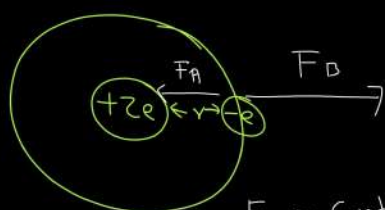


in proton and electron magnitude of charge same but sign opposite



App to Coulomb's law

$+q \quad -q$
 $F = k \frac{(+q)(-q)}{r^2}$



$F_A = \text{Centripetal force / Coulombic attractive force}$
 $F_B = \text{Centrifugal force}$

For F_A

$$F_A = k \frac{(+Ze)(-e)}{r^2}$$

$$F_A = -\frac{kZe^2}{r^2}$$

$$F_B = \frac{mv^2}{r}$$

When an object moves on circular path
Centripetal force = Centrifugal force

$$F_A = -F_B$$

$$\Rightarrow \boxed{mv^2 = \frac{kze^2}{r}} \quad (1)$$

from Bohr's atomic theory

as we know

$$J = \frac{nh}{2\pi}$$

$$\boxed{J = mvr}$$

Angular momentum

$$\boxed{mvr = \frac{nh}{2\pi}} \quad (2)$$

$$\boxed{mv^2 = -\frac{kze^2}{r}}$$

$$\boxed{mvr = \frac{nh}{2\pi}}$$

Z = atomic no

e = charge on electron

$$(-1.6 \times 10^{-19} \text{ C})$$

$$(-4.8 \times 10^{-10} \text{ ESU})$$

r = radius of an orbit

n = n. of orbit

$$\pi = 3.14$$

h = plank's const

$$(6.67 \times 10^{-27} \text{ erg cm})$$

(in cgs)

Where m = mass of an electron
($9.1 \times 10^{-31} \text{ kg}$ / $9.1 \times 10^{-28} \text{ g}$)

v = Velocity of an electron

k = Coulomb's const (in cgs system $k=1$)

as we know

$$mvr = \frac{nh}{2\pi}$$

$$\boxed{v = \frac{nh}{2\pi mr}}$$

Putting the value of v in eqn (1)

$$mv^2 = \frac{kze^2}{r}$$

$$m \left(\frac{nh}{2\pi mr} \right)^2 = \frac{kze^2}{r}$$

$$\frac{m n^2 h^2}{4 \pi^2 m^2 r^2} = \frac{kze^2}{r}$$

$$\frac{m n^2 h^2}{4 \pi^2 m^2 r} = kze^2$$

$$\boxed{r = \frac{n^2 h^2}{k 4 \pi^2 m z e^2}}$$

$$r = \frac{n^2 h^2}{k 4 \pi^2 m z e^2}$$

$$r = \frac{h^2}{k 4 \pi^2 m e^2} \left(\frac{n^2}{z} \right)$$

Putting the value of h, k, π, m, e
in CGS system

$$k = 1$$

$$r = \frac{(6.62 \times 10^{-27})^2}{1 \times 9 \times (3.14)^2 (9.1 \times 10^{-31}) (4.8 \times 10^{-10})^2} \left(\frac{n^2}{z} \right)$$

$$r = 0.529 \times 10^{-8} \frac{n^2}{z} \text{ cm}$$

$$r = 0.529 \times 10^{-8} \cdot \left(\frac{n^2}{z} \right) \text{ cm}$$

$$r = 0.529 \times 10^{-10} \left(\frac{n^2}{z} \right) \text{ m}$$

$$1 \text{ m} = 10^{-10} \text{ A}$$

$$r = 0.529 \left(\frac{n^2}{z} \right) \text{ A}^\circ$$

n - orbit no
 z = Atomic no

$$r = \frac{n^2 h^2}{4 \pi^2 m z e^2 k}$$

$$r = 0.529 \times \frac{n^2}{z} \text{ A}^\circ$$

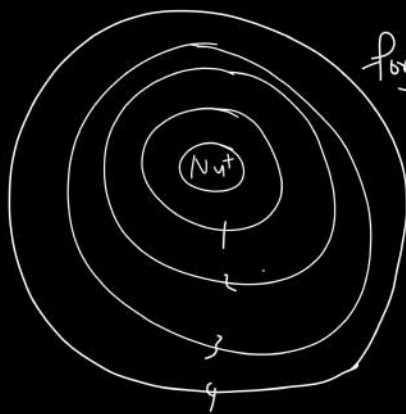
$$r = 0.529 \times 10^{-8} \left(\frac{n^2}{z} \right) \text{ cm}$$

$$r = 0.529 \times 10^{-10} \left(\frac{n^2}{z} \right) \text{ m}$$

n - orbit no
/ shell no

z = Atomic no

Calculate the radius of 1st, 2nd, 3rd and 4th Bohr's orbit of hydrogen atom.



for H-atom

$$r = 0.529 \frac{n^2}{Z}$$

$$r_H = 0.529 \times n^2$$

↳ radius of H-atom

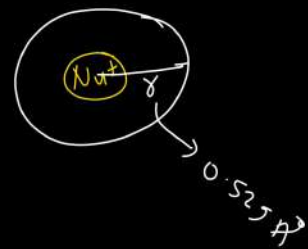
Calculate the radius ratio of 3rd & 5th orbit of He²⁺

$$r_{H1}^1 = 0.529 \times (1)^2 = 0.529 \text{ \AA}$$

$$r_H^2 = 0.529 \times (2)^2 = 0.529 \times 4$$

$$r_H^3 = 0.529 \times (3)^2 = 0.529 \times 9$$

$$r_H^4 = 0.529 \times (4)^2 =$$



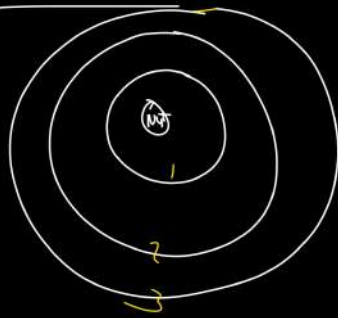
Q Calculate the radius ratio of 2nd orbit of hydrogen and 3rd orbit of Li²⁺

$$\frac{r_{Li^{2+}}}{r_H} = \frac{0.529 \frac{n^2}{Z}}{0.529 \frac{n^2}{Z}} = \frac{\cancel{0.529} \times \frac{(3)^2}{3}}{\cancel{0.529} \times \frac{(2)^2}{1}}$$

Some Important terms

Ground state — The state at which energy of an electron is minimum (G.S)

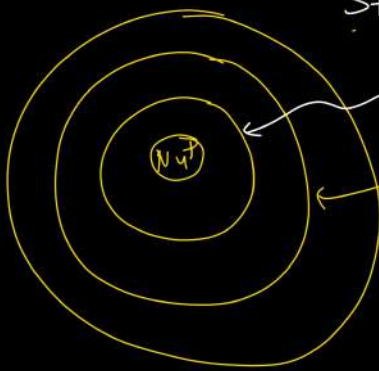
for H-atom



energy $\propto$ orbit no

in this condition 1st is a ground state

Excited state (E.S) — Any state of an electron except ground state is called excited state.



energy minimum
(G.S) ← Ground state

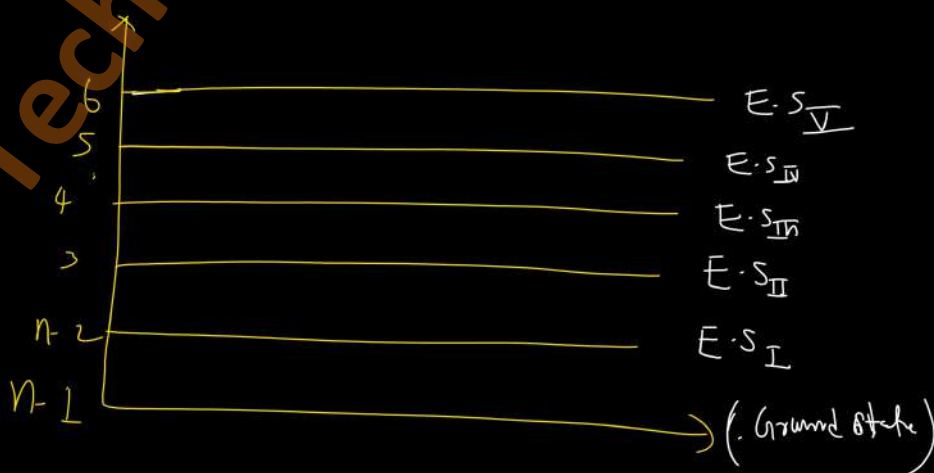
excited state

$n=4$	E.S
$n=3$	E.S
$n=2$	E.S
$n=1$	G.S

n — orbit / shell no

for an atom

Different Types of excited state



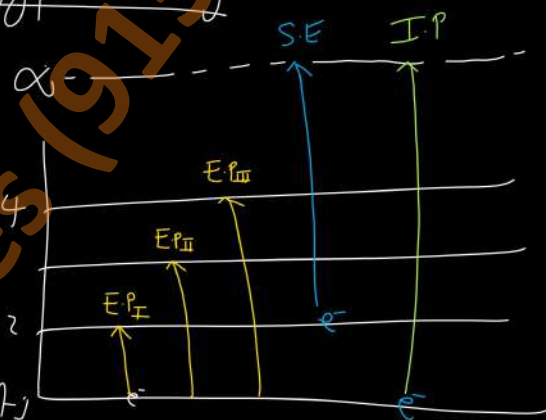
Calculate the radius ratio of 2nd excited state of Hydrogen and 1st excited state of Li²⁺

$$\frac{r_{Li^{2+}}}{r_H} = \frac{0.529 \frac{n^2}{Z}}{0.529 \frac{n^2}{Z}} = \frac{0.529 \frac{(2)^2}{3}}{0.529 \frac{(3)^2}{1}}$$

Excitation potential/energy/enthalpy

Separation energy

Ionisation energy

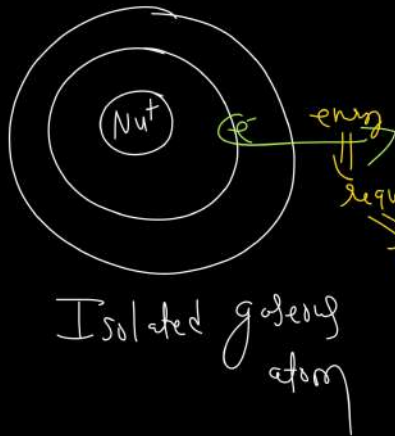


Excitation Potential — The energy required to transfer electron from Ground state to any excited state

Separation energy — The energy required to transfer electron from excited state to infinite

Ionisation Potential — The energy required to transfer electron from ground state to infinite

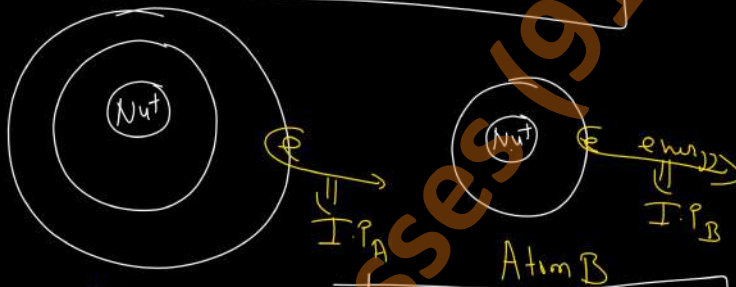
Ionisation Potential



The minimum amount of energy required to remove electrons from any Isolated gaseous atom.

minimum required energy
I.P

$$I.P \propto \frac{1}{\text{Atomic Size}}$$



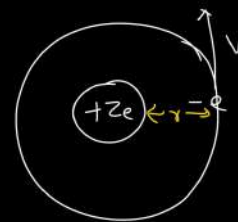
CA Force $\propto \frac{1}{r^2} \Rightarrow I.P \propto \frac{1}{r}$

Atomic size $A > B$
 $I.P = I.P_A < I.P_B$

Atomic size $\propto \frac{1}{I.P}$

Calculation of energy (E)

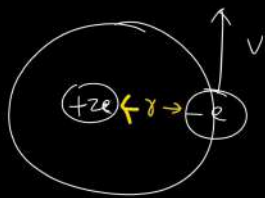
Total energy (E_n) = K.E + P.E



Energy (E_n)

$E_n \Rightarrow n^{\text{th}}$ orbit
energy

$$\text{Total energy} = \text{Kinetic energy} + \text{Potential energy}$$
$$(E_n) \quad (K.E) \quad (P.E)$$



$$K.E = \frac{1}{2} m v^2$$

as we know

$$m v^2 = \frac{z e^2}{r}$$

$$K.E = \frac{1}{2} \frac{z e^2}{r}$$

$$K.E = \frac{z e^2}{2r}$$

$$P.E = k \frac{q_1 q_2}{r^2}$$

$$= k \frac{(+ze)(-e)}{r}$$

$$P.E = - \frac{k z e^2}{r}$$

in CGS unit system $k=1$

$$P.E = - \frac{z e^2}{r}$$

$$\text{Total energy} = K.E + P.E$$
$$(E_n)$$

$$= \frac{z e^2}{2r} + \left(- \frac{z e^2}{r} \right)$$

$$= \frac{z e^2 + (-2 z e^2)}{2r}$$

$$E_n = - \frac{z e^2}{2r}$$

$$K.E = \frac{z e^2}{2r}$$

$$P.E = - \frac{z e^2}{r}$$

Relation b/w E_n , K.E & P.E

$$E_n = -K.E = \frac{P.E}{2}$$

→ In this relation K.E not negative, It is only a Relation ship

Question

$$K.E = 0.34 \text{ V}$$

$$E_n = ?$$

$$E_n = -K.E = -0.34 \Rightarrow E_n$$

Question

$$E_n = -0.54 \text{ V}$$

$$P.E = ?$$

$$E_n = \frac{P.E}{2} \Rightarrow P.E = 2E_n$$

$$P.E = 2(-0.54) = -1.08 \text{ V}$$

$$E_n = -\frac{Ze^2}{2a}$$

Putting the value of a in this equation

$$a = \frac{n^2 h^2}{4\pi^2 m Ze^2}$$

$$E_n = -\frac{Ze^2}{2 \left(\frac{n^2 h^2}{4\pi^2 m Ze^2} \right)}$$

$$E_n = -\frac{Ze^2 \cdot 2\pi^2 m Ze^2}{n^2 h^2}$$

$$E_n = \frac{Z^2 e^4 2\pi^2 m}{n^2 h^2}$$

$$E_n = -\frac{2\pi^2 m e^4}{h^2} \left(\frac{Z^2}{n^2} \right)$$

Putting the value of π , m , e & h in CGS units

$$E_n = -\frac{2(3.14)^2(9.1 \times 10^{-28} \text{ g})(-4.8 \times 10^{-10})^4}{(6.67 \times 10^{-27})^2} \left(\frac{Z^2}{n^2} \right)$$

$$E_n = -2.18 \times 10^{-18} \left(\frac{Z^2}{n^2} \right) \text{ J/atom}$$

$$E_n = -13.6 \left(\frac{Z^2}{n^2} \right) \text{ eV/atom}$$

Q Calculate the energy of 1st, 2nd, 3rd and 4th orbit of hydrogen atom

$$Z=1$$

$$E_n = \frac{-13.6}{n^2} \rightarrow \text{for H-atom}$$

n=1 for H-atom

$$E_1^H = \frac{-13.6}{(1)^2} = -13.6 \text{ eV}$$

$$E_2^H = \frac{-13.6}{(2)^2} = -\frac{13.6}{4} = -3.4 \text{ eV}$$

$$E_3^H = \frac{-13.6}{(3)^2} = -\frac{13.6}{9} = -1.51 \text{ eV}$$

$$E_4^H = \frac{-13.6}{(4)^2} = -\frac{13.6}{16} = -0.85 \text{ eV}$$

$$E_5^H = \frac{-13.6}{(5)^2} = -\frac{13.6}{25} = -0.54 \text{ eV}$$

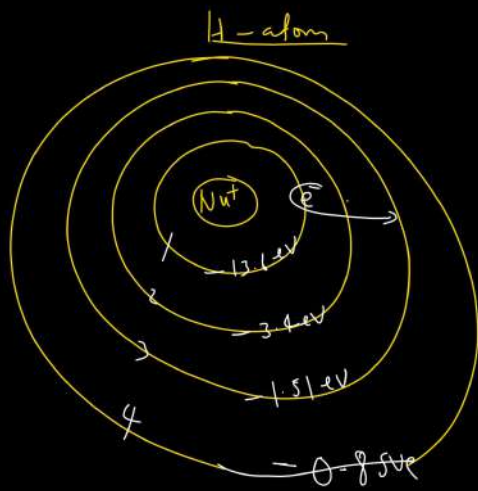
Q Calculate energy of 2nd orbit of He^{2+}

$$Z=2 \quad n=2$$

$$E_n = -13.6 \left(\frac{Z^2}{n^2} \right)$$

$$= -13.6 \left(\frac{(2)^2}{(2)^2} \right)$$

$$= -13.6 \text{ eV}$$



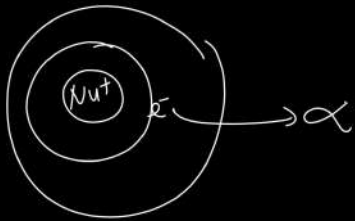
Q Calculate Excitation potential
When electron transits from
Ground state of H-atom to
2nd excited state

$$E_{H} = -1.51 - (-13.6 \text{ eV})$$

$$= -1.51 + 13.6 \text{ eV}$$

$$=$$

Q Calculate Ionisation potential in case of H-atom



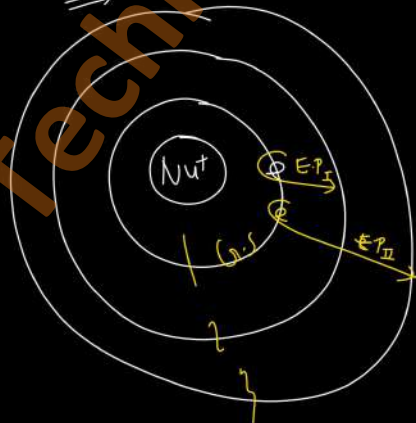
$$E_n = -\frac{13.6}{n^2}$$

$$= -\frac{13.6}{\infty} = 0$$

$$I.P = E_{\infty} - E_1$$

$$= 0 - (-13.6) = +13.6 \text{ eV}$$

Q Calculate 2nd Excitation potential for H-atom



$$E.P_{II} = E_3 - E_1$$

$$= -1.51 \text{ eV} - (-13.6 \text{ eV})$$

$$= 12.09 \text{ eV}$$

Velocity of an electron

$$m v^2 = \frac{z e^2}{r} \quad \text{--- (1)}$$

$$m v r = \frac{n h}{2 \pi} \quad \text{--- (2)}$$

Divide eq (1) by (2)

$$\frac{m v^2}{m v r} = \frac{z e^2}{r} \times \frac{2 \pi}{n h}$$

$$v = \frac{2 \pi z e^2}{n h}$$

$$v = \frac{2 \pi e^2}{h} \left(\frac{z}{n} \right)$$

z = Atomic no n - no of orbit

$$v = \frac{2 \pi e^2}{h} \left(\frac{z}{n} \right)$$

Putting the value of π, e & h in equation

$$v = \frac{2 (3.14) (-4.8 \times 10^{-10})^2}{(6.62 \times 10^{-27} \text{ kg})} \left(\frac{z}{n} \right)$$

$$v = 2.18 \times 10^6 \left(\frac{z}{n} \right) \text{ m/s}$$

Calculate velocity of electron

present in 2nd orbit of He^{2+} Given $\text{He } z=2$
 $n=2$

$$v = 2.18 \times 10^6 \left(\frac{z}{n} \right)$$

$$v = 2.18 \times 10^6 \left(\frac{2}{2} \right)$$

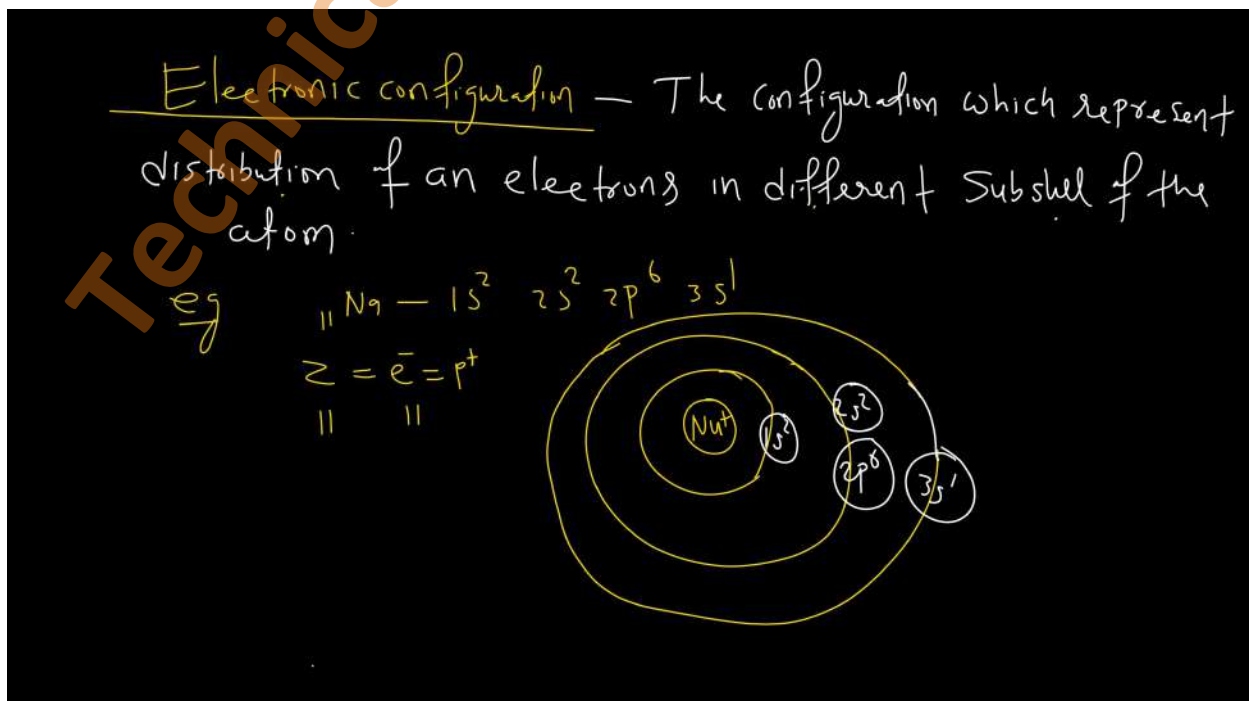
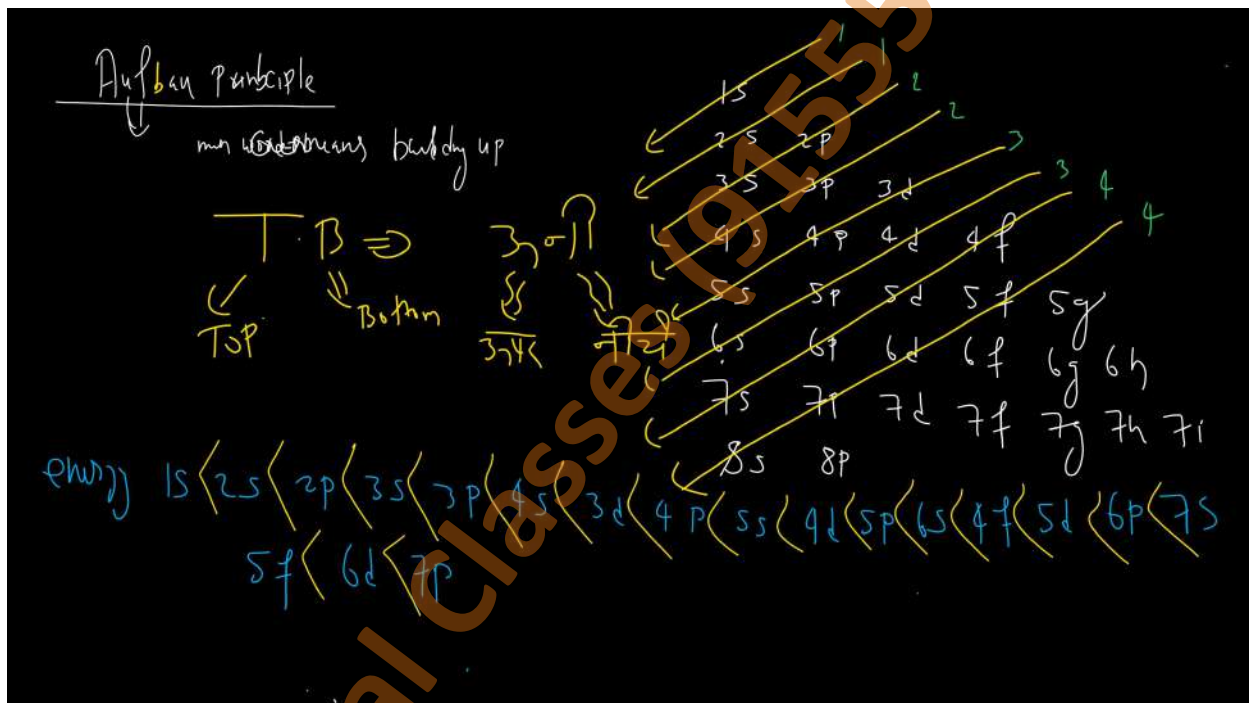
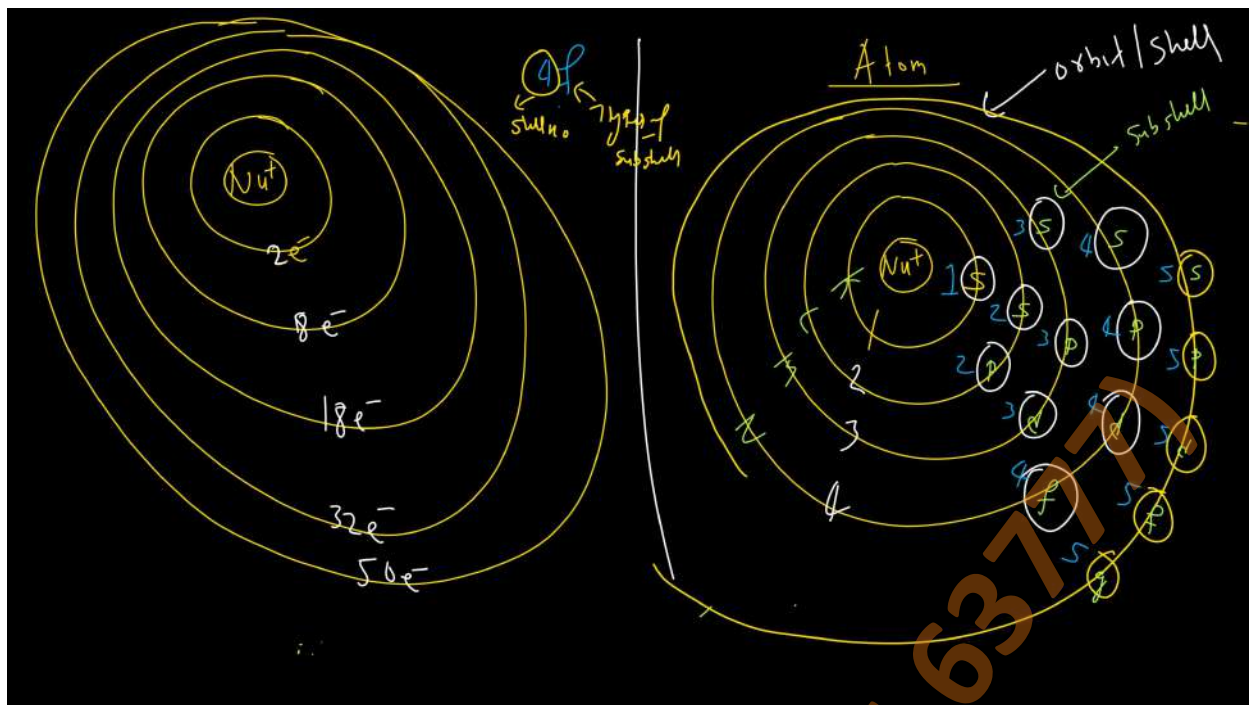
$$v = 2.18 \times 10^6 \text{ m/s}$$

Bohr-Bury principle

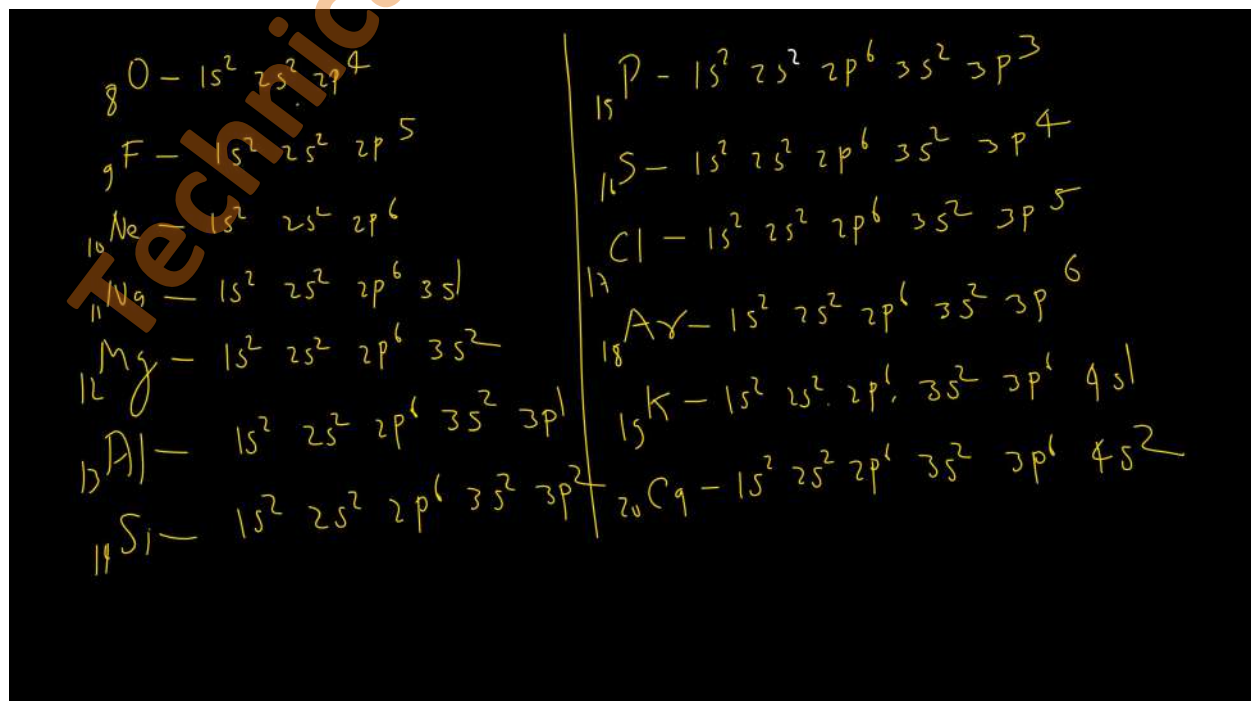
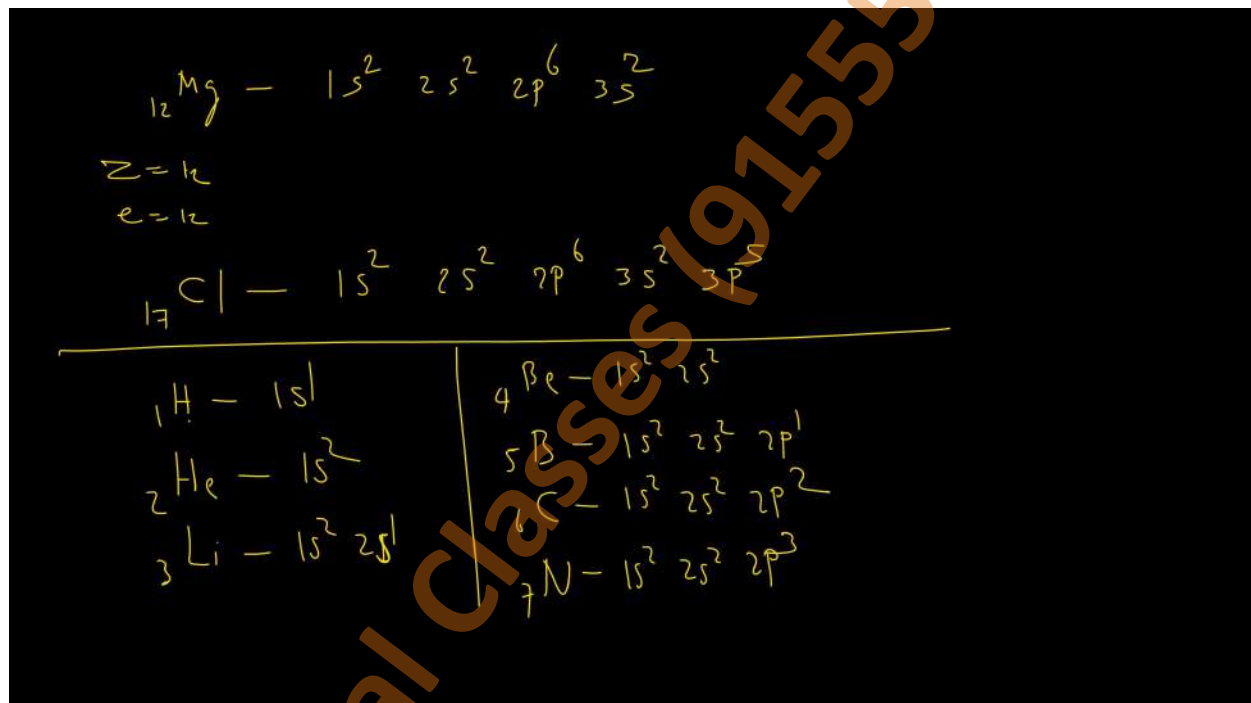
Maximum number of electrons present in a orbit = $2n^2$

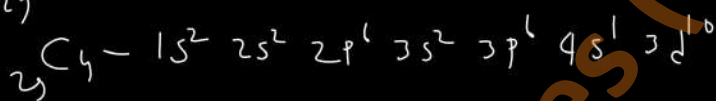
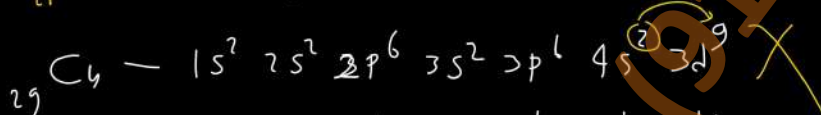
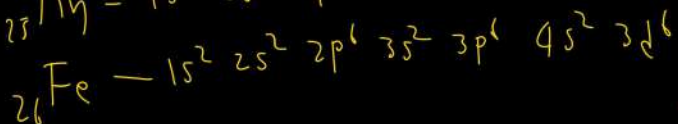
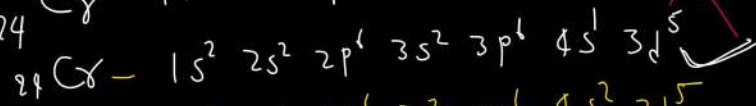
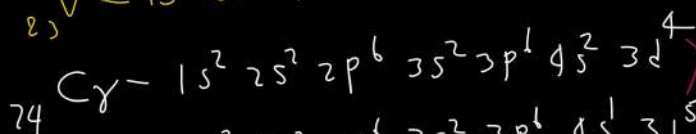
where n - no of orbit / shell

1 st	2 nd	3 rd	4 th	5 th	1 st orbit = $2(1)^2 = 2e^-$
1 st	2 nd	3 rd	4 th	5 th	2 nd " = $2(2)^2 = 8e^-$
1 st	2 nd	3 rd	4 th	5 th	3 rd " = $2(3)^2 = 18e^-$
1 st	2 nd	3 rd	4 th	5 th	4 th " = $2(4)^2 = 32e^-$
1 st	2 nd	3 rd	4 th	5 th	5 th " = $2(5)^2 = 50e^-$

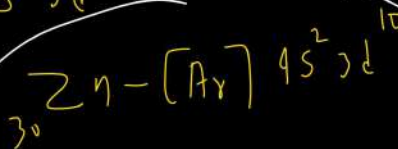


Atom ↓ shell / orbit ↓ Subshell	Types of shell	
	Subshell	maximum no of e ⁻
	s (sharp)	2e ⁻
	p (principal)	6e ⁻
	d (diffused)	10e ⁻
	f (fundamental)	14e ⁻
Q maximum number of electron present in i subshells (g) 2 (b) 10 (d) 18 (f) 26		18e ⁻ 32e ⁻ 21e ⁻





He Ne Ar



How
short E.C

Electronic configuration of 24Cr & 29Cu

Types of subshell = (i) Full filled subshell (F.F.S)

eg $2s^2$, $3p^6$, $4d^{10}$, $5f^{14}$

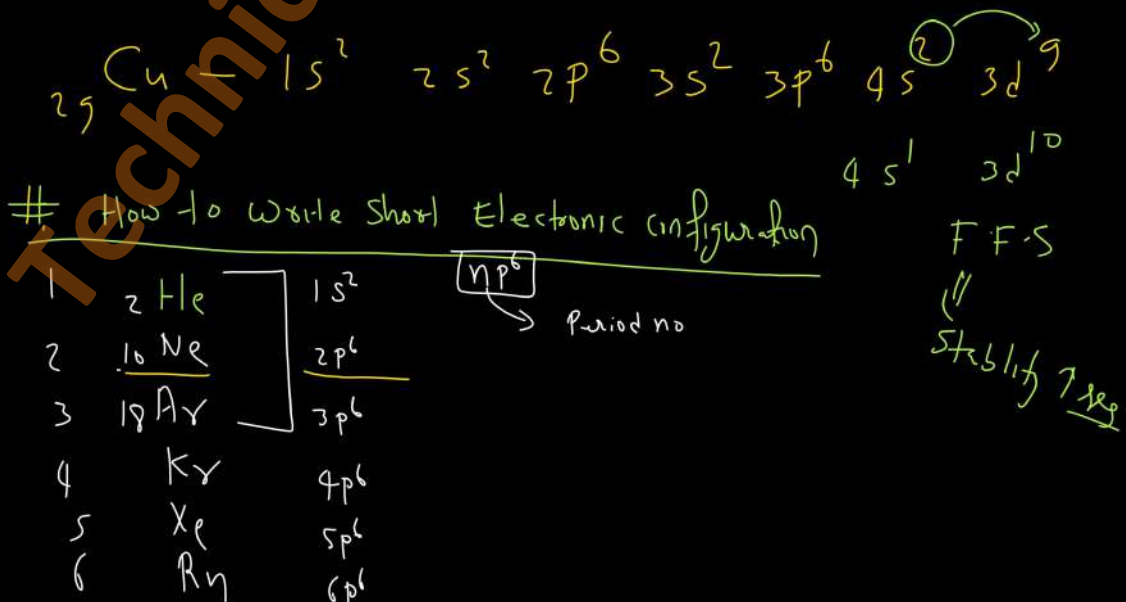
(ii) half filled subshell

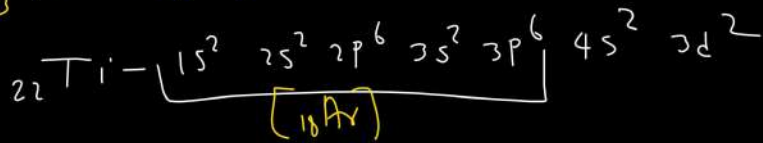
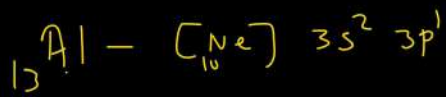
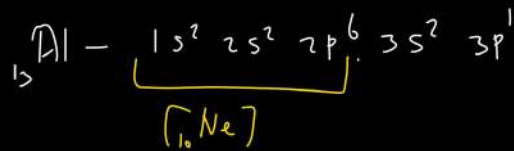
eg $2s^1$, $3p^3$, $5d^5$, $4f^7$

(iii) more than half fill eg np^4 np^5 , $3d^6$

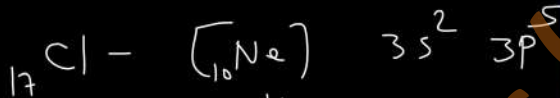
(iv) less than half filled eg - np^2 , np^1 , nd^4 nd^1

Stability = F.F.S > H.F.S > M.H.F > L.H.S

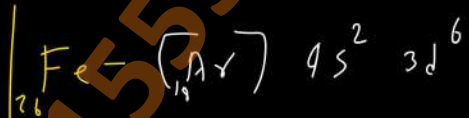




$$25 - 18 = 7$$



$$17 - 10 = 7$$



$$26 - 18 = 8$$

Along

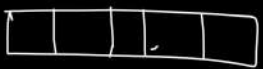
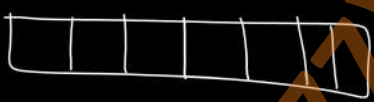
↓
 Shell / orbit (K, L, M, N)

1, 2, 3, 4

↓
 Sub shell - (s, p, d, f)

↓

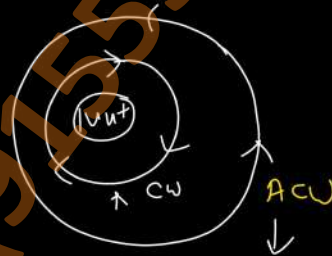
Orbital

Subshell	maximum n.e	No of orbitals	Representation
s	$2e^-$	1	
p	$6e^-$	3	
d	$10e^-$	5	
f	$14e^-$	7	
g	$18e^-$	9	
h	$22e^-$	11	
i	$26e^-$	13	

Representation of an electron

Up spin - $\uparrow$ or 1

Down spin - $\downarrow$ or L



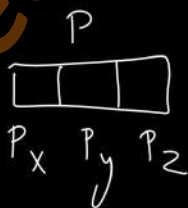
Hund's Rule A/c to Hund's at first single electrons

filled in all degenerate orbitals in same spin

When all degenerate orbitals got single electrons then

Pairing occurs in opposite spin.

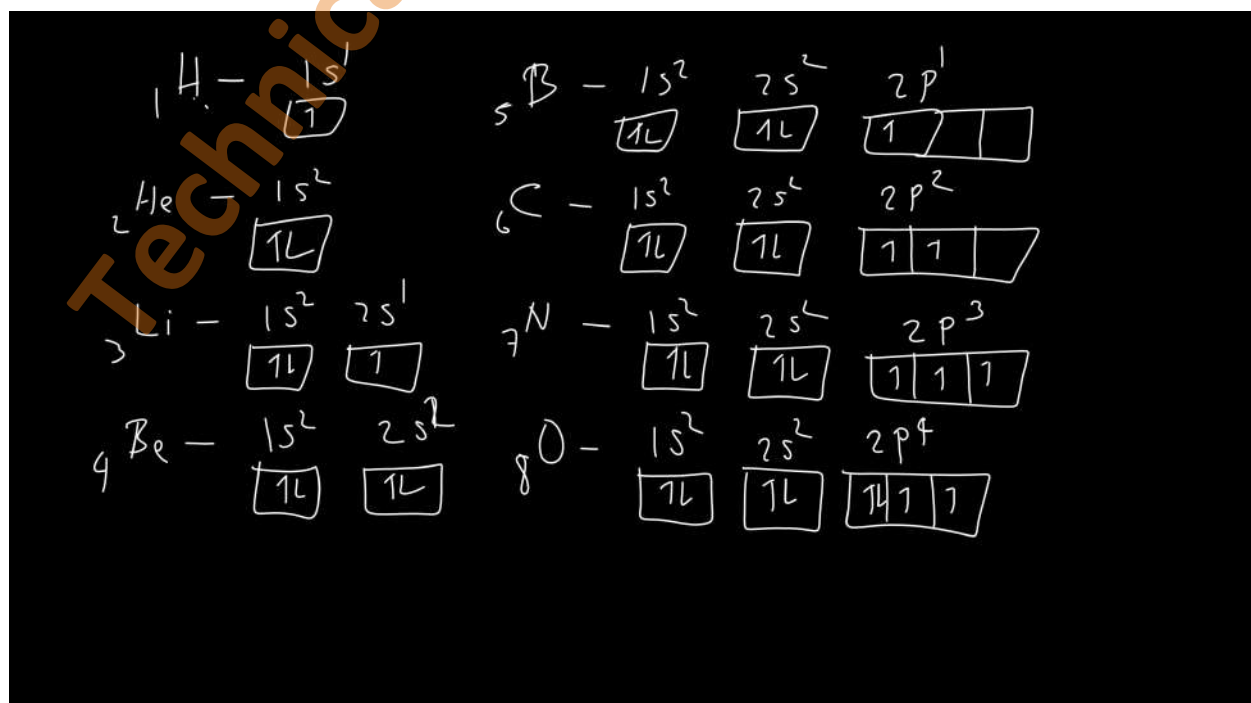
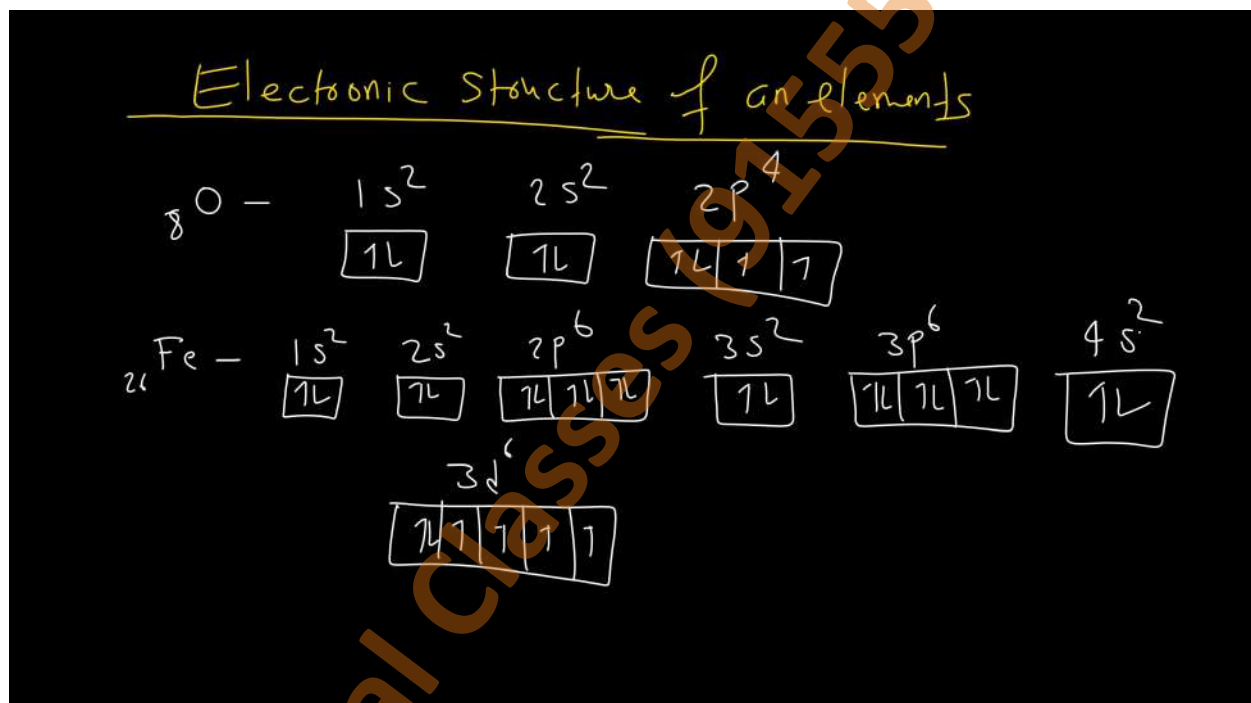
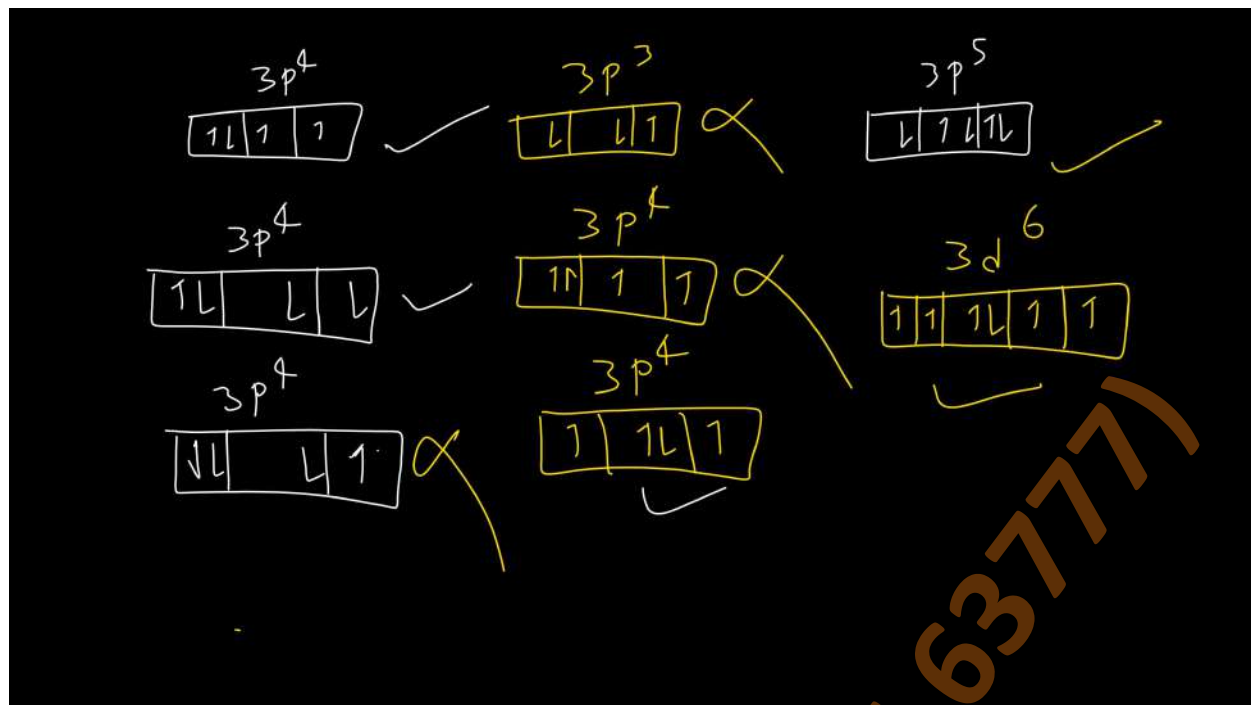
degenerate orbital - Orbitals having same energy i.e orbitals of same subshell

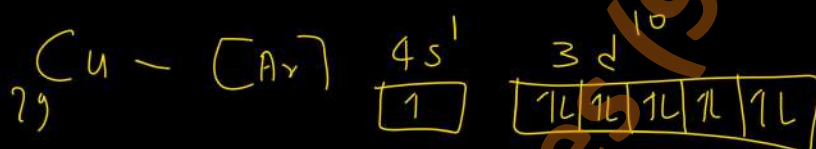
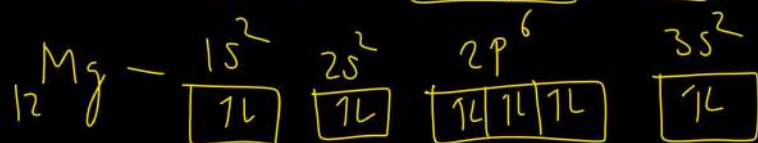
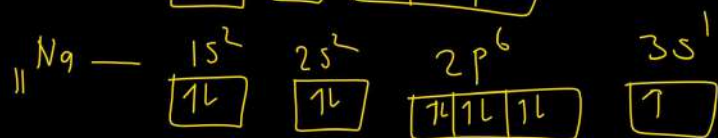
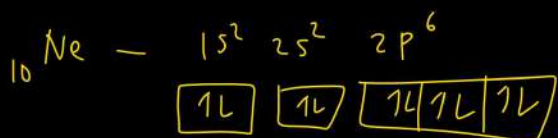
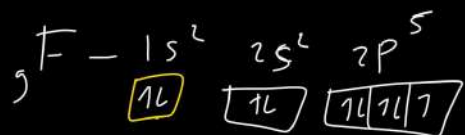


$$energy = P_x = P_y = P_z$$



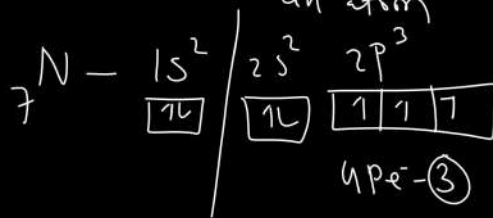
energy of all orbitals of this subshell becomes same





Some Important terms

- ① Unpaired electron — The single electron present in orbitals of outermost shell (Valence shell) of an atom

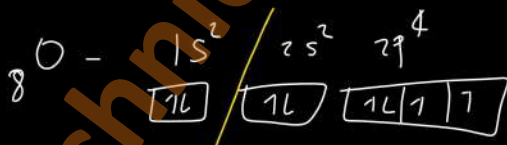
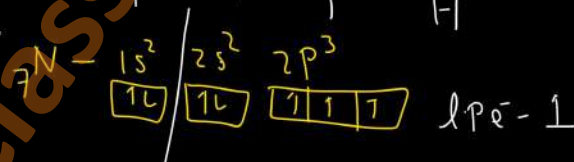
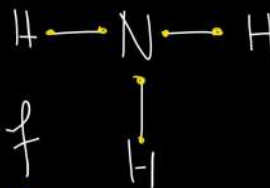


Unpaired electrons are also known as bond paired electrons because they directly participate in bond formation

eg ammonia (NH_3)

lone paired electron (l.p.e)

The paired electrons present in orbitals of outermost shell.



$$\text{u.p.e} / \text{b.p.e} = 2$$

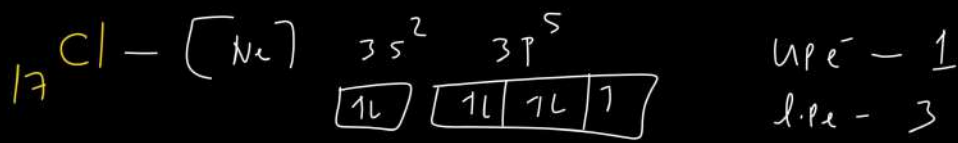
$$\text{l.p.e} = 2$$

Lewis symbol



for nitrogen





Lewis symbol - $\cdot \ddot{\text{Cl}} \cdot$
 # Electronic Configuration of ions

ions

✓

Cation = +ve charge

⇓

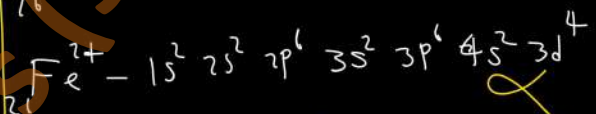
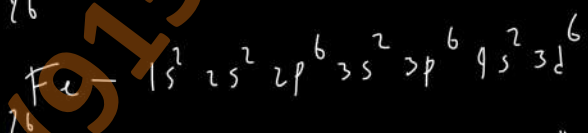
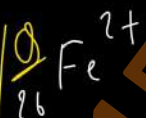
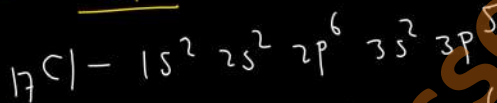
due to loss of electron

✗

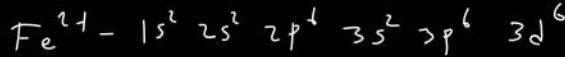
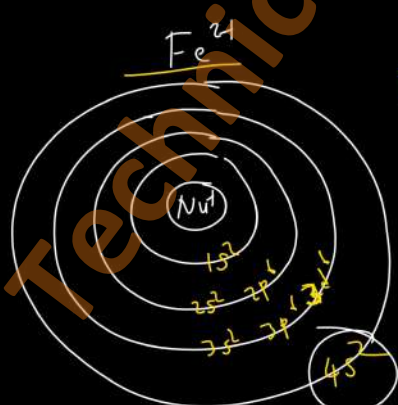
Anion ⇒ negative charge

⇓

Due to gain of electron



electrons added or removed only from outermost shell of the atom during the formation of ions



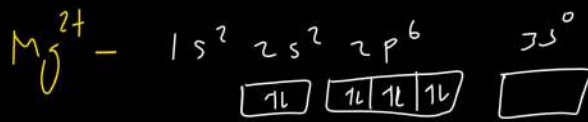
Paramagnetic Nature - which

contain unpaired electron

Diamagnetic Nature = which contain no unpaired electron.

magnetic moment = $\sqrt{n(n+2)}$

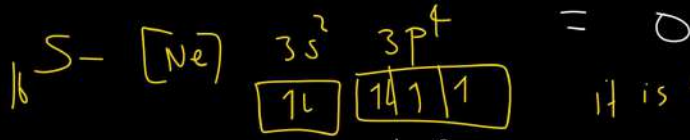
n - number of unpaired electron.



$$U.P.e - 0$$

Diamagnetic nature

$$\text{magnetic moment} = \sqrt{n(n+2)}$$



$$U.P.e - 2$$

$$L.P.e - 2$$

it is paramagnetic in nature

$$m.m = \sqrt{2(2+2)}$$

Quantum number

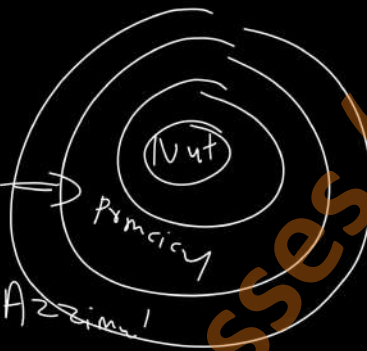
Atom

↓
shell / orbit

↓
Subshell ⇒ Azimuthal

↓
Orbital ⇒ Magnetic

↓
Group ⇒ Spin



Solar Syst

3rd shell ⇒ Earth / orbit

91 ⇒ Country

8 5 4 2 0 2 ⇒ Area

11 N-294 ⇒ House

Quantum number - The number which used to locate

the position of an electron in the atom

Types of Quantum number

- (i) Principal Quantum number (n)
- (ii) Azimuthal " " (l)
- (iii) Magnetic " " (m_l) (m)
- (iv) Spin " " (m_s) or (s)

① Principal quantum (n) A quantum number which represent shell / orbit of an electron.

<u>Shell / orbit</u>	<u>Value of n</u>
K - shell	1
L - shell	2
M - "	3
N "	4
O "	5
P "	6
Q "	7

Azimuthal quantum Number (l) — A quantum number which represent subshell of an electron.

<u>Subshell</u>	<u>Value of l</u>
s	0
p	1
d	2
f	3
g	4
h	5
i	6

Q Which of the following set of quantum number not possible

	<u>n</u>	<u>l</u>	<u>Subshell</u>	
(i)	0	1	0p	not possible
(ii)	1	0	1s	possible
(iii)	3	4	3g	not possible
(iv)	4	3	4f	possible
(v)	6	6	6i	Not possible

Magnetic quantum number (m_l or m)

Quantum Number

Types

- (i) Principal Quantum number (Given by - Bohr)
- (ii) Azimuthal Quantum number
or
Angular " " (Given by - Sommerfeld)
Secondary " "
Subsidiary " "

(iii) Magnetic Quantum number (Given by Linde)
or

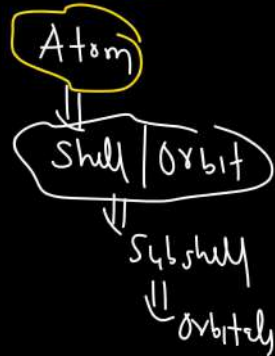
Orientation Quantum number

(iv) Spin Quantum number (s)

- Given by - Goudsmit & Uhlenback

① Magnetic Quantum Number (m or m_l)

It represent orientation of orbital



Value of m = $+l$ to $-l$ including zero

for p-orbital $l = 1$

$$m = +1, 0, -1$$

for d-orbital $l = 2$

$$m = +2, +1, 0, -1, -2$$

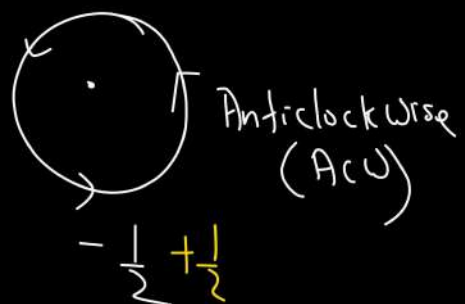
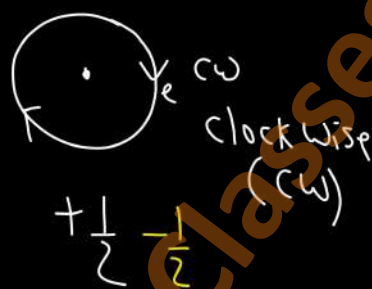
<u>Subshell</u>	<u>Orbitals</u>	<u>value of l</u>	<u>value of m</u>
s	1	0	0
p	3	1	-1, 0, +1
d	5	2	-2, -1, 0, +1, +2
f	7	3	-3, -2, -1, 0, +1, +2, +3

Q Which of the following set of quantum number possible

	<u>n</u>	<u>l</u>	<u>m</u>		
(I)	2	1	0	2p	possible
(II)	3	0	-1	3s	not possible
(III)	4	2	-2	4d	possible
(IV)	1	1	0	(1p)	not possible

(IV) Spin Quantum number

It represent spin of an electron



Q Which of the following set of quantum

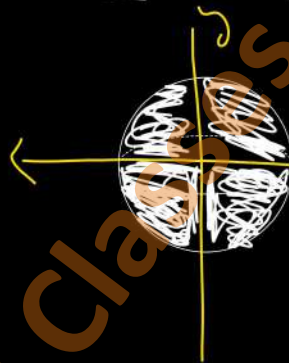
	<u>n</u>	<u>l</u>	<u>m</u>	<u>s</u>	
(I)	1	0	0	$+\frac{1}{2}$	1s it's possible
(II)	5	4	-3	$-\frac{1}{2}$	5g possible
(III)	3	3	0	$+\frac{1}{2}$	3f not possible
(IV)	4	3	(+4)	$-\frac{1}{2}$	4f not possible

Orbitals - The 3 dimensional space around nucleus where finding probability of an electron is maximum.

Types of orbitals are its shape

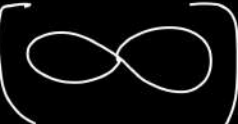
(i) S-orbital

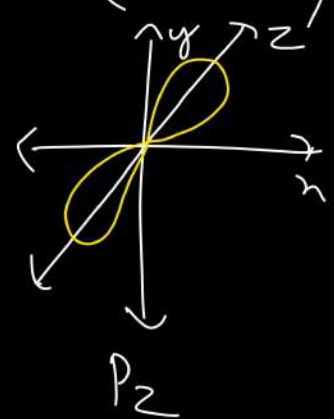
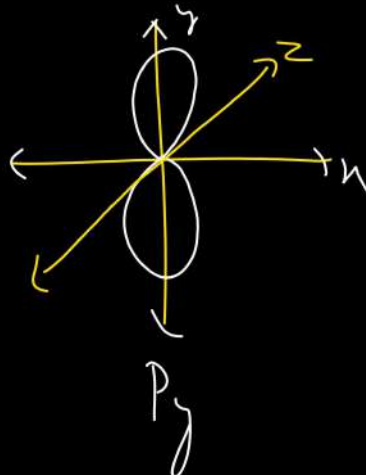
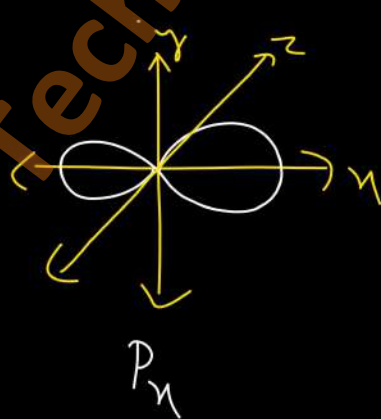
Shape - Spherical



It is symmetrical around all axis

(ii) P-orbitals

Shape - dumbbell ()



$2 = n$ $\swarrow$ 2p - Subshell $\searrow$ $l = 1$

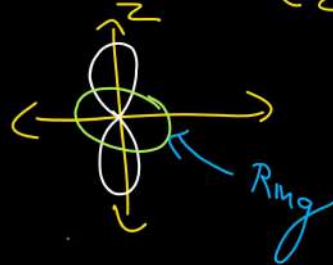
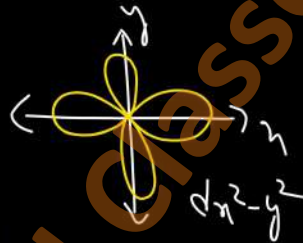
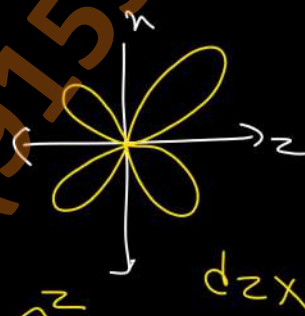
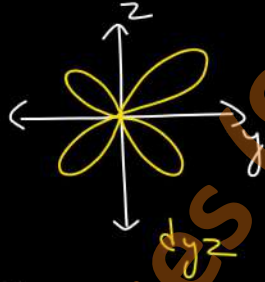
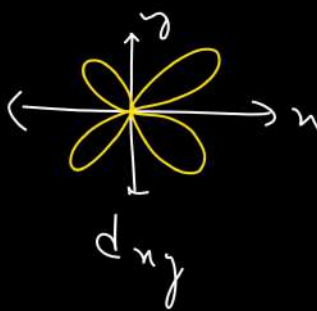
p_x	p_y	p_z
-------	-------	-------

$m = -1 \quad 0 \quad +1$

d-orbitals Shape = double dumbbell



Types of d-orbitals



$3 = n$ $\swarrow$ 3d $\searrow$ $l = 2$

--	--	--	--	--

$-2 \quad -1 \quad 0 \quad +1 \quad +2$

Some Important terms

- ① Node Point
- ② Node Surface
- ③ Node Plane

① Node Point - The point in orbital where finding probability of an electron is minimum.
for s orbital

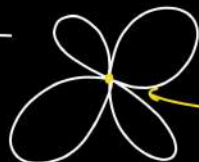


for p-orbital



Node Point = 1

for d-orbital



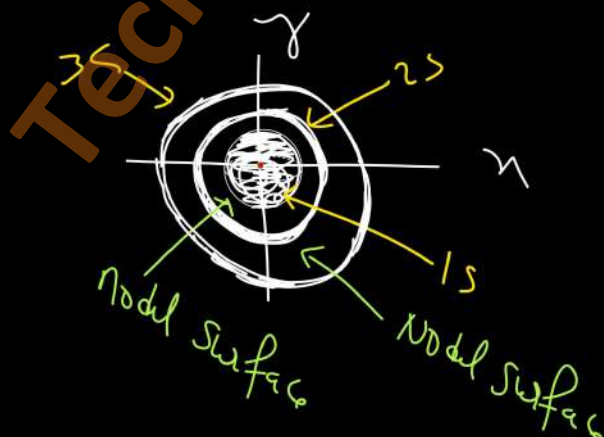
Node Point = 1

except s-orbital
all orbitals have
one node point.

- # Node point ✓
- # Node Surface
- # Node Plane

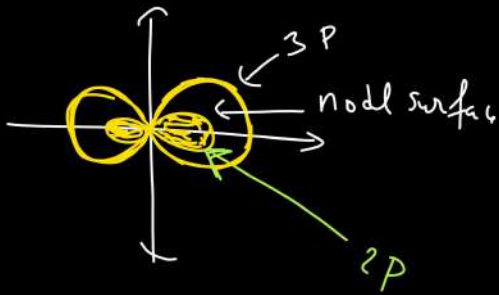
Node Surface - The surface between the atomic orbital where finding probability of an electron is minimum

for example - s-orbital

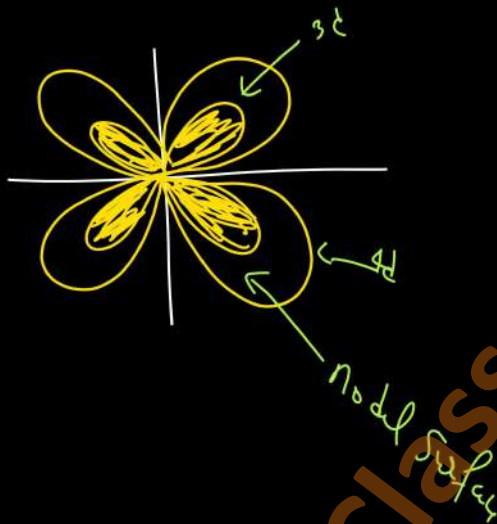


<u>Orbital</u>	<u>Node surface</u>
1s	0
2s	1
3s	2
ns	$(n-1)$

for p-orbital

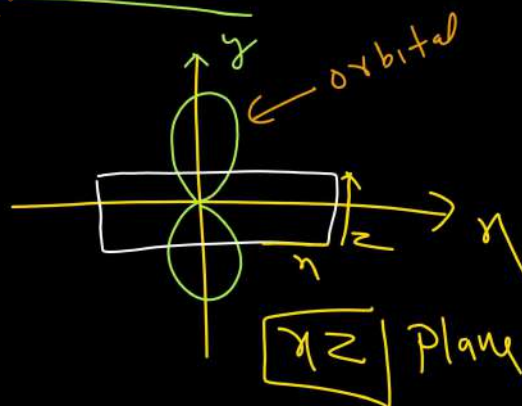


<u>Orbital</u>	<u>Node Surface</u>
2p	0
3p	1
4p	2
np	$(n-2)$



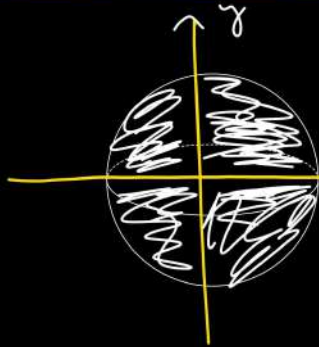
<u>Orbital</u>	<u>Node Surface</u>
3d	0
4d	1
5d	2
nd	$n-3$

Node plane



The plane around atomic orbitals where finding probability of an electron is minimum.

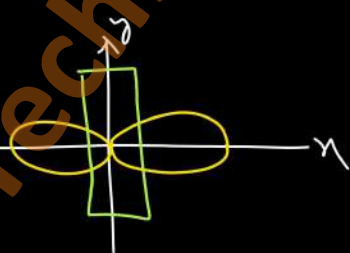
for s-orbital



→ it is symmetrical around all axis so nodal plane zero

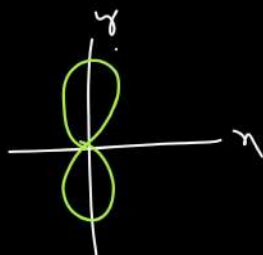
for p-orbital

$$n(y) \neq n(x) \neq n(z)$$



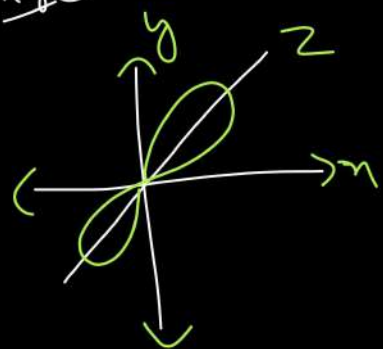
p_x -orbital

Nodal plane - yz or xy



p_y -orbital

xz or xz plane



p_z -orbital

xy or yx -plane

Node plane in d-orbitals

<u>Orbital</u>	<u>node plane</u>
d_{xy}	xz or yz
d_{yz}	xy or xz
d_{zx}	xy or yz
$d_{x^2-y^2}$	z
d_{z^2}	0

xy

xy

xy

$(n + l)$ Rule

n - Principal Quantum Number

l - Azimuthal quantum no

To decide energy of subshell

$$\text{energy} = 1s < 2s < 2p < 3s < 3p < 4s$$

Q Write sequence of subshell in increasing order of energy

(1) $4s$ $5s$ $3d$ $4p$

#(i) more the value of $(n+l)$ more will be energy

eg	1s	2s	2p	energy = 1s < 2s < 2p
n	1	2	2	
l	0	0	1	
(n+l)	1	2	3	

(ii) if $(n+l)$ value same, then more value of n , more will be energy

	2p	3s	energy = 2p < 3s
n	2	3	
l	1	0	
(n+l)	3	3	

	4s	5d	3d	4p	
n	4	5	3	4	
l	0	2	2	1	
(n+l)	4	7	5	5	

energy = 4s < 3d < 4p < 5d

arranged in increasing order of energy

Q (i) $5f$ $6d$ $4p$ $4s$

(ii) $3d$ $4p$ $4s$ $2p$ $3p$

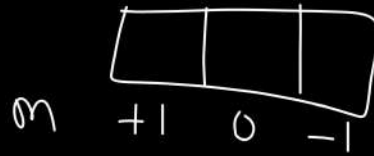
(iii) $4f$ $5f$ $4d$ $6s$ $4p$

(iv) $6s$ $5f$ $4f$ $6d$ $6p$ $7p$

Pauli exclusion principle

no any two electrons of same atom
have same set of all four Quantum
Number

	$9F$	$1s^2$	$2s^2$	$2p^5$
n		1	2	2
l		0	0	1
m		0	0	+1, 0, -1
s		$+\frac{1}{2}, -\frac{1}{2}$	$+\frac{1}{2}, -\frac{1}{2}$	$+\frac{1}{2}, -\frac{1}{2}, +\frac{1}{2}$



- (I) Spectrum
- (II) Wave mechanical model
- (III) de broglie relationship
- (IV) Heisenberg uncertainty principle

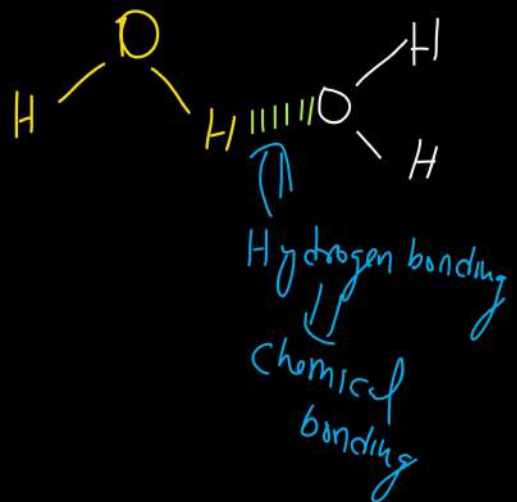
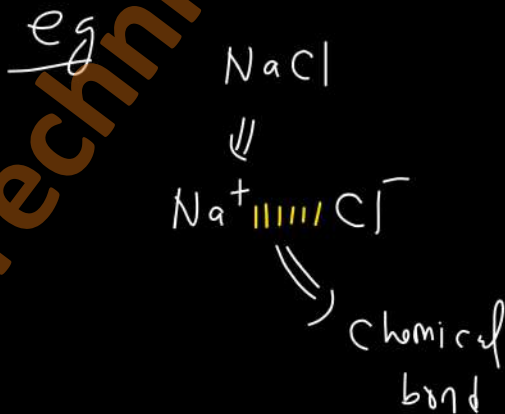
Chemical bond - A force

of attraction which hold atoms
in a molecule or compound

in H_2O molecule - A force of attraction
works between Hydrogen and
Oxygen atom



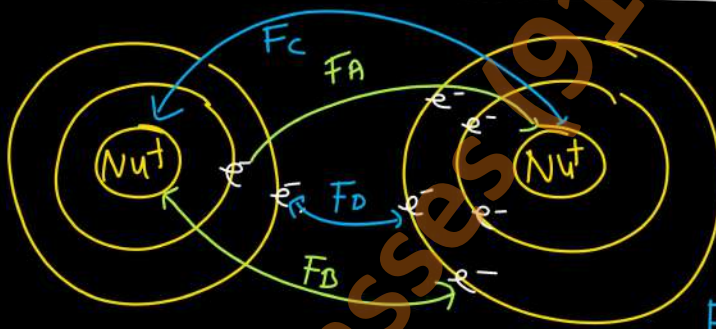
Chemical bonds also formed b/w
molecules and ions



Chemical bond — A force of attraction which act between chemical species (atom/molecules/ions)

Reason for formation of chemical bonding

(i)



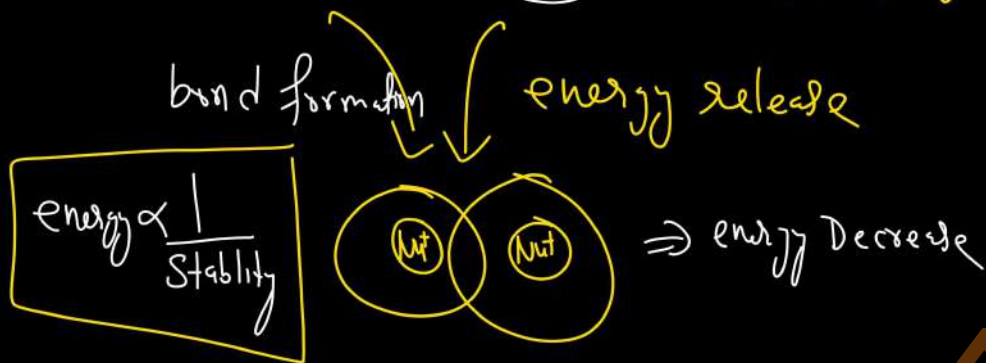
F_A & F_B — force of attraction

F_C & F_D = force of Repulsion

$$F_A + F_B > F_C + F_D \Rightarrow \text{chemical bond formed}$$

$$F_A + F_B < F_C + F_D \Rightarrow \text{chemical bond not formed}$$

(11)  Atoms at Isolated State $\Rightarrow$ high energy

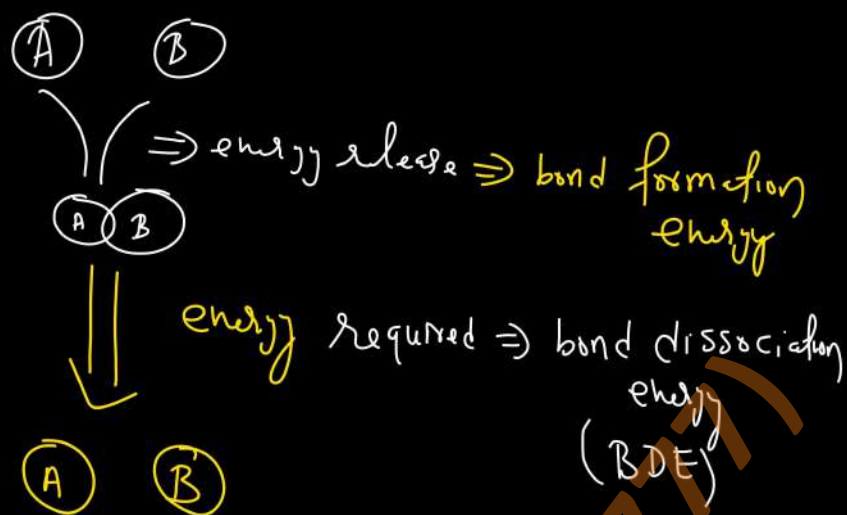


Atoms are participated in bond formation to increase it's stability.

During the formation of bond energy release

bond energy / bond formation energy — The amount of energy release during the formation of one mole bond.

Bond dissociation energy — The amount of energy required to Break one mole bond



Concept of chemical bonding

- (I) Lewis Kossel concept of chemical bonding
- (II) Valence bond Theory (VBT)
- (III) Valence Shell ^{electron} Pair repulsion Theory (VSEPR Theory)
- (IV) Hybridisation
- (V) Molecular orbital Theory (MOT)

Lewis Concept of chemical bonding

all atom try to achieve its nearest inert gas (He, Ne, Ar etc) by sharing or transfer its electron

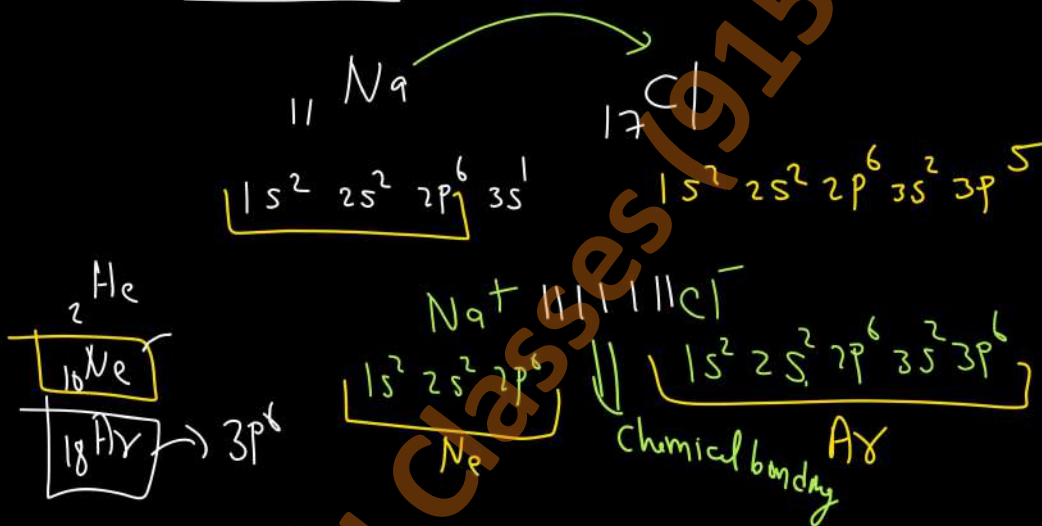
$\swarrow$ accept $\searrow$ donor

Inert gas

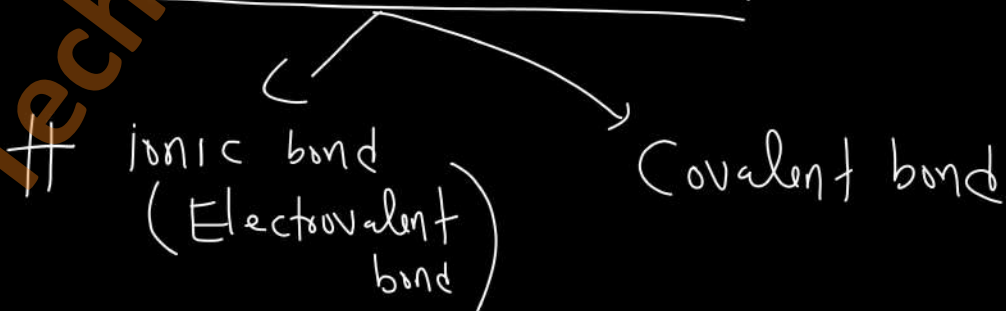


due to complete filled orbitals these are inert in nature.

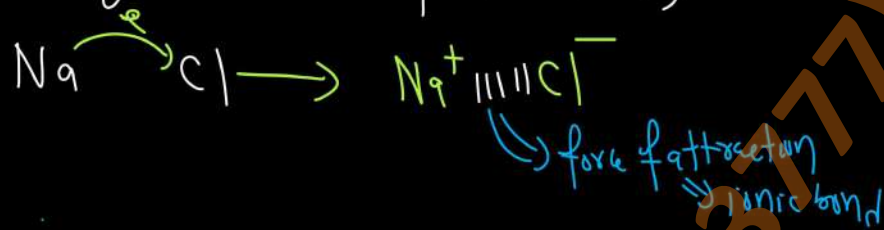
Example



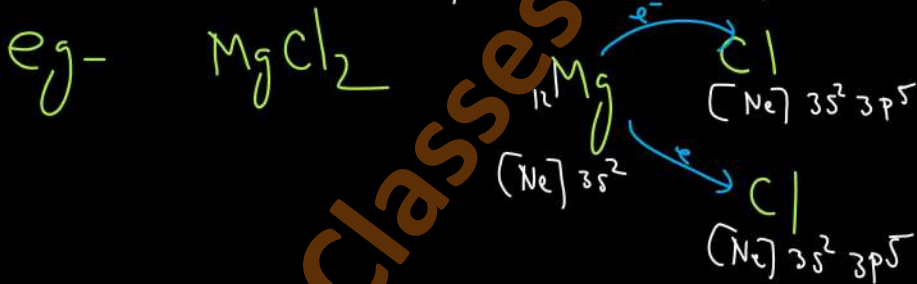
Types of chemical bond

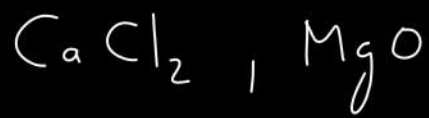


Ionic bond — Such a types of chemical bond which form by transfer of electrons



it is a electrostatic force of attraction which act between ions due to transfer of an electron.

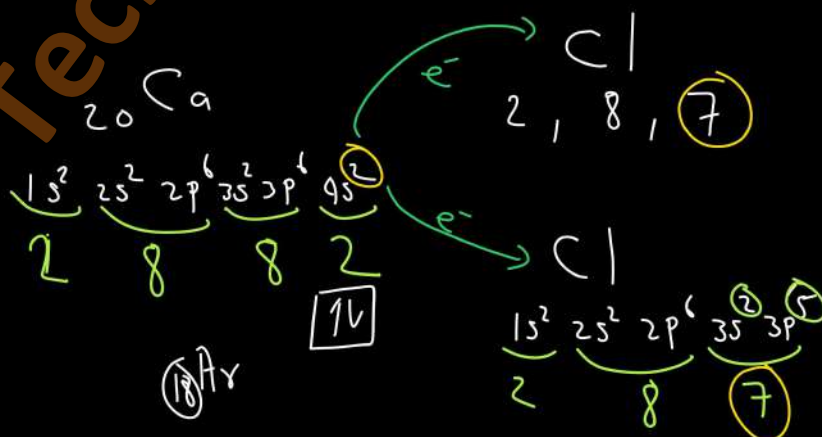




in last class

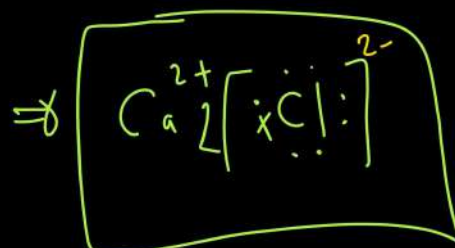
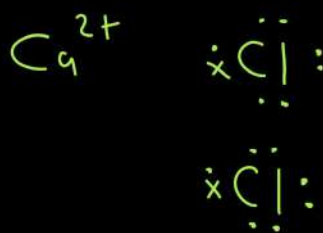
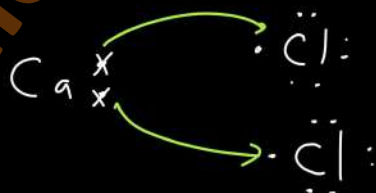
- chemical bonding
- Different concepts
- Types of chemical bonding

formation of bond in CaCl_2



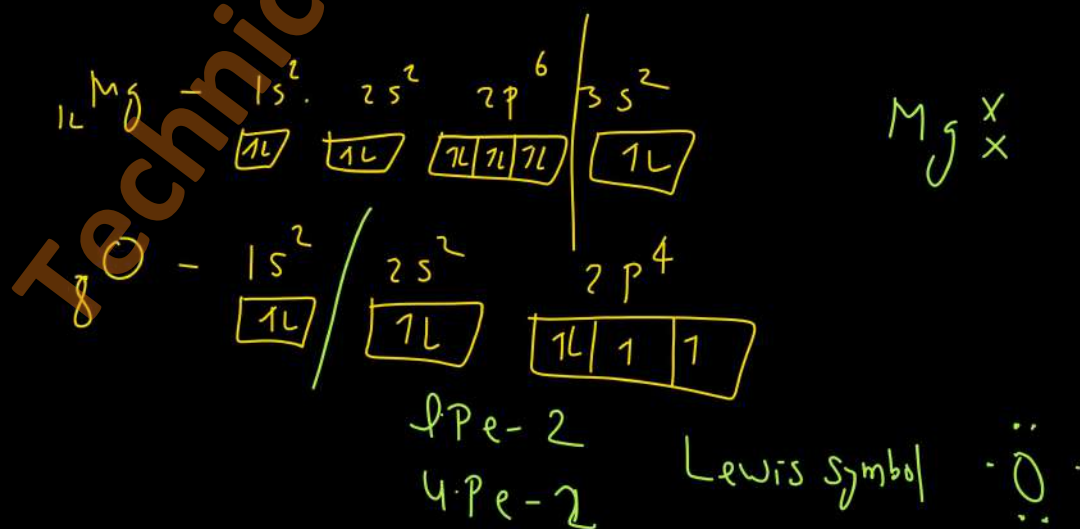
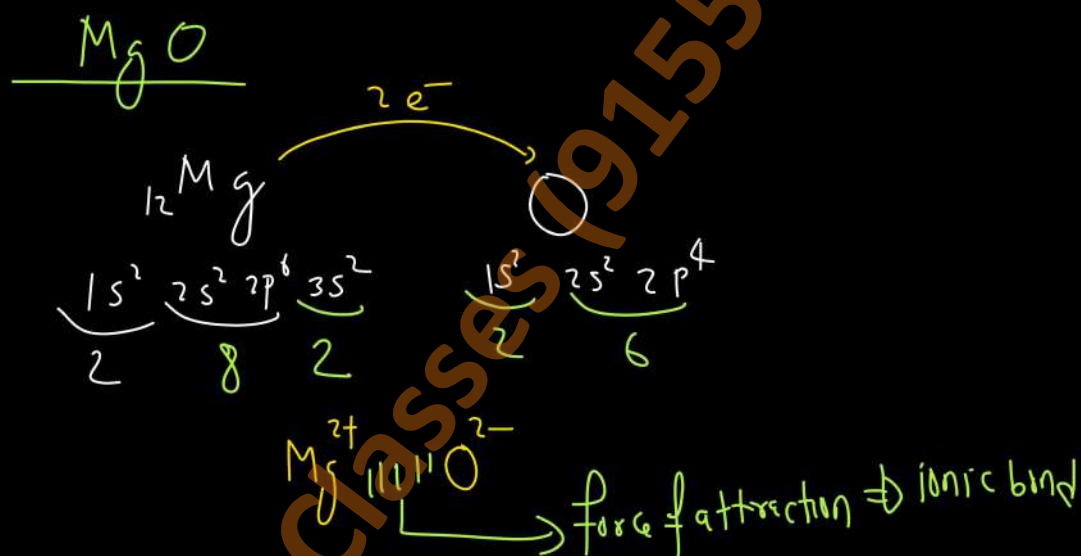


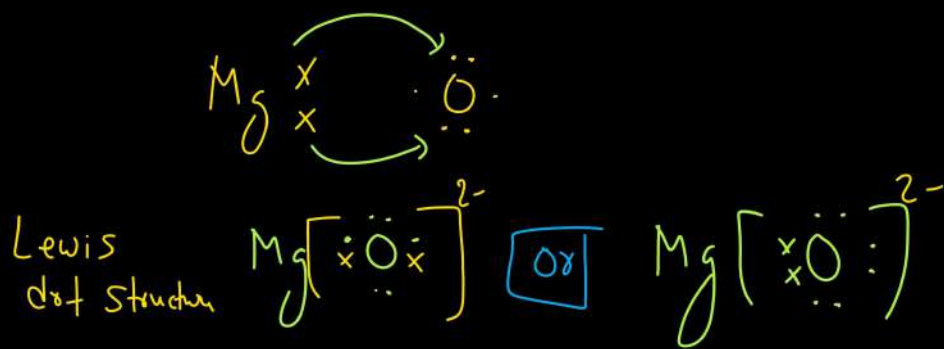
Lewis dot structure of CaCl_2



Octet Rule — every element try to achieve $8e^-$ in its outermost shell except hydrogen it is known octet the Rule is known as octet rule

hydrogen try to achieve two electrons in its outermost shell it known as duplet

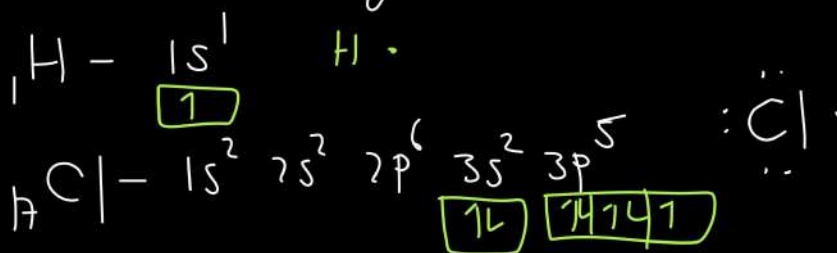


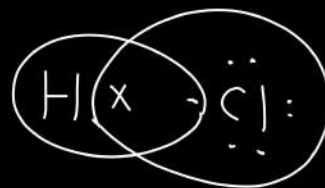
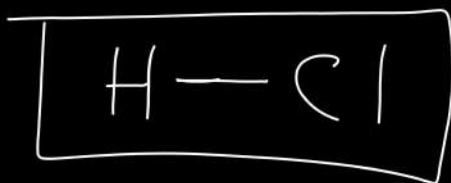


Covalent bond — Such type of chemical bond which form between two atoms by mutual sharing of an electrons.

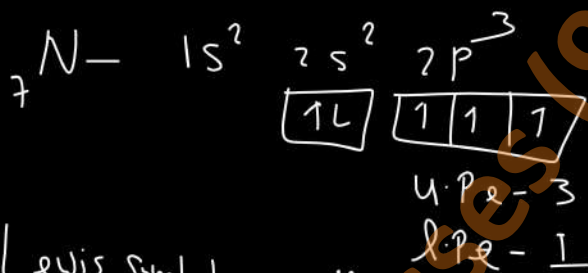


HCl (Hydrogen chloride
or
hydrochloric acid)

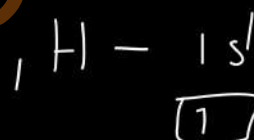




NH_3 - Ammonia

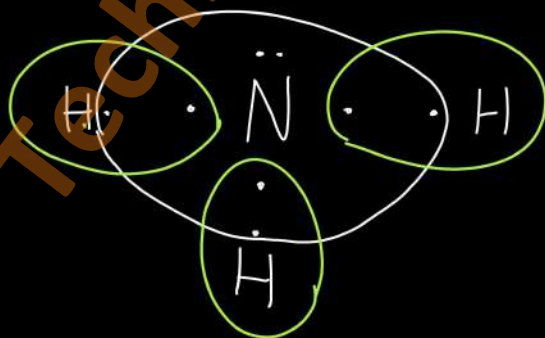


Lewis symbol - $\cdot \ddot{\text{N}} \cdot$



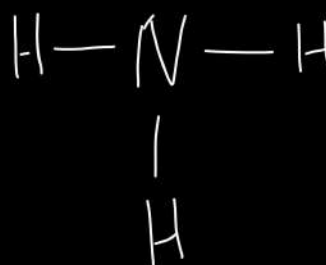
L.P.S $\Rightarrow$ H.

NH_3



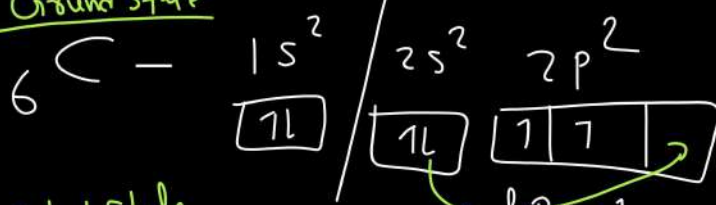
Lewis dot str

Structural formula

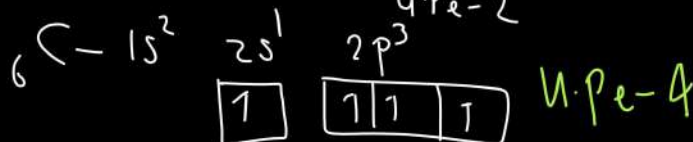


CH₄ - Methane

Ground state



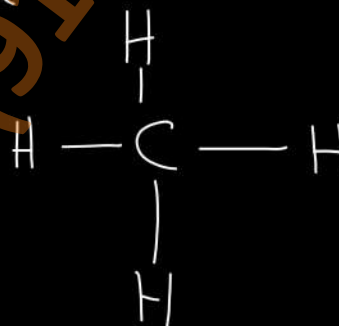
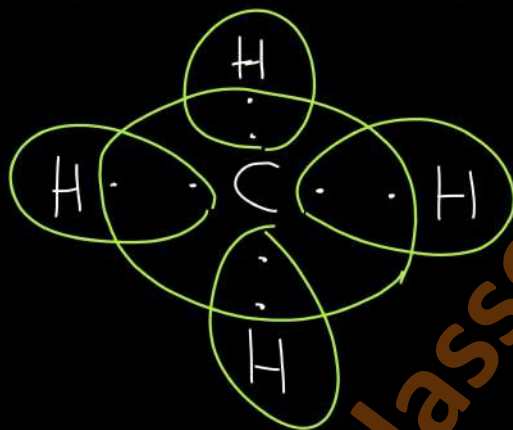
excited state



Lewis symbol



Carbon makes bond in it's first excited state

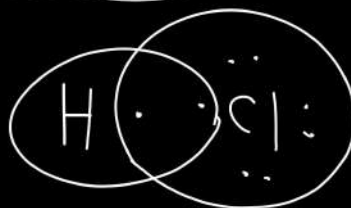
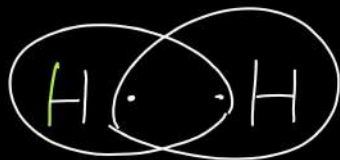


Types of Covalent bond

- ① Single bond — such a types of covalent bond which form by mutual sharing of single electrons between two atom

for example

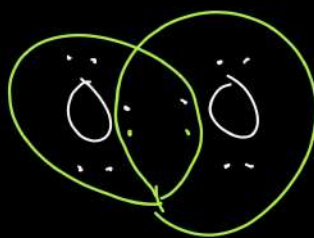
H_2 - molecule



① Double bond — Such a type of covalent bond which forms by mutual sharing of two electrons between two atoms

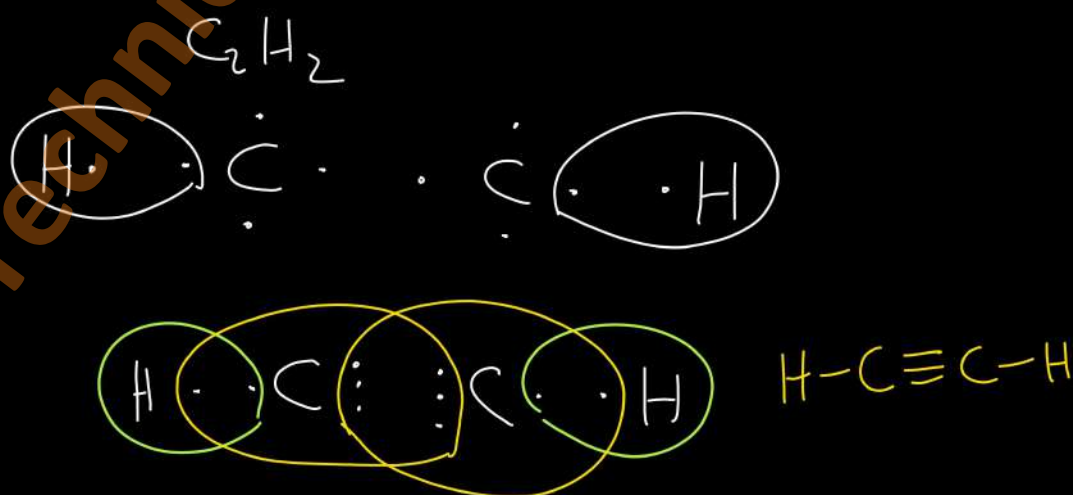
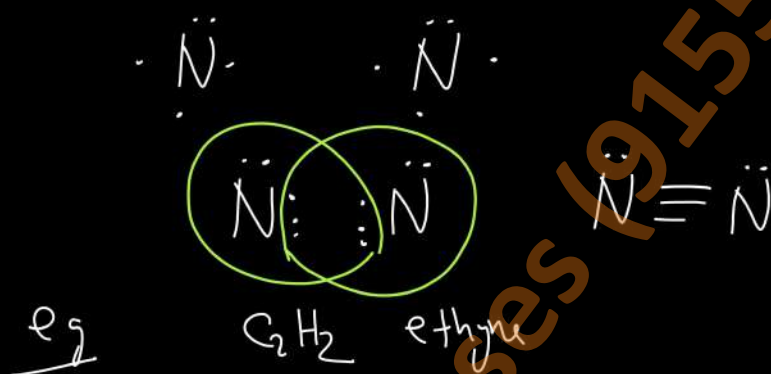
for example

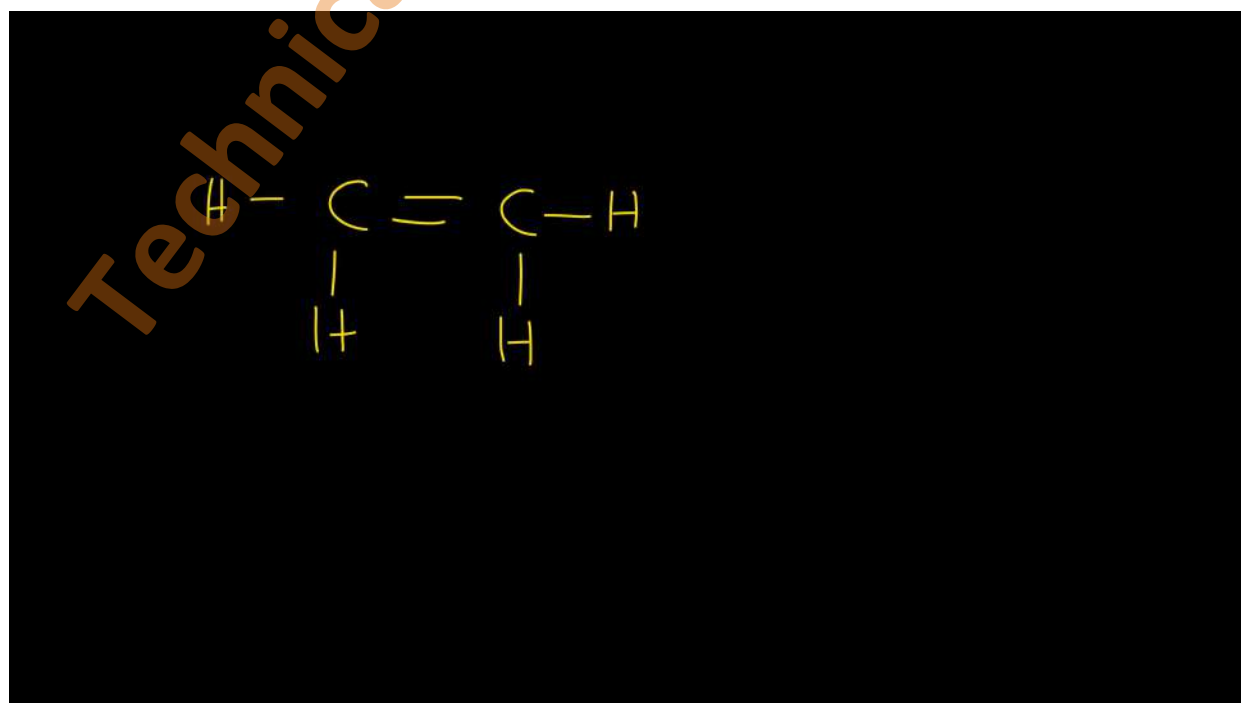
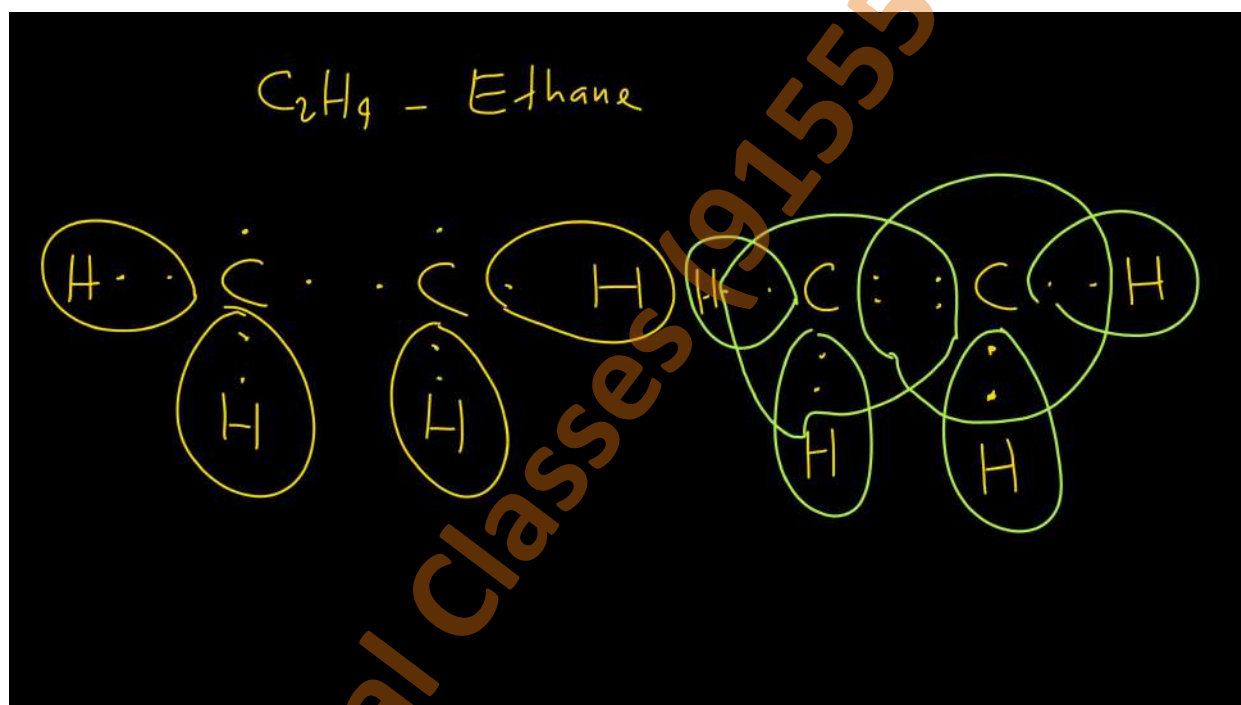
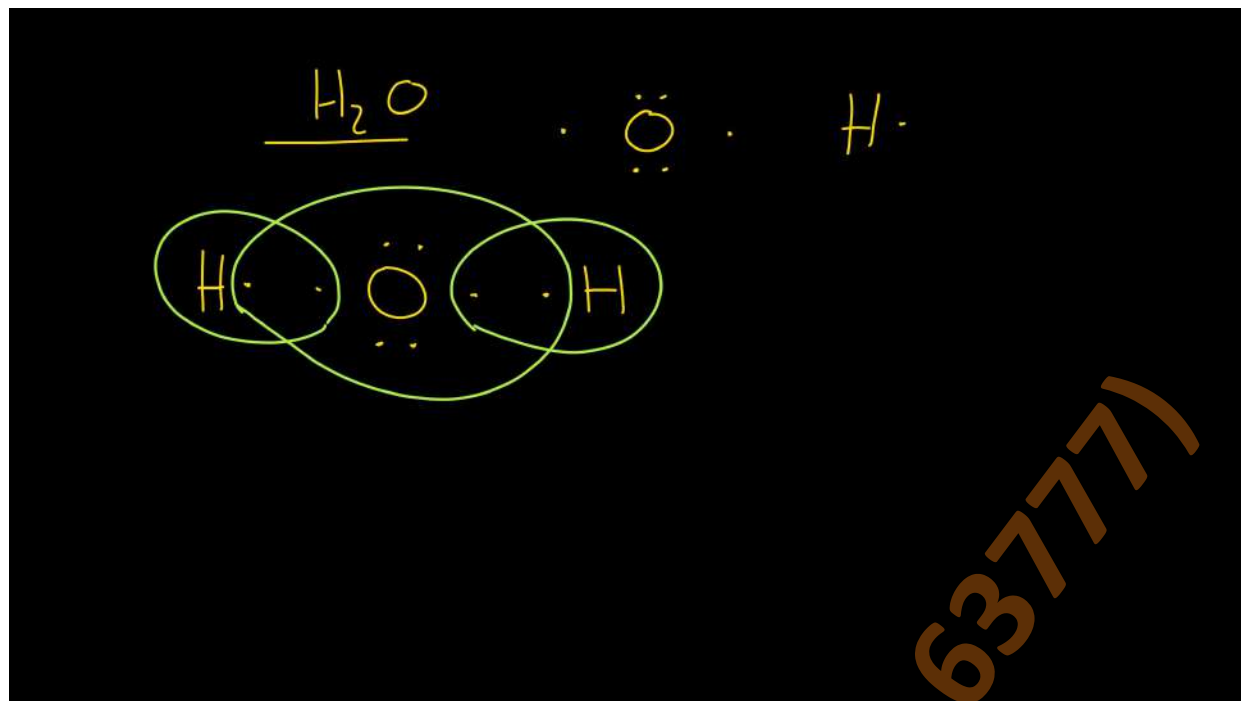
O_2 - molecule



Triple bond — Such a type of covalent bond which is mutual sharing of three electrons between two atoms

eg- N_2



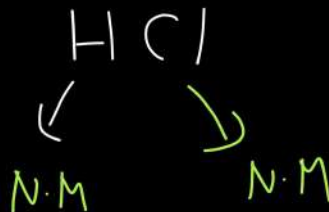
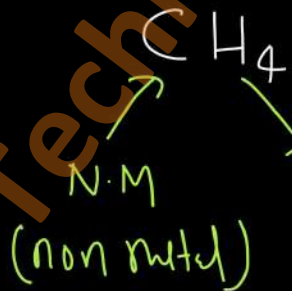




How to identify Covalent & Ionic bond

Covalent bond formed between

nonmetal & nonmetal



ionic bond formed between

metals & non metal



TRICK (not apply always)

Name of metal end with 'ium'

e.g - sodium, calcium

Name of non metal not end with ium

e.g - chlorine, carbon

Thanks

last class

→ Types of covalent bond

Types of compounds on the basis of chemical bond

- (i) Covalent compounds
- (ii) Ionic compounds

Covalent Compounds — Those compound which form by covalent bond. are known as Covalent Compounds

eg - Water - H_2O

Carbon dioxide - CO_2

Ammonia - NH_3

Methane - CH_4

Covalent compound are generally made by non metals and non metals

H_2O — hydrogen oxide
non metal $\Rightarrow$ non metal

Properties of Covalent Compounds

- (i) Covalent compounds have low melting points and boiling point
- (ii) Covalent compounds made covalent bonds
- (iii) Covalent compounds show Isomerism

Isomerism
same

molecular formula

C_2H_6O (molecular formula same)

C_2H_5OH

Ethanol

CH_3OCH_3

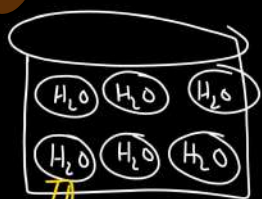
Methoxy methane

Q Covalent compound have low melting point and boiling point why?

Ans Covalent compound are exist in form of molecule but ionic compounds are exist in form of lattice crystal so Covalent compounds have low melting and boiling point

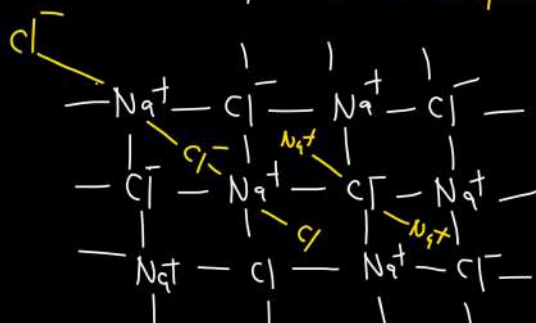
eg

H_2O - Covalent compound

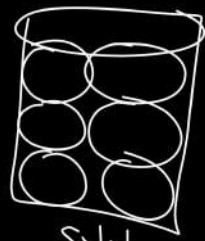


molecule

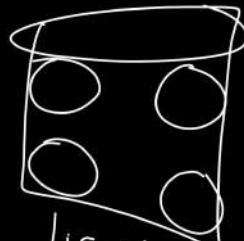
$NaCl$ - ionic compound



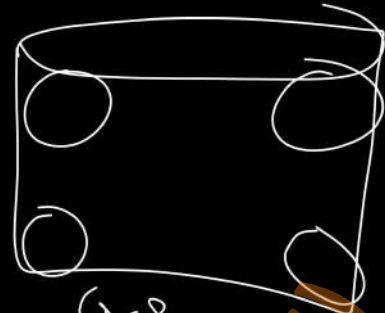
In $NaCl$, one Na^+ attached with 6 Cl^- and one Cl^- attached with 6 Na^+



Solid



Liquid

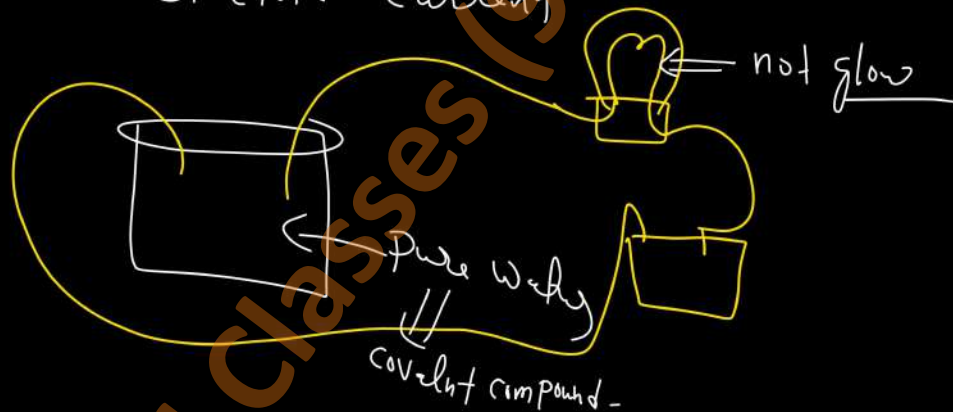


Gas

Interparticle _{space} = $s < l < g$

Interparticle force of attraction $s > l > g$

(iv) Covalent Compounds not conduct electric current

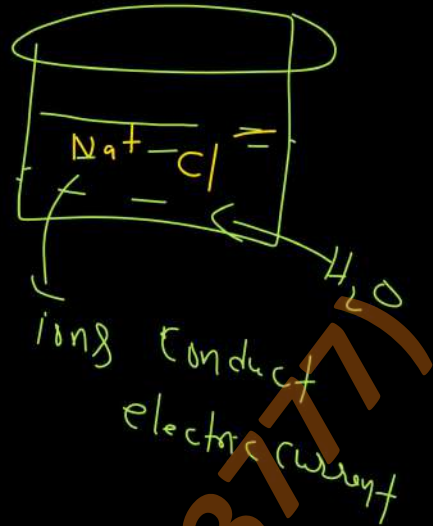


Any substance conduct electric current due to presence of free electrons or ions. due to absence of free electrons or ions covalent compounds do not electric current.

metal wire



Conduction
of electric current



Ionic compounds — Those compounds which made by ionic / Electrovalent bonds are called ionic compounds.

eg — $NaCl$ — Sodium chloride

$MgCl$ — Magnesium chloride



etc

Ionic compounds are made by metal and non metal generally.

eg

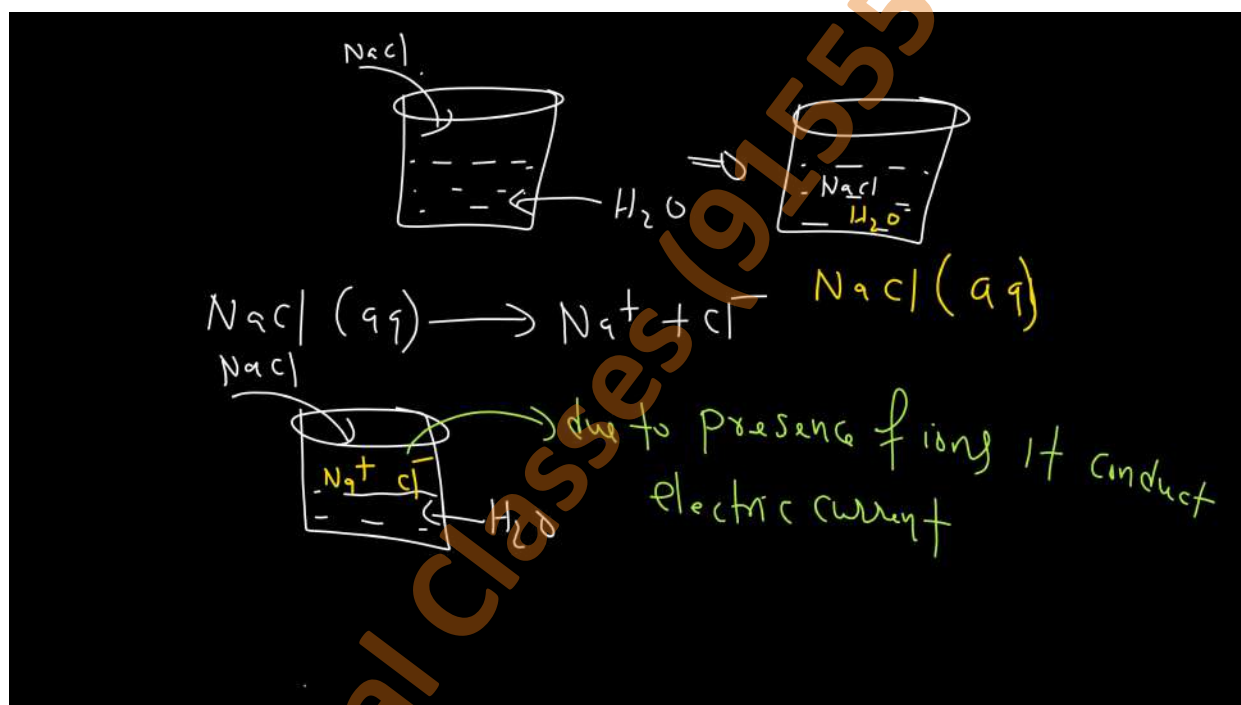


metal

non metal

Properties of Ionic Compounds

- (i) ionic compounds have high melting and boiling points
- (ii) ionic compound conduct electric current in aqueous or molten state



- (iii) ionic compounds made by ionic bonds
- (iv) ionic compound do not show isomerism generally.

Types of covalent molecules

- (I) Polar molecules
- (II) Non polar molecules.

→ Required topics

→ Electronegativity

→ Dipole moment

Electronegativity (Snapshot)

The tendency to pick up shared pair electron by an atom is called electronegativity



Electronegativity of some important elements

H 2.1						
3 Li	4 Be	5 B	6 C	7 N	8 O	9 F
1.0	1.5	2.0	2.5	3.0	3.5	4.0
-0.1 (Na	Mg	Al	Si	P	S	Cl
0.9	1.2	1.5	1.8	2.1	2.5	3.0
+0.3	+0.3	+0.3	+0.3	+0.4	+0.5	+0.5
						Br 2.8
						I 2.5

for 2nd Period elements (Li to F)

$$E.N = \frac{Z-1}{2}$$

$Z = \text{Atomic no}$

He 2.1	Value of Electronegativity (X)					
3 Li	4 Be	5 B	6 C	7 N	8 O	9 F
1.0	1.5	2.0	2.5	3.0	3.5	4.0
-0.1 (Na	Mg	Al	Si	P	S	Cl
0.9	1.2	1.5	1.8	2.1	2.5	3.0
+0.3	+0.3	+0.3	+0.3	+0.4	+0.5	+0.5
						Br 2.8
						I 2.5

highest electronegative element = $\boxed{{}_9\text{F}}$

for 2nd period element

$$E.N = \frac{Z-1}{Z}$$

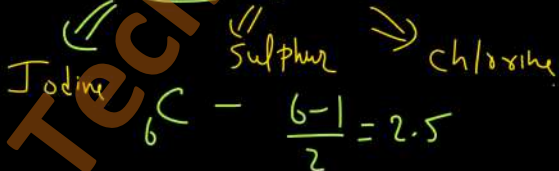
Z - Atomic Number.

${}_4\text{Be}$

$$\frac{4-1}{2} = \frac{3}{2} = 1.5$$

TRICK

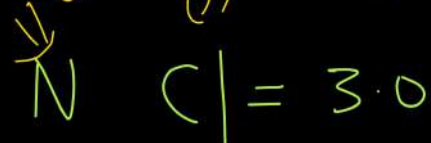
$$\text{I} \text{ S } \text{C} = 2.5$$



$$\text{P} \text{ H} = 2.1$$



Nitrogen Chlorine



(नवम)

Dipole moment — (μ)

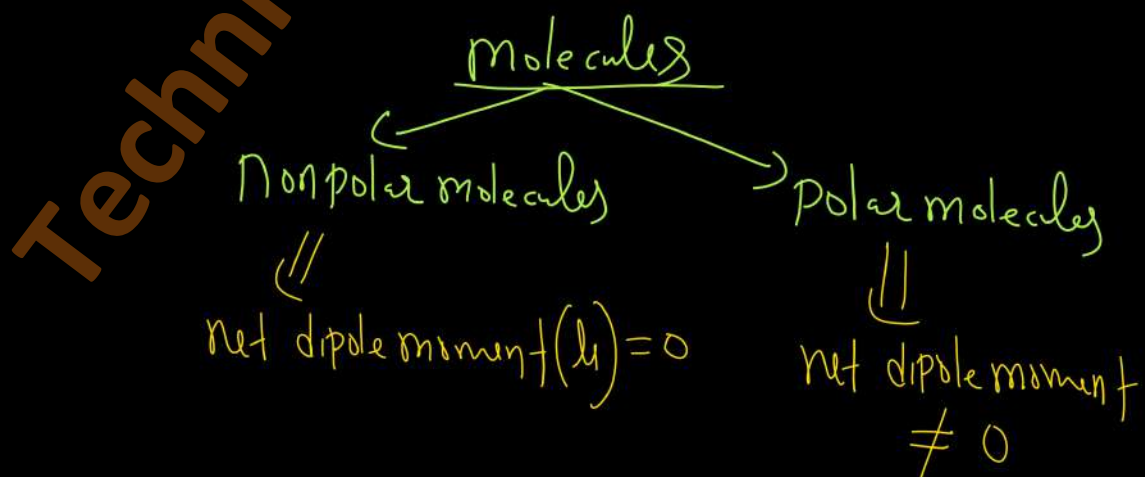
$\mu = \text{magnitude of charge} \times \text{distance}$
Dipole Moment

$$\mu = q \times d$$

it is a vector quantity

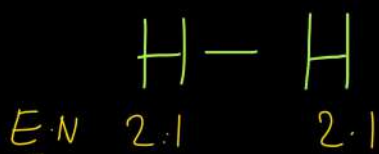
Vector quantity $\rightarrow$ magnitude & Direction

Debye $\Rightarrow$ unit of dipole moment



Non polar molecules — Those molecules in which net dipole moment is equal to zero

To represent dipole moment we

$$\left(+ \longrightarrow \right)$$


No any polarisation

(formation of pole (+ δ or - δ) occurs.

net dipole moment = zero
H₂ is a non polar molecule



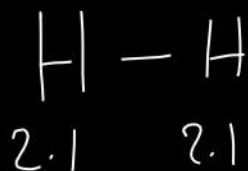
|| Polarisation occurs so net dipole does not equal to zero
So HCl is a polar molecule



Partial charge generated due to shifting of an electron



complete charge generated due to transfer of an electron

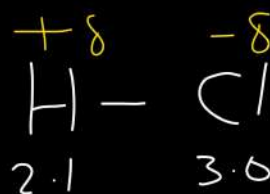


$\Rightarrow$ no any pole former

$\Downarrow$

non polar molecule

$$\Delta EN (\text{change in EN}) = 0$$



$\Rightarrow$ Pole form i.e. polarisation occurs

So HCl is a polar molecule

$$\Delta EN \neq 0$$

Alc to syllabus

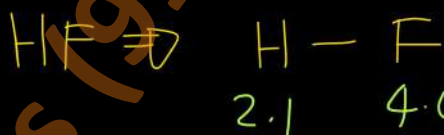


4.0 4.0

$$\Delta EN = 4 - 4 = 0$$

$\hookrightarrow$ change in Electronegativity

it is a non polar molecule



2.1 4.0

$$\Delta EN = 4 - 2.1 = 1.9$$

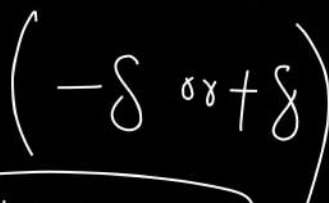
$$\Delta EN \neq 0$$

it is a polar molecule

non polar

$\Downarrow$
not

Generate pole

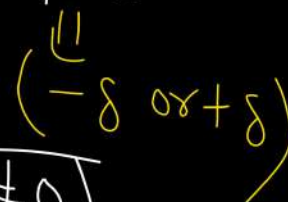


$$\Delta EN = 0$$

Polar molecule

$\Downarrow$

Generate pole



$$\Delta EN \neq 0$$

ΔX
change $\rightarrow$ electronegativity

Polar molecules — Those molecules
in which net dipole moment
not equal to zero

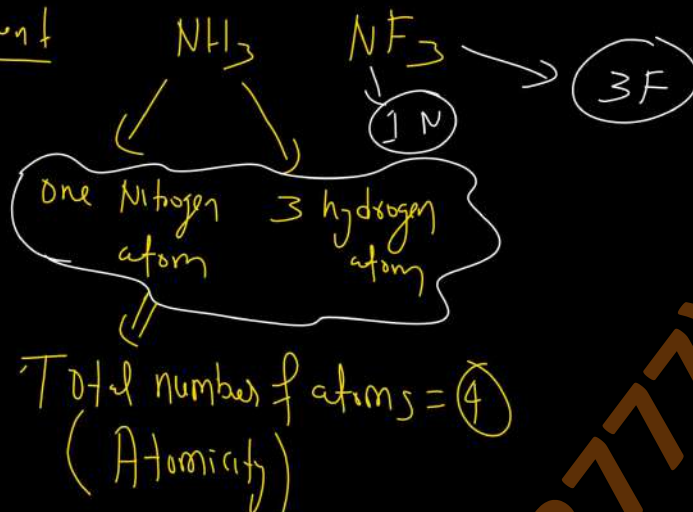
eg HF, HCl

Dipole moment in diatomic molecules

HF, HCl, H₂ etc

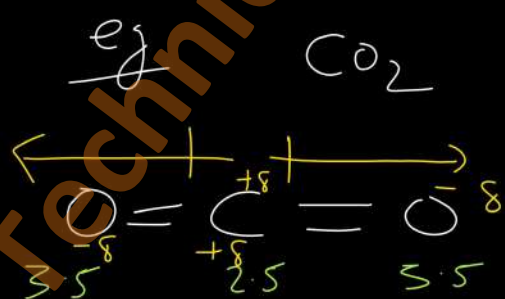
$\downarrow$
on the basis of difference in
electronegativity

Dipole moment



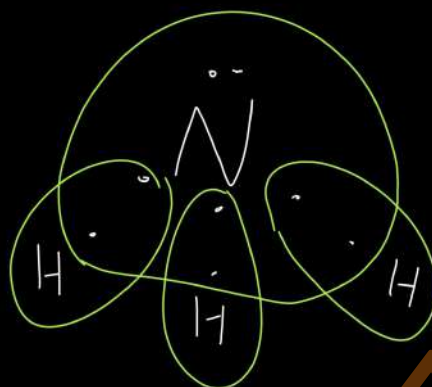
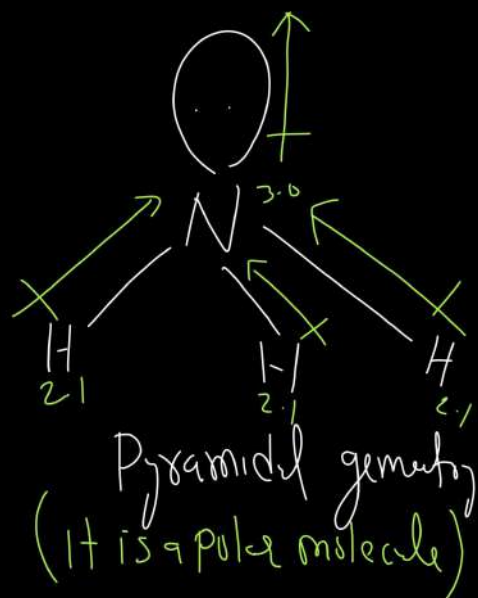
in NH_3 & NF_3 — Polarity decide on the basis of ΔEN and Angle

Applicable
Any molecules which
have more than
two atom

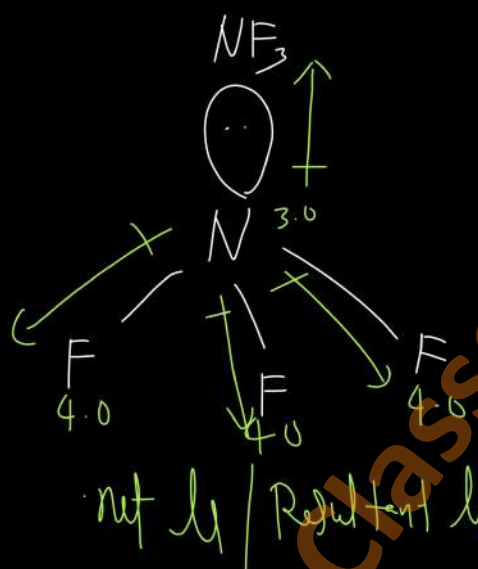


net dipole moment = 0
due to 180° angle

~~# due to presence of δ^+ & δ^- charge it is a polar molecule~~



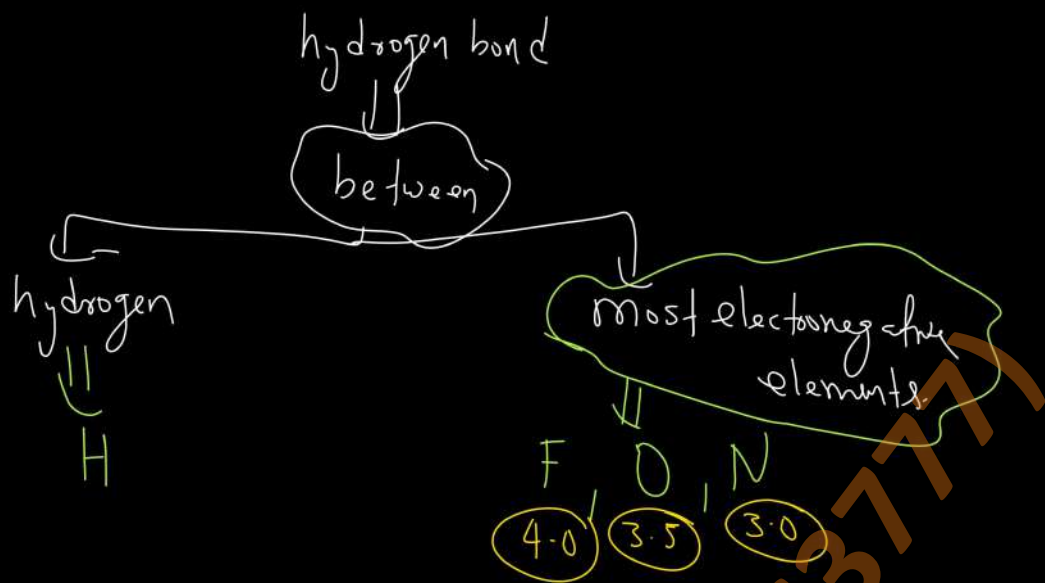
$$\text{net } \mu = 1.47 \text{ Debye}$$



$$15N - 8N = 7N$$

Some other Types of bond

- ① Hydrogen bond — it is a type of bond which forms between hydrogen and most Electronegative elements



TRICK for hydrogen bonding

H-bond करे करे

F, O, N है करे करे

Q In which of the following molecule

H-bonding present

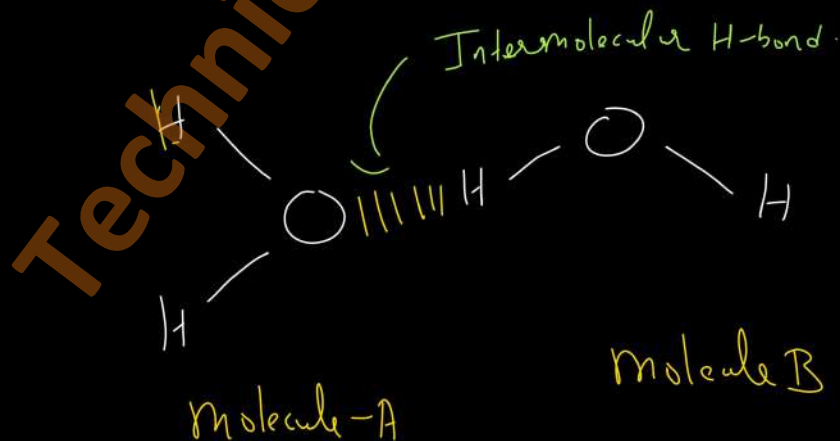
- (a) HCl (b) HF (c) HBr
- (d) HI

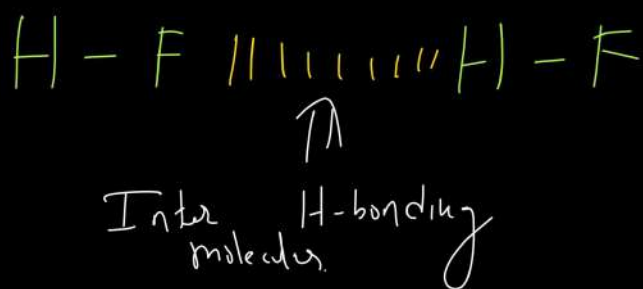
Types of hydrogen bonding

① Intermolecular H-bonding

Inter + molecular
|| ||
in between molecule

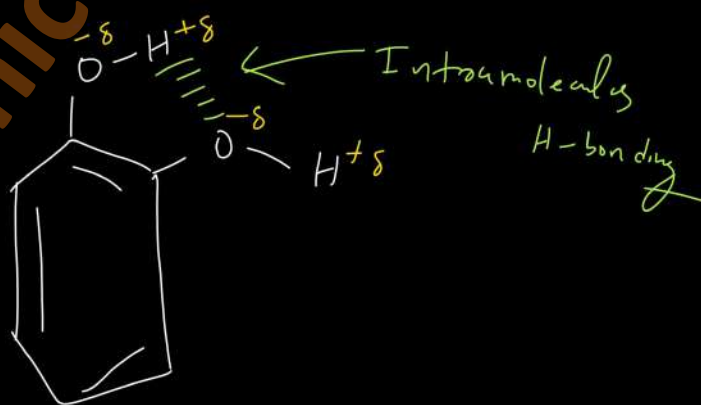
Such a type of hydrogen bonding
which form between H and F or
or O or N of different molecule





Intramolecular H-bond - Such a type of hydrogen bond which form between hydrogen and F or O or N of same molecule

Intra molecule
b/w the atoms of same molecule



NH_3 NF_3 ✓

Hydrogen bonding ✓

Coordinate bond / Dative bond ✓

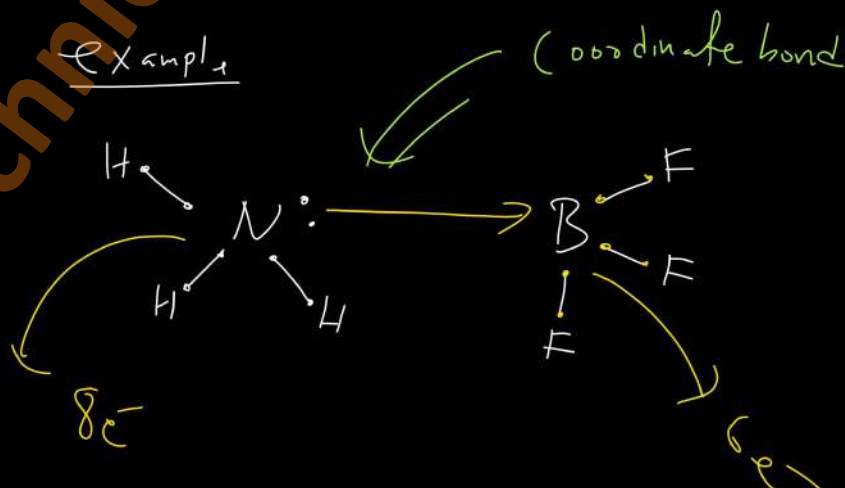
Solution & HS Concentration ✓

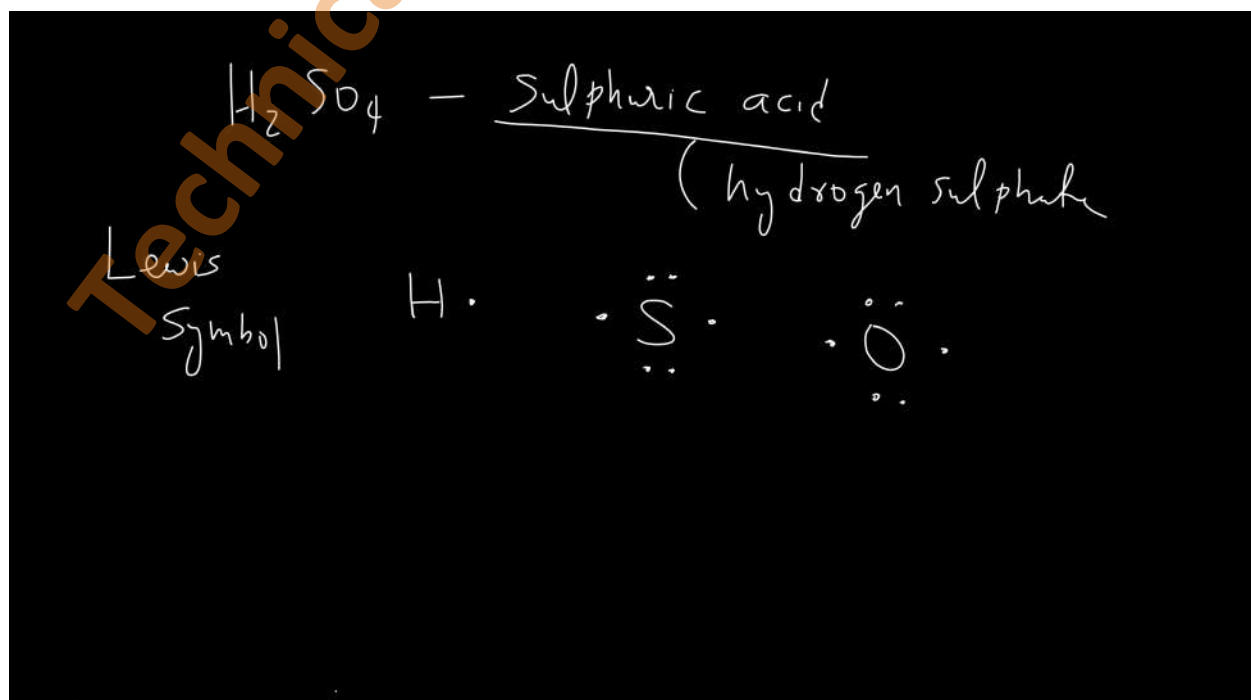
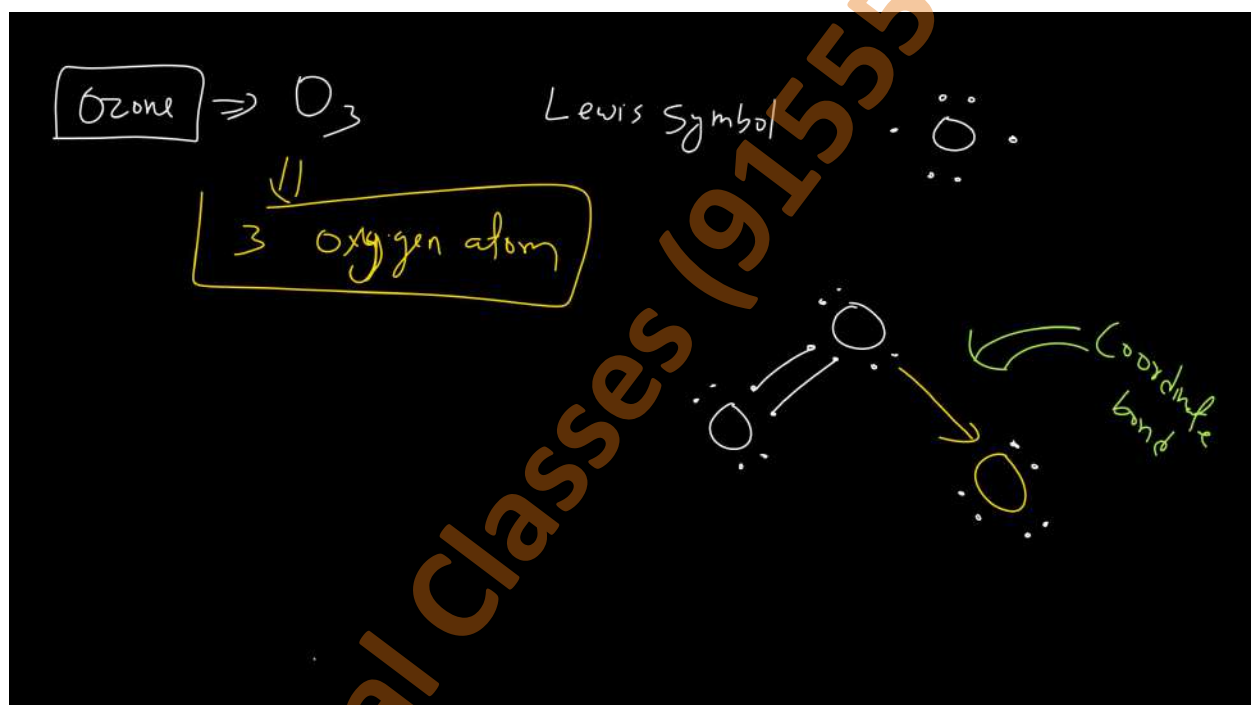
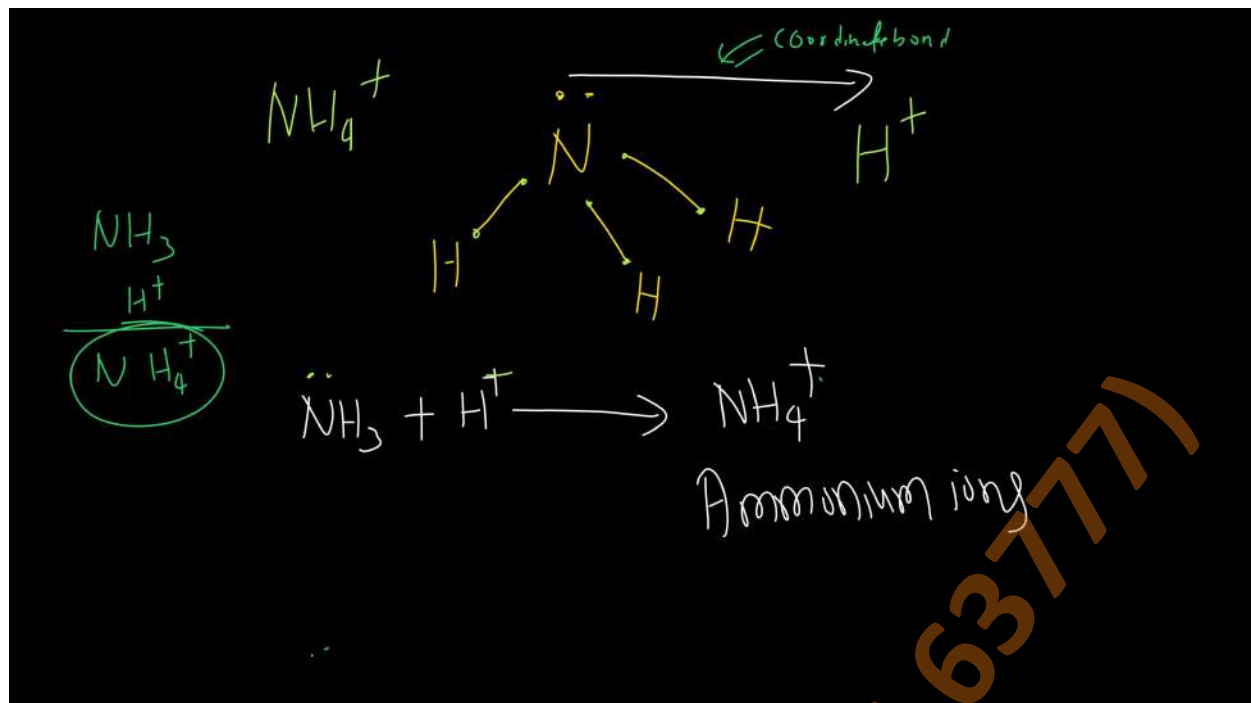
Other left topics ✓

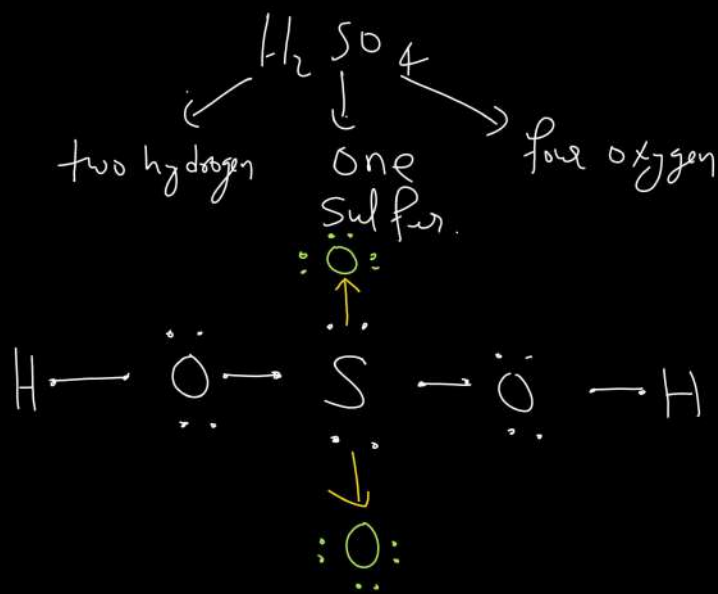
Coordinate bond / Dative bond

Such a types of covalent bond which form by one sided sharing of electrons.

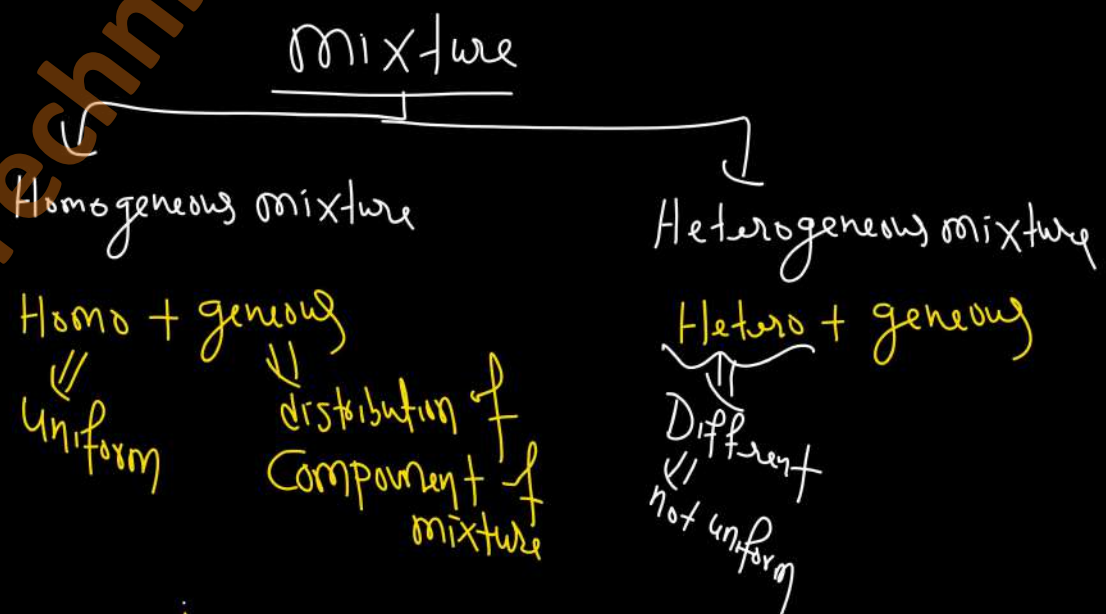
Example







Two coordinate bonds are present in H_2SO_4 between sulfur and oxygen atom



Homogenous mixture — Those of mixtures in which components and properties of mixture are uniformly distributed
for example — Sugar solution $\Rightarrow$ Sugar + Water



← uniform distribution of Sugar and Water

Heterogeneous mixture — Those types of mixture in which properties and component of mixture not uniformly distributed

ex
mixture of
Sand and Water



Water / Sand

Sand / Water



In this mixture A, B and C are known as its Component

Sugar
Solution



Sugar and water are components of mixture

mixtures are made by different substance
those substance are known as
components of mixture.

Solution

It is homogeneous mixture of two or more than two non reacting substances

example

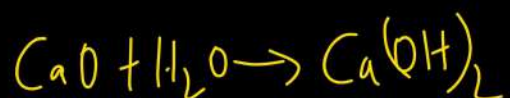
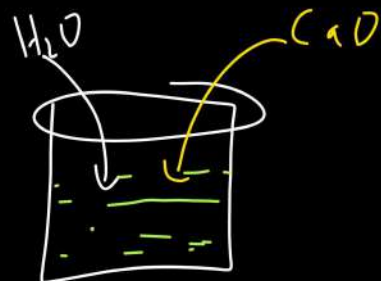
Water + Sugar

mixture

||
Sugar solution

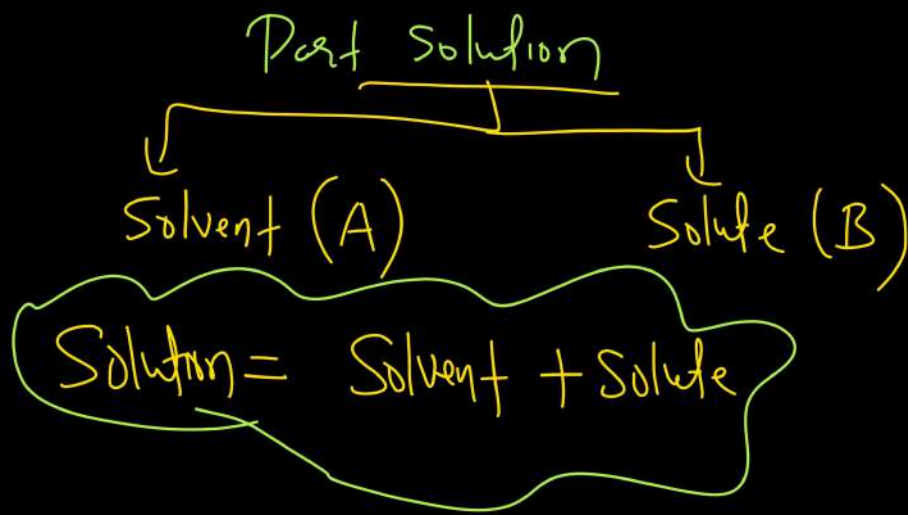


Sugar and water not
react with each other



solution not
formed

Calcium
hydroxide

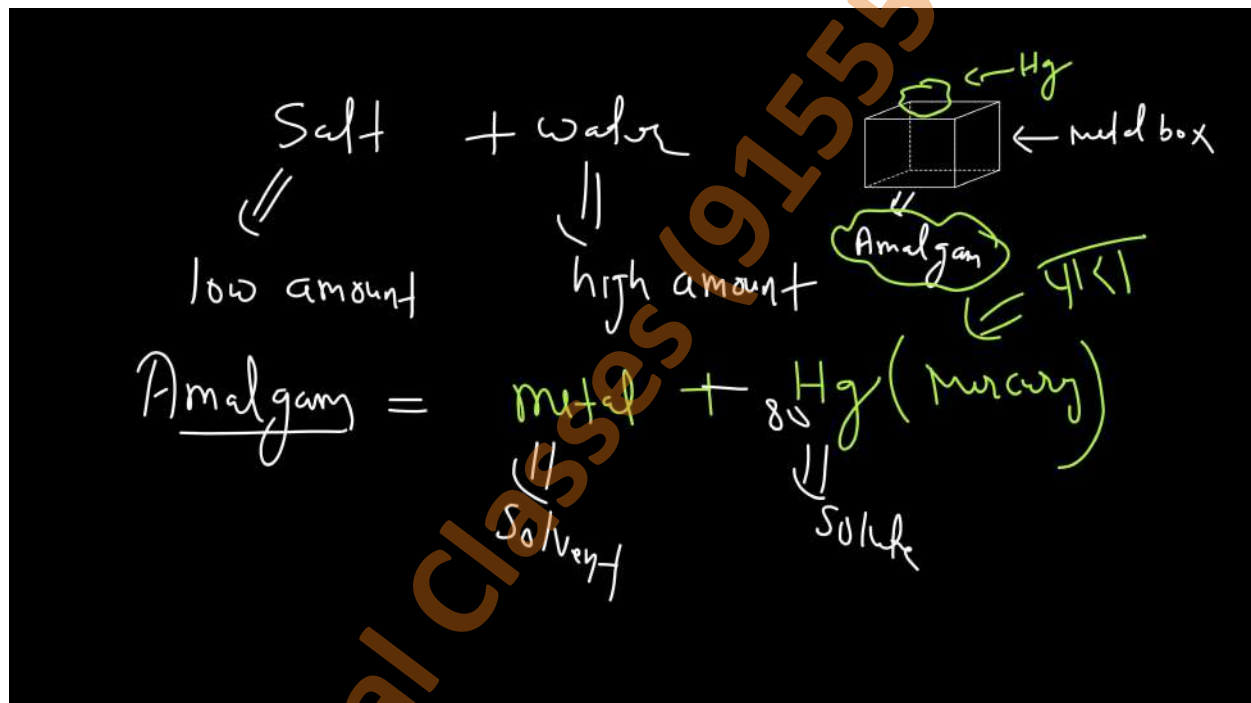
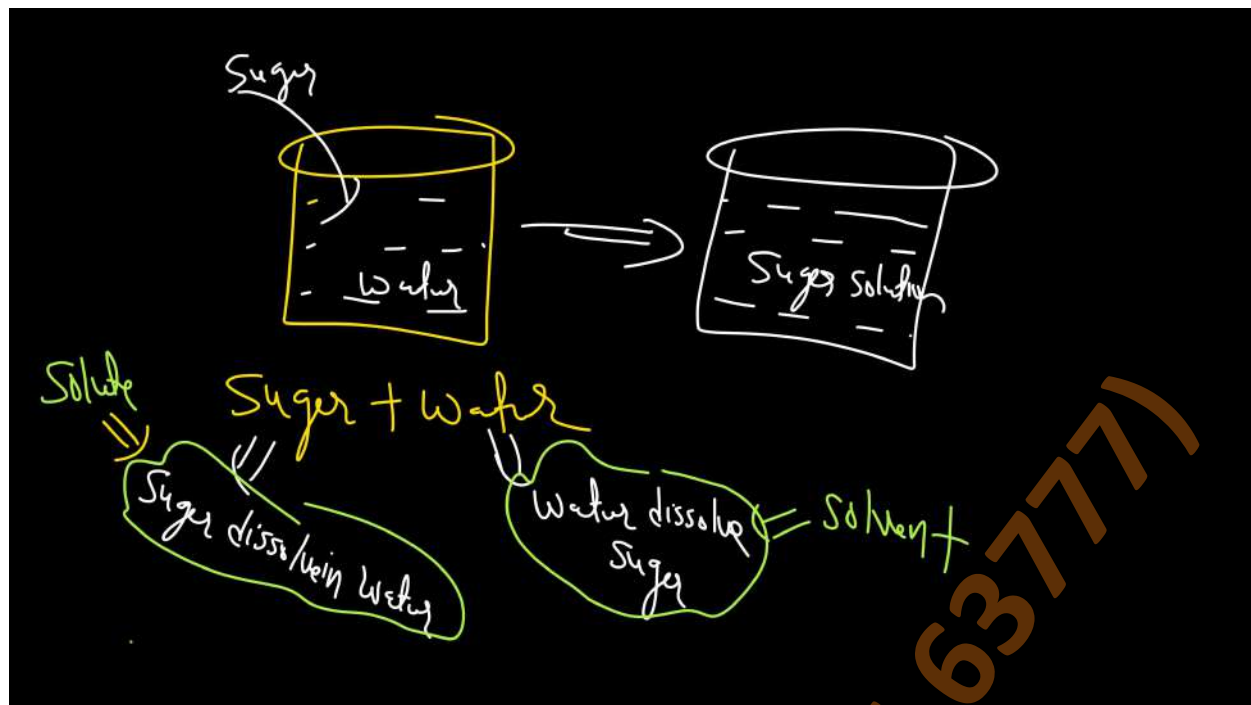


Solvent — Those substance which dissolve solute

or
those substance which present in high amount in solution

Solute — Those substance which dissolve in solvent.

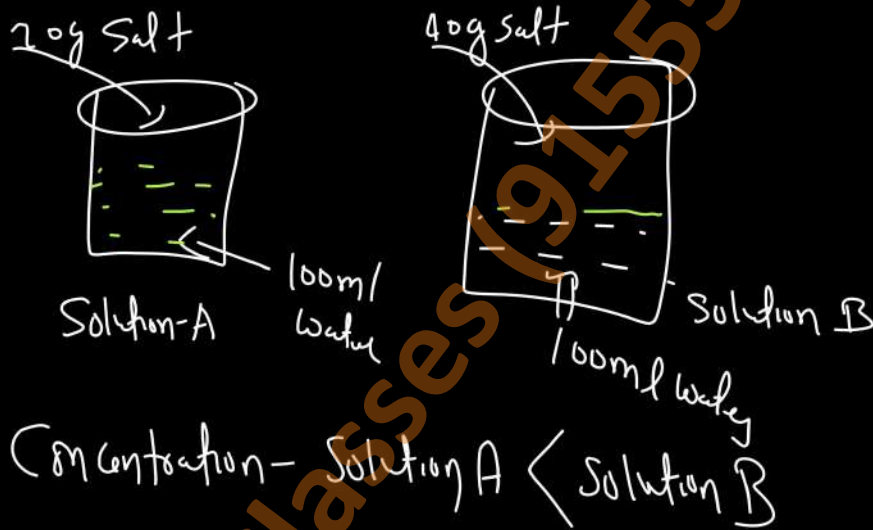
or
Those substance which present in low amount in solution



water is called universal solvent due to its high value of dielectric constant

Concentration of solution

The amount of solute present in per unit amount of solvent or solution is known as Concentration of solution



Unit of Concentration

- mass %
- Volume %
- molarity (M)
- Molality (m)
- Strength of solution

Normality (N)

Required concept for unit of concentration

- # mole concept
 - # Molar mass
 - ✓ # Atomic mass
 - ✓ # molecular mass
- In Snapshot

Atomic mass — It is mass of an atom in unified unit (u)

Example

Element

Atomic mass

H

1u

He

2u

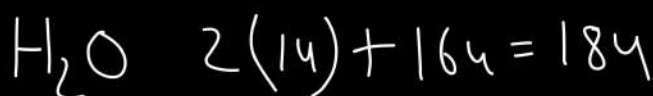
Li

7u

C

12u

Molecular mass — It is sum of atomic mass of atoms present in a molecule



18u is molecular mass of one H_2O molecule

Mole & Molar mass

Unit of concentration

- Molarity
- Molality
- etc

Mole - it is SI unit of amount of substance

$$\text{Mole} = \frac{\text{mass}}{\text{Molar mass}}$$

Molar mass - mass of one mole substance

eg - $\text{CO}_2 = (12\text{g}) + 2(16\text{g})$
 $= 12\text{g} + 32\text{g} = 44\text{g}$

for carbon

12 u

mass of one carbon atom

12 g

mass of one mole carbon atom
or
mass of 6.022×10^{23} carbon atom

1 kg
mass of iron bell

1 किलोग्राम
mass of 100 iron bell

18 u

mass of one water molecule
molecular mass of H_2O

18 g

mass of 1 mole (6.022×10^{23}) water molecules
molar mass of H_2O

Q calculate moles of 440g
Carbon dioxide $\rightarrow$ mass

$$\text{mole} = \frac{\text{mass}}{\text{molar mass}} = \frac{\text{Weight}}{\text{molar weight}}$$

$$\text{CO}_2 = 12\text{g} + 2(16\text{g}) = 12 + 32 = 44\text{g}$$

$$\text{moles of CO}_2 = \frac{440}{44} = 10 \text{ mole}$$

Q calculate moles of 360g of water
(H_2O)

$$\begin{aligned}\text{Molar mass of H}_2\text{O} &= 2(1\text{g}) + 16\text{g} \\ &= 18\text{g mol}^{-1}\end{aligned}$$

$$\text{mole} = \frac{\text{mass}}{\text{molar mass}}$$

$$= \frac{360}{18} = 20 \text{ moles}$$

Unit of Concentration

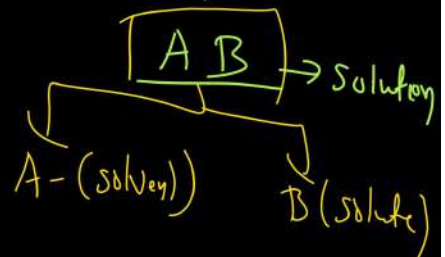
① Molarity (M) — The number of moles of solute present in per liter volume of solution

$$M = \frac{\text{no of moles of solute}}{\text{Volume of Solution in liter}}$$

$$M = \frac{n_B}{V_{AB}(\text{in liter})}$$

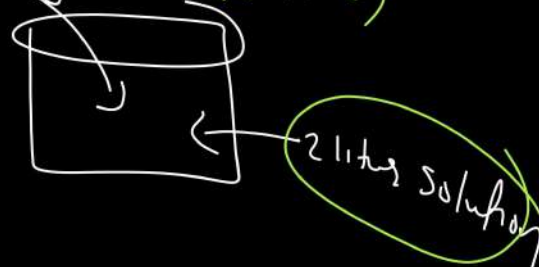
n_B — no of moles of solute

$$\text{Mole} = \frac{\text{mass}}{\text{molar mass}}$$



Q Calculate molarity if 200g CaCO_3 dissolve in 2 liter volume of solution

Given 200g CaCO_3 (Solute)



$$\text{Mass of } \frac{\text{solute}}{(\text{CaCO}_3)} = 200\text{g}$$

$$\text{molar mass of } \text{CaCO}_3 = 40\text{g} + 12\text{g} + 16 \times 3$$

$$40 + 12 + 48$$

$$= 100\text{g mol}^{-1}$$

$$\text{Mole of } \frac{\text{CaCO}_3}{(\text{solute})} = \frac{200\text{g}}{100\text{g}} = 2\text{mole}$$

$$\text{molarity} = \frac{n_B}{V_{AB}(\text{liter})}$$

$$= \frac{2\text{ mole}}{2\text{ liter}} = 1\text{ M}$$

$$\boxed{1\text{ mole/liter}}$$

$$\text{mass no}(A)$$

$$A = p + n$$

$$\text{mass no} = \text{no of proton} + \text{no of neutron}$$

$$\text{Atomic mass}$$

It is mass of one atom in unified unit

Numerical value of mass no and
approx value of Atomic mass
will be same generally



Molality (m) — The number of moles of
Solute Present in (per kg
mass of solvent

$$m = \frac{\text{Number of moles of solute}}{\text{mass of solvent in kg}} = \frac{n_B}{W_A (\text{in kg})}$$

$$m = \frac{n_B}{W_A (\text{in kg})}$$

n_B = no of moles of
solute

W_A = mass of solvent
in kg

Q Calculate molality of the solution
if 780g benzene present in
5 kg of solvent

Given

Solute (B) = Benzene (C_6H_6)

$$W_B = 780g$$

molar mass of Benzene (C_6H_6)

$$= 6(12g) + 6(1g)$$

$$72g + 6g = 78g/mol$$

$$\text{moles of Benzene} = \frac{780g}{78g}$$

$$= 10 \text{ mole}$$

$$\text{molality} = \frac{\text{moles of solute}}{\text{mass of solvent in kg}}$$

$$= \frac{10 \text{ mole}}{5 \text{ kg}} = 2m$$

Concentration
of solution

$$2 \text{ mol/kg}$$

$$M = \frac{n_B}{V_{AB}(\text{in liter})} = \frac{\text{mole}}{\text{volume}} = (\text{depends upon } T \text{ \& } P)$$

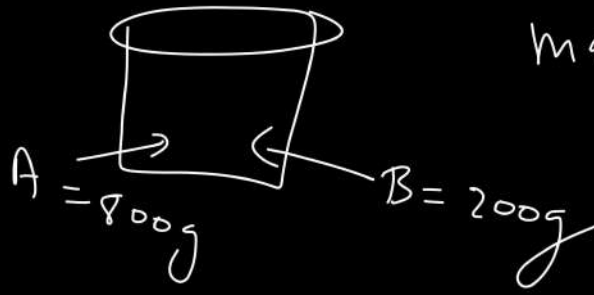
$$m = \frac{n_B}{W_A(\text{in kg})} = \frac{\text{mole}}{\text{mass}} \quad (\text{Not depends upon } T \text{ \& } P)$$

moles and mass does not depends upon Temperature, but volume depends upon Temperature
So, those unit of concentration which have Volume, depends upon temp^{er} and pressure

$$\boxed{\text{Mass \%} = \frac{\text{Mass of one component}}{\text{Total mass of solution}} \times 100}$$

Q

A solution made by two components 'A' and 'B' having mass 800 g and 200 g respectively calculate mass % of each component



$$\text{Mass \% A} = \frac{800}{800+200} \times 100$$

$$= \frac{800}{1000} \times 100$$

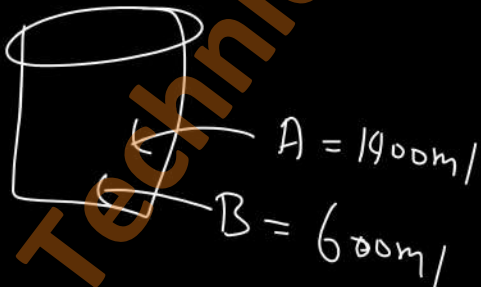
$$= 80\%$$

$$\text{Mass \% of B} = \frac{200}{800+200} \times 100$$

$$= \frac{200}{1000} \times 100 = 20\%$$

$$\boxed{\text{Volume \%} = \frac{\text{Volume of one Component}}{\text{Volume of solution}} \times 100}$$

Q Calculate Volume Percentage of each component if 1400ml A and 600ml B Present in a solution



$$\text{Volume \% of A} = \frac{1400}{1400+600} \times 100$$

$$= \frac{70}{2000} \times 100$$

$$= 70\%$$

$$\text{Volume \% of B} = \frac{600}{600+1400} \times 100$$

$$= \frac{600}{2000} \times 100$$

$$= 30\%$$

Normality (N)

✓ # Normality, strength of solution

wave mechanical model of an atom

Spectrum

Normality — The number of equivalent of solute present in per liter volume of solution

$$\text{Normality} = \frac{\text{Number of equivalent of solute}}{\text{Volume of solution in liter.}}$$

$$\text{Number of equivalent of solute} = \frac{\text{mass of solute}}{\text{equivalent mass of solute}}$$

$$\text{equivalent mass} = \frac{\text{molar mass}}{n\text{-factor}}$$

$$\text{Normality} = \frac{n_{eq}(B)}{V_{AB}(\text{m liter})}$$

$$n_{eq}(B) = \frac{W_B}{eq^t \text{ mass}(B)}$$

$$\text{Normality} = \frac{\frac{W_B(\text{mg})}{eq^t \text{ mass}(B)}}{V_{AB}(\text{m liter})}$$

Solute - B

Solvent - A

Solution - AB

$$N = \frac{W_B (\text{in g})}{\text{eqt mass (B)} \times V_{AB} (\text{in liter})}$$

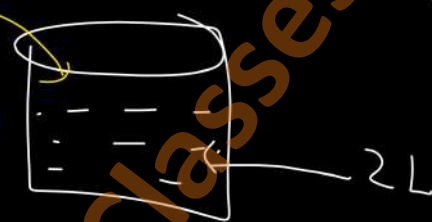
#

$$\text{Normality} = \frac{\text{mass of solute in g}}{\text{equivalent mass of solute} \times \text{Volume of solution in liter}}$$

Q calculate normality of the solution if
200g CaCO_3 dissolve in 2 liter of
the solution

Solⁿ

200g
 CaCO_3

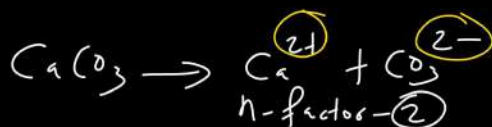


$$\text{Given} = W_B (\text{in g}) = 200\text{g}$$

$$V_{AB} = 2 \text{ liter}$$

$$N = ??$$

Solute CaCO_3



$$\text{Equivalent mass} = \frac{\text{molar mass}}{\text{n-factor}} / \text{Molecular mass}$$

$$\text{CaCO}_3 = 40\text{g} + 12\text{g} + 3(16\text{g}) = 100\text{g}$$

$$\text{Equivalent mass} = \frac{100}{\text{n-factor}} = \frac{100}{2} = 50$$

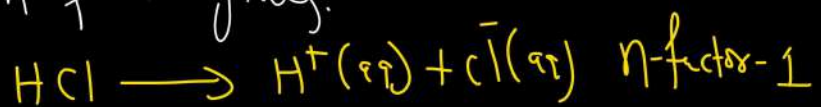
$$\text{Normality} = \frac{\text{mass of solute in g}}{\text{equivalent mass} \times \text{Volume of solution in litres}}$$

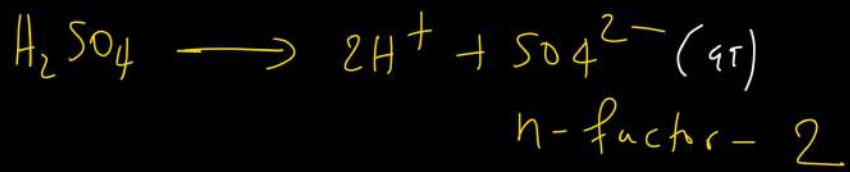
$$= \frac{\overset{4}{\cancel{200}} \text{g}}{\cancel{50} \times \cancel{2} \text{L}} = 2 \text{ N}$$

Valence factor — The number of species of a
 n-factor compound participated in chemical bonding
equivalent factor

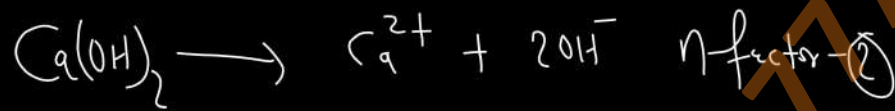
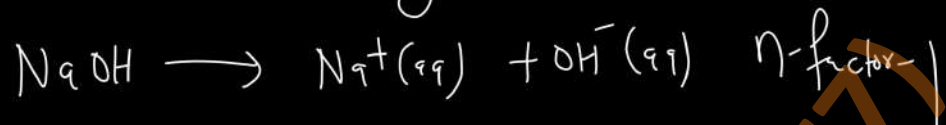
How to calculate n factor

for acid — n.o.f H^+ given.

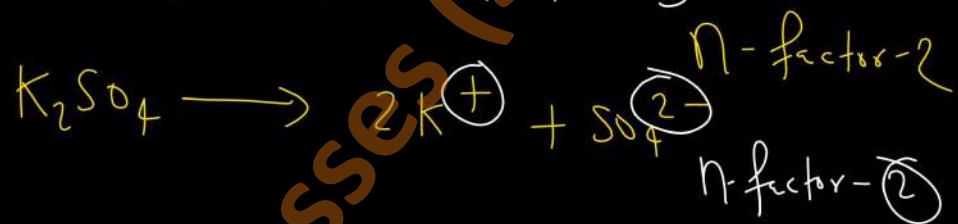




for Base - No. of OH^- given.



for Salt - maximum charge



Strength of solution - The mass of solute present in per liter volume of solution

$$\text{Strength of solution} = \frac{\text{mass of solute}}{\text{Volume of solution in liter}}$$

Q Calculate strength of solution if 10g NaCl present in 500ml of solution

Ans

$$\text{Strength of solution} = \frac{\text{mass of solute in g}}{\text{Volume of solution in liter}}$$

Given

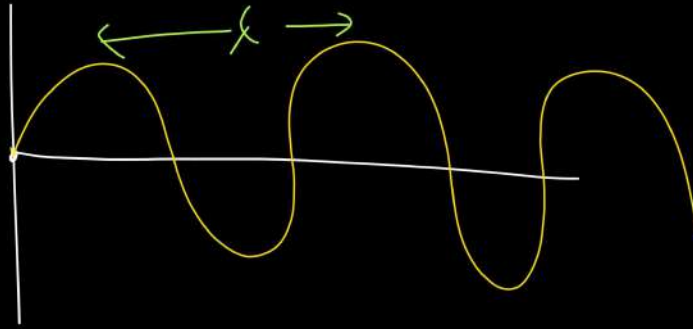
$$\begin{aligned} \text{mass of solute} &= 10\text{g} \\ \text{Volume of solution} &= \frac{500\text{ml}}{1000} = 0.5 \text{ Liter} \end{aligned}$$

$$\text{Strength of solution} = \frac{10\text{g} \times 10}{0.5\text{L}} = \frac{100}{0.5} = 200\text{g/L}$$

=

as we know

Electromagnetic radiation



$$C = \nu \lambda$$

Speed of
EM wave
(Electromagnetic-EM)

$$3 \times 10^8 \text{ m/s}$$

frequency
(unit s^{-1}
or
 Hz)

Wave length

(unit - unit of length)
 $\text{cm}, \text{\AA}$

as we know that

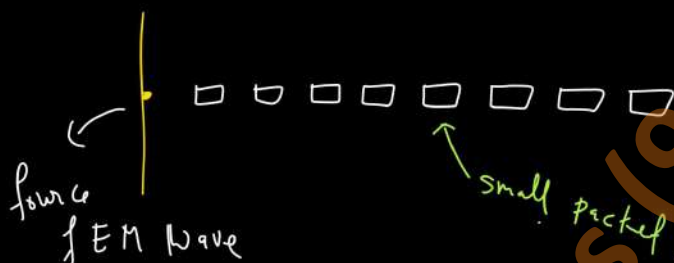
from Bohr's model of the atom

$$mvr = \frac{nh}{2\pi}$$

Planck's quantum theory

Given by max plank's

#(1) EM waves are transmit in form of small packet of energy which is known quanta



in terms of light those small packet of energy are known as 'photon'

(II) energy of quant / Electromagnetic waves directly proportional to frequency (ν)

$$\boxed{E \propto \nu}$$
$$\boxed{E = h\nu}$$

Energy $\rightarrow$ E $\rightarrow$ frequency ν $\rightarrow$ Planck's Const h

$$E = h\nu$$

plank's const.

$$C = \nu \lambda$$

$$\nu = \frac{\lambda}{c}$$

$$E = \frac{h \lambda}{c}$$

energy

wavelength

$3 \times 10^8 \text{ m/s}$

In test class

① quantum theory

$$E \propto \nu$$

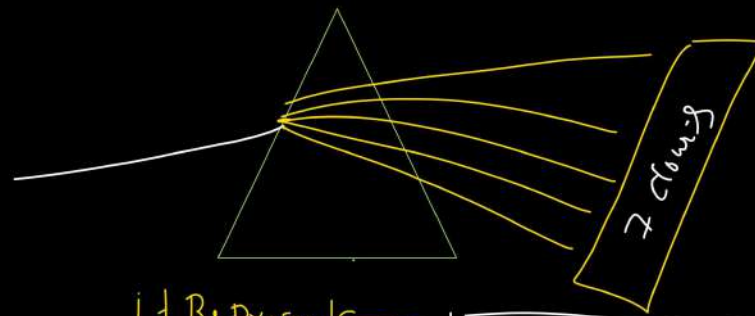
$$E = h\nu$$

$$C = \nu \lambda$$

$$\nu = \frac{\lambda}{c}$$

$$E = h \frac{\lambda}{c}$$

Spectrum - A Range of electromagnetic waves, which have different frequency (ν) and wave length (λ)



It Represents
Visible region of
electromagnetic waves

VIBGYOR

Except visible region (VIBGYOR)
electromagnetic waves having other
region also for example radio waves
microwaves etc

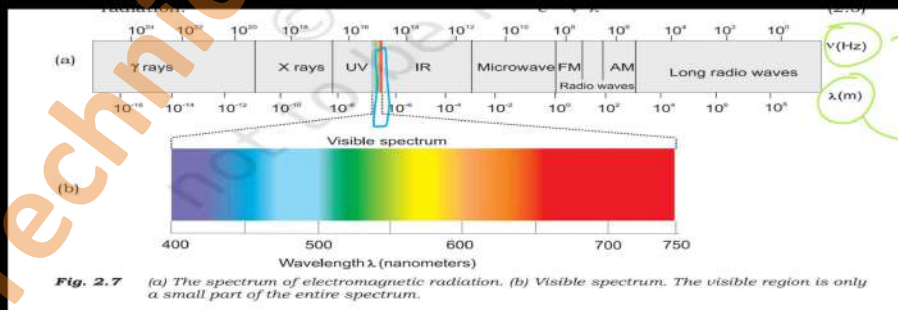


Fig. 2.7 (a) The spectrum of electromagnetic radiation. (b) Visible spectrum. The visible region is only a small part of the entire spectrum.

TRICK

Gamma X U V In M Range
 ↓ ↓ ↓ ↓ ↓ ↓
 Gamma rays X-rays Ultraviolet rays Visible region Infra red Micro wave Radio waves

Gamma < UV in my range
frequency = $\gamma\text{-rays} < \text{X-rays} < \text{Ultraviolet} < \text{Infrared} < \text{microwaves}$
 $> \text{Radio waves}$

Q which of the following have lowest frequency

- (a) Infrared
- ☒ (b) Radiowaves
- (c) microwaves
- (d) $\gamma\text{-rays}$

Q which of the following have maximum frequency

- (a) microwaves
- (b) Radiowaves
- (c) Visible region
- ☒ (d) X-rays

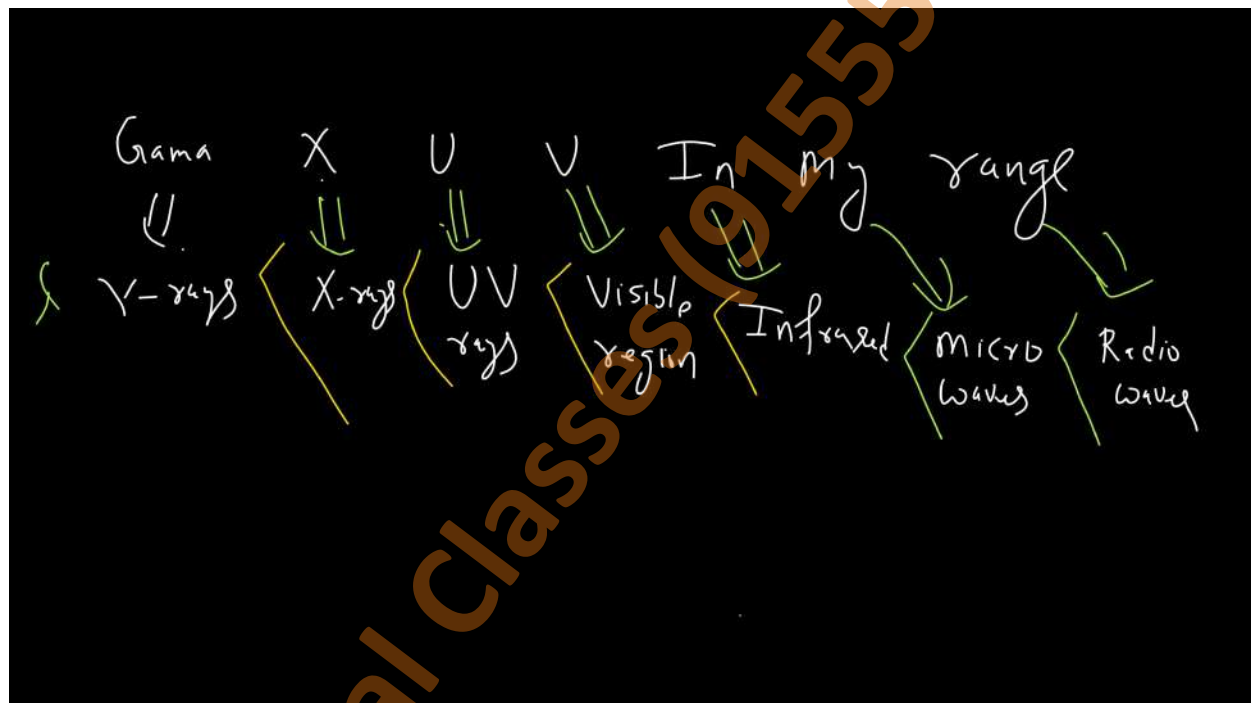
$$c = \nu \lambda$$

$$\lambda = \frac{c}{\nu}$$

$$\lambda = c \times \frac{1}{\nu}$$

$$\lambda \propto \frac{1}{\nu}$$

$$\text{Wavelength} \propto \frac{1}{\text{frequency}}$$



Q Which of the following have maximum wavelength

- (a) X-rays
- (b) IR
- (c) UV
- (d) Radio

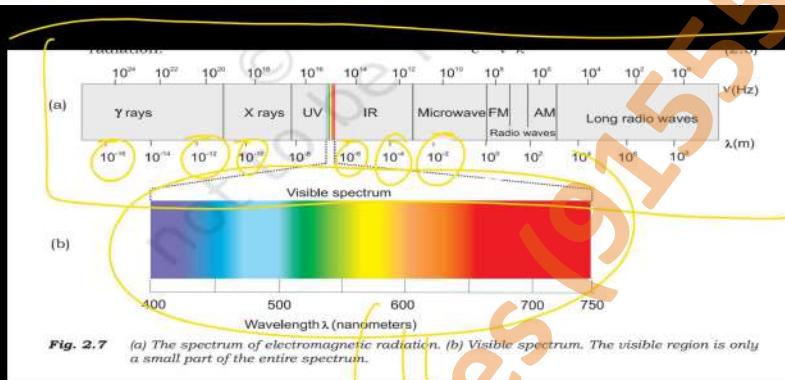
Q which of the following have lowest wavelength

(a) Microwave

(b) UV

☒ (c) γ -rays

(d) IR

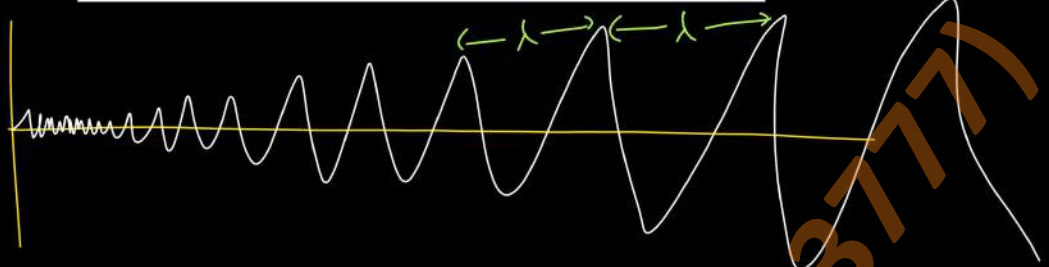
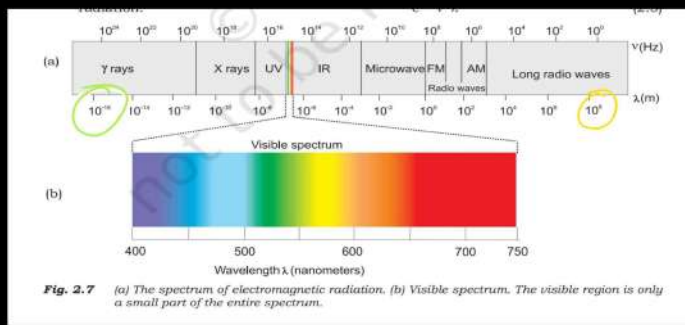


Spectrum

Types of radio waves

$\nu = FM > AM > \text{long radio wave}$

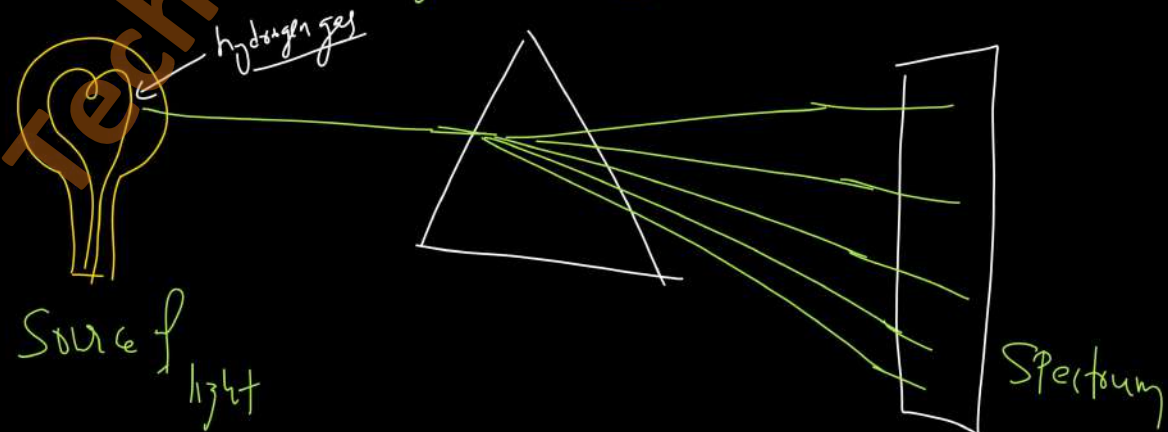
$\lambda \Rightarrow FM < AM < \text{long radio wave}$

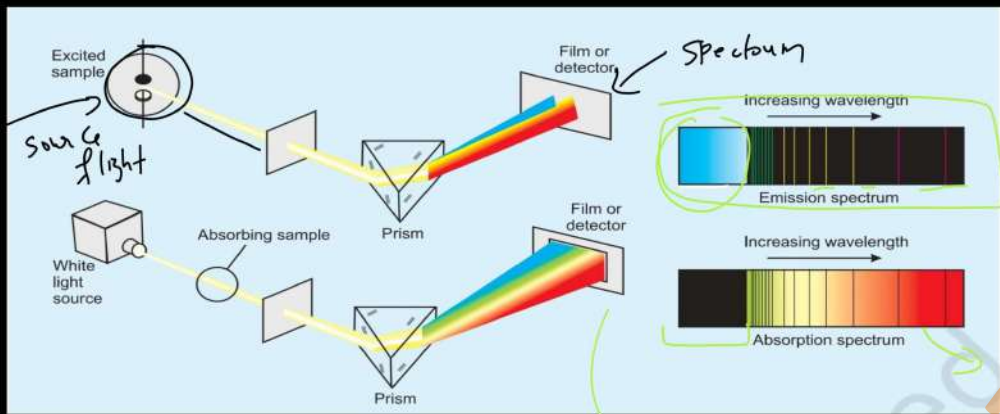


Types of spectrum

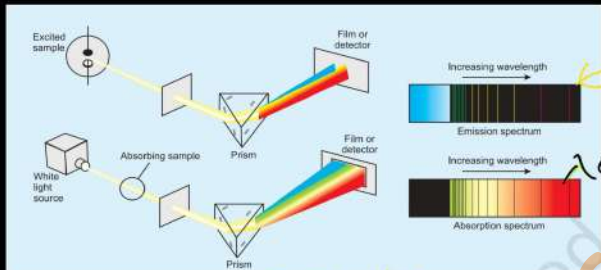
- (i) Emission spectrum
- (ii) Absorption spectrum.

Hydrogen Spectrum





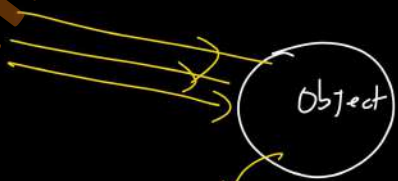
Detect $\Rightarrow$ different region of EM wave



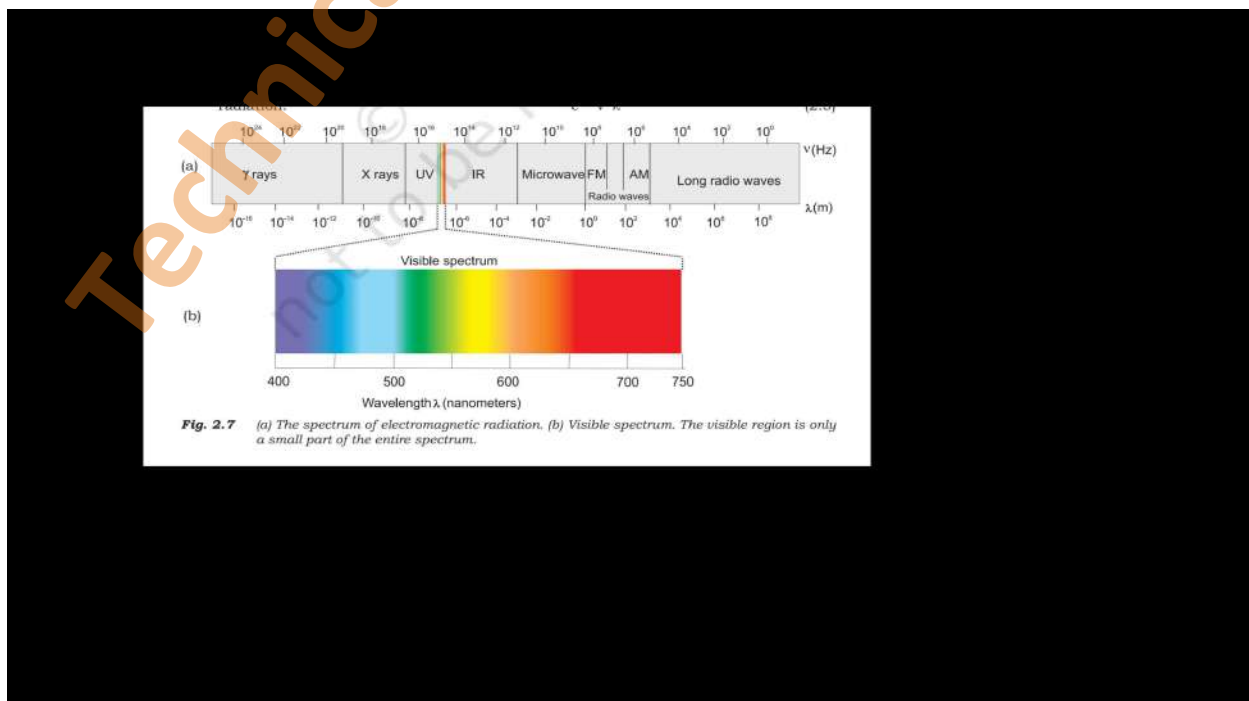
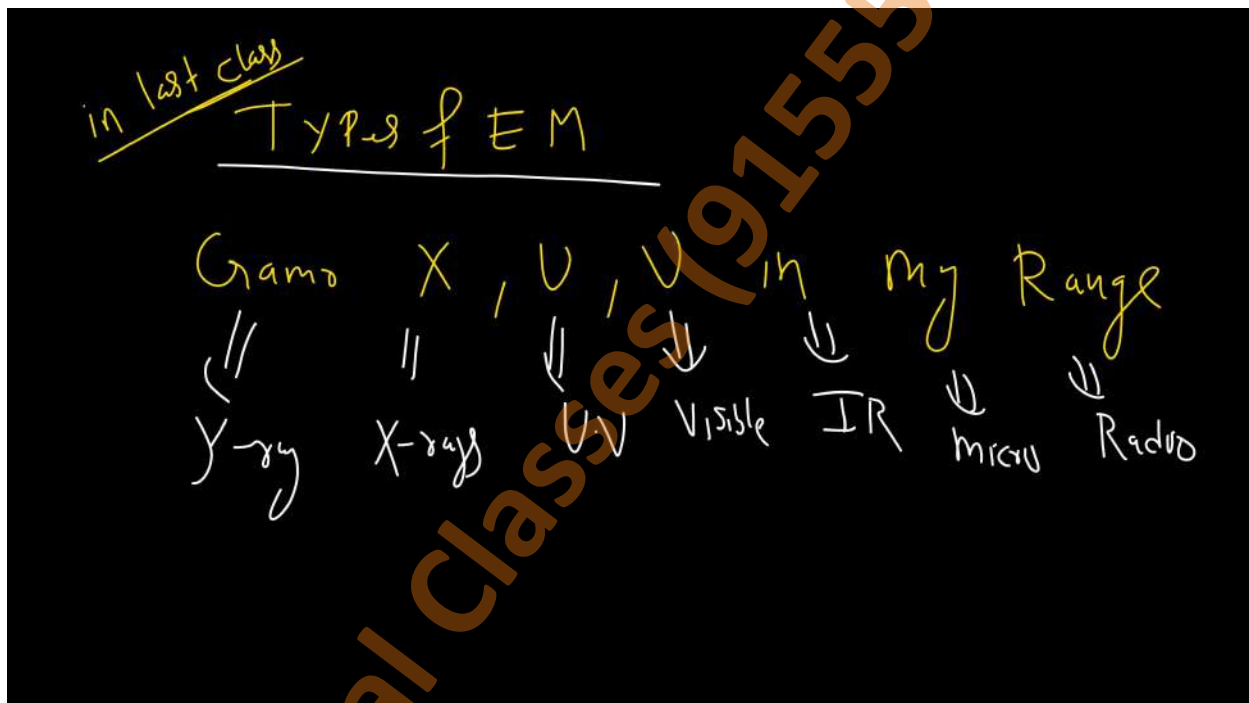
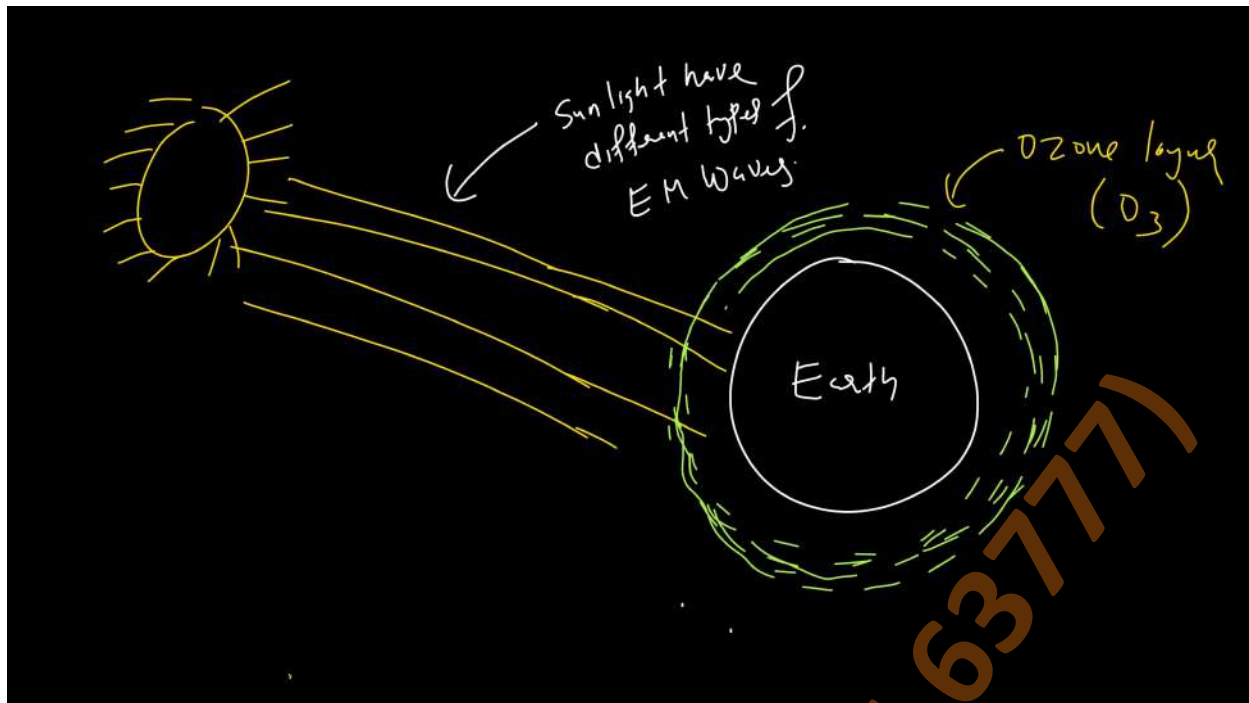
dark side wavelength

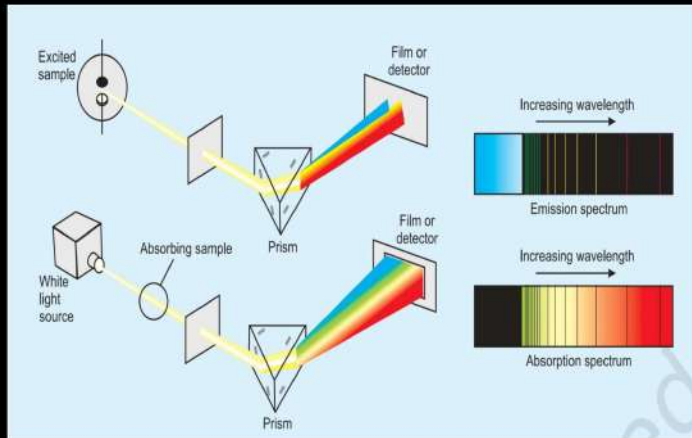
wavelength λ

absorption



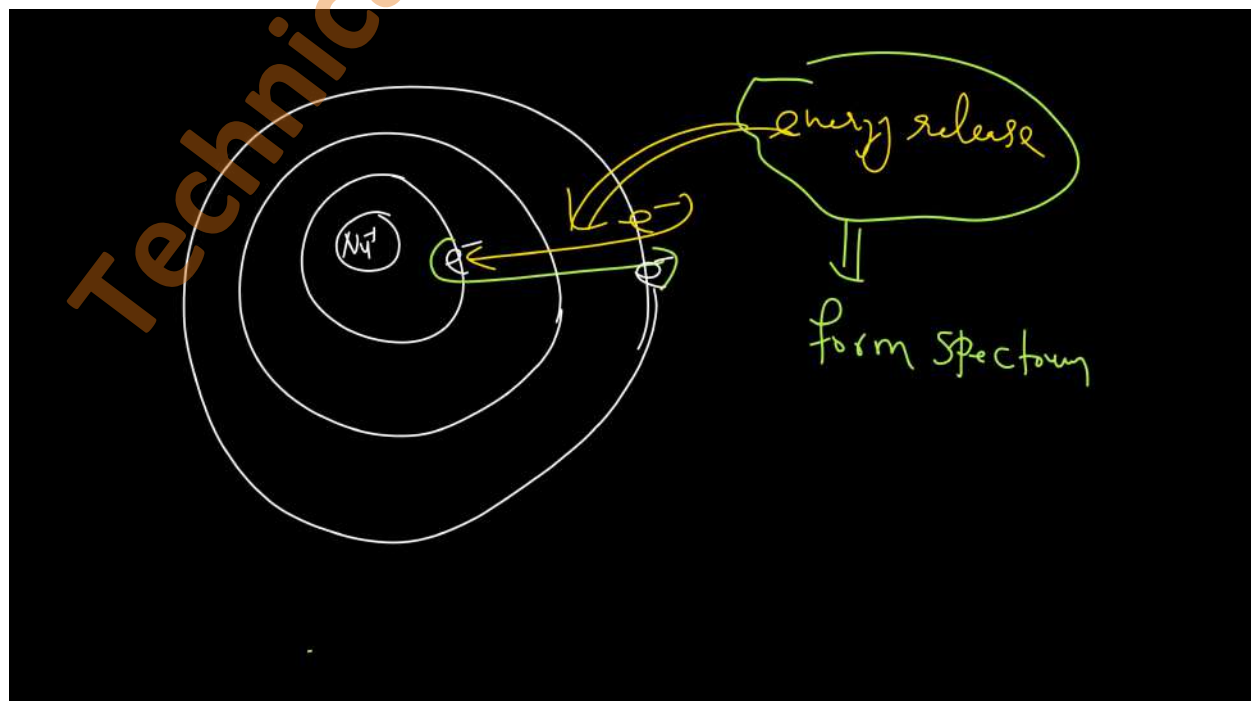
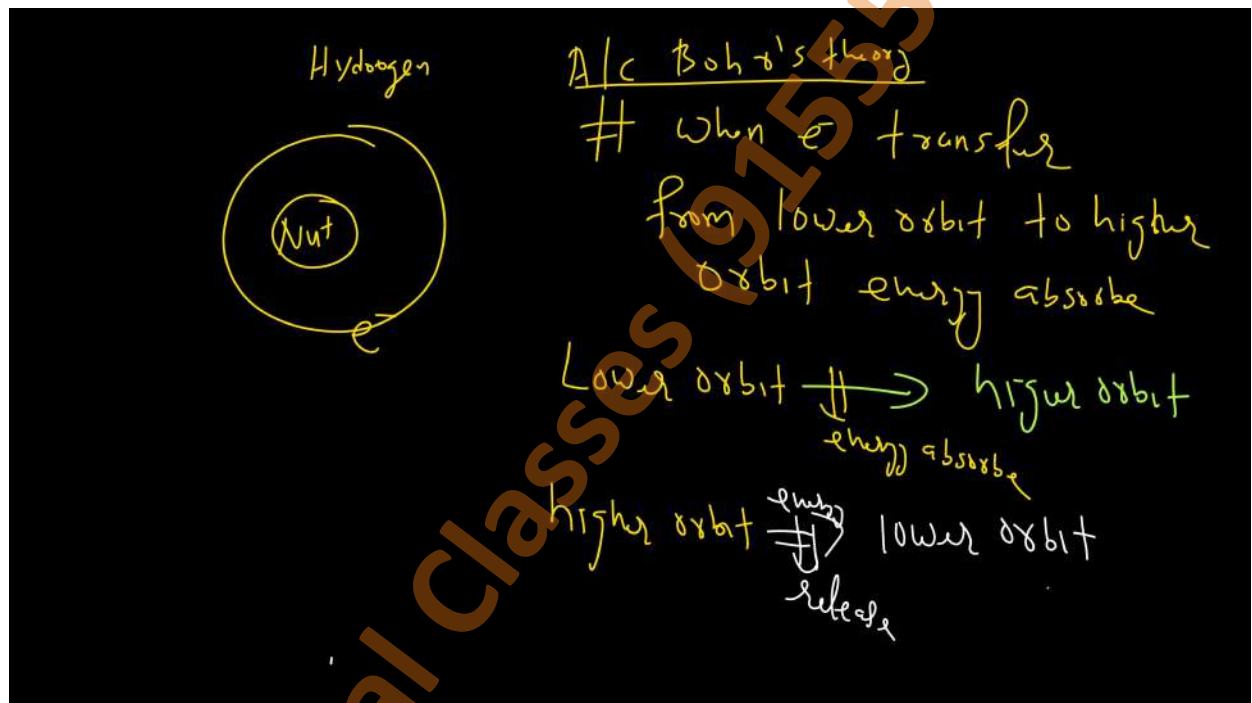
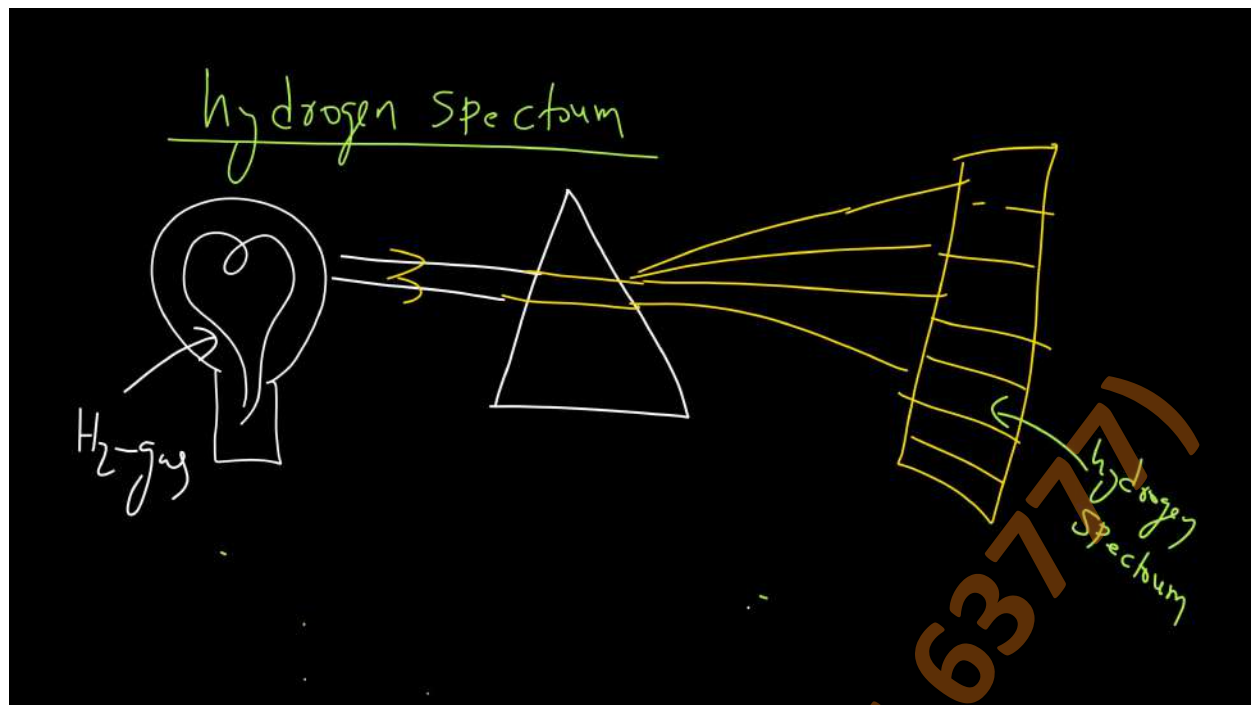
If object absorb light
 $\downarrow$
 then they look black
 Otherwise they different colour

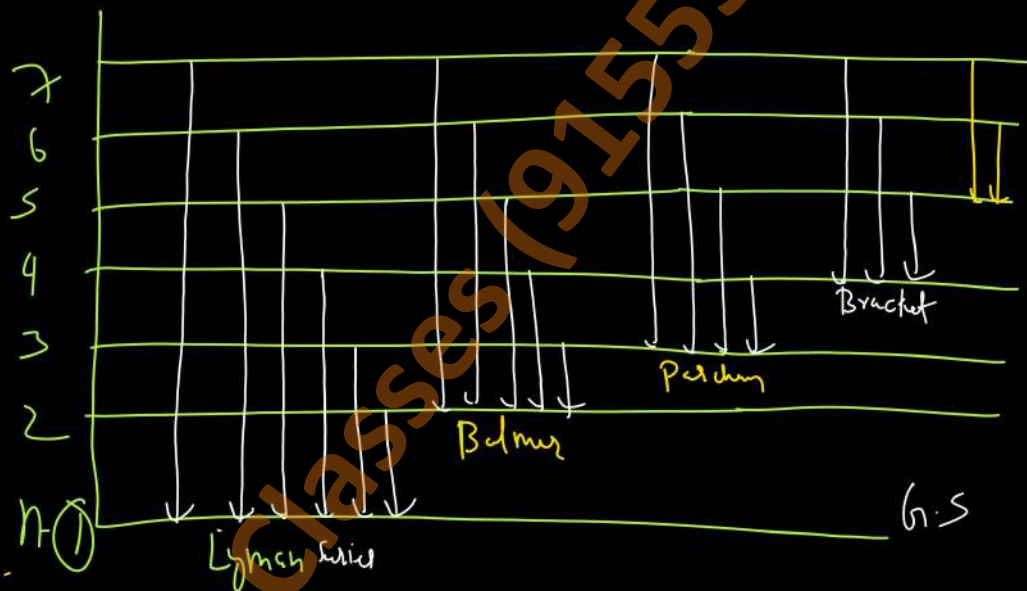
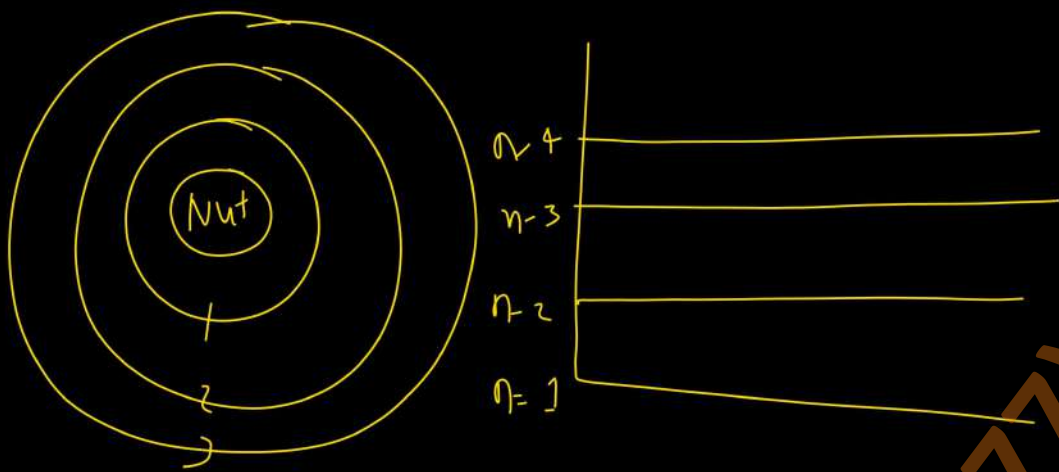




Absorption spectrum — Dark line or gaps
where certain wavelengths
are absorbed by a medium

Emission spectrum — Bright lines at specific
wavelengths produced





Hydrogen Spectrum

Series	n_1	n_2	Spectral Region
Lyman	1	2,3....	Ultraviolet
Balmer	2	3,4....	Visible
Paschen	3	4,5....	Infrared
Brackett	4	5,6....	Infrared
Pfund	5	6,7....	Infrared

IR

Which of the series belongs to Visible Region

(a) Lyman

☒ (b) Balmer

(c) Pfund

(d) None of these

Wave mechanical model of An atom

This model consists the followings

it consist complete new concept
of Atom

(i) Dual nature of matter

(ii) Heisenberg's Uncertainty Principle

Light / EM waves

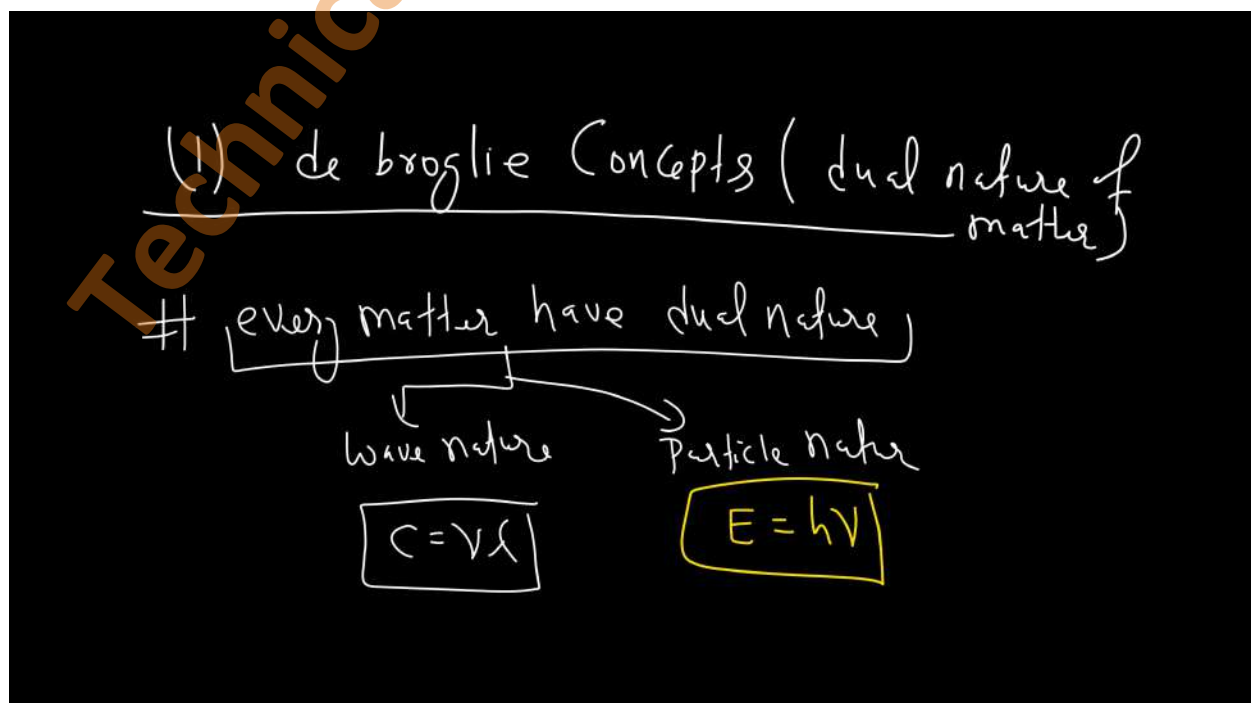
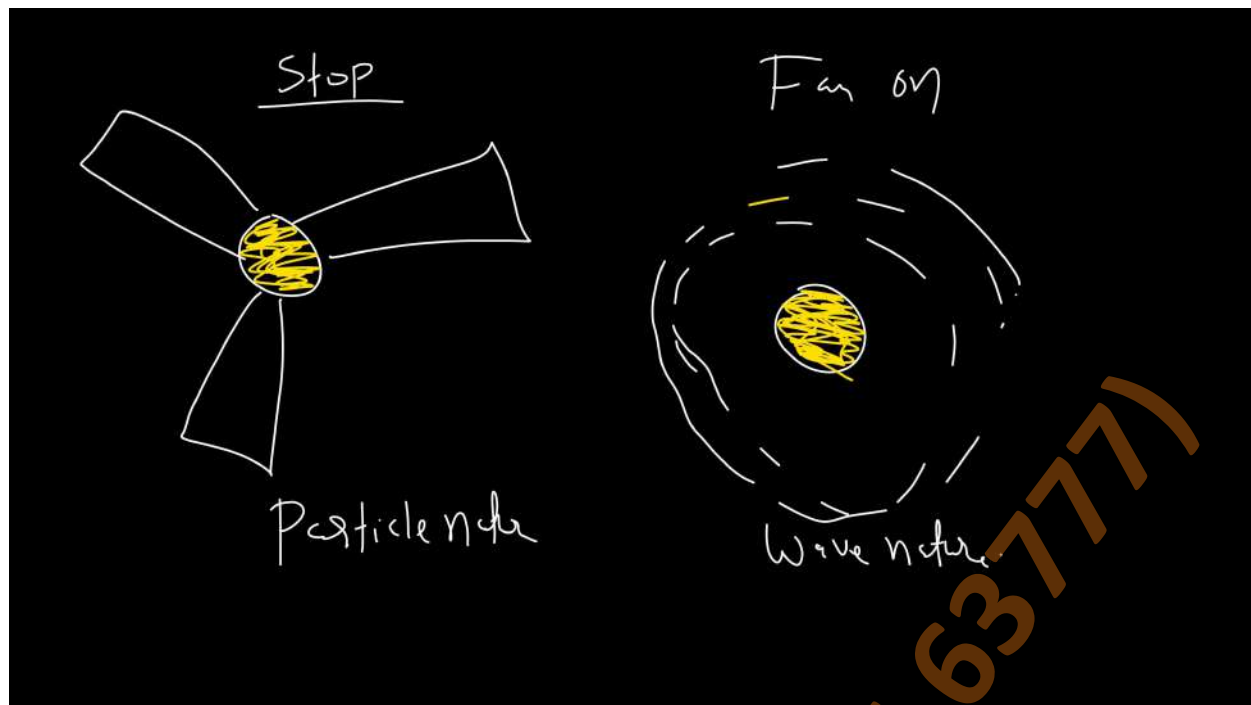
wave nature

$$c = \nu \lambda$$

Particle nature

$$E = h\nu$$

Quantum
theory



According to de Broglie wavelength λ of electron
is inversely proportional to its momentum

$$\lambda \propto \frac{1}{p}$$

Wavelength $\rightarrow$ momentum

$$\lambda = h \frac{1}{p}$$
$$\lambda = \frac{h}{p}$$

$$\lambda = \frac{h}{p}$$

$$p = m v$$

$\nearrow$ momentum $\downarrow$ mass $\downarrow$ velocity

$$\lambda = \frac{h}{m v}$$

Planck's constant

$$c = \nu \lambda$$
$$\lambda = \frac{c}{\nu}$$

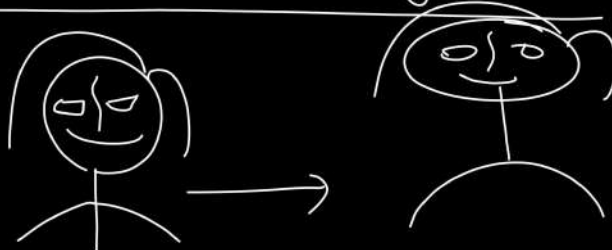
speed of light $3 \times 10^8 \text{ m/s}$

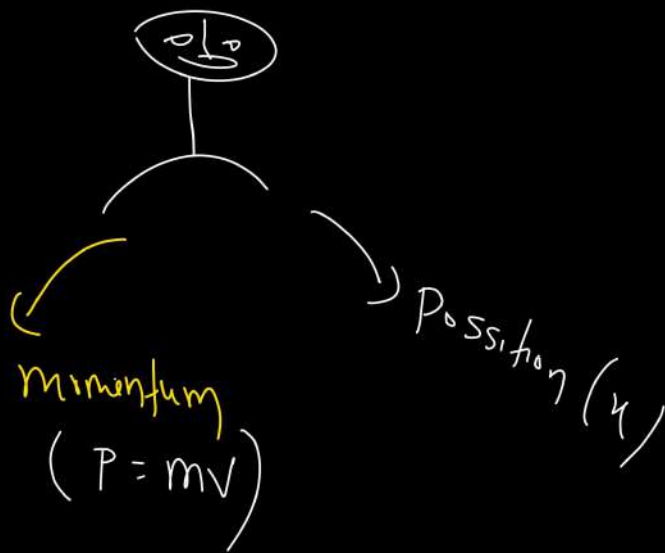
$$\frac{c}{\lambda} = \frac{h}{p}$$

frequency

$$\frac{c}{\lambda} = \frac{h}{m v}$$

Heisenberg Uncertainty principle





It is impossible to measure exact
position and momentum of a
Object at a same time

If change position Δx and change in
momentum Δp

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

← Planck's const

change in position change momentum

for question

$$\Delta x \cdot \Delta p = \frac{h}{4\pi}$$

$$\frac{2h}{8\pi}$$

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

$$p = m v$$

$$\Delta p = m \Delta v$$

$$\Delta x \cdot m \Delta v \geq \frac{h}{4\pi}$$

for Question

$$\Delta x \cdot \Delta p = \frac{h}{4\pi}$$

$$\Delta x \cdot m \Delta v = \frac{h}{4\pi}$$

$$m = \frac{h}{4\pi \Delta v \Delta x}$$

Δx - change in position

Δp - change in momentum

Δv - change in velocity

m - mass

h - plank's const

$$\pi = 3.14$$

Q The uncertainty in position and velocity of a particle are 10^{-10} m and $5.27 \times 10^{-24} \text{ m s}^{-1}$ respectively. Calculate the mass of the particle

$$h = 6.625 \times 10^{-34} \text{ J s}$$

$$\Delta n \cdot m \Delta v = \frac{h}{4\pi}$$

$$m = \frac{h}{\Delta n \Delta v 4\pi} = 3.14$$

Question

→

I.I.W

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Welcome to Technical classes

TECHNICAL CLASSES

Topics

Understanding

- Atomic structure
- Chemical bonding

Understanding
comes memory
based topic

Introduction

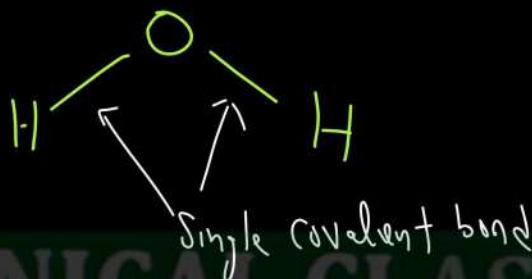
Water

Some important point

- ⇒ molecular formula — H_2O
- ⇒ chemical name — hydrogen oxide
- ⇒ i

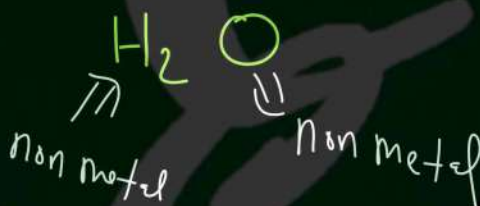


in H_2O molecule single bond present between hydrogen and oxygen

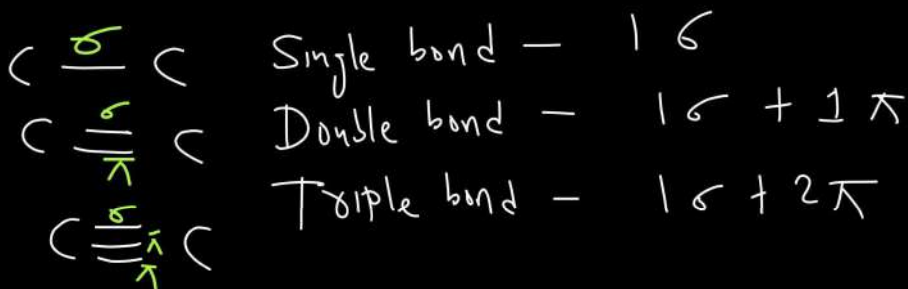


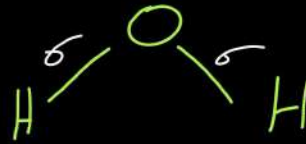
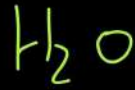
TECHNICAL CLASSES

$\Rightarrow$ Water / hydrogen oxide is a covalent compound



Sigma & π bond
(σ)





2 σ (sigma) bond & 0 π bond

molecules of water is polar in nature



water exist in Solid, liquid and Vapour state

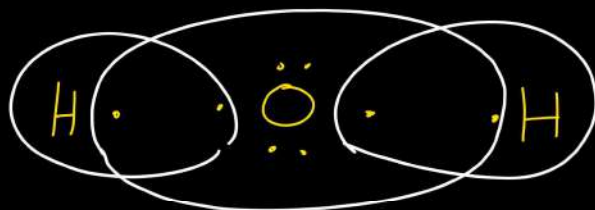
Ice — Solid state of water

Water — liquid state of water

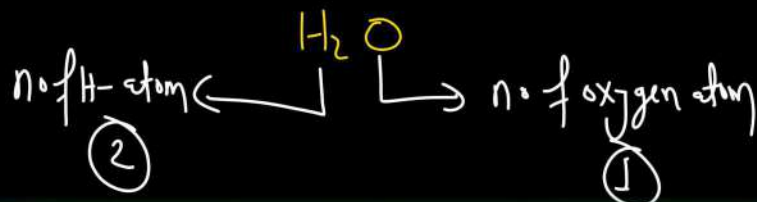
Water-Vapour — gaseous state of water.

at room temperature water exist in its natural state i.e. liquid state

water molecules is made by hydrogen and oxygen atom by covalent bond



In one water molecule



TECHNICAL CLASSES

Physical state of water



Gas

Oxygen present in
gaseous state

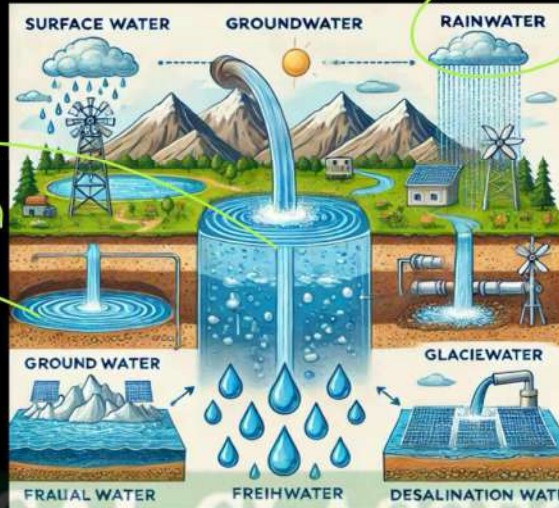
Oxygen present in gaseous state
at Room Temp^o (R.T)

Vapour

Water exist in
in it's Vapour phase

Water exist in
liquid state at R.T

Sources of Water



The main sources of water include:

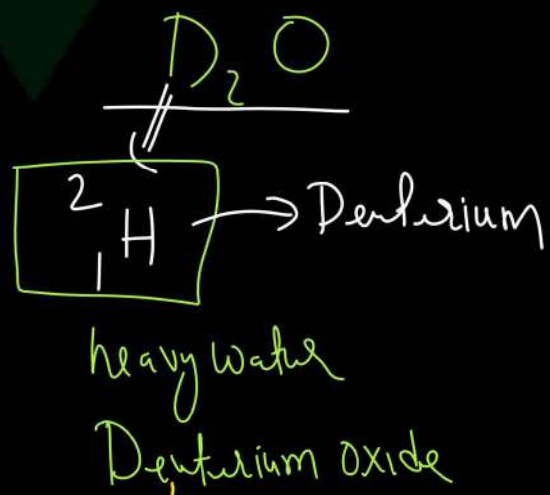
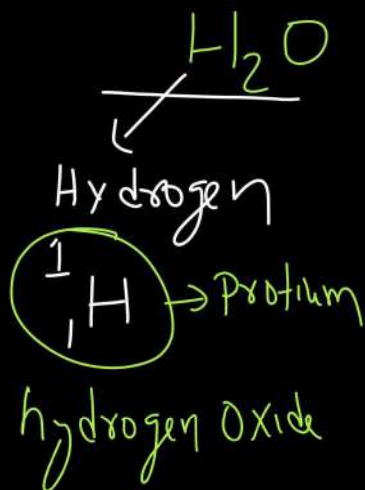
Surface Water: Rivers, lakes, reservoirs, ponds, and oceans.

Groundwater: Wells, borewells, and springs.

Rainwater: Water collected from precipitation.

Glacial Water: Melting of glaciers and snow.

Desalinated Water: Water obtained from desalination of seawater.





Normal fire
सामान्य आग

Reaction
Combustion RXN
to stop
Use H_2O
hydrogen oxide

Nuclear Reactor

Nuclear RXN
To stop
Use D_2O - Heavy water.

TECHNICAL CLASSES

Hardness of Water

Water
साबुन + Water → Lather
(आग)

Water + साबुन → Lather not produced
Hard water
(आग)
not a hard water

Water

Soft water Hard water

Produced lather with soap # Which not produced lather with soap



Hardness in water is due to the presence of dissolved salts of calcium and magnesium

Hardness in water

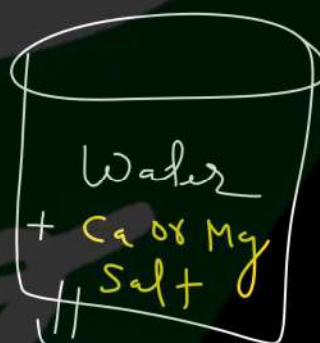
Reason

⇒ presence of salt of Ca & Mg

TECHNICAL CLASSES



Soft water
⇒ Produced lather



Hard water
do not produced lather

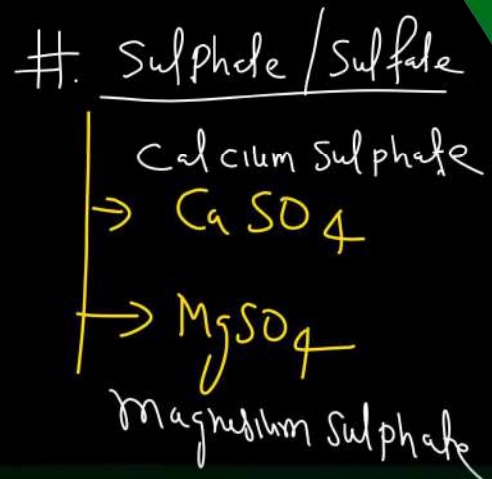
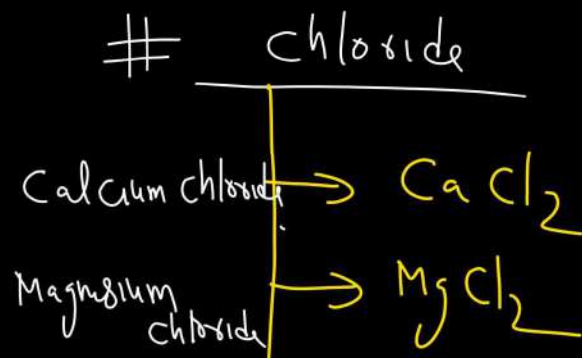
Salt of Calcium and Magnesium present in hard water.

⇒

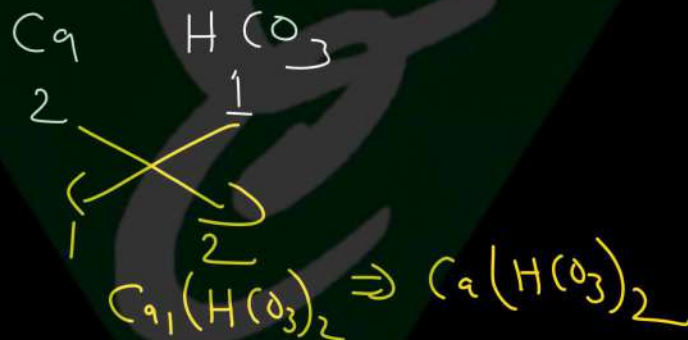
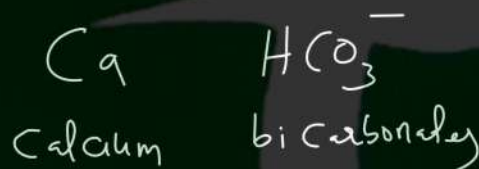
bicarbonates

→ $\text{Ca}(\text{HCO}_3)_2$ — Calcium bi carbonate

→ $\text{Mg}(\text{HCO}_3)_2$ — Magnesium bi carbonate



TECHNICAL CLASSES



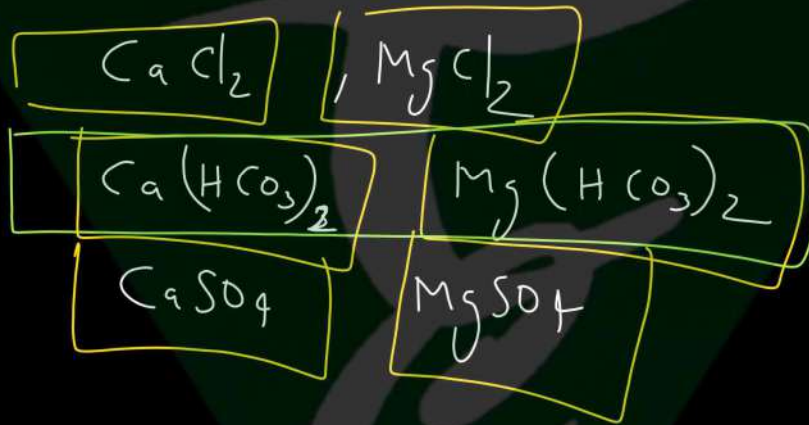
Hardness of water

Due to presence of salt of
Ca & Mg

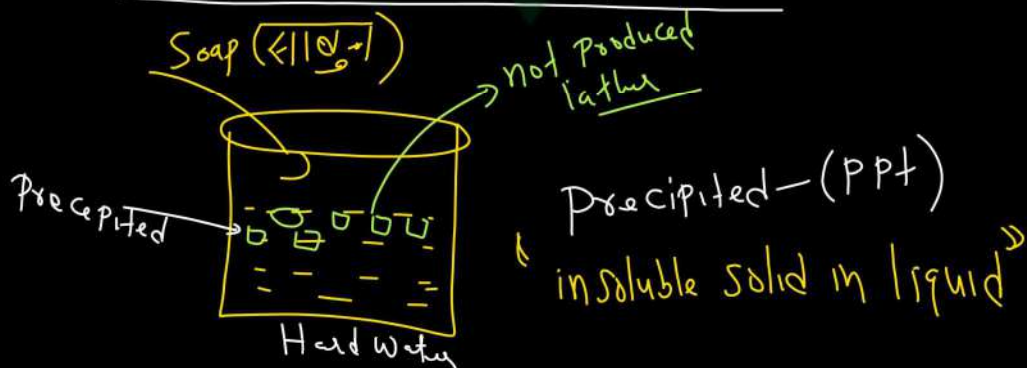


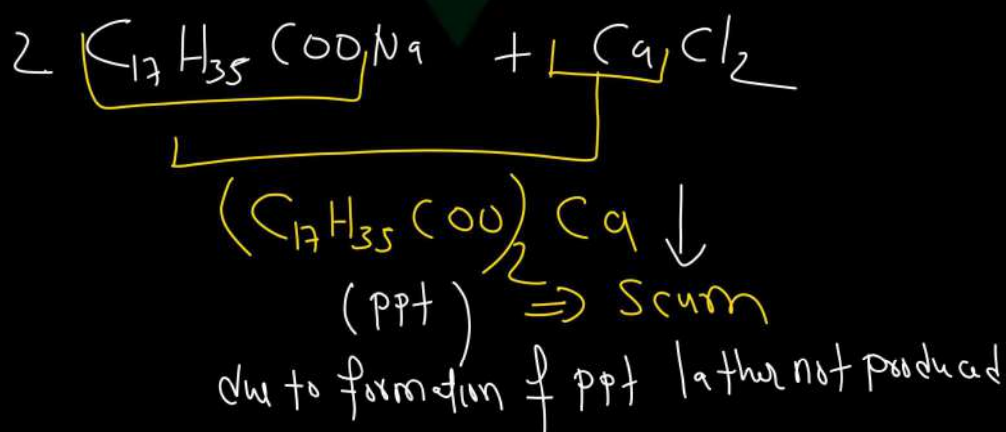
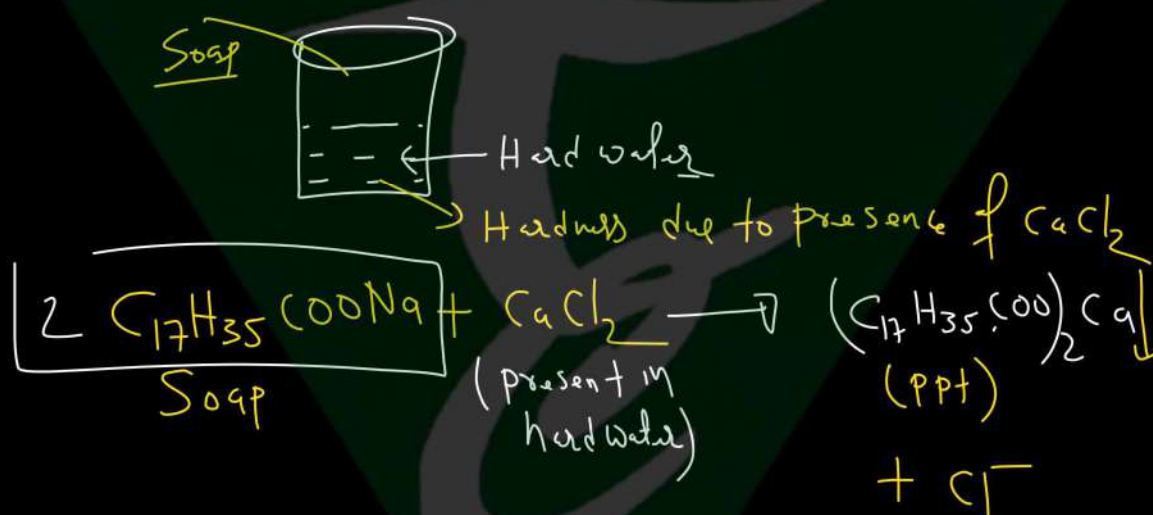
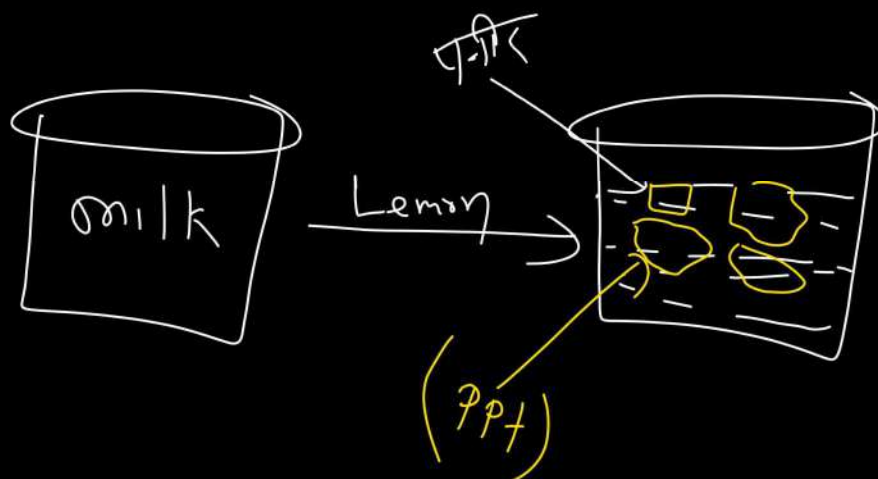
Types of water on the basis of hardness

- ① Hard water - Those type of water which not produce lather with soap due to presence of Salt (chloride, sulphate, bicarbonate) of Calcium and magnesium



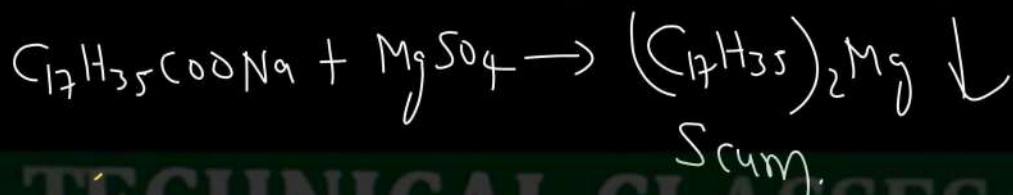
Reason for hardness of water



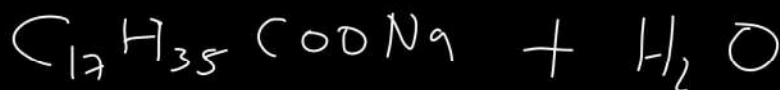
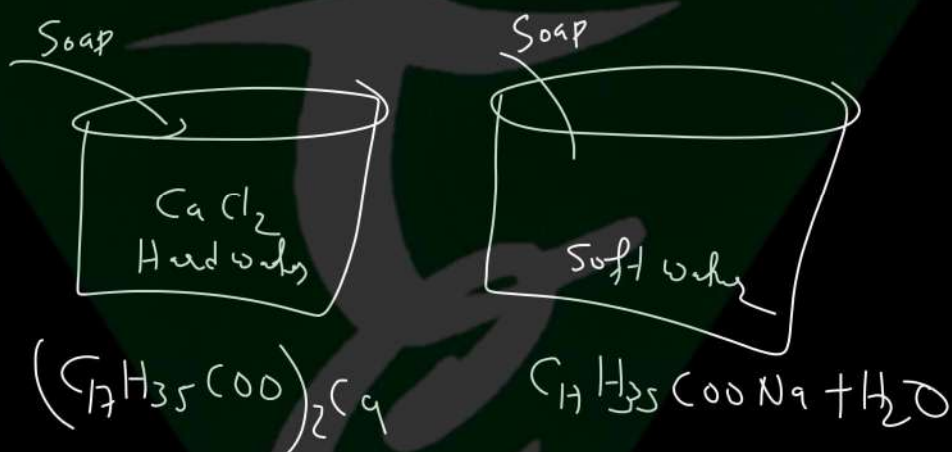




Scum - the insoluble solid formed after reaction of soap with impurities present in hard water.

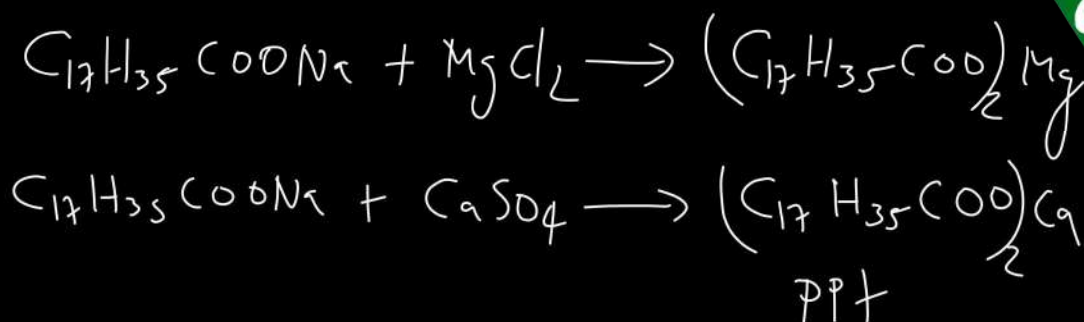


TECHNICAL CLASSES



Soap





TECHNICAL CLASSES

Soft water — Those types of water which produce lather with Soap, due to absence of salt of calcium and magnesium.

Types of hardness of water

Permanent hardness

in which chloride and Sulphate of Ca & Mg Present

Temporary hardness

in which bicarbonate of Ca & Mg Present

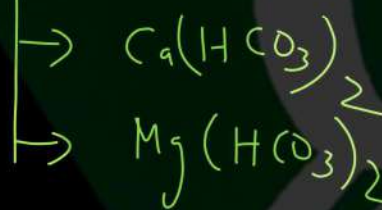


① Temporary hardness of water

Those types of hardness of water which easily remove by boiling and these types of hardness due to presence of bicarbonate of calcium and magnesium.

TECHNICAL CLASSES

In Temporary hard water



Q In which of the compound present in Permanent hard water.

- (a) Calcium bicarbonate
- (b) Magnesium Sulphate
- (c) Calcium chloride
- ☒ (d) both (b) & (c)



Permanent hardness of water - Those types of hardness of water which not remove by boiling due to presence of chloride and sulphate of calcium and magnesium.

TECHNICAL CLASSES

Compounds responsible for permanent hardness

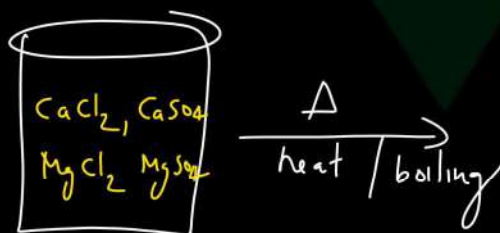
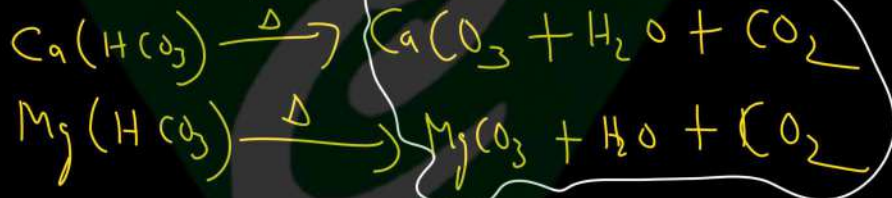
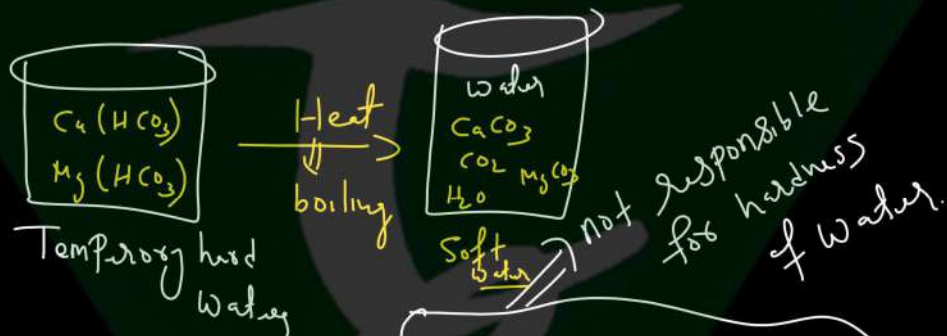
- | | |
|-----------------------|----------------------|
| (i) CaCl_2 | (ii) MgCl_2 |
| (iii) CaSO_4 | (iv) MgSO_4 |



Q Temporary hardness of water easily remove by boiling but Permanent not why?

Ans

Temporary hardness due to $\text{Ca}(\text{HCO}_3)_2$
 $\text{Mg}(\text{HCO}_3)_2$
 Permanent hardness = due to CaCl_2 , MgCl_2
 CaSO_4 & MgSO_4



Permanent hardness

CaCl_2 / MgCl_2 / CaSO_4 / MgSO_4 these compound not decompose on heating / Boiling



Ans for Temporary hardness of water

responsible compound $\text{Ca}(\text{HCO}_3)_2$ and $\text{Mg}(\text{HCO}_3)_2$ decompose into other compound on heating or boiling so due to this reason Temporary hardness of water easily remove.



but in case of Permanent hardness responsible compounds are CaCl_2 , MgCl_2 , CaSO_4 or MgSO_4 these compounds are not decompose after heating or boiling. So Permanent hardness of water can't remove by boiling.

in class 10th

Decomposition Reaction

One substance $\Rightarrow$ Split up $\Rightarrow$ more than one substance
 $\Downarrow$
 विभाजन





Composition

Combination Reaction

संयोजन अभिक्रिया

Decomposition Rxn

विघटन अभिक्रिया

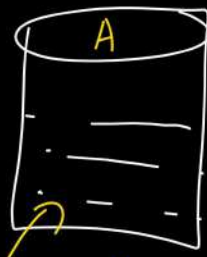


Science

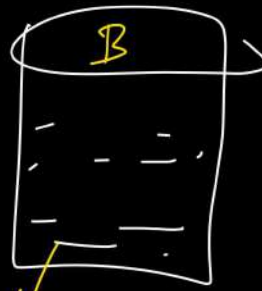
- word minor mistake
- Sentence with meaning gives marks
- Grammar not requirement

Degree of hardness

- # it is a way to calculate the hardness of water.
- ## it is use to compare hardness of different water.



hard water



hard water

Degree of hardness = $A < B$

B is more hard water as compare to A

TECHNICAL CLASSES

How to calculate Degree of hardness

Degree of hardness calculated by following methods

① Parts Per million (ppm)

②

Next class

Degree of hardness

Degree of hardness calculated by

① ppm (parts per million)

② mg per liter (mg/Liter)

③ Degree Clarke

④ Degree of French (°Fr)

Unit for calculate degree of hardness.

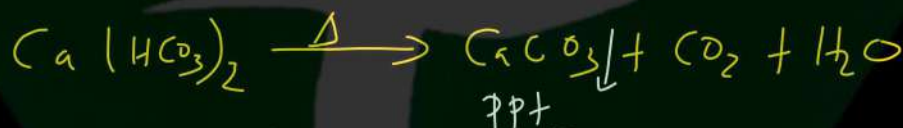


To calculate degree of hardness used CaCO_3 (calcium carbonate)

To calculate degree of hardness used CaCO_3 for following reason

(1) it is a precepted (ppt) which for after removing hardness of water.

TECHNICAL CLASSES



Sample of hard water.



10 mg CaCO_3



20 mg CaCO_3

(11) molar mass / molecular mass of CaCO_3

is 100u / 100g respectively

CaCO_3 to calculation in this situation quite easy.

$$40 + 12 + 3(16)$$

$$40 + 12 + 48 = 100$$



(III) equivalent mass of CaCO_3 is 50

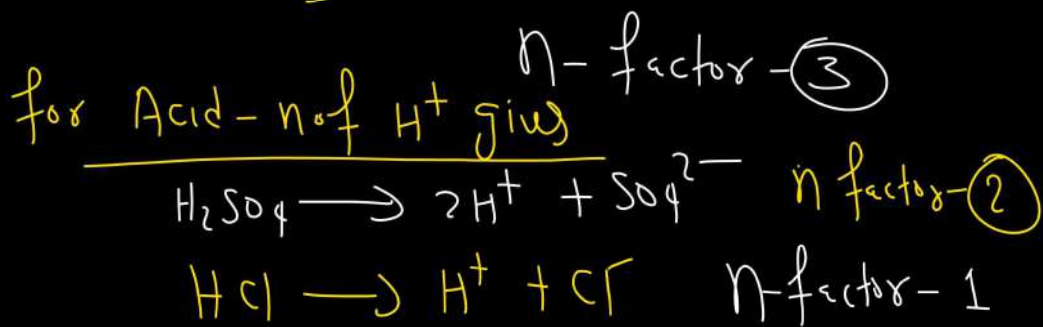


$$\begin{aligned} \text{equivalent mass} &= \frac{\text{molecular mass}}{\text{Valence factor}} \\ &= \frac{100.4}{2} = 50 \end{aligned}$$

TECHNICAL CLASSES



in case of salt — $\text{V.F.} = 2$
Valence factor
is equal to maximum
charge present on
cation (+) or anion (—)





for base - no. of OH^- gives



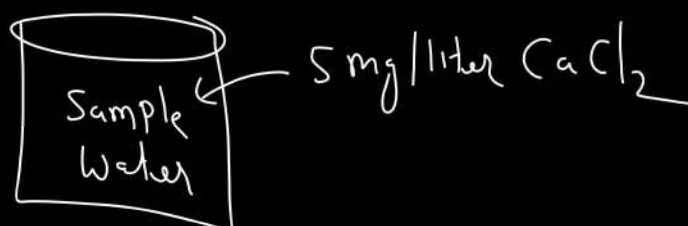
n-factor - (2)
n-factor - (3)

TECHNICAL CLASSES

Degree of hardness also calculate in terms of CaCO_3 equivalent

$$\text{CaCO}_3 \text{ equivalent} = \frac{\text{mass of hardness producing substance} \times \text{equivalent mass of CaCO}_3}{\text{equivalent mass of hardness producing substance}}$$

Q A water sample contains 5mg of CaCl_2 per liter calculate the hardness in terms of CaCO_3 equivalent.



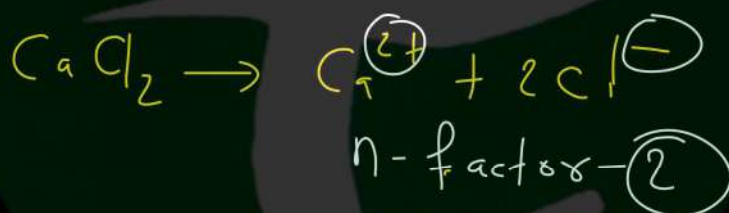


mass of hardness producing substance = 5mg

equivalent mass of $\text{CaCO}_3 = 50$

equivalent of (hardness producing substance)

$$\text{equivalent mass} = \frac{\text{molar mass}}{n\text{-factor}} = \frac{\text{CaCl}_2}{40 + 2 \times 35.5} = \frac{40 + 71}{2} = \frac{111}{2} = 55.5$$



$$\text{CaCO}_3 \text{ equivalent} = \frac{\text{mass of hardness producing substance} \times \text{equivalent mass of CaCO}_3}{\text{equivalent mass of hardness producing substance}}$$

for this question

$$\text{CaCO}_3 \text{ equivalent} = \frac{5 \text{ mg} \times \text{mass of CaCl}_2 \times \text{equivalent mass of CaCO}_3}{\text{equivalent mass of CaCl}_2} = \frac{5 \times 55.5 \times 50}{55.5}$$



$$\text{CaCO}_3 \text{ equivalent} = \frac{\cancel{5} \times 50 \times 10}{\cancel{555} \cancel{5}} \\ \frac{500}{111} = 4.5$$

TECHNICAL CLASSES

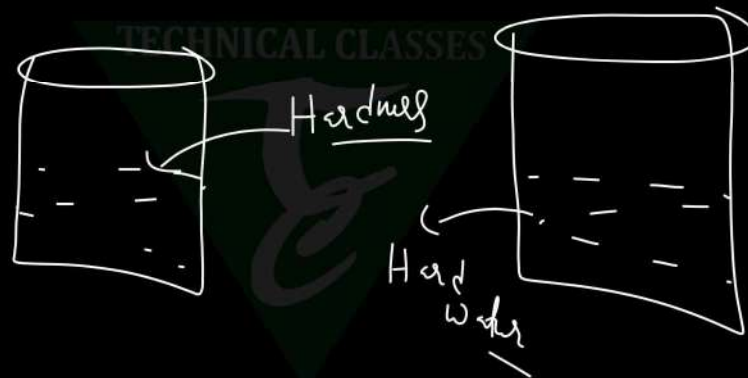


Unit of Degree of hardness

① Parts per million (ppm)



Degree of hardness



Technical Classes || Cont. - 91555 63777 / 93347 89450

Degree of hardness calculated by different methods and by using unit

Units of Degree of hardness

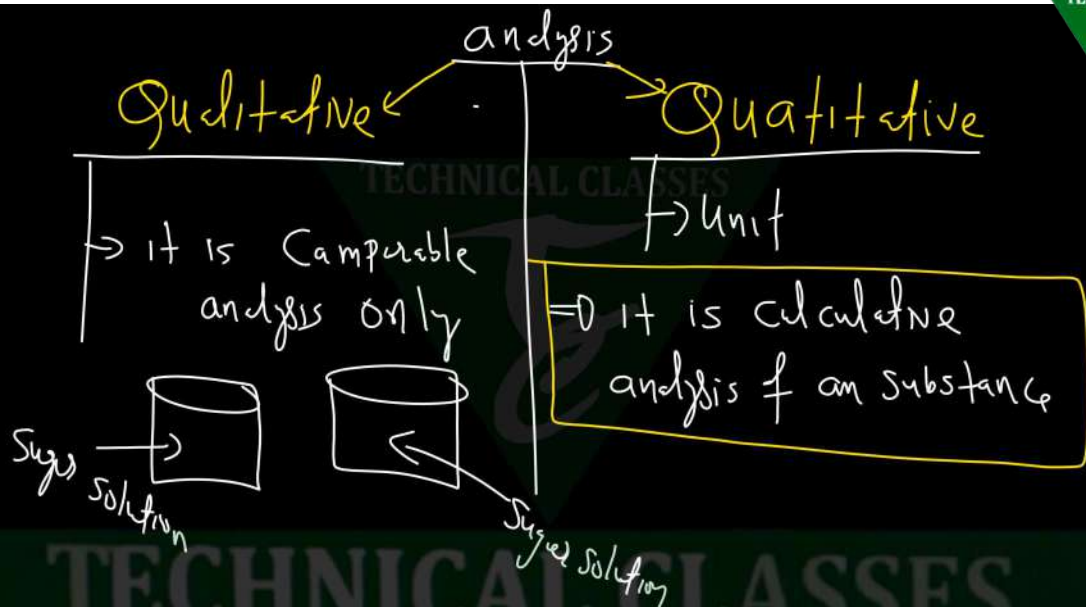
① PPM = Parts per million

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Unit of Degree of hardness

It gives quantitative value of degree of hardness

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① Parts per million it is unit of degree of hardness which represent 1 mg of CaCO_3 present in per liter water

1 ppm = 1 milligram present in 1 liter.

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$$1 \text{ ppm} = 1 \text{ mg per liter} \\ = \frac{1}{1000} \text{ g per liter}$$

$$1 \text{ g} = 1000 \text{ mg}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450



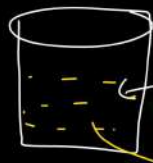
200 ppm

degree of hardness

In this water 200 mg CaCO_3 present in per liter water.

$$\text{In this water } \frac{200}{1000} \text{ g } \text{CaCO}_3 \text{ present in per liter.} \\ = 0.2 \text{ g } \text{CaCO}_3 \text{ present in per liter}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450



20 Liter hard water

10 PPM degree of hardness.

10 PPM = 10 mg CaCO_3 present in one liter.

If 1 liter water contain 10 mg CaCO_3

20 " " " " $10 \times 20 = 200 \text{ mg } \text{CaCO}_3$

$$\frac{200}{1000} \text{ g } \text{CaCO}_3$$

$$0.2 \text{ g } \text{CaCO}_3$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

100L
Volume



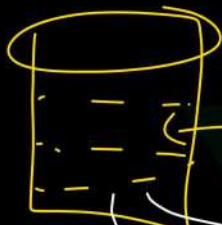
Water

60 PPM degree of hardness

60 mg Per liter

$$\frac{60}{1000} = 0.06 \text{ g per liter.}$$

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25 PPM

20 liter water.

CaCO_3 ??

in 1 liter water — 25 mg CaCO_3

20 " " — $25 \times 20 = 500 \text{ mg}$

$$\frac{25}{1000} \text{ g per liter}$$

$$25 \text{ mg per liter}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450



Q A container contain hardness which degree of hardness is 30 ppm if volume of water is 100 liter than calculate CaCO_3 present in it.

$$\text{mill} - 10^3$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

30 ppm degree of hardness
100 L volume

30 ppm = 30 mg per liter.

1 L ——— 30 mg CaCO_3

100 L ——— $30 \times 100 = 3000 \text{ mg}$
 $\frac{3000}{1000} = 3 \text{ g}$

Technical Classes || Cont. - 91555 63777 / 93347 89450

in gram

$$\text{amount of } \text{CaCO}_3 - \text{hardness in ppm} \times \text{volume in L} \times \frac{1}{1000}$$

$$\begin{aligned} \text{amount of } \text{CaCO}_3 &= 30 \times 100 \times \frac{1}{1000} \\ &= 3 \text{ g} \end{aligned}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450



in mg

$$\text{mass of } \text{CaCO}_3 = \text{hardness in ppm} \times \text{Volume}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

A contain contain water with hardness 20 ppm
if volume of water is 20 L than calculate
amount CaCO_3 in g

$$\begin{aligned} \text{amount of } \text{CaCO}_3 &= \frac{20 \text{ ppm} \times 20 \text{ L}}{1000} \\ &= \frac{400}{1000} = 0.4 \text{ g} \end{aligned}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

$$\begin{aligned} \text{Amount of } \text{CaCO}_3 &= 20 \text{ ppm} \times 20 \text{ L} \\ &= 400 \text{ mg} \end{aligned}$$

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Unit of hardness

- ① PPM — 1 mg Per liter
- ② mg / liter — 1 mg Per liter.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Degree French ($^{\circ}\text{Fr}$) — 10 mg of CaCO_3 per
liter of water

$$1^{\circ}\text{Fr} = 10 \text{ mg/L}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

Q A 10L water contain 20°Fr CaCO_3
than calculate mass of CaCO_3 in
water.

$$1^{\circ}\text{Fr} = 10 \text{ mg/L}^1$$

$$20^{\circ}\text{Fr} = 10 \times 20 \text{ mg} \\ = 200 \text{ mg/L}^1$$

$$\text{In } 10\text{L water} = 200 \times 10 = 2000 \text{ mg } \text{CaCO}_3$$

Technical Classes || Cont. - 91555 63777 / 93347 89450



$$\text{PPM} = \frac{\text{mg/L}}{1 \text{ mg/L}}$$

$$\text{mg/L} = 1 \text{ mg/L}$$

$$\text{°F} = 10 \text{ mg/L}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

Degree Clark (°Cl) -

1 grain of CaCO_3 per gallon of water

64.8 mg

$$\text{U.S.} = 3.785 \text{ liter}$$

$$\text{U.K.} = 4.546 \text{ liter}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

Definitions

°Cl - it is unit of hardness of water which represent 1 grain of CaCO_3 per gallon of water.

Degree french - it is unit of Degree of hardness which represent 10mg of CaCO_3 per liter.

Technical Classes || Cont. - 91555 63777 / 93347 89450



PPm — It is unit of degree of hardness
Which represent one mg of
 CaCO_3 per liter.

Technical Classes || Cont. - 91555 63777 / 93347 89450

$1^\circ\text{Cl} = 1 \text{ gram of } \text{CaCO}_3 \text{ per gallon}$

for Objective Question

Technical Classes || Cont. - 91555 63777 / 93347 89450

Q One $^\circ\text{Cl}$ is eqd to

- (a) 1mg CaCO_3 per liter
- (b) 10 mg CaCO_3 per liter
- ☒ (c) 1 gram of CaCO_3 per gallon
- (d) 20 gram of CaCO_3 per gallon

Technical Classes || Cont. - 91555 63777 / 93347 89450



$$\text{Degree Clark (}^\circ\text{Cl)} = 14.25 \text{ mg/Liter.}$$

$$1^\circ\text{Cl} = 14.25 \text{ mg/L}$$

$$1 \text{ PPM} = 1 \text{ mg/L}$$

$$1 \text{ F}^\circ = 10 \text{ mg/L}$$

$$1 \text{ Cl}^\circ = 14.25 \text{ mg/L}$$

for Question

Technical Classes || Cont. - 91555 63777 / 93347 89450

Q A water have degree of hardness is 20°Cl , in 30 liter of water how much amount of CaCO_3 present.

$$1^\circ\text{Cl} = 14.25 \text{ mg/L}$$

$$20 = 20 \times 14.25 \text{ mg}$$

$$\text{In } 30 \text{ L} = 20 \times 30 \times 14.25 \text{ mg}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

Hardness level

if a water which contain very few amount of CaCO_3 for example 1 PPM CaCO_3 i.e. it is not consider as hard water.

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<u>Hardness level</u>	<u>amount of CaCO_3 in ppm (mg/L)</u>
(i) Soft water	$< 60 \text{ ppm}$
(ii) Moderate hard water	$61 - 120 \text{ ppm}$
(iii) Hard water	$121 - 180 \text{ ppm}$
(iv) Very hard water	$> 180 \text{ ppm}$

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*** Difference between hard and soft water

<u>Hard water</u>	<u>Soft water</u>
(i) it contain salt of calcium and magnesium in high amount	(ii) it contain salt of calcium and magnesium in low amount

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<u>Hard water</u>	<u>Soft water</u>
(i) it do not produce lather with soap easily	(ii) it produced lather easily with soap.
(iii) it produce scum	(iii) it do not produce scum generally

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Hard water

(IV) It formed when water passes through limestone, chalk or gypsum deposit

Compounds of Ca



Technical Classes || Cont. - 91555 63777 / 93347 89450

Hard water

(V) The Test of hard water is slightly rich taste

Soft water

(V) The test of soft water is testless

Technical Classes || Cont. - 91555 63777 / 93347 89450

Hard water

(VI) hardness of hard water remove by boiling or other chemical process than it used

Soft water

(VI) It naturally able to used because there are no any hardness present in it in high amount

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In exam

Difference between A & B

A

B

(i)

(ii)

(iii)

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In case of 3 marks questions

→ A/c to exam

→ 3 point

my suggestion

$$3 + 1 = 4$$

In case of 4 marks questions

A/c to exam - 4 point

my sugg = 4 + 1

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Treatment of hardness of water

(A) In case of Temporary hard water

Temporary hard water easily change into soft water by boiling

Technical Classes || Cont. - 91555 63777 / 93347 89450



[B] In case of Permanent hardness of water

Permanent hardness of water remove by different chemical process and other types of process.

in chemical process many chemical are used for treatment of hardness of water.

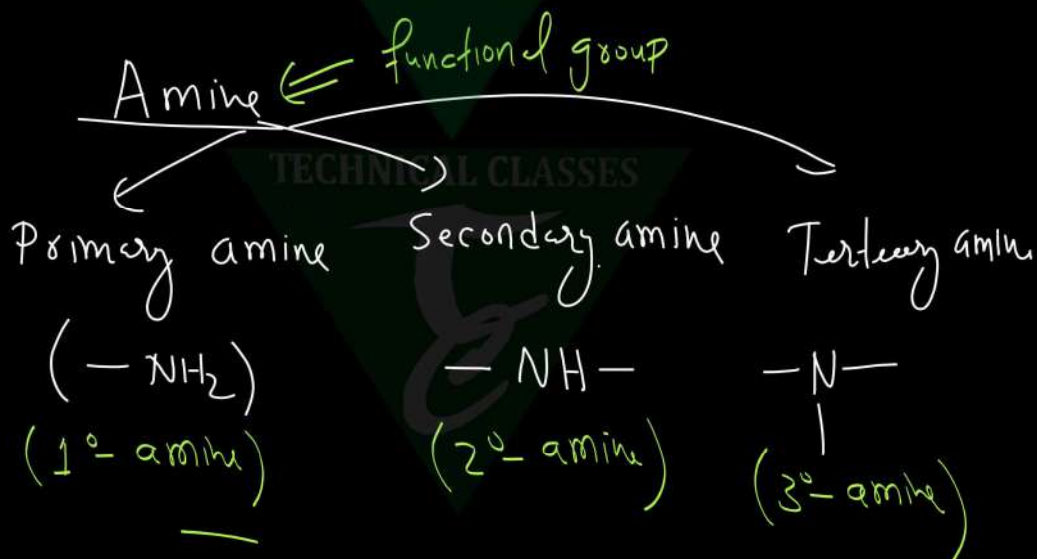
Technical Classes || Cont. - 91555 63777 / 93347 89450

Some Important chemical

① EDTA - Ethylene diamine tetra acetate

two (di)amine = amine $-NH_2$, $-NH-$, $-N-$
tetra = ④

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Technical Classes || Cont. - 91555 63777 / 93347 89450



Ethylene - $\text{CH}_2=\text{CH}_2$
(Ethene)

Carboxylic Acid - $-\text{COOH}$

Acetate - COO^-

Acetic acid - CH_3COOH - CH_2COOH

Technical Classes || Cont. - 91555 63777 / 93347 89450

Ethylene diamine tetraacetic acid



Technical Classes || Cont. - 91555 63777 / 93347 89450

Some important point about EDTA

- ⊕ It is not highly soluble in water.
- # So it not used directly in different types of methods.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Ethene diamine tetraacetate



TECHNICAL CLASSES

Technical Classes || Cont. - 91555 63777 / 93347 89450

PPM- it is defined as the part of CaCO_3
equivalent hardness present
in 10^6 parts of water

1mg ←

1mg CaCO_3 in 10^6 mg water
--

→ 100

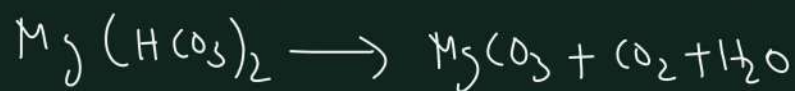


TECHNICAL CLASSES

Q Why boiling works for Temporary hardness not for Permanent hardness

Ans — boiling works for temporary hardness because in temporary hard water $\text{Ca}(\text{HCO}_3)_2$ and $\text{Mg}(\text{HCO}_3)_2$ are present which is responsible for temporary hardness $\Rightarrow$

When temporary hard water boils these compounds dissociate to other compounds





but in case of Permanent hardness responsible compounds are CaSO_4 , MgSO_4 , CaCl_2 and MgCl_2 . these compounds not dissociated on boiling so, Permanent hardness of water can't remove by boiling.

Q Which of the following is a major cause of water hardness

- (a) Sodium chloride
- ☒ (b) Calcium and magnesium salt
- (c) Potassium Permanganate
- (d) Carbon dioxide

Q Temporary hardness in water can be remove by

- ☒ (a) Boiling
- (b) Filtration
- (c) chlorination
- (d) Reverse osmosis (RO)

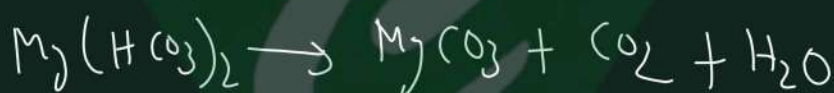


Q The chemical formula of EDTA is



TECHNICAL CLASSES

Q Write the chemical reaction involved in the removal of temporary hardness by boiling



Q hard water not form lather with Soap why?

Ans— hard water not form lather with Soap because Soap react with compound present in hard water like CaCl_2 , MgCl_2 , CaSO_4 , MgSO_4 , $\text{Ca}(\text{HCO}_3)_2$ and $\text{Mg}(\text{HCO}_3)_2$ to



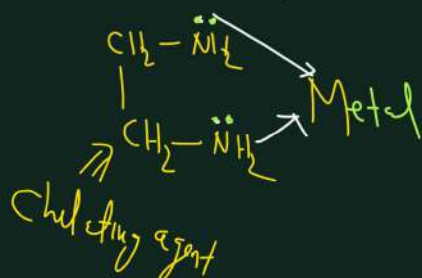
form precipitated, so soap not available to form lather. due to this reason soap not form lather with hard water.

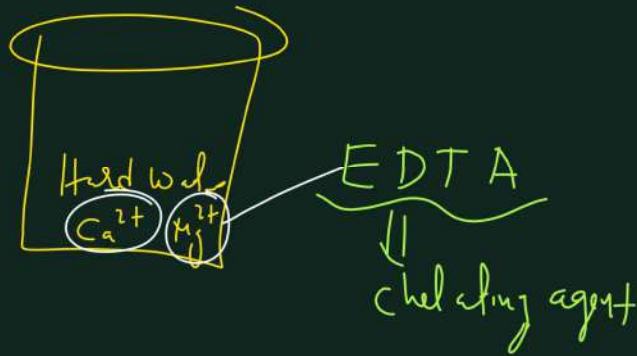
TECHNICAL CLASSES

EDTA - Ethylen diamine tetraacetic acid

EDTA - EDTA is an organic chelating agent with four carboxyl ($-\text{COOH}$) and two amine ($-\text{NH}_2$) functional group it forms stable complexes with metal like Ca^{2+} and Mg^{2+}

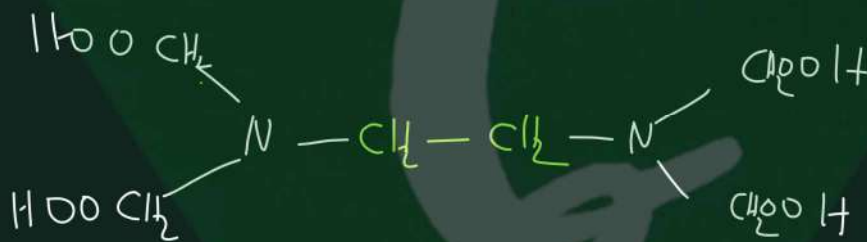
Chelating agent - those compound which have multiple donor site and form multiple bond with metal





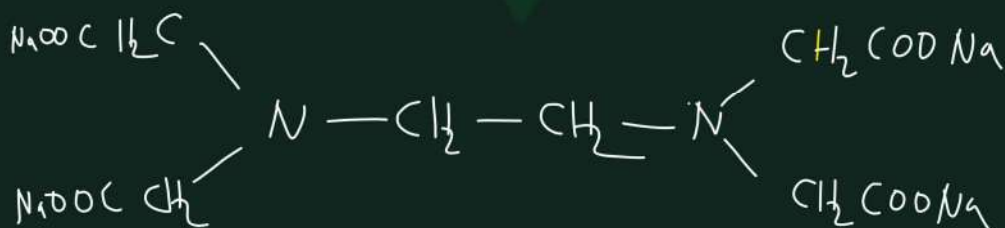
TECHNICAL CLASSES

Ethylene diamine tetra acetic acid



With out any metal like Na, Mg, Ca

With Na metal



Na_4EDTA



Topics
(आत्म शायरी) 201

TECHNICAL CLASSES

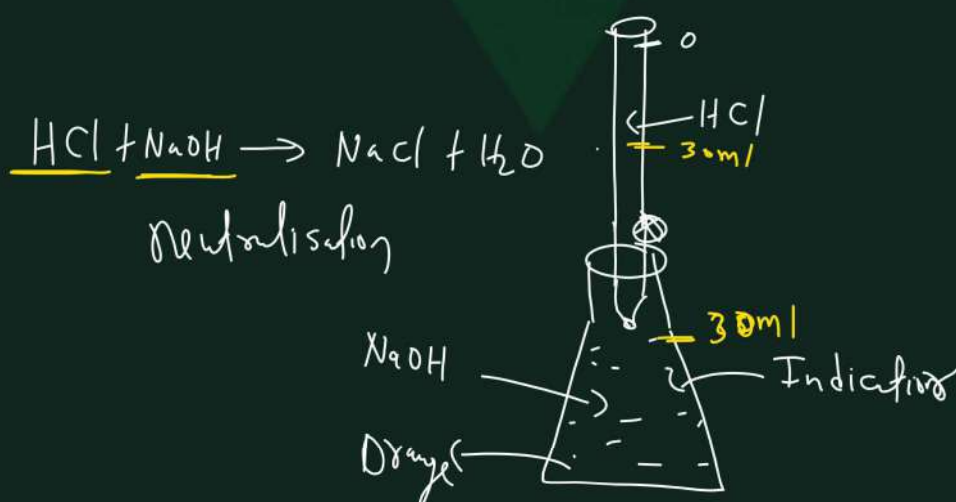
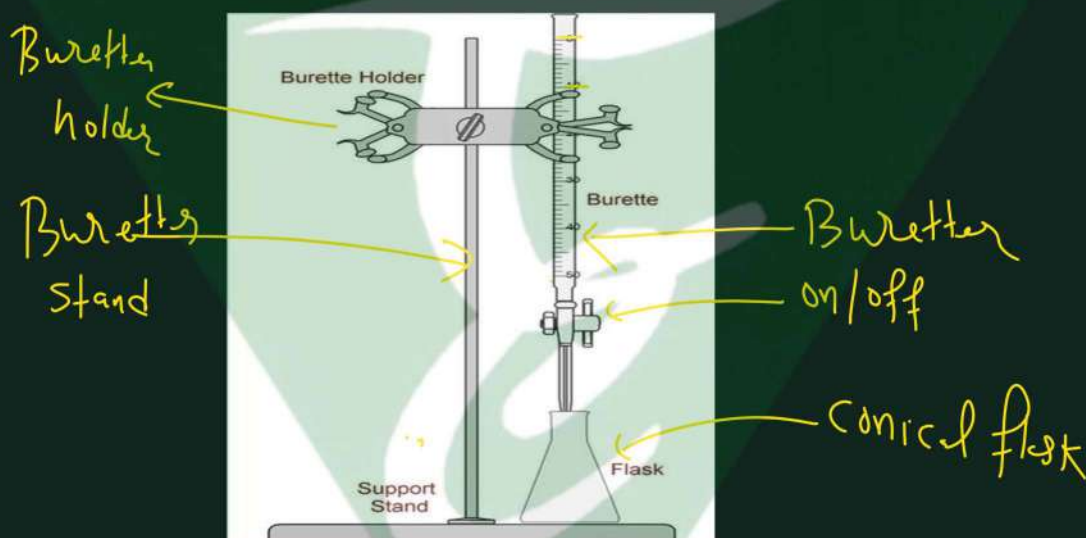


Quantitative measurement of water hardness
by EDTA by Titration

Quantitative measurement - in this type of
measurement amount calculated in a
precise manner.



Titration — it is a laboratory method
 Used to determine the concentration
 of an unknown solution by reacting
 it with a solution of known concentration
 until the reaction reaches the endpoint
 it indicated by a change in colour.





in Titration

Un known solution + known solution $\rightarrow$ change colour

TECHNICAL CLASSES

measurement of hardness of water by EDTA

Requirement

- ✓ (I) EDTA (standardized 0.01 M)
- ✓ (II) Eriochrome Black T indicator
- ✓ (III) Ammonia Buffer solution (pH - 10)
- ✓ (IV) Distilled Water
- ✓ (V) Water Sample (unknown concentration)

(III)



Ammonia buffer solution

$\Rightarrow$ It is a type of solution which not change its pH when small amount of acid or base added



What is indicator

A indicator is a substance which change its colour or odour in different medium (acidic, Basic or neutral)
for example- Litmus paper, methyl orange, Phenolphthaleine etc.



→ when it react with Ca^{2+} and Mg^{2+} ions its colour

change to $\Rightarrow$ Wine Red (Acidic)

P. Blue (Basic)

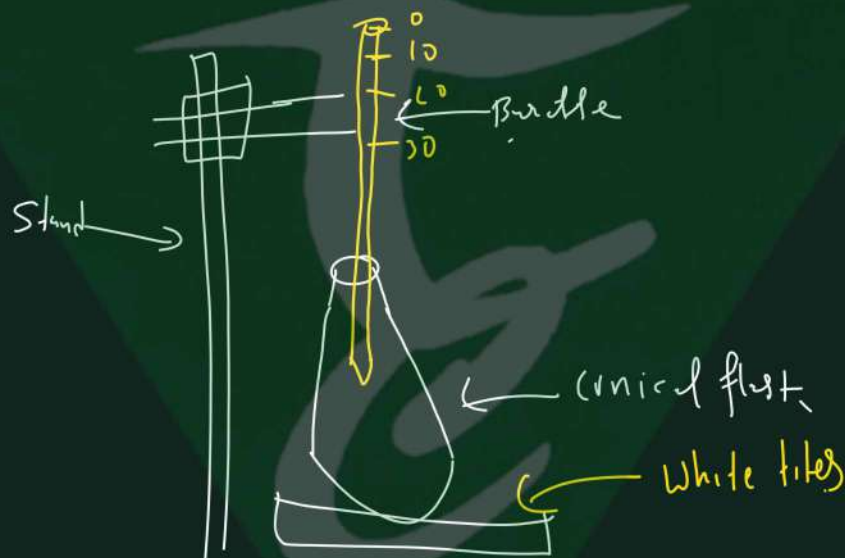
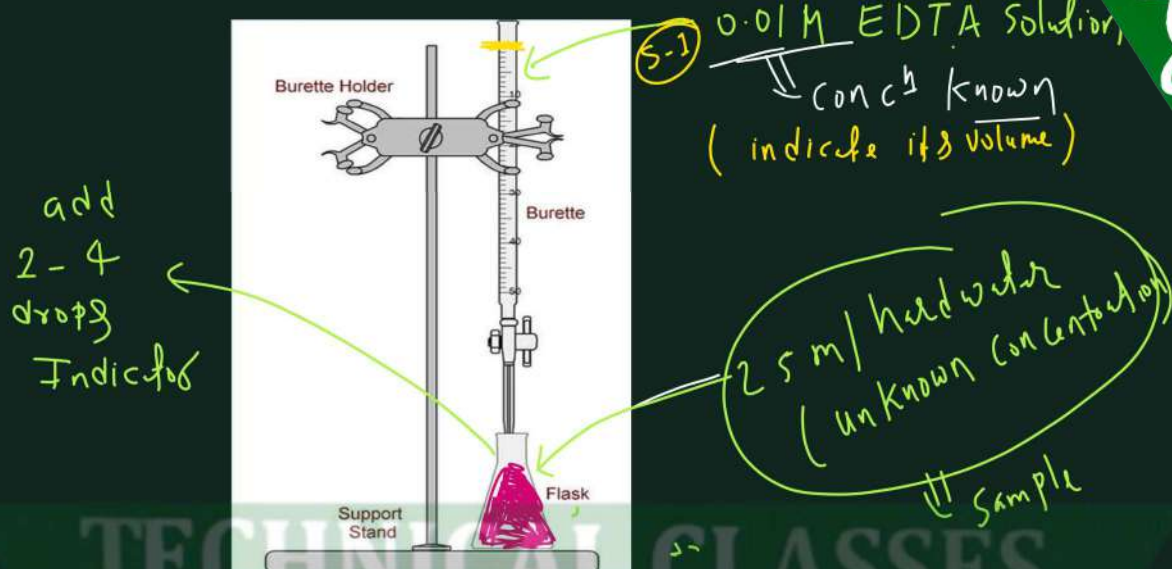


Indicator

Practical

Aim — ✓

Requirement — — ✓



Procedure

- Step-I add 0.01 M EDTA solution in Burette (measure its volume)
- Step-II add 25 ml hard water (Sample) in conical flask
- Step-III add indicator (two to four drops) in conical flask



Step-III add drops of EDTA solution into conical flask time to time and then observe colour change this process apply again and again until solution present in conical flask change in p. Blue

Step-IV measure change volume of EDTA solution present Burette and calculation occurs.

Calculation of hardness of water.
by EDTA through Titration

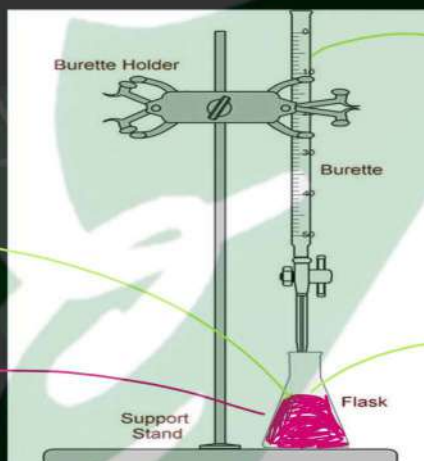


Indicator
ERIOCHROME BLACK T
Solochrome Black T
 $C_{20}H_{22}N_3O_7SNa$

Formula

Technical Classes || Cont. - 91555 63777 / 93347 89450

2-4 drops
of indicator
P. Blue

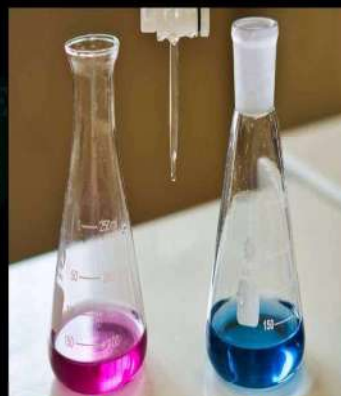


0.01M
EDTA
soln

Water
Sample -
(25ml)

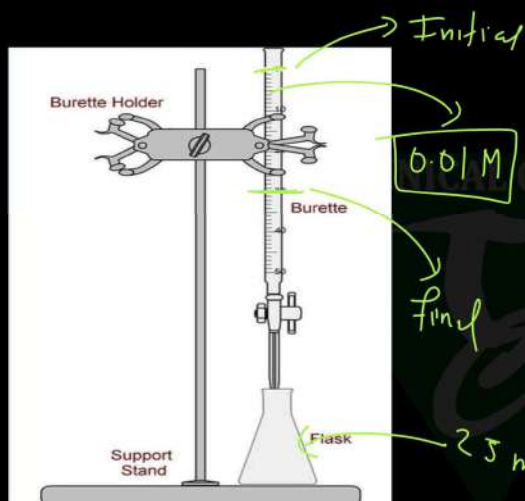
Technical Classes || Cont. - 91555 63777 / 93347 89450

after the process of
titration some calculation
shows actual hardness
of the water in ppm



Before
Titration After
titration

Technical Classes || Cont. - 91555 63777 / 93347 89450



Volume of EDTA = 30 ml

Molarity of EDTA = 0.01 M

Volume of water

Sample = 25 ml

Technical Classes || Cont. - 91555 63777 / 93347 89450

$$\text{Total hardness (in ppm)} = \frac{\text{Volume of EDTA} \times \text{Molarity of EDTA} \times 1000}{\text{Volume of water sample}}$$

$$\text{Total hardness} = \frac{30 \text{ ml} \times 0.01 \text{ M} \times 1000}{25} \rightarrow \text{Result hardness}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

Sample	hardness in ppm
Soft water	0 - 60 ppm
Moderate hardness	60 - 120 ppm
Hard water	120 - 180 ppm
Very hard water	180 ppm above

Technical Classes || Cont. - 91555 63777 / 93347 89450



Question A 30ml Sample of hard water
Present in a Conical flask if
0.01M EDTA solution Present in
a beaker have initial volume 0ml and
Final volume is 60ml then calculate hardness
of water by EDTA using titration

Technical Classes || Cont. - 91555 63777 / 93347 89450

Given

Molarity of EDTA solution = 0.01M

Volume of water sample = 30 ml

Volume of EDTA = 60 - 0 = 60 ml

Technical Classes || Cont. - 91555 63777 / 93347 89450

$$\begin{aligned}
 \text{Hardness of water} &= \frac{\text{Volume of EDTA} \times \text{Molarity of EDTA} \times 1000}{\text{Volume of Sample}} \\
 &= \frac{60 \times 0.01 \times 1000}{30} \\
 &= 20 \text{ ppm} \quad \text{It is a soft water.}
 \end{aligned}$$

Technical Classes || Cont. - 91555 63777 / 93347 89450



Advantage of EDTA Method

- (i) Highly accurate and reliable
- (ii) Can determine both total hardness and individual Ca^{2+} and Mg^{2+} hardness separately
- (iii) Quick and easy to perform

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Limitation of EDTA Methods

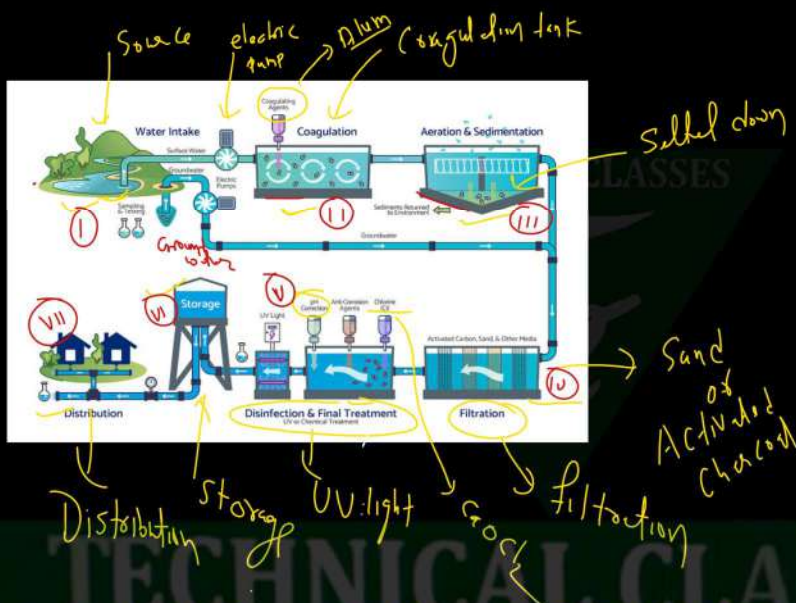
- (i) Requires a buffer solution to maintain pH
- (ii) Presence of interfering ions (Fe^{2+} , Al^{3+} , Mn^{2+}) can affect result

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Uses of EDTA method

This method is widely used in water quality analysis, boiler feed water testing and industrial water treatment

Technical Classes || Cont. - 91555 63777 / 93347 89450



Technical Classes || Cont. - 91555 63777 / 93347 89450

Water Softening Techniques (hard water to soft water)
Water softening is the process of removing hardness — causing minerals, primarily Calcium and magnesium salt from water

Technical Classes || Cont. - 91555 63777 / 93347 89450

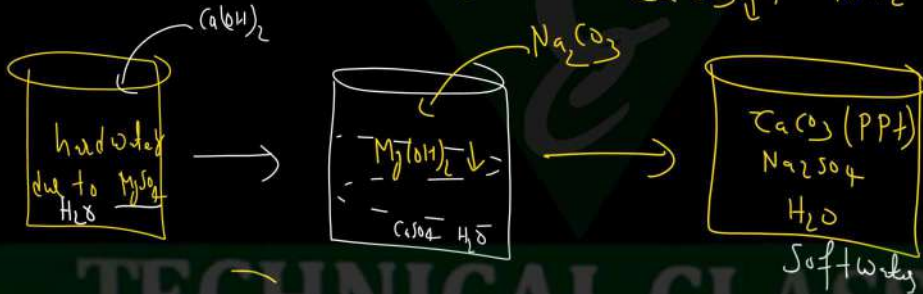
Most common ^{water softening} Techniques are

(a) Soda lime process — This process involves addition of Sodium carbonate (Na_2CO_3) and calcium hydroxide ($\text{Ca}(\text{OH})_2$) to hard water.
 Na_2CO_3 — Soda
 $\text{Ca}(\text{OH})_2$ — lime

Technical Classes || Cont. - 91555 63777 / 93347 89450

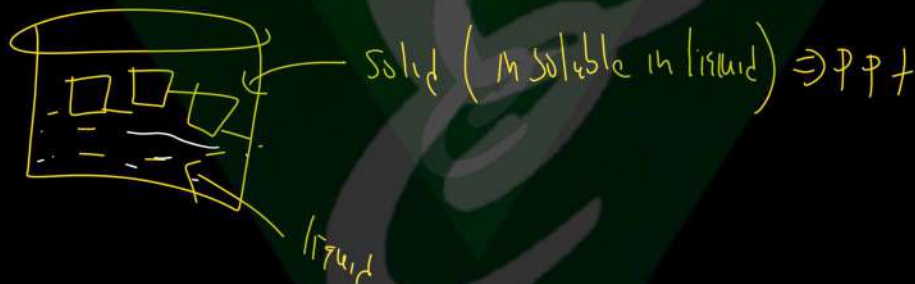


Case of hardness



Technical Classes || Cont. - 91555 63777 / 93347 89450

Precipitated — Insoluble solid in liquid



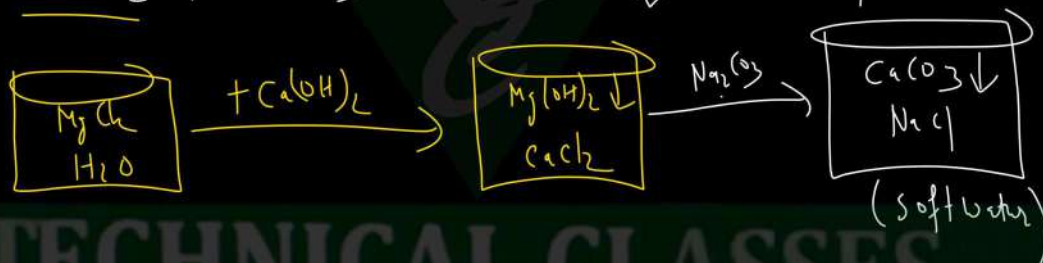
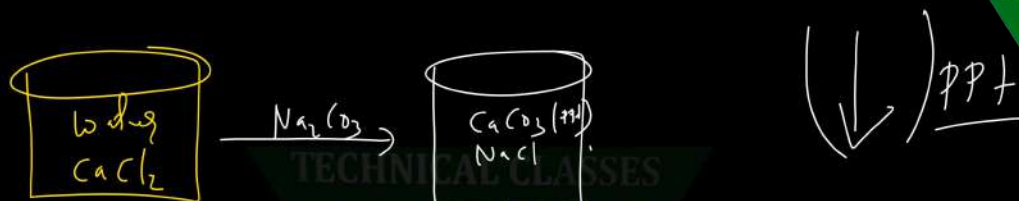
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Compound responsible for hardness

Ca and Mg Salt



Technical Classes || Cont. - 91555 63777 / 93347 89450



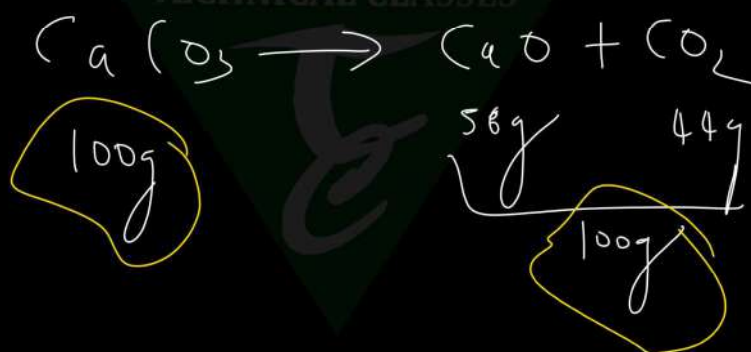
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unbalanced chemical equation is not correct representation of chemical reaction

Technical Classes || Cont. - 91555 63777 / 93347 89450

Question by Students



Technical Classes || Cont. - 91555 63777 / 93347 89450



Mass Nature created not be destroyed
It only convert from one form
to another form

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Municipal supply of water

The municipal supply of water refers
to the system by which water is
sourced, treated and distributed to household
industries and commercial establishments

Technical Classes || Cont. - 91555 63777 / 93347 89450

The key steps of municipal supply of water

- (I) Source of water - Rivers, lakes, reservoirs
groundwater (wells, borewells)
- (II) Collection and Storage - water is collected from
natural sources and stored in reservoir

Technical Classes || Cont. - 91555 63777 / 93347 89450



(III) Treatment - Water is treated to remove impurity present in it

(IV) Distribution - After treatment, water is supplied through a network of pipelines to consumers.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Treatment of water

Treatment of water is essential to ensure that the supplied water is safe for consumption. the main steps in water treatment are

Technical Classes || Cont. - 91555 63777 / 93347 89450

Step-I - Screening - Remove large debris like leaves, twigs and plastics.

Step-II Sedimentation - Allows suspended solids to settle at the bottom



Technical Classes || Cont. - 91555 63777 / 93347 89450



(III) Coagulation and Flocculation— chemical Coagulant (like alum) are added to help particles clump together and settle faster

✓ Potash alum— $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24 H_2O$
(पुश्करी)

Technical Classes || Cont. - 91555 63777 / 93347 89450

Q What is Coagulant and write name and chemical formula of a Coagulant

Ans A substance which ^{used} in water treatment to help particles clump together and settle faster.

for example— Potash alum— $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24 H_2O$

Technical Classes || Cont. - 91555 63777 / 93347 89450

(IV) Filtration— water is passed through layers of sand, gravel and charcoal to remove smaller particles

(V) Disinfection— chlorine, ozone, or UV radiation is used to kill harmful bacteria and viruses

Technical Classes || Cont. - 91555 63777 / 93347 89450



(VI). pH treatment - Lime or other chemicals are added to maintain an optimal pH level.

pH of ^{pure} water is 7

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as we know

$\text{pH} = 7$ neutral

$\text{pH} > 7$ Basic

$\text{pH} < 7$ Acidic

Technical Classes || Cont. - 91555 63777 / 93347 89450

hard water $\rightarrow$ soft water

How to remove Ca and Mg salt from water.

Technical Classes || Cont. - 91555 63777 / 93347 89450



In last class

Soda lime process

- # in this method hardness of water remove by using soda and lime
- # this method applied in one or more than one steps.

Technical Classes || Cont. - 91555 63777 / 93347 89450

- # in some cases hardness remove in single steps but in other cases hardness remove in more than one steps.
- # by using soda lime process hardness remove by formation of precipitate (ppt)
- # in some cases hardness not remove after the formation of precipitate

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Zeolite method

- ⇒ It is a method in which hardness of water remove by using Zeolite
- ⇒ Zeolite is a chemical which is also known Sodium Aluminosilicate which capture Calcium and magnesium ions from hardwater

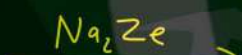
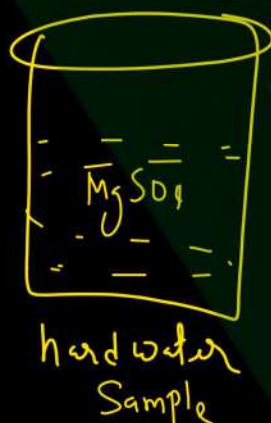
Technical Classes || Cont. - 91555 63777 / 93347 89450



Zeolite is represented as Na_2Ze



Technical Classes || Cont. - 91555 63777 / 93347 89450



Now, in this water sample there are no any compound present which is responsible for hardness of water

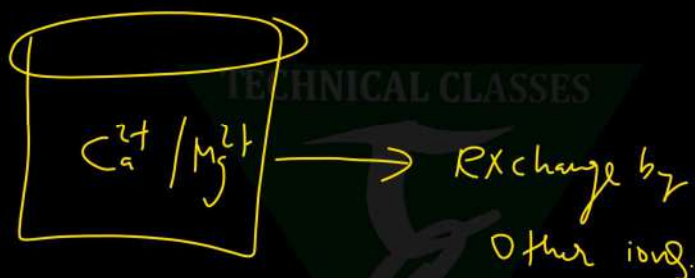
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Ion exchange methods

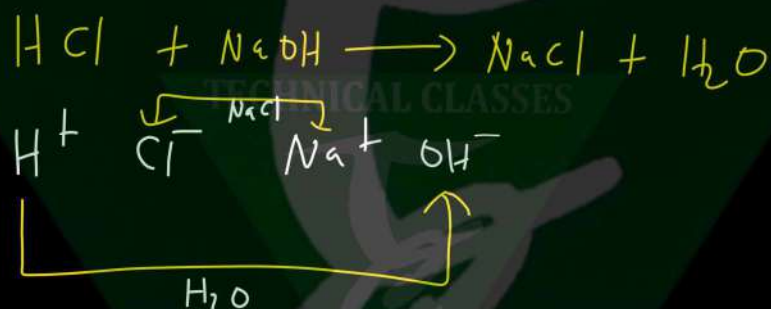
in this method calcium and magnesium ions remove from water by exchange of an
as we know Displacement / Double Displacement reaction



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Technical Classes || Cont. - 91555 63777 / 93347 89450



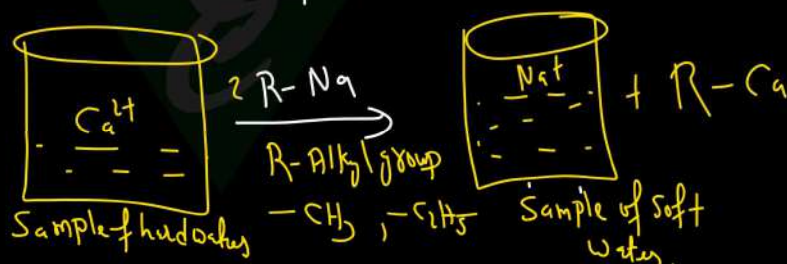
in this reaction exchange of ions occurs. so it is
also known as ion exchange for a
Chemical reaction

Technical Classes || Cont. - 91555 63777 / 93347 89450

ion exchange method (To remove hardness of water)

In this method Na^+ and H^+ ions used to remove hardness of water.

for example



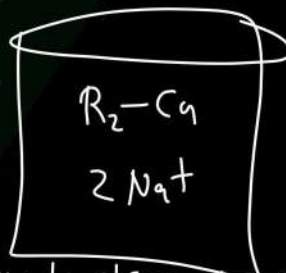
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R- Alkyl group

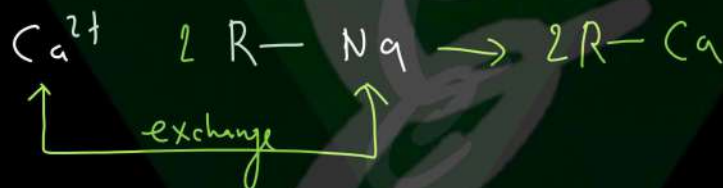
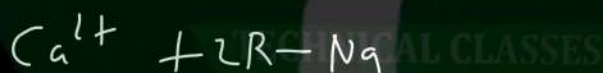


R

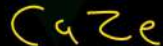
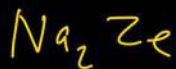


Due to absence of Ca^{2+} it behaves as Soft Water.

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Technical Classes || Cont. - 91555 63777 / 93347 89450



Technical Classes || Cont. - 91555 63777 / 93347 89450



TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

✓ Water Quality Index

it is a numerical expression used to
assess the quality of water based on
various physical, chemical, biological parameters.



It help in understanding the suitability of
water for drinking, industrial purposes

TECHNICAL CLASSES

Parameter of WQI (Water Quality Index)

(1) Biological oxygen demand (BOD)

It is amount of oxygen required
by microorganisms to decompose organic
matter in water under aerobic conditions.
Over the specific period (typically 5 days at 20°C)

Importance

- # High BOD value indicate a high level of organic pollution
- # low BOD levels suggest cleaner water.

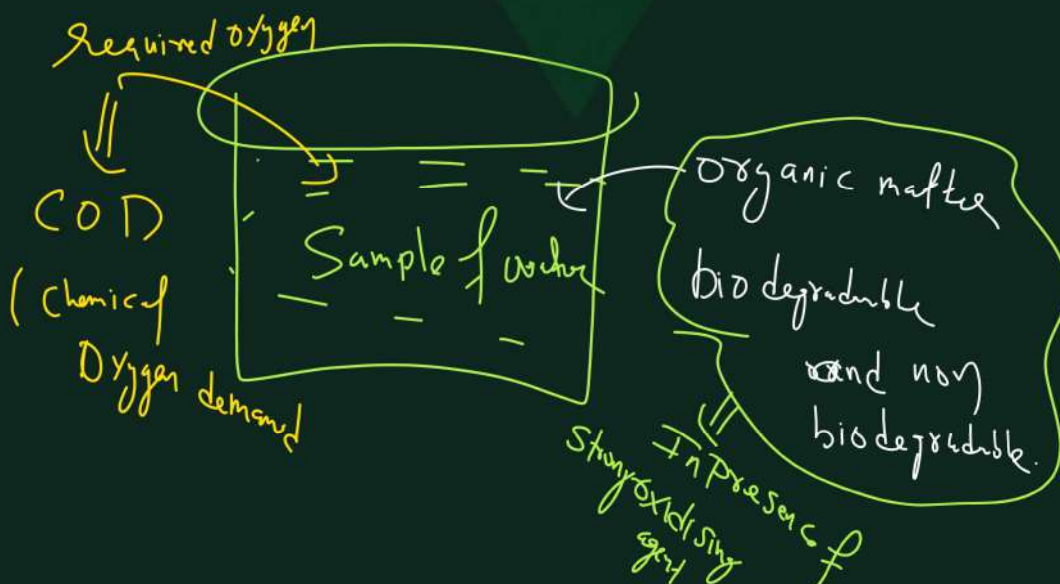
Acceptable limit (as per Indian Standards)

Drinking water - less than 2mg/L

TECHNICAL CLASSES

2. Chemical oxygen demand (COD)

It measures the total amount of
oxygen required to oxidize both
biodegradable and non biodegradable
organic matter in a water sample using
a strong chemical oxidant.





Some Important points

- # COD is express in mg/L
- # Oxidant used in measurement is generally strong like $\text{K}_2\text{Cr}_2\text{O}_7$ in H_2SO_4 (potassium di chromate)

TECHNICAL CLASSES

Acceptable limit
Drinking water — below 10 mg/L

3. Determination of Dissolved oxygen (DO)

- # it refers to the amount of oxygen present in water essential for the survival of aquatic organism (in water)



Factors affecting DO

① Temperature $\propto \frac{1}{DO}$

if T high DO low
or if T low DO high

TECHNICAL CLASSES

Q Aquatic animals are more comfortable in cold water as compared to hot water why?

Ans In cold water Dissolved Oxygen is high due to low Temperature. So aquatic animals are more comfortable but in hot water DO is low so Aquatic animal less comfortable

organic pollution $\propto \frac{1}{DO}$



Indian Standard Specification of Drinking Water

The Bureau of Indian Standards (BIS) has set guidelines for safe drinking water under IS 10500:2012. The key parameters include

TECHNICAL CLASSES

Physical Parameters

$$\text{pH} = 6.5 - 8.5$$

Turbidity - Should not exceed 1 NTU
(Nephelometric Turbidity Unit)

Chemical Parameter

$$\text{BOD} < 2 \text{ mg/L}$$

$$\text{COD} < 10 \text{ mg/L}$$

$$\text{DO} > 6 \text{ mg/L}$$

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Technical Classes

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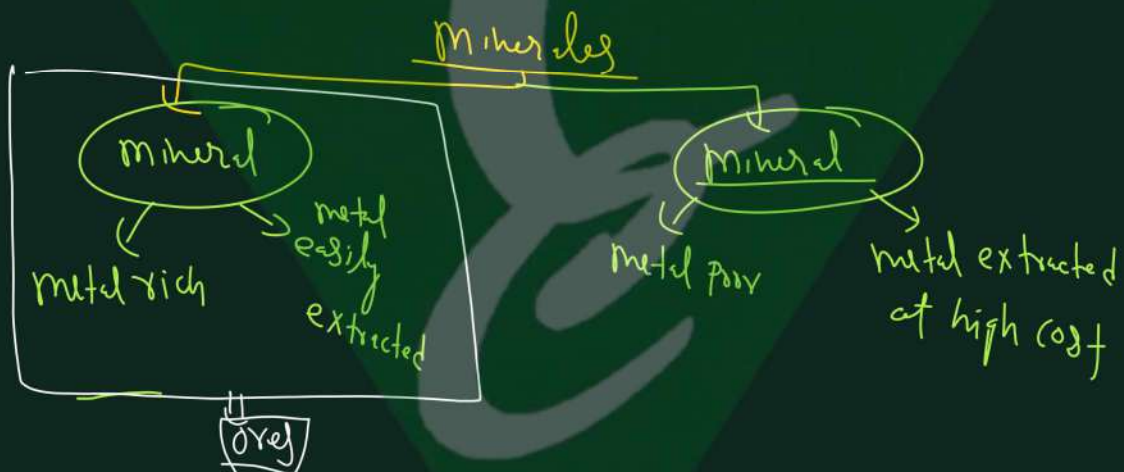
Engineering materials

Minerals

- ⇒ Naturally occurring substances obtained from the earth's crust is called mineral
- ⇒ minerals can be metals, non metals or compounds.

TECHNICAL CLASSES

Extraction of metal



Ores

those types of minerals from which metals can be economically extracted at low cost

for example -

<u>ores</u>	<u>metal</u>
Bauxite	Al
Hematite	Fe
Chalcopyrite	Cu



all ores are minerals
but
all minerals are not ores

TECHNICAL CLASSES

Metallurgy

Metallurgy is the science and technology of extracting metals from their ores and refining them for use

Process of extraction of metal

Step - I Crushing and Grinding of ores
Concentration of ores

Step - II Oxidation of concentrated ores

Step - III Reduction

Step - IV Purification / Refining



(1) Concentration of ores

Concentration of ores is the process of removing gangue (like Sand, clay, rock pieces) from the ore.

TECHNICAL CLASSES

Gangue / matrix

The physical impurities like clay, Sand, Rock pieces present in ore are called gangue.

Need for concentration of ores

- # Ores are found with large amounts of impurities.
- # Metallurgical extraction is more efficient if the ore is purified first.
- # It saves cost, time and energy during extraction.



Methods of Concentration of ores

(1) Hydraulic washing (Gravity Separation) method

Hydraulic washing

hydro

Water

साथ करना

Gravity Separation

Gravitational force

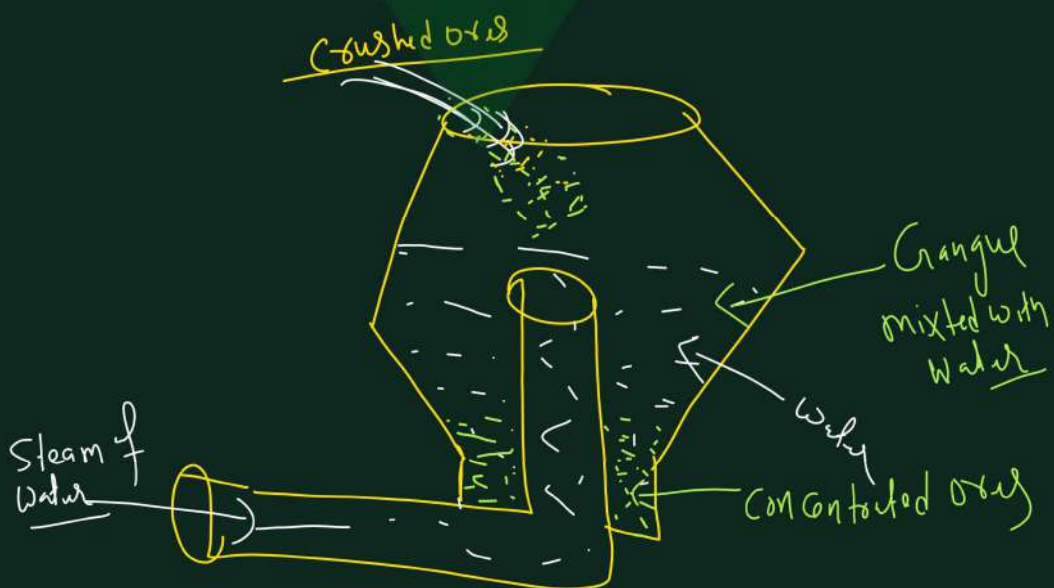
अलग करती

TECHNICAL CLASSES

Principle — Different in densities of ores and gangue.

The crushed ore is washed with a stream of water.

Lighter gangue particles are washed away, heavier ore particles settle.





for example

It is used in Concentration
of Haemetite (Fe_2O_3), Tin Stone (SnO_2)
etc ores.

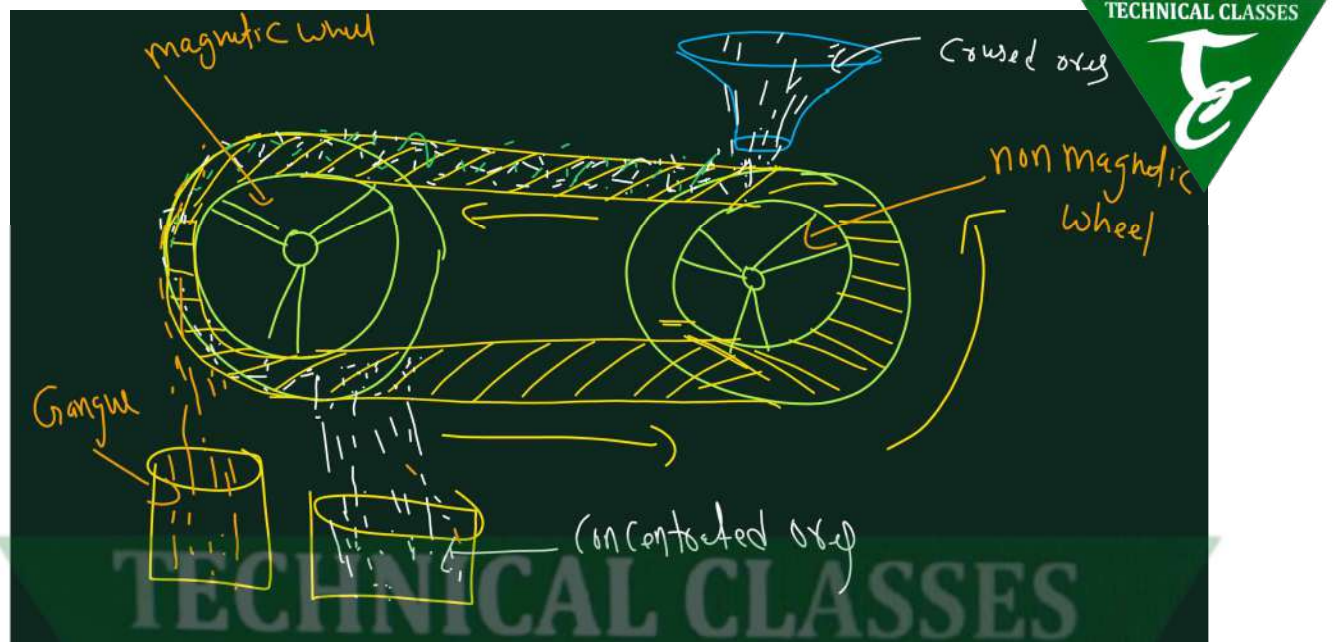
TECHNICAL CLASSES

2 Magnetic Separation

Principle - this method used in
Concentration of those types of
ores in which either ore or
gangue shows magnetic properties.

in this method a magnetic
separator is used.

Magnetic ore is attracted to the
magnet, non magnetic gangue is left
behind



for example

Magnetic separation methods generally used for concentration of following ore.
Magnetite (Fe_3O_4)

Froth Flotation method

Froth $\Rightarrow$ झाँझ

Flotation = फ्लोट करनी
जल

Principle Differences in the wetting properties of ores and gangue with water and oil

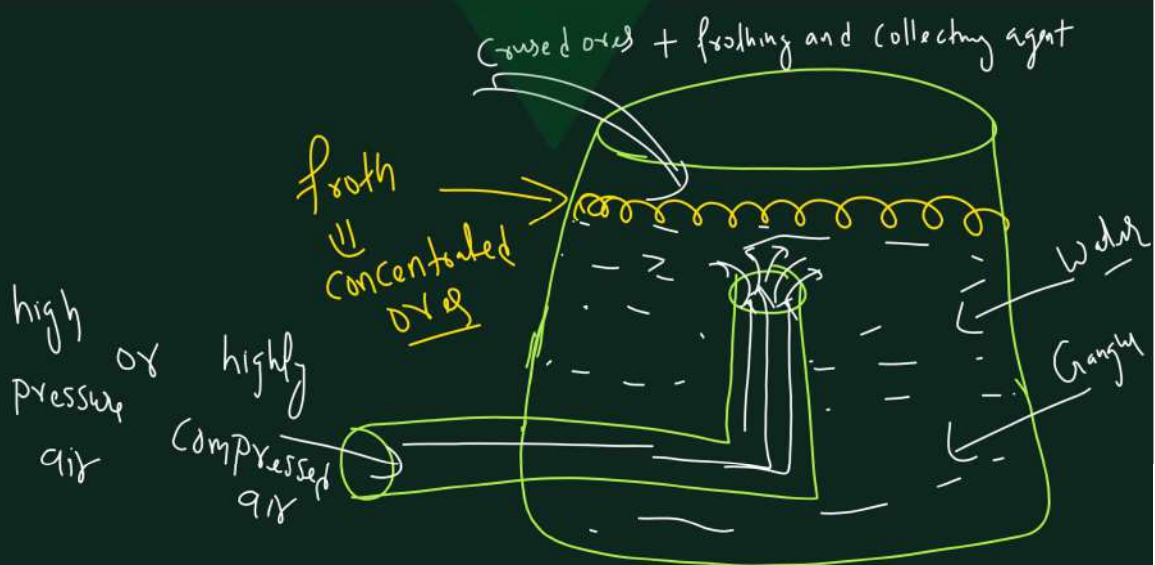


Ore particles are preferentially
Wetted by oil, gangue by water.

A foaming agent (eg- pine oil) and
collectors (eg xanthates) are added
झोला बनाने वाला) collect करने में मदद करने वाला

TECHNICAL CLASSES

Compressed air is blown to form
foam, which carries the ore
particles to the surface





for example

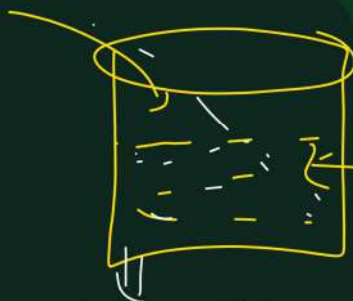
forth flotation method is generally used for concentration of Sulphide ores like Galena (PbS) Zinc blende (ZnS), Copper Pyrites ($CuFeS_2$)

4 Leaching

Principle - Solubility of ore in suitable solvent

Ore is dissolved in a chemical solution. impurities remain insoluble.

(used ore)



it is a chemical method for concentration of ore

Chemical

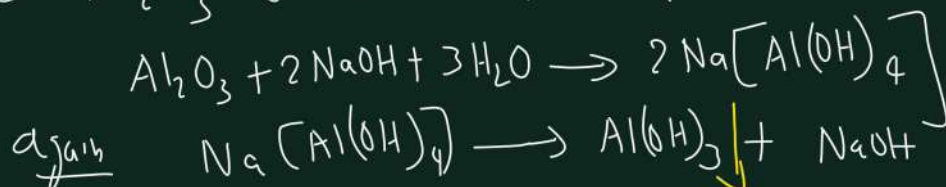
Suitable solvent

ores soluble in chemical
impurities (gangue) remain insoluble

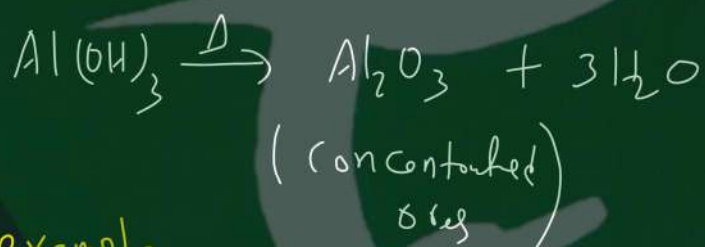


for example - Bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$)
in Bayer's process.

$\Rightarrow \text{Al}_2\text{O}_3$ dissolved in NaOH (suitable solvent)



TECHNICAL CLASSES



for example

Leaching process is used for Bauxite ore
and ore of Silver and Gold.

Bayer's Process (concentration of Bauxite ore)

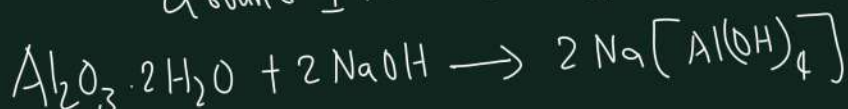
Step-I Crushing and Grinding

Bauxite ore is crushed and ground into fine particles to increase surface area for reaction.



Step II Digestion (Leaching reaction)

Finely powdered bauxite is heated with concentrated NaOH solution at around $140^{\circ} - 150^{\circ} \text{C}$

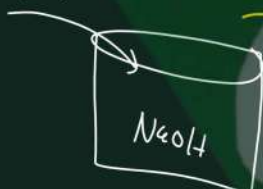


TECHNICAL CLASSES

Aluminium oxide dissolved to form Sodium aluminate (NaAlO_2)

~~***~~ # Impurities like Fe_2O_3 , SiO_2 remain undissolved.

Bauxite



Step-III Filtration

The solution is filtered to remove the insoluble impurities (gangue or red mud)

Step-4 Precipitation

The clear solution is cooled to $\text{Al}(\text{OH})_3$



Step-V Calcination

The precipitated $\text{Al}(\text{OH})_3$ is heated at about 1100 to 1200°C to form pure Alumina



TECHNICAL CLASSES



as we know

Extraction of metal

✓ Step-I

Concentration of ore

Step-II

oxidation of concentrated ore

Step-III

Reduction

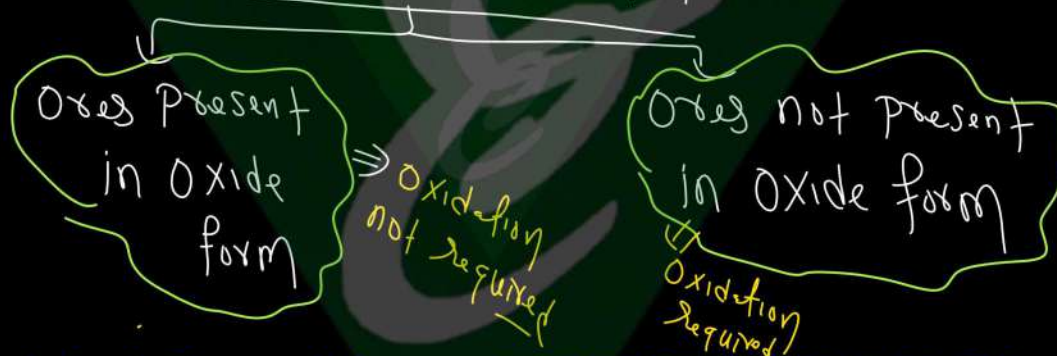
Step-IV

Refining

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Step-II Oxidation of concentrated ores

after concentration



Technical Classes || Cont. - 91555 63777 / 93347 89450

Note

metals are easily extracted from it's oxide form as compared to other form.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Oxidation of Concentrated Oxes

Such a process in which concentrated oxes are converted into its oxide form.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Process for concentration of oxes

- (i) Roasting
- (ii) Calcination

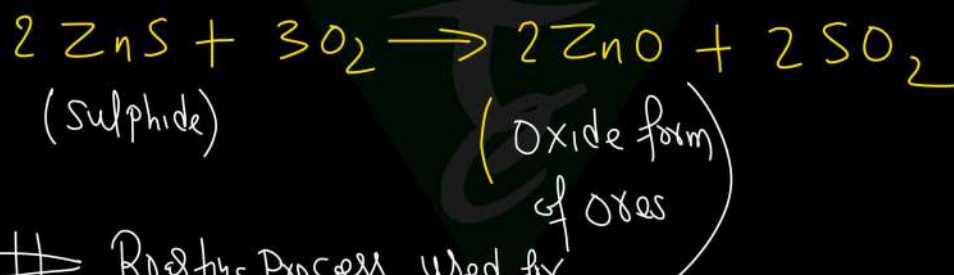
Technical Classes || Cont. - 91555 63777 / 93347 89450

(i) Roasting — Such a process in which concentrated oxes converted into oxide in the presence of excess oxygen (air) at high temperature.

Technical Classes || Cont. - 91555 63777 / 93347 89450



for example



Roasting process used for Sulphide oxes

Technical Classes || Cont. - 91555 63777 / 93347 89450

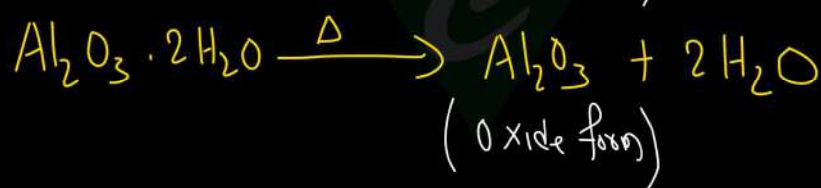
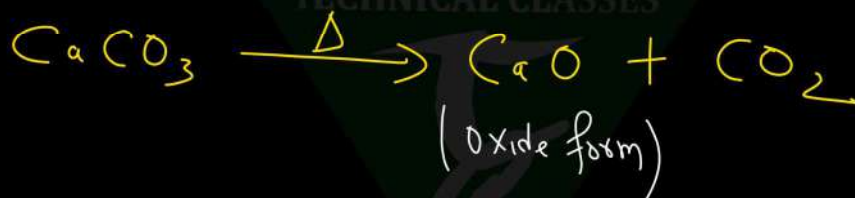
(II) Calcination — Such a process

in which concentrated oxes are converted into its oxide form by heating in absence of oxygen (air)

Some time this process occurs in limited air supply.

Technical Classes || Cont. - 91555 63777 / 93347 89450

for example



Technical Classes || Cont. - 91555 63777 / 93347 89450



Some important points

- # Calcination process also used to remove volatile impurities (like CO_2 , water)
- # in calcination process carbonate ore or hydride ore are participated.

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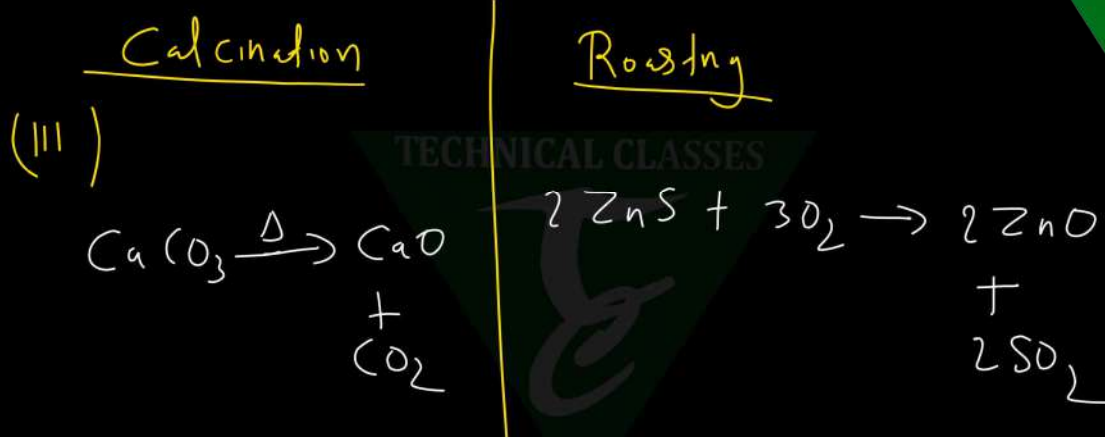
Difference between Calcination and Roasting

Calcination VS Roasting

Technical Classes || Cont. - 91555 63777 / 93347 89450

<u>Calcination</u>	<u>Roasting</u>
(I) Convert concentrated ores into its oxide by heating in absence of air or oxygen	(I) Convert concentrated ores into its oxide by heating in presence of air or oxygen.
(II) It used in carbonate and hydrated ore	(II) It used in sulphide ore.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Technical Classes || Cont. - 91555 63777 / 93347 89450

Step-III Reduction of Oxide form to metal

Such a process in which Oxide form of ores under goes reduction to form metal.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Types of Reduction method

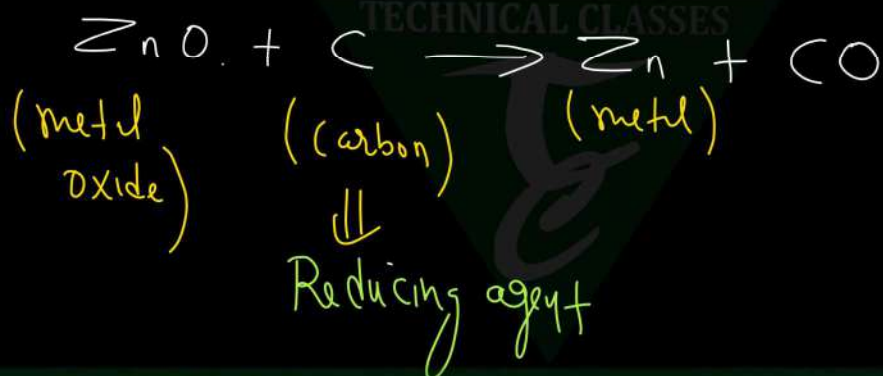
(1) Reduction by Carbon (Smelting)

Such a process in metal oxide under goes reduction by using carbon to form metal.

Technical Classes || Cont. - 91555 63777 / 93347 89450



for example



Technical Classes || Cont. - 91555 63777 / 93347 89450

Notes

- # Smelting Process used for metal like iron, zinc, lead, copper.
- # in this process oxide is heated with carbon (coke/charcoal) which acts as a reducing agent.

Technical Classes || Cont. - 91555 63777 / 93347 89450

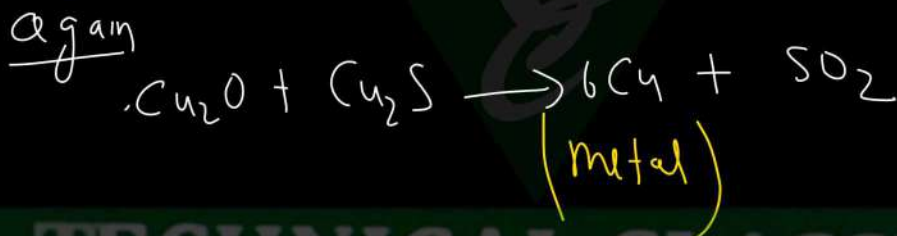
(II) Self Reduction (Auto reduction)

Such a process of reduction of some sulphide ores (eg Cu_2S , PbS) are heated in air to partially converted to oxides, then react with remaining sulphide

Technical Classes || Cont. - 91555 63777 / 93347 89450



for example



Technical Classes || Cont. - 91555 63777 / 93347 89450

3 Reduction by Aluminium (Thermite process)

Such a process of reduction of oxide form of metal by using Aluminium
Used for highly reactive metals.

Eg Cr_2O_3 , MnO_2 etc

Technical Classes || Cont. - 91555 63777 / 93347 89450

Aluminium is strong reducing agent.
for example



Technical Classes || Cont. - 91555 63777 / 93347 89450



4 Electrolytic Reduction

Such a process of reduction of metal oxide in which electrolysis occurs.



Technical Classes || Cont. - 91555 63777 / 93347 89450

Notes

Electrolytic reduction used for very reactive metal.

for example - Na, K, Al, Ca, Mg

Technical Classes || Cont. - 91555 63777 / 93347 89450

Step-IV Refining of metal

Such process in all other impurities present in metal finally remove.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Types of process of Refining

(1) Electrorefining (most common method)

Such a process of refining of metal in which metal refine in presence of electric current. i.e. by the process of electrolysis.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Electrorefining generally used for
 Cu , Zn , Al , Ni , Au , Ag .

In this method, impure metal is made the anode, pure metal the cathode, an appropriate electrolyte is used.

Technical Classes || Cont. - 91555 63777 / 93347 89450

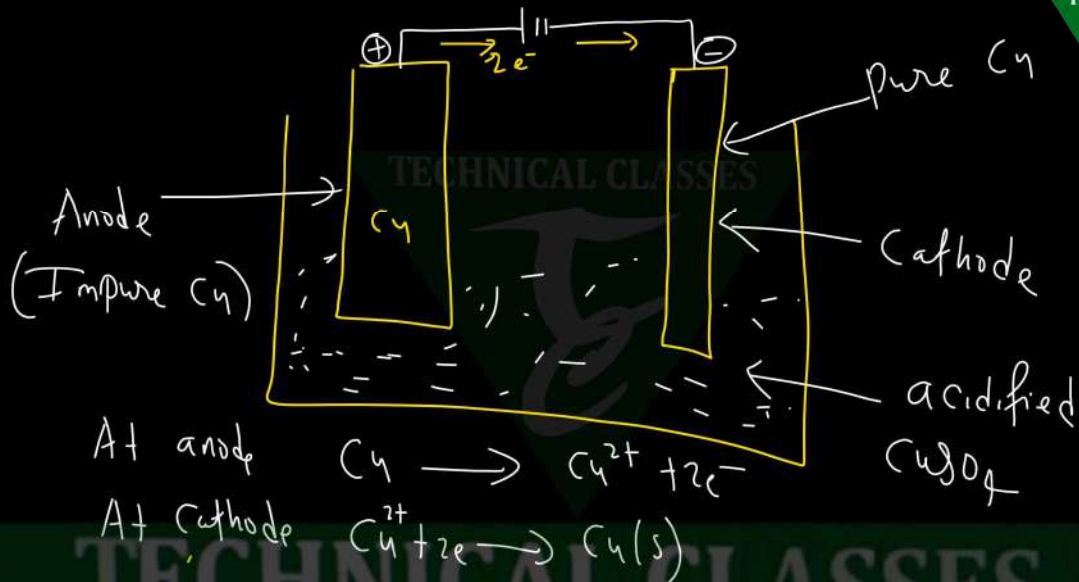
Pure metal gets deposited on the Cathode.

Anode - Impure Cu

Cathode - Pure Cu

Electrolyte - Acidified Copper Sulfate (CuSO_4)

Technical Classes || Cont. - 91555 63777 / 93347 89450



Technical Classes || Cont. - 91555 63777 / 93347 89450

afterwards

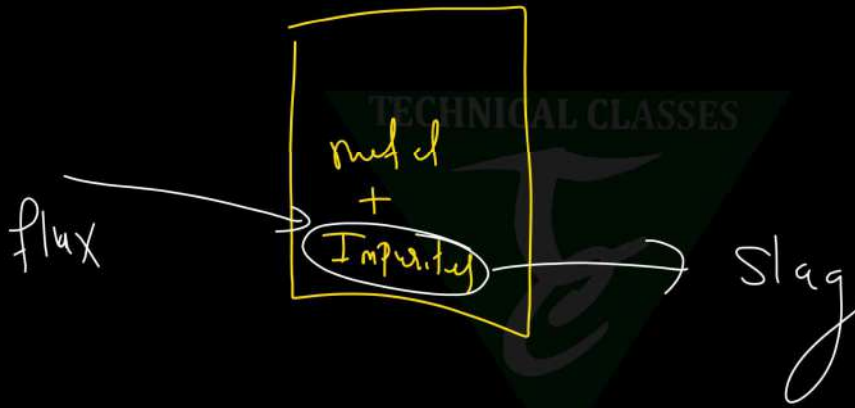


Technical Classes || Cont. - 91555 63777 / 93347 89450

Flux

Flux is a substance added during the smelting of ores to remove impurities. It reacts with gangue (nonmetallic impurities like Silica, Alumina) to form a slag.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Technical Classes || Cont. - 91555 63777 / 93347 89450

Purpose to use flux

- # It is used to convert impurities into a fusible, separable material.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Types of flux

(I) Acidic flux (e.g. SiO_2)

Used when gangue is basic.

(II) Basic flux (for example - CaO , MgO)

Used when gangue is acidic.

Technical Classes || Cont. - 91555 63777 / 93347 89450



(III) Neutral flux (eg - fluor spar)

Used to adjust melting Point without reacting.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Slag

Slag is by product formed when the flux reacts with gangue during smelting. It is usually less dense and floats over the molten metal, making it easy to remove.

Technical Classes || Cont. - 91555 63777 / 93347 89450



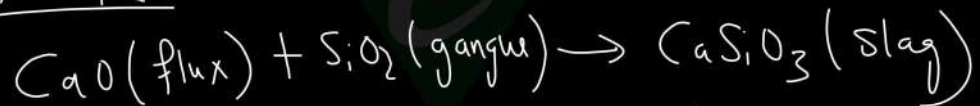
Technical Classes || Cont. - 91555 63777 / 93347 89450



Compositions

Mostly silicates and aluminates of Calcium and magnesium.

example



TECHNICAL CLASSES

Technical Classes || Cont. - 91555 63777 / 93347 89450





Ancient Indian Metallurgy

I Early Metal use in India

Copper age - (Chalcolithic Period)

around 3000 BCE - use of copper tools and artifacts

Technical Classes || Cont. - 91555 63777 / 93347 89450

Bronze age (Indus Valley Civilization)

Advance metallurgy with bronze

Bronze is a alloy of copper and tin.

Harappans produced tools weapons, statues and ornaments

Technical Classes || Cont. - 91555 63777 / 93347 89450

Dancing Girl statue

Made of bronze around 2500 BCE

Technical Classes || Cont. - 91555 63777 / 93347 89450



#2 Iron metallurgy

- # Iron age in India began around 1200 BCE
- # Ancient Indians used Wootz steel.
a high quality steel known for its toughness and sharp edge.

Technical Classes || Cont. - 91555 63777 / 93347 89450

- # Exported to middle east and Europe known as Damascus steel in West.
- # Iron Pillar in Delhi (4th century CE)
 - # Stands over 7 meters tall.
 - # Remarkable for its rust-resistant nature even after 1600 years.

Technical Classes || Cont. - 91555 63777 / 93347 89450

- # Shows mastery in forge welding and corrosion resistance

Technical Classes || Cont. - 91555 63777 / 93347 89450



3. Zinc and brass

- # Zinc distillation was pioneered in india at Zawar mines (Rajasthan) by the 12th century CE.
- # world's first known distillation of Zn

Technical Classes || Cont. - 91555 63777 / 93347 89450

Brass - (alloy of Cu & Zn)

Technical Classes || Cont. - 91555 63777 / 93347 89450

Gold and Silver

- # Used extensively for jewelry, coins and idols.
- # Sophisticated techniques is smelting refining and alloying.

Technical Classes || Cont. - 91555 63777 / 93347 89450



5 Contributions and Legacy

- # Metallurgy was part of Ayurveda (Rasa shastra) for preparing medicinal compounds.

Technical Classes || Cont. - 91555 63777 / 93347 89450

- # Texts like Rasa Ratna Samuccaya, Asthashastha and Sushruta Samhita document metal use.
- # India influenced metallurgy in Persia, Arabia and Europe through trade.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Extraction of different important metal

1 Extraction of Aluminium

Important ores

Bauxite - $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$

Technical Classes || Cont. - 91555 63777 / 93347 89450



Extraction process

(a) Purification of Bauxite - Bayer's Process

Impurities - Fe_2O_3 , SiO_2

In Bayer's process Bauxite is treated with NaOH (hot conc)

Technical Classes || Cont. - 91555 63777 / 93347 89450



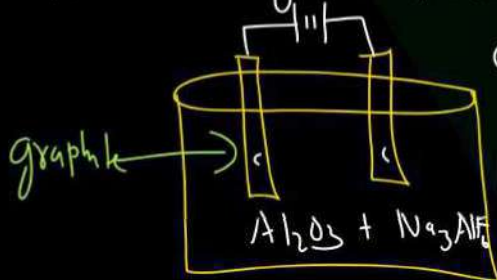
On cooling and dilution $\text{Al}(\text{OH})_3$ precipitates



Technical Classes || Cont. - 91555 63777 / 93347 89450

(c) Electrolytic Reduction - Hall-Heroult process

Electrolyte - Molten Al_2O_3 dissolved in Cryolite (Na_3AlF_6)



Technical Classes || Cont. - 91555 63777 / 93347 89450



Cathod (Reduction)



Anode (Oxidation) (Pure Aluminium)



Aluminium form at Cathode

Technical Classes || Cont. - 91555 63777 / 93347 89450

Properties of Aluminium

- # Aluminium is a Lightweight, Silver-white ductile metal.
- # It is Good Conductor of heat and electricity
- # Resistant to Corrosion due to Al_2O_3 layer

Technical Classes || Cont. - 91555 63777 / 93347 89450

Uses of Aluminium

- # It is used in aircraft bodies, electric wire.
- # It is all used Packaging (foil)
- # It is all used Alloys formation ($Al + Cu + Mg + Mn$)

Technical Classes || Cont. - 91555 63777 / 93347 89450



Extraction of Iron

Important ores

Hematite (Fe_2O_3)

Magnetite (Fe_3O_4)

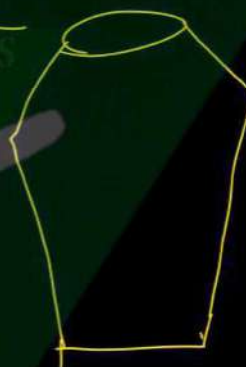
Limonite ($\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$)

TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

Extraction - Blast furnace

Step-I Concentration

Crushing and magnetic separation.



Technical Classes || Cont. - 91555 63777 / 93347 89450

Step-II Reduction in Blast furnace

Raw materials - Hematite, Coke, limestone

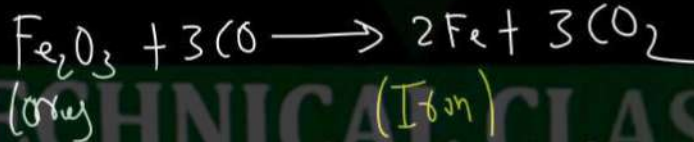
Temperature - 200°C - 1500°C

Technical Classes || Cont. - 91555 63777 / 93347 89450



Reactions in Blast furnace

Combustion of Coke



Technical Classes || Cont. - 91555 63777 / 93347 89450

Different forms of Iron

Pig iron — high Carbon Content (3-5%)

Wrought iron — Purest form (less than 0.3% Carbon)

Steel — Controlled % of Carbon Present (0.2-1.5%)

Technical Classes || Cont. - 91555 63777 / 93347 89450

Uses of Iron

Construction

Tools, machinery, Ship

Stainless Steel (Fe + Cr + Ni)

Technical Classes || Cont. - 91555 63777 / 93347 89450



alpha slide - c2



line stone



TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

Extraction of Cu

Important ores

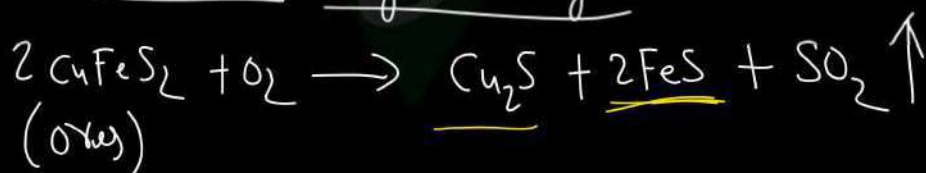
- # Copper Pyrites (CuFeS_2) Most important
- # Cuprite (Cu_2O)
- # Malachite ($\text{CuCO}_3 \cdot \text{Cu(OH)}_2$)

Technical Classes || Cont. - 91555 63777 / 93347 89450

Process of extraction

Step-I Concentration - by using
Froth Flotation.

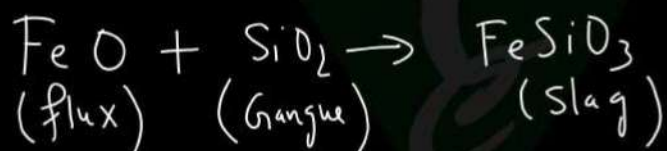
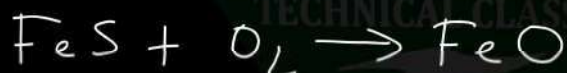
Step-II Oxidation - by Roasting



Technical Classes || Cont. - 91555 63777 / 93347 89450



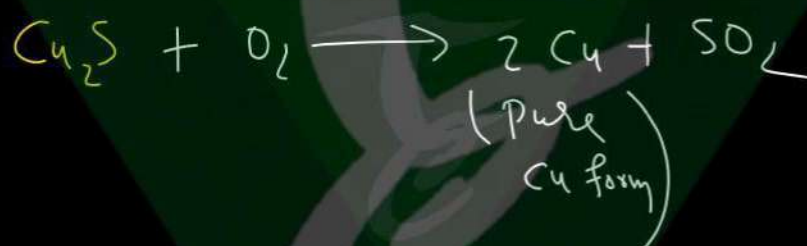
Step-III Smelting (in furnace)



† CuS remains present

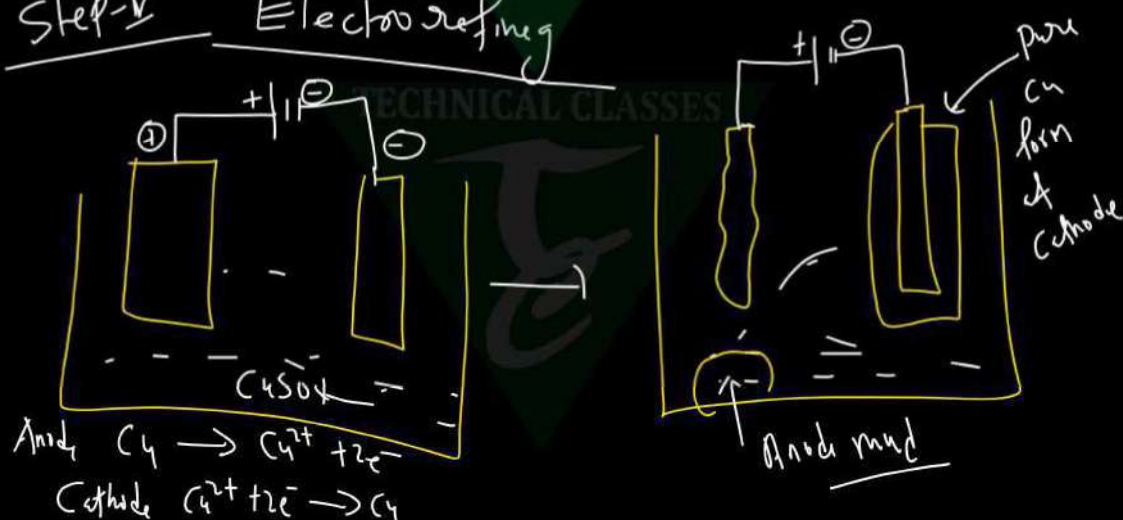
Technical Classes || Cont. - 91555 63777 / 93347 89450

Step-IV Bessemerization



Technical Classes || Cont. - 91555 63777 / 93347 89450

Step-V Electrorefining



Technical Classes || Cont. - 91555 63777 / 93347 89450



Anode - Impure Cu

Cathode - Pure Cu

Electrolyte - Acidified $CuSO_4$

Cu dissolves at anode, deposit at Cathode.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Properties of Cu

- # it is Reddish brown, malleable and ductile in nature
- # it is excellent conductor of electricity and heat.
- # it Resists corrosion in air and water.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Uses of Cu

- # it used in electrical wiring, electronics.
- # it used in alloys formation
brass ($Cu + Zn$)
bronze ($Cu + Sn$)
- # used in Roofing, Coins, plumbing.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Alloys

An alloy is a homogeneous mixture or solid solution of two or more than two elements where at least one is a metal.

TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

(a) we know

Homogeneous mixture

↳ in which all components and properties are uniformly distributed

Types of solution on the basis of physical state

Solid in Solid Liquid in Solid Gas in Solid	Solvent $\Rightarrow$ Solid $\Rightarrow$ Solid solution
---	--

Technical Classes || Cont. - 91555 63777 / 93347 89450

Note

Alloys are usually formed to enhance the properties of the base metal such as strength, corrosion resistance or conductivity.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Example

Brass - It is an alloy of copper and zinc

Bronze

Technical Classes || Cont. - 91555 63777 / 93347 89450

Purpose of Alloying $\Rightarrow$ Process of formation of Alloy

Alloying is done due to

- # Improve mechanical strength and hardness
- # Enhance corrosion and oxidation resistance
- # Improve electrical and thermal properties.

Technical Classes || Cont. - 91555 63777 / 93347 89450

- # Lower melting point for ease of casting.
- # To improve melting point
- # Modify color and appearance
- # Reduce cost by using cheaper elements.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Types of Alloys

Alloys are broadly classified into

(A) Ferrous Alloys (contain iron as the base metal)

properties # it is known for strength and durability
often magnetic

Technical Classes || Cont. - 91555 63777 / 93347 89450

less rusting properties.

Ferrous alloy (definition) - Such a type of alloy which contain iron as the base metal.

for example -

Technical Classes || Cont. - 91555 63777 / 93347 89450

<u>Alloy</u>	<u>Composition</u>	<u>Properties</u>	<u>Applications</u>
(I) Steel	Iron + Carbon (0.1-1.5%)	High tensile strength, hardness	Construction tools, machinery
(II) Stainless Steel	Iron + Cr (10-20%) + Ni	Corrosion resistant tough	Cutlery, surgical instruments
(III) Cast Iron	Iron + Carbon (2-4%) + Si	Hard, brittle good compressive strength	Pipes, engine blocks.

Technical Classes || Cont. - 91555 63777 / 93347 89450



[B] Non Ferrous Alloys

Such a type of Alloy which do not contain iron as the base metal.

Properties

it is Lightweight, Corrosion Resistant

it is non magnetic generally.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Used where ferrous alloys are unsuitable

Example

<u>Alloy</u>	<u>Base Metal</u>	<u>Composition</u>	<u>Properties</u>	<u>Application</u>
Brazing	Cu	Cu (60-70%) + Zn (30-40%)	Malleable Corrosion resistant	Plumbing fitting musical Instruments bolts

Technical Classes || Cont. - 91555 63777 / 93347 89450

Brass	Cu	Cu-88% Sn-12%	Harder than Cu Corrosion resistance	Statues bearings medals.
Duralumin	Al	Al-90-95% Cu-3-5% Mg 0.5-1% Mn ~ 0.5%	Lightweight Strong Corrosion Resistant	Aircraft Parts Automotive frames.
Solder	Tin	Sn-60% Pb-40%	Low melting point ductile, conductive	Joining metals Plumbing

Technical Classes || Cont. - 91555 63777 / 93347 89450



(II) Copolymer

Such a type of Polymer which formed from two or more different monomers.

e.g. Nylon 6,6

Technical Classes || Cont. - 91555 63777 / 93347 89450

Types

Random Copolymer - Such a type of Copolymers in which monomers arranged randomly e.g. SBR rubber
Styrene-butadiene rubber.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Alternating Copolymer

Such a type of Copolymer in which alternating arrangement of monomer
e.g. Nylon 6,6

Technical Classes || Cont. - 91555 63777 / 93347 89450



Block Copolymer — Such a types of Copolymer in which Long blocks of one monomer followed by blocks of another.
eg Styrene-Butadiene-Styrene (SBS)

TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

Graft Polymer

Such a types of Polymer in which chains of one monomer grafted onto the backbone of Another

eg Graft polystyrene (NR-g-PS)

Technical Classes || Cont. - 91555 63777 / 93347 89450

Natural and Synthetic Polymer

Natural Polymer — Polymer found in nature,
Produced by living organisms
for example $\Rightarrow$



Natural Polymer

- (I) Proteins
- (II) Cellulose
- (III) Natural Rubber
- (IV) DNA (Deoxyribonucleic acid)
RNA (Ribonucleic acid)

Monomer

Amino acid.
Glucose
Isoprene.
Nucleotides.

Synthetic Polymer

Those Polymer which is man made and Synthesized from petrochemical monomers.

Example $\Rightarrow$

Synthetic Polymer

- (I) Polyethylene
- (II) Polyvinyl chloride (PVC)
- (III) Polystyrene (PS)
- (IV) Teflon

Monomer

Ethylene
Vinyl chloride ($\text{CH}_2=\text{CHCl}$)
Styrene
Tetrafluoroethylene



<u>Synthetic Polymer</u>	<u>Monomer</u>
Nylone 6, 6	Hexamethylenediamine + adipic acid
Bakelite	Phenol & Formaldehyde.
Polyester	Polyethylene terephthalate

TECHNICAL CLASSES

Types of Polymerization → process of forming of polymer.

(A) Addition Polymerization

Polymerization without the elimination of any small molecules

Addition Polymerization (Definition)

It is a process in which unsaturated monomer (with double bond or triple bond) add to each other without the elimination of any by products, forming a long polymer chain.



Monomer
unsaturated

Polymer

Note Addition Polymerization is also known as Chain Growth Polymerization)

TECHNICAL CLASSES

Some Import. points about addition Polymerization

- # monomers must have $\text{C}=\text{C}$ double bonds or other reactive groups.
- # In addition Polymerization no small molecules (like H_2O or HCl) is eliminated

[B] Condensation polymerization

Polymerization where each step releases a small molecules like water or HCl

Definition Condensation Polymerization is a process in which monomer join together with the elimination of a small molecules like H_2O or HCl



Thermosetting plastic

Polymer that undergo Permanent hardening on heating cannot be reshaped.

TECHNICAL CLASSES

Some important Polymers

1 Polythene (Polyethylene)

Monomer - C_2H_4 ethylene

Technical Classes || Cont. - 91555 63777 / 93347 89450

Types of Polythene

- (I) Low Density Polyethylene
- (II) High Density Polyethylene

Technical Classes || Cont. - 91555 63777 / 93347 89450



low density polyethylene (LDPE)

Method - Free radical polymerization

Catalyst - Peroxide

Uses - Plastic bags, containers, squeeze bottles.

TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

High density Polyethylene

Method - Ziegler - Natta Polymerization

Catalyst - Ziegler Natta Catalyst
($\text{TiCl}_4 + \text{Al}(\text{C}_2\text{H}_5)_3$)

Uses - Pipes, toys, kitchenware etc

Technical Classes || Cont. - 91555 63777 / 93347 89450

2 Polyvinyl chloride (PVC)

monomer

Vinyl chloride ($\text{CH}_2=\text{CHCl}$)

Application

Pipes, cable insulation, vinyl flooring

Technical Classes || Cont. - 91555 63777 / 93347 89450



Synthesis

Methods - free radical polymerization.

Initiator - Benzoyl Peroxide etc

Technical Classes || Cont. - 91555 63777 / 93347 89450

Oxlon (Polyacrylonitrile or PAN)

Monomer

Acrylonitrile ($\text{CH}_2=\text{CH}-\text{CN}$)

Methods for synthesis - Free radical polymerization of

acrylonitrile
Initiator - Organic Peroxide

Technical Classes || Cont. - 91555 63777 / 93347 89450

Applications

Wool like synthetic fibres

Clothing, blankets

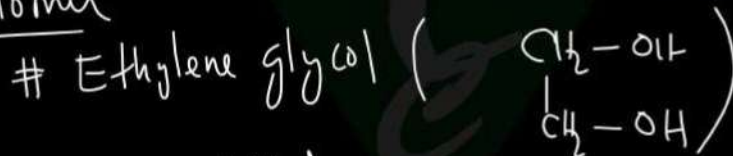
Outdoor fabrics (resistant to sunlight)

Technical Classes || Cont. - 91555 63777 / 93347 89450



4 Terylene (polyethylene Terephthalate) or PET

Monomer



Terephthalic acid



Technical Classes || Cont. - 91555 63777 / 93347 89450

Synthetic method

Method - Condensation Polymerization

Applications

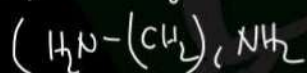
Textile Fibres (polyester clothing)
PET bottles and containers
photographic film.

Technical Classes || Cont. - 91555 63777 / 93347 89450

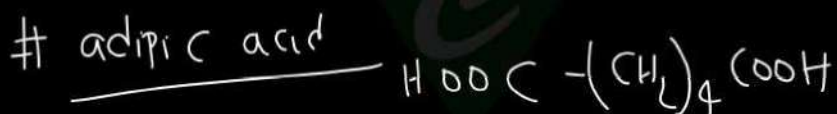
Nylon 6,6

Monomer

Hexamethylene diamine



adipic acid



Technical Classes || Cont. - 91555 63777 / 93347 89450



Synthesis methods

Condensation Polymerisation

Application

- # Fibers in textiles, ropes and Carpets
- # Mechanical parts

Technical Classes || Cont. - 91555 63777 / 93347 89450

Nylon 6

Monomer

Caprolactam (a cyclic amide)

Synthesis method

Ring Opening Polymerization

Technical Classes || Cont. - 91555 63777 / 93347 89450

Uses

- # Textiles, Carpets
- # Engineering plastics.

Technical Classes || Cont. - 91555 63777 / 93347 89450



7 Bakelits (phenol-Formaldehyde resin)

Monomers

Phenol - C_6H_5OH

Formaldehyde ($HCHO$)

Synthesis Step growth condensation

Catalyst Acid or base

Technical Classes || Cont. - 91555 63777 / 93347 89450

Applications

Electrical Insulator, Switches, Sockets

Kitchenware handles, radios and telephones

Technical Classes || Cont. - 91555 63777 / 93347 89450

Natural Rubber

Natural rubber is an elastic material
Obtained from the latex of rubber trees
(*Hevea brasiliensis*)

It is polymer of Isoprene (2-methyl-1,3-butadiene)
Chemical formula (C_5H_8)

Technical Classes || Cont. - 91555 63777 / 93347 89450



Source

- # it is extracted from latex, which is a milky fluid obtained by tapping the rubber.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Properties of natural Rubber

- # it show high elasticity
- # Moderate Tensile Strength
- # Poor Thermal Stability
- # Soluble in non polar solvent in benzene.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Vulcanization of Rubber

Vulcanization is a chemical process in which natural rubber is heated with sulfur - containing compounds to improve its properties.

Technical Classes || Cont. - 91555 63777 / 93347 89450



Process

- # Rubber is heated at $140-160^{\circ}\text{C}$ with 3-5% sulfur.
- # Sulfur forms cross links (disulfide bridge) between polymer chains.

Technical Classes || Cont. - 91555 63777 / 93347 89450

- # In this process we can also use accelerators (for example zinc oxide stearic acid) to speed up the process.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Advantage of Vulcanized Rubber

- # Vulcanized rubber has improved elasticity, allowing it to retain its shape and flexibility over a wide range of temperature.

Technical Classes || Cont. - 91555 63777 / 93347 89450



- (ii) it is stronger and more durable.
- (iii) it resists heat and does not melt easily.
- (iv) it resists oils, solvents and chemical.
- (v) it does not crack in sunlight or ozone
- (vi) it absorbs less water
- (vii) it lasts longer.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Buna-S (Styrene-Butadiene Rubber)
'SBR'

Full form - Butadiene + Na (sodium catalyst)
+ Styrene

Technical Classes || Cont. - 91555 63777 / 93347 89450

Monomer

1,3-butadiene & Styrene

Polymerisation

Copolymer of butadiene and Styrene

Ratio - 75% butadiene + 25% Styrene

Technical Classes || Cont. - 91555 63777 / 93347 89450



Properties

- # Poor resistance to oil and solvent
- # Moderate heat resistance
- "

TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

Uses

- # Car tyres
- # Footwear

Technical Classes || Cont. - 91555 63777 / 93347 89450

Buna-N (Nitrile Rubber (NBR))

Full form

Butadiene + Na (Sodium catalyst) + Nitrile
(acrylonitrile)

Monomers

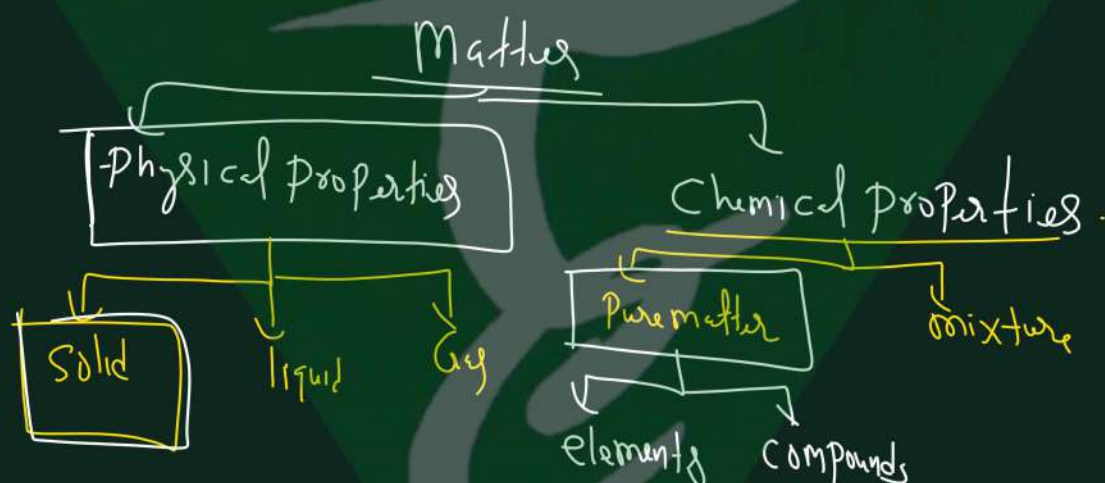
1,3-Butadiene
Acrylonitrile.

Technical Classes || Cont. - 91555 63777 / 93347 89450



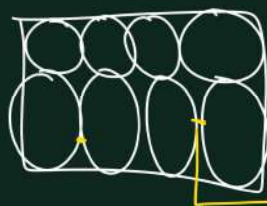
The Solid State

matters are mainly exist is three Physical state - i.e Solid liquid and Gas.



Properties of Solid

- (i) Solids have fixed shape and volume
- (ii) Solid have high Interparticle force of attraction



Interparticle force of Attraction high



(III) least interparticle space

In the particle
in between

(IV) do not have tendency to flow
So it is not fluids

(V) - high density

Types of solids

Crystalline Solid
(True Solid)

संरचित Solid

example - ice cube, diamond

Amorphous Solid

Pseud Solid

(असंरचित Solid)

eg - Plastic, Glass, Rubber.

Crystalline Solid

- # it is a true solid
- # Sharp and fixed melting point

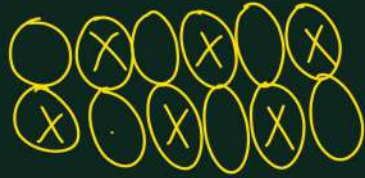
Amorphous Solid

- # it is a pseudo solid
- # not a sharp and fixed melting point



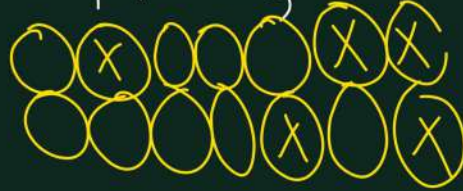
Crystalline solid

- # Long range order of particles



Amorphous solid

- # Short range order of particles



TECHNICAL CLASSES

Crystalline

- # Anisotropic in nature

An + Iso + tropic
 (//) Same
 (\\) Not

⇒ Physical properties in different direction

Amorphous

- # Isotropic in nature

Iso + tropic
 (//) Same

⇒ Physical properties in different direction

Crystalline

- # Define Geometry - Well define shape

example - ice cube
 Diamond Graphite
Quartz Glass

Amorphous

- # not define Geometry
- #^{es} Glass, Rubber, Plastic



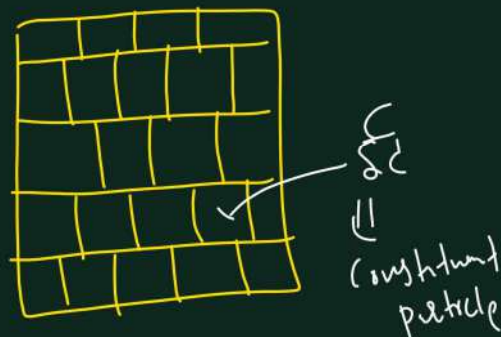
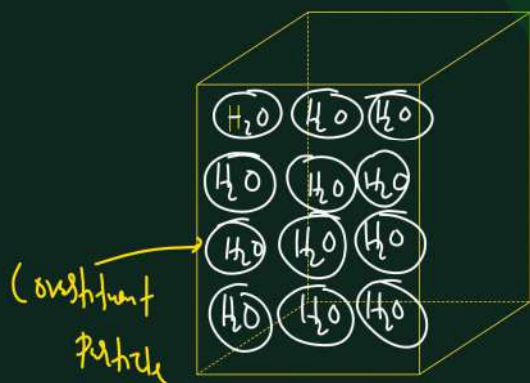
Types of Crystalline Solid

- (I) Molecular solid
- (II) Ionic Solid
- (III) metallic solid
- (IV) Covalent solid (Network solid)

Constituent Particle

— Matter is made by small particles, those particles are known as constituent particles.

Ice Cube — Water solid state $\Rightarrow$ H_2O molecule is constituent particle





<u>Matter</u>	<u>Constituent Particle</u>
Common salt (Sodium chloride) NaCl	Na^+ & Cl^- ions
iron cube	Fe atom
Diamond.	Carbon atom

TECHNICAL CLASSES

Types of solids on the basis of Constituent Particles and interparticle forces

- (I) Molecular solid
- (II) Metallic solid
- (III) ionic solid
- (IV) Covalent solid or Network solid

Technical Classes || Cont. - 91555 63777 / 93347 89450

(i) Molecular solid - It is type of solid in which constituent particles are molecules.

e.g - HCl(s) , $\text{H}_2(\text{s})$, Ar(s)

Technical Classes || Cont. - 91555 63777 / 93347 89450



Types of molecular solids

- (i) Non polar molecular solid
- (ii) Polar molecular solid
- (iii) Hydrogen bonded molecular solid.

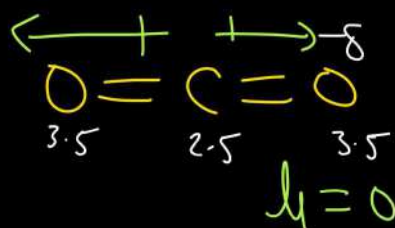
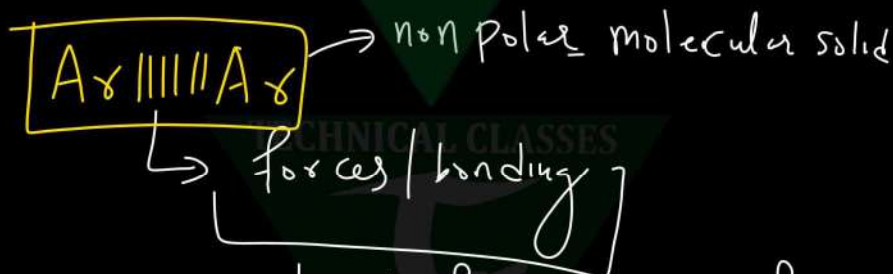
Technical Classes || Cont. - 91555 63777 / 93347 89450

(i) Non polar molecular solid

It is types of molecular solid in which constituent particles of nonpolar molecules and they are bonded with Dispersion or London forces

eg - $\text{Ar}_{(s)}$, $\text{CCl}_{4(s)}$, $\text{H}_2(s)$, $\text{I}_2(s)$, $\text{CO}_2(s)$ etc

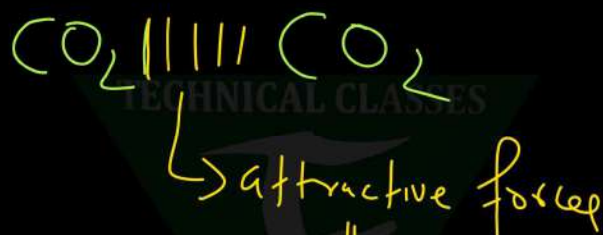
Technical Classes || Cont. - 91555 63777 / 93347 89450



London force / Dispersion force

$\text{CO}_2(s) \Rightarrow$ non polar molecular solid

Technical Classes || Cont. - 91555 63777 / 93347 89450



↘
London force

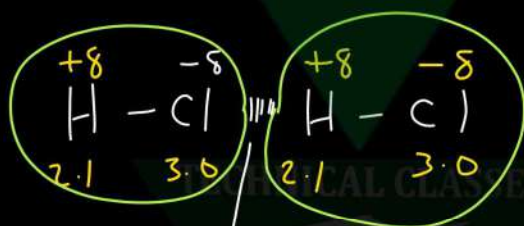
A force which act between two non polar molecule is known as London force or Dispersion force

Technical Classes || Cont. - 91555 63777 / 93347 89450

(ii) Polar molecular solid — those types of solids in which constituent particles are polar molecules and they are bonded with dipole-dipole interaction

example HCl(s) , $\text{SO}_2(\text{s})$

Technical Classes || Cont. - 91555 63777 / 93347 89450



↘ attractive force

↘
dipole-dipole interaction

(dipole)
↘
two $-\delta \quad +\delta$

A force of Attraction which act with two polar molecule is known as dipole dipole interaction

Technical Classes || Cont. - 91555 63777 / 93347 89450

Hydrogen bonded molecular solid

those solids in which constituent particles are bonded with hydrogen bonding



eg- $H_2O(s)$
 $HF(s)$
 $NH_3(s)$

Technical Classes || Cont. - 91555 63777 / 93347 89450

TRICK

H-bonding करेते करेते
 F, O, N से होते होते

Technical Classes || Cont. - 91555 63777 / 93347 89450

Properties of molecular solid

Molecular solid are soft in nature
 except hydrogen bonded molecular

these solids are ^{Solid} Insulator of electric current

molecular solids have low melting point
 but non polar molecular molecular solid have very low m.p

Technical Classes || Cont. - 91555 63777 / 93347 89450



(11) Metallic solids - those types of solids in which constituent particles are metal which bonded with metallic bond.

eg. Fe(s) , Cu(s) , Ag(s) , Mg(s)
Other metals.

Technical Classes || Cont. - 91555 63777 / 93347 89450



forces

metallic bond



forces $\Rightarrow$ metallic bond

Metallic bond - metallic bond is the forces that holds metal atoms together in a metallic substance.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Properties of metallic solids

- # metallic solids are hard but malleable and ductile
- # metallic solids conductors in solid state as well as in molten state
- # metallic solid have high melting point

Technical Classes || Cont. - 91555 63777 / 93347 89450



(iii) Ionic Solid — those types of solids in which constituent particles are ions and they bonded with ionic bond Coulombic attractive force or electrostatic forces.

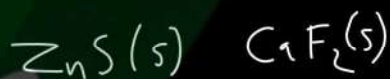
Technical Classes || Cont. - 91555 63777 / 93347 89450

eg - $\text{NaCl}(s)$, $\text{MgCl}_2(s)$, $\text{KCl}(s)$



C.A. Forces

or
Ionic bond



Technical Classes || Cont. - 91555 63777 / 93347 89450

Properties of ionic solids

- (i) It is hard but brittle.
- (ii) Conductors in molten state as well as aqueous state but insulator in solid state
- (iii) High melting point.

Technical Classes || Cont. - 91555 63777 / 93347 89450



4 Covalent Solid or Network Solid

Such a type of solid in which constituents particles are atoms and they bonded with covalent bond.

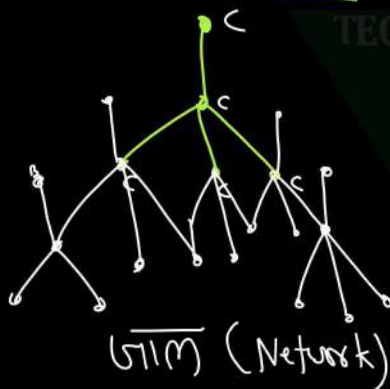
eg- SiO_2 (quartz), SiC , diamond, AlN graphite etc

Technical Classes || Cont. - 91555 63777 / 93347 89450

in covalent solid atoms are bonded with covalent bond and form a large network of atoms so these types of solids are known as Network solid.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Diamond



Technical Classes || Cont. - 91555 63777 / 93347 89450



Properties of network solids

TECHNICAL CLASSES



TECHNICAL CLASSES

Technical Classes || Cont. - 91555 63777 / 93347 89450

Properties of network solid

- # network solids are generally hard in nature for example Diamond
- * Some network solids are soft in nature for example graphite.

- # network solids are generally behave as insulator.
e.g - Diamond
- but some network solids behave as conductor
e.g graphite.

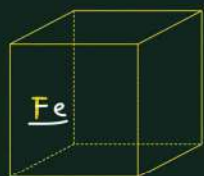


Covalent solid / network solid
have high melting point.

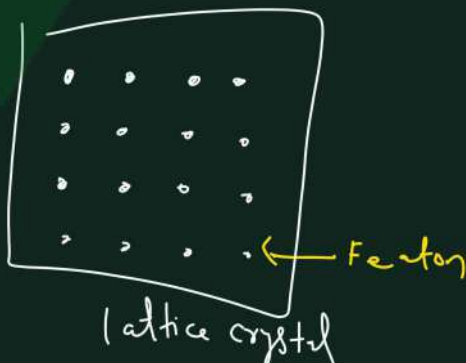
TECHNICAL CLASSES

Lattice, Crystal and unit cell

Lattice crystal — A lattice crystal is a regular, repeating arrangement of points in space. Each point in the lattice represent the position of constituent particle (i.e. atom / molecule / ion)



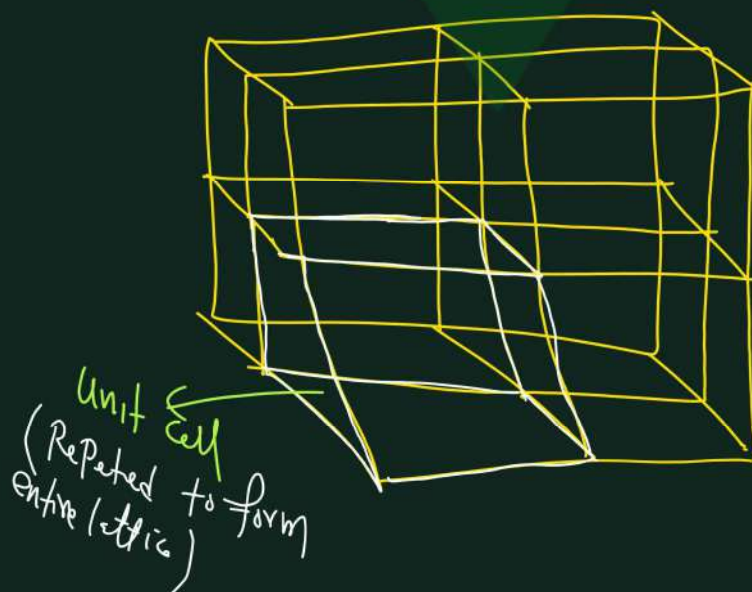
It made by
Fe atom
i.e. Fe atom is constituent
particle





Unit cell

A unit cell is the smallest repeating unit of a crystal lattice that, when repeated in all direction, forms the entire crystal structure / lattice crystal.





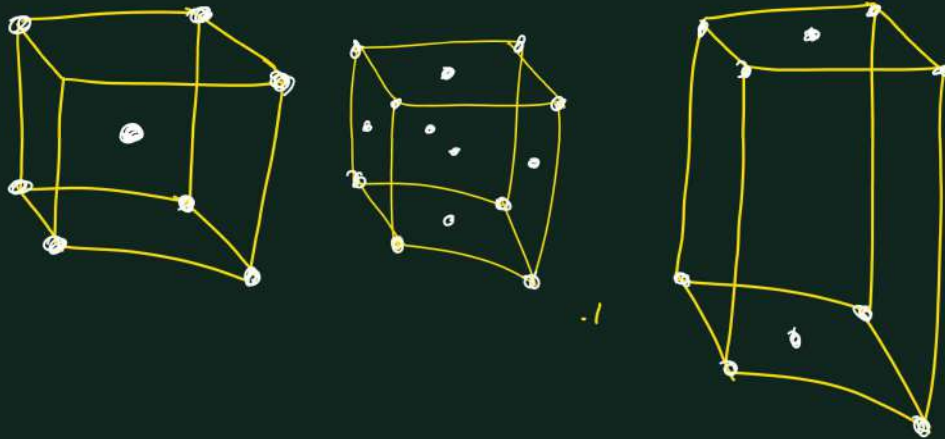
Types of unit cell

- ① Primitive unit cell — Such a type of unit cell in which constituent particles are present at only corner position.



- ② Non Primitive unit cell / Centred unit cell

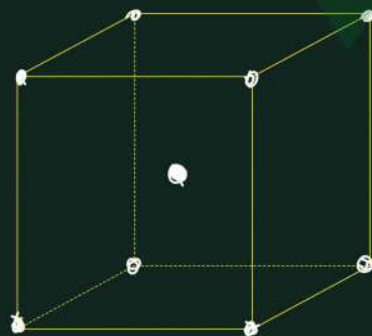
Such a type of unit cell in which constituent particles are present at all corner position as well as body center, face center or end center.



TECHNICAL CLASSES

Types of non primitive unit cell

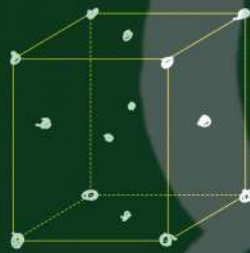
- ① Body centered unit cell — Such a type of unit cell in which constituent particles are present at all corner as well as the center of the body.



body centered unit cell.

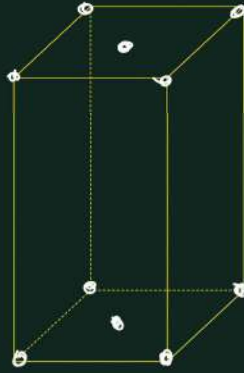


(11) Face Centered unit cell — Such a type of cell in which constituent particles are present at all corner as well as all face center.



End Center unit cell — Such a type of unit cell in which constituent particles are present at all corner as well as both end of the cell

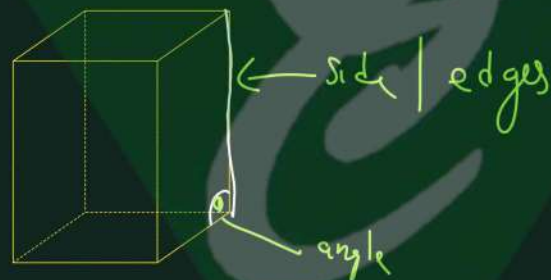
?



end centered
unit cell.

TECHNICAL CLASSES

Types of unit cell on the basis of
sides and angle (Bravais Lattice)



A/c to bravais parameters edge/side
is represented by a , b and c
and angles are represented by α , β and γ

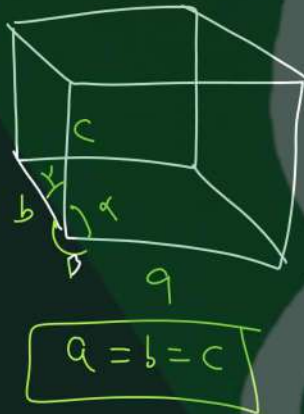


edge / side - a, b, c

angles = α, β, γ

Rhombohedron also known as
Trigonal

TECHNICAL CLASSES



Q for cubic which
of the is correct

- (a) $a = b = c$
- (b) $a = b \neq c$
- (c) $a \neq b \neq c$
- (d) none of the

Monoclinic

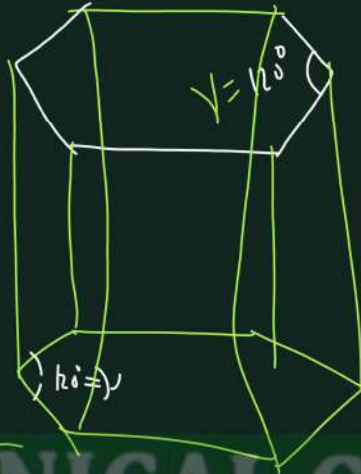
- C_4 — $a = b = c$
- T — $a = b \neq c$
- O — $a \neq b \neq c$
- R — $a = b = c$
- $I-h$ — $a = b \neq c$
- Mo — $a \neq b \neq c$ ✓
- T_d



TRICK	X X X	edge	angle
C ₄	Cubic	$a = b = c$	$\alpha = \beta = \gamma = 90^\circ$
T	Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90^\circ$
O	Orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90^\circ$
R	Rhombohedral	$a = b = c$	$\alpha = \beta = \gamma \neq 90^\circ$
He	Hexagonal	$a = b \neq c$	$\alpha = \beta = 90^\circ \quad \gamma = 120^\circ$
Mo	Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90^\circ \quad \beta \neq 90^\circ$
Tx	Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90^\circ$

C ₄	$a = b = c$	$\alpha = \beta = \gamma = 90^\circ$
T	$a = b \neq c$	$\alpha = \beta = \gamma = 90^\circ$
O	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90^\circ$
R	$a = b = c$	$\alpha = \beta = \gamma \neq 90^\circ$
He	$a = b \neq c$	$\alpha = \beta = 90^\circ \quad \gamma = 120^\circ$
Mo	$a \neq b \neq c$	$\alpha = \gamma = 90^\circ \quad \beta \neq 90^\circ$
Tx	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90^\circ$

$a = b = c$
$a = b \neq c$
$a \neq b \neq c$
$a = b = c$
$a = b \neq c$
$a \neq b \neq c$
$a \neq b \neq c$



$$\gamma = 120^\circ$$

$$\alpha = 90^\circ$$

$$\beta = 90^\circ$$

$$\alpha = \beta = 90^\circ$$

TECHNICAL CLASSES

Primitive

body center

face center

End center

P

B

F

E

P B F E

3 2 4 1 1 2 1

Cu	3	Primitive (P)	body center (B)	face center (F)	
T	2	P, B			
O	4	P	B	F	E
R	1	P			
He	1	P			
Mo	2	P		E	
Ty	1	P			



TECHNICAL CLASSES

Cy	3	P	B	F	E
T	2	P	B	F	E
O	4	P	B	F	E
R	1	P			
He	1	P			
Mo	2	P	B	B	E
Ty	1	P			

P B F E



Q Which of the following not possible in Cubic unit cell

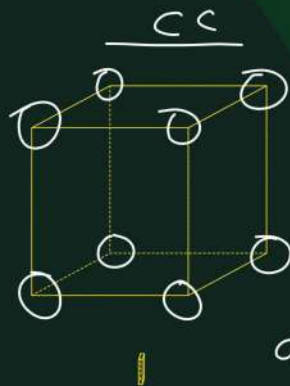
- (a) Primitive (b) Body Centred
(c) face center (d) ~~end center~~.

TECHNICAL CLASSES

Types of Cubic unit cell

- ① Primitive Cubic unit cell / Simple Cubic (CC) unit cell

Such a type of Cubic unit cell in which constituent Particles are present at only corner position



$$a = b = c$$

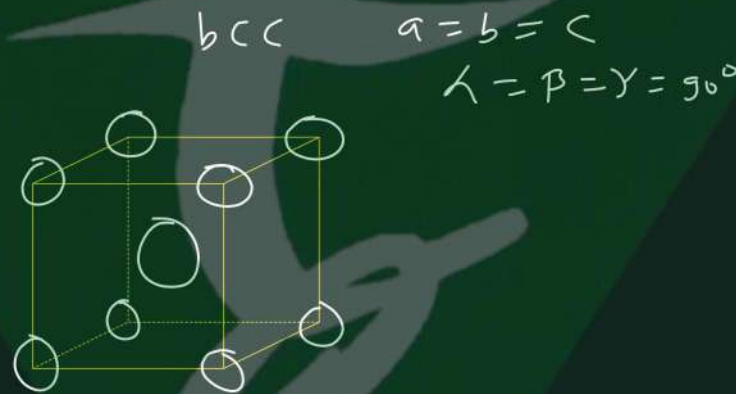
$$\angle = \beta = \gamma = 90^\circ$$



(11) Body centered cubic unit cell (bcc)

Such a type of Cubic unit cell in which Constituent particles present at all corner position as well as center of the body

TECHNICAL CLASSES



Face centered cubic unit cell (FCC)

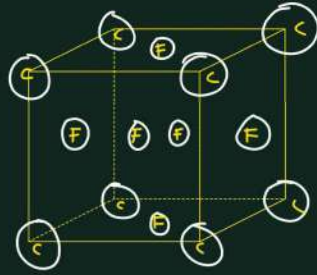
Such a type of Cubic unit cell in which constituent particles are present at all corner position as well as all face of the body.



Fcc

$$a = b = c$$

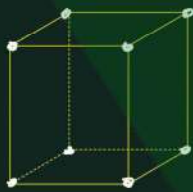
$$\alpha = \beta = \gamma = 90^\circ$$



TECHNICAL CLASSES

Number of lattice point in a unit cell

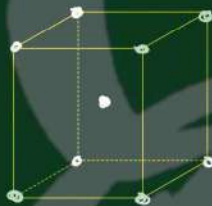
cc



Lattice Point -

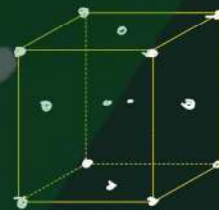
8

bcc



$$8 + 1 = 9$$

Fcc



$$8 + 6 = 14$$

*** Number of constituent particles (Z)

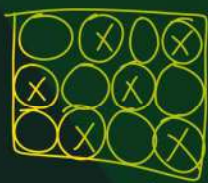
<u>Unit</u>	<u>No. of constituent particles</u>
cc	1
bcc	2
Fcc	4



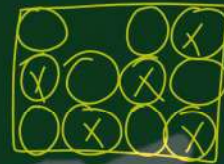
Defects in crystalline solids

or Imperfection in solid

Crystalline solids have regular arrangement of constituent particles. if due to some reason their regular arrangement of constituent particle change. It is known as defect in solid.



Crystalline solid



defect in crystalline solid

Types of defect

- (I) Point defect
- (II) line defect
- (III) surface defect
- (IV) 3D defect

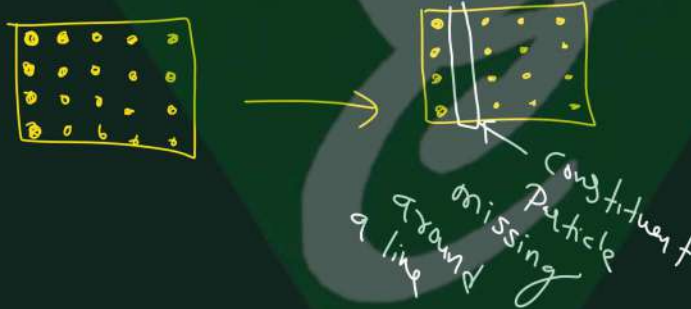


① Point defect — Such a types of defect in Crystalline solid which Created as a Point



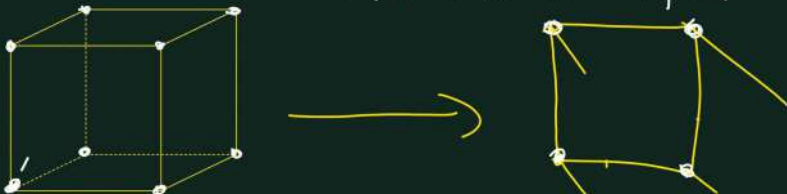
Point defect

② line defect — Such a types of defect in Crystalline solid which created in a line.



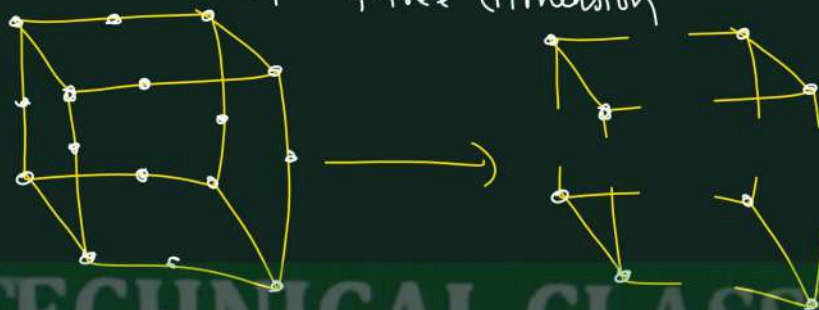
Constituent missing particle around a line

③ Surface defect — Such a defect in Crystalline solid which Created around a surface





(IV) 3D defect — Such a types of defect in crystalline solid which created in three dimension



Types of point defects

(1) Stoichiometry defect

Such a types of point defect that do not disturb the stoichiometry of the solid. They are also known as Intrinsic or thermodynamic defect

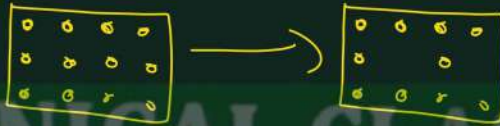
Types of stoichiometry defect

(1) Vacancy defect

(II) Interstitial defect

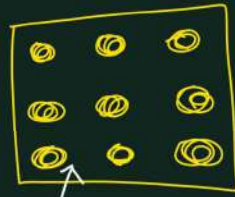


(I) Vacancy defect - Such a type of Stoichiometry defect which created when some of lattice site are vacant from crystalline solid.



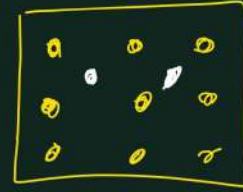
due to vacancy defect density of substance decreases due to missing of constituent particle from lattice site

(II) Interstitial defect - Such a type of point defect in which some other constituent particle occupy interstitial site.



Vacant space
//
Interstitial site

Interstitial defect



Interstitial defect

mass increase

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

Density increase.

TECHNICAL CLASSES

Vacancy defect

vs

Interstitial defect

(I) Constituent particle missing from lattice site

(II) Density of solid Decreases

(I) Other Constituent Particle occupy interstitial site.

(II) Density of solid Increases

Stoichiometry defect

for non ionic substance / solid

Vacancy defect
Interstitial defect

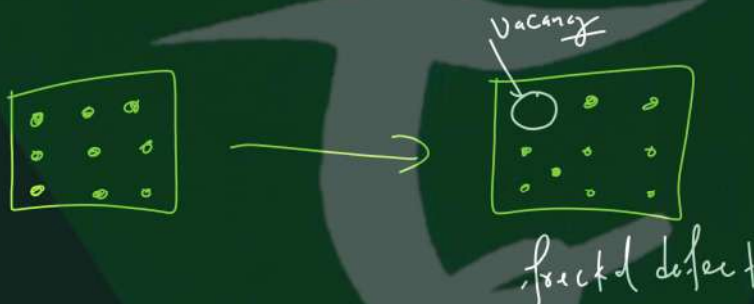
for ionic substance / solid

(I) Frenkel defect

Schottky defect.



(1) Frenkel defect — Such a types of defect in ionic solid in which smaller ions (usually cation) dislocated from its normal site and create a vacancy. these types of defects are known as Frenkel defect.

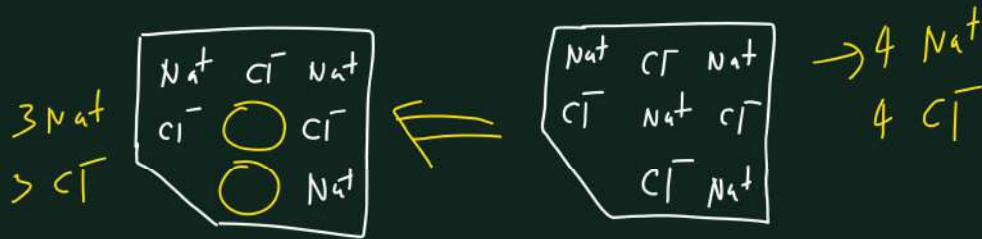


- # Frenkel defect is also known as dislocation defect
- # it does not change density of substance.

Schottky defect

Such a defect in crystalline solid in which equal number of cation and anion are missing. to maintain electrical neutrality.

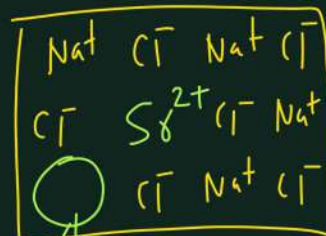
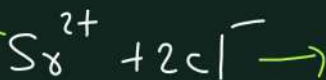
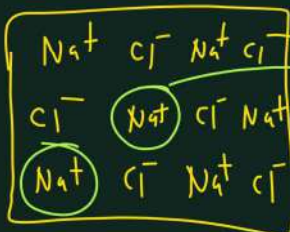
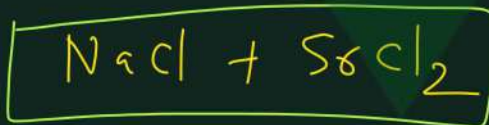
for example NaCl, KCl, CsCl, AgBr



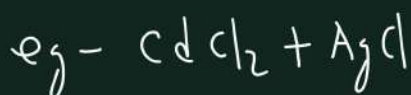
~~###~~
 $\rightarrow$ equal Number of Na^+ & Cl^- missing.
AgBr shows both Frenkel and Schottky defect

Impurity defect

Such a defect in crystalline solid which arise due to the presence of foreign atoms (बाहरी)



$\hookrightarrow$ Vacant space
 Cationic Vacancy.



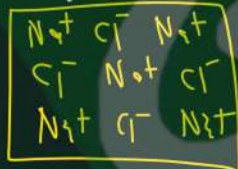


Types of Impurity defect

- (I) Substitutional defect - foreign atom replace host atom
- (II) Interstitial defect - foreign atom occupies the space between atom.

TECHNICAL CLASSES

Non-stoichiometry defect — Such a types of defects in crystalline solid which do not disturb the stoichiometry of the crystalline substance.



Such a types of point defect in ionic solid where the ratio of cation and anion is not in the simple whole number as indicated by chemical formula.



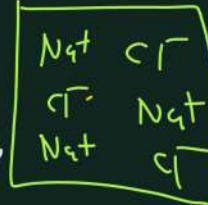


Types of non stoichiometry defect

① Metal excess defect

Such a types of impurity defect which created due to

- # A negative ion (Cl^-) is missing from its lattice site

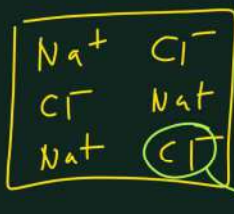


TECHNICAL CLASSES

Metal excess defect due to

[A] Due to Anion vacancy

- # A negative charge ion (Cl^-) missing
- # An electron occupying the vacant space to maintain charge balance
- # these trapped electron are called F-centre which gives colour to crystal.



(yellow)

→ f-centre

NaCl metal excess defect due to anionic fccs

yellow

gives colour to compound



Example -

If NaCl heated in Sodium Vapour, Cl^- leaves and an electron takes its place -

NaCl appears yellow

TECHNICAL CLASSES

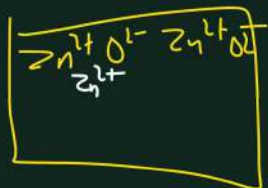
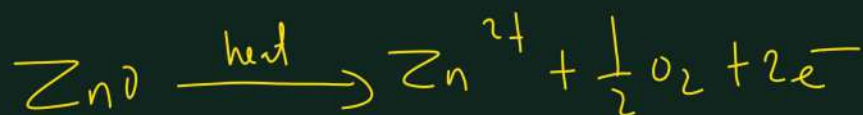
(B) Def of extra cations in interstitial site

Such types of metal excess defect in which extra metal ions occupy the interstitial site.

free electrons are also present to maintain neutrality.

Example

If ZnO on heating





Metal deficiency defect

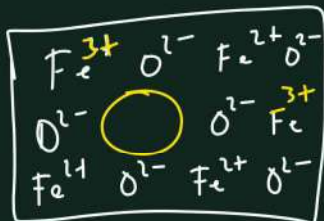
Such a defect in crystalline solid in which a cation is missing from lattice site

The charge is balanced by another metal ions having a high oxidation state. (Fe^{3+})

Example

in FeO , some Fe^{2+} ions are missing

and some Fe^{2+} ions are oxidized to Fe^{3+} to balance the loss



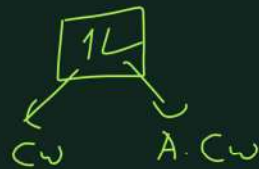
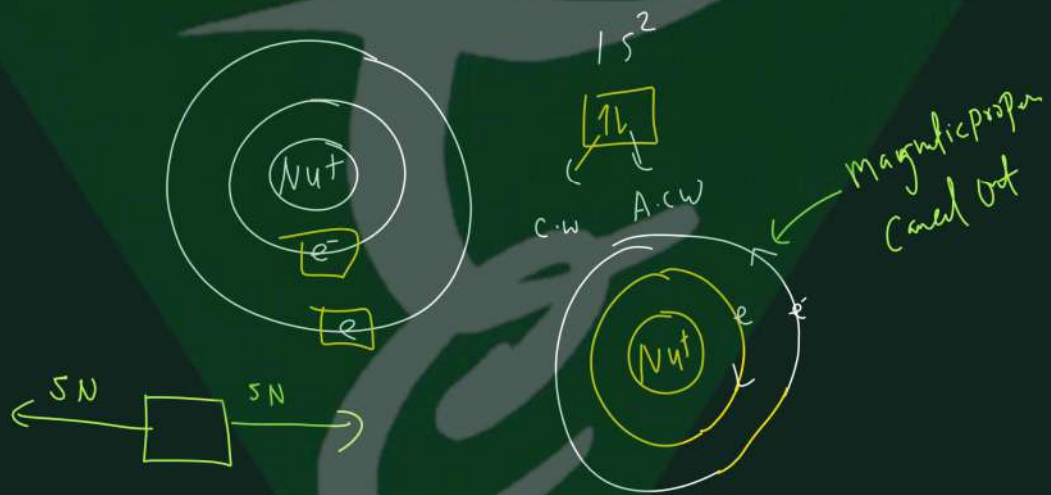
high charge
high oxidation
state.



Magnetic properties of Solids

Magnetic properties of solids refers to the behaviour of solid material in the presence of magnetic field

TECHNICAL CLASSES



Substance show magnetic properties mainly due to presence of unpaired e⁻s

No any other e⁻s are present

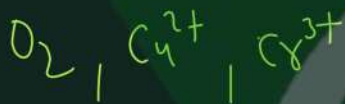


On the basis of magnetic properties substances are classified as

(1) Para magnetic substance / Paramagnetism.

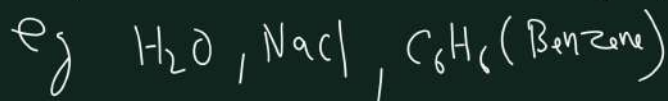
Those substance which are weakly attracted by a magnetic field. Due to presence of one or more electron are known as Paramagnetic substance and property is known as paramagnetism.

For example - Fe^{3+}



Diamagnetic substance

Those substance which are weakly repelled by a magnetic field due to absence of unpaired are known as diamagnetic substance and these properties are known as diamagnetism.





(III) Ferromagnetic substance

Those types of substance which is strongly attracted by magnetic field

for example - Iron, Cobalt, Nickel, CrO_2

these substance are known as Ferromagnetic substance and property are known as Ferromagnetism

TECHNICAL CLASSES

Antiferromagnetic substances/Antiferromagnetism

those types of substance which have opposite and equal magnetic moments cancel each other so net magnetism is zero



eg - MnO

Ferrimagnetism / Ferrimagnetic substance

those types of substance which have unequal opposite magnetic result in a net magnetic moment

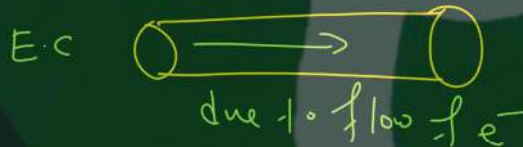


eg Fe_3O_4 , $MgFe_2O_4$, $ZnFe_2O_4$

Electrical Properties of Solid Substances

Electrical properties related to electrical conductivity i.e. ability of a material to allow the flow of electric current

it depends on the availability of free charge carriers



On the basis of conductivity solid substances are classified as

- (i) Conductors - which have high conductivity
eg - Metals
- (ii) Semiconductors - which have moderate conductivity
eg - Silicon, germanium

(III) Insulators — which have low conductivity
eg Glass, rubber etc

Band theory of solids

Next class.

TECHNICAL CLASSES

Electrical Properties

Conductors

Semi Conductors

Insulator

Introduction

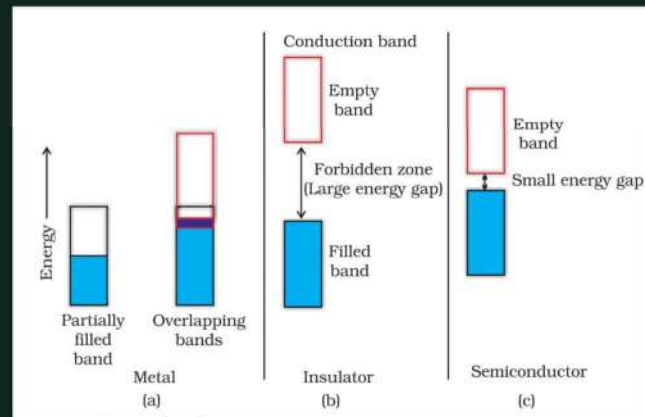
↓

last class

Band theory (Electronic band structure)

Band theory —

Band theory explains the electrical conductivity of solids based on the distribution of electrons in different energy bands



Conductor

TECHNICAL CLASSES

energy band

Energy bands are formed due to the interaction of atomic orbitals in solids.

Types of energy band

- ① Valence band
- ② Conduction band



Some Important point

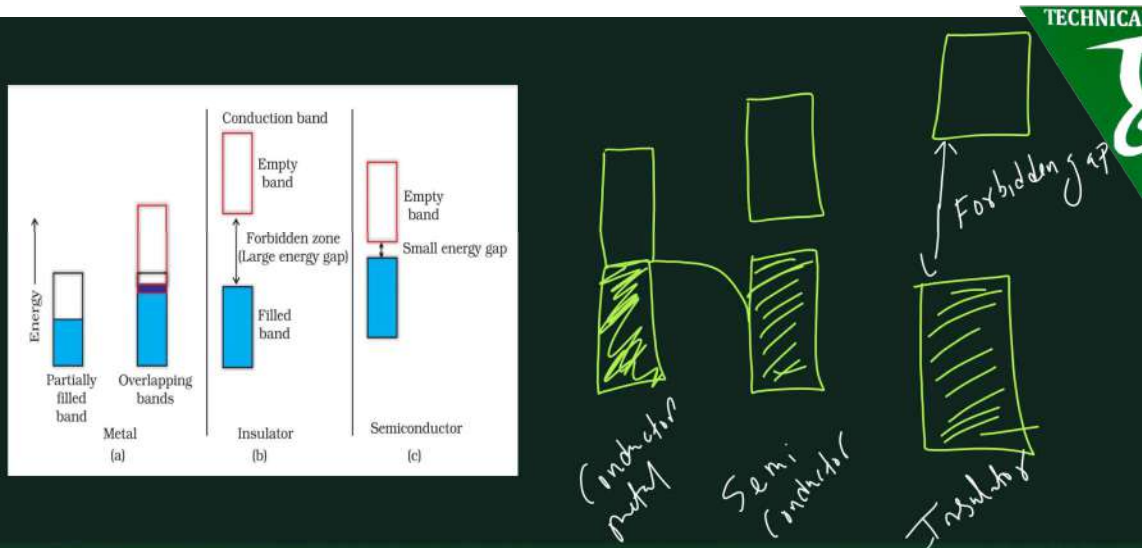
Valence band - highest range of

- electron energies in which electrons are normally present at 2000 K (0 K)

TECHNICAL CLASSES

Conduction band - highest energy band where electrons can move freely allowing electrical conduction

Band Gap (eg) The energy difference between the valence band and conduction band



TECHNICAL CLASSES

According to band theory

Conductors — No band gap exists or it is negligible

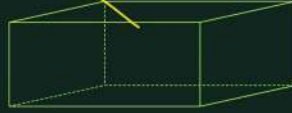
Semiconductors — a small gap exist between both types of band.

Insulator — in which large gap
Present between bands



X-ray diffraction method

X-ray $\Rightarrow$ Study $\Rightarrow$ Crystal structure



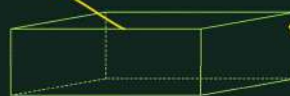
Solid

TECHNICAL CLASSES

X-ray diffraction (XRD) is a powerful analytic technique used to study the crystal structure of material.

when a beam of X-ray strikes a crystalline solid, it is scattered by the atoms present in solid.

X-ray



Scattered the X-rays.



Bragg's law / equation

*

$$n\lambda = 2d \sin \theta$$

Where n - order of reflection (an integer value 1, 2, 3, ...)

✓ ① - Angle of incidence (Bragg angle) ✓ λ = wavelength of incident X-ray
 d - distance between atomic planes

Bragg's equation

$$n\lambda = 2d \sin \theta$$

Technical Classes || Cont. - 91555 63777 / 93347 89450

Question

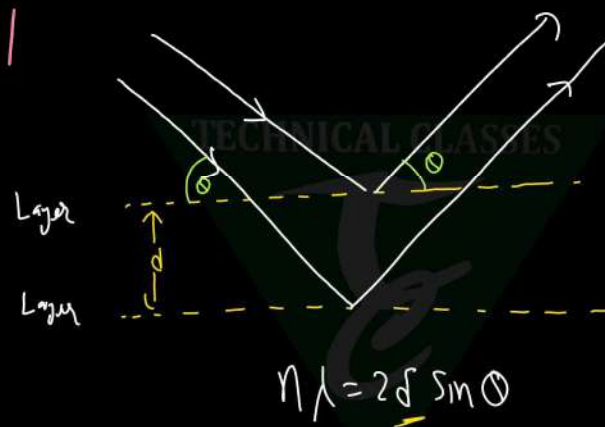
Q What is the formula of Bragg's law?

Ans- $n\lambda = 2d \sin \theta$

Q What does 'd' represent in Bragg's law?

Ans d represent distance between atomic layers in a crystal

Technical Classes || Cont. - 91555 63777 / 93347 89450



TECHNICAL CLASSES
Technical Classes || Cont. - 91555 63777 / 93347 89450

Q Which types of waves are used in Bragg's law experiment

Ans - X-rays

Q What is theta in Bragg's law?

Ans Angle of reflection

Technical Classes || Cont. - 91555 63777 / 93347 89450

Q Who gave Bragg's law?

Ans - William Henry Bragg and William

Lawrence Bragg

Father & son

Technical Classes || Cont. - 91555 63777 / 93347 89450



Q What happens if Bragg's law is not Satisfied

Ans No strong reflection (Weak or no signal)

Technical Classes || Cont. - 91555 63777 / 93347 89450

⇒ Melting Point determination of Crystalline Solid

⇒ Crystalline Solids have sharp melting point
So determination of melting point of a crystalline solid helps to know about its properties.

Technical Classes || Cont. - 91555 63777 / 93347 89450

Practical

Aim To find melting point of a pure solid

Melting point — Pure solid have a sharp melting
Temp^s at which solid convert into liquid

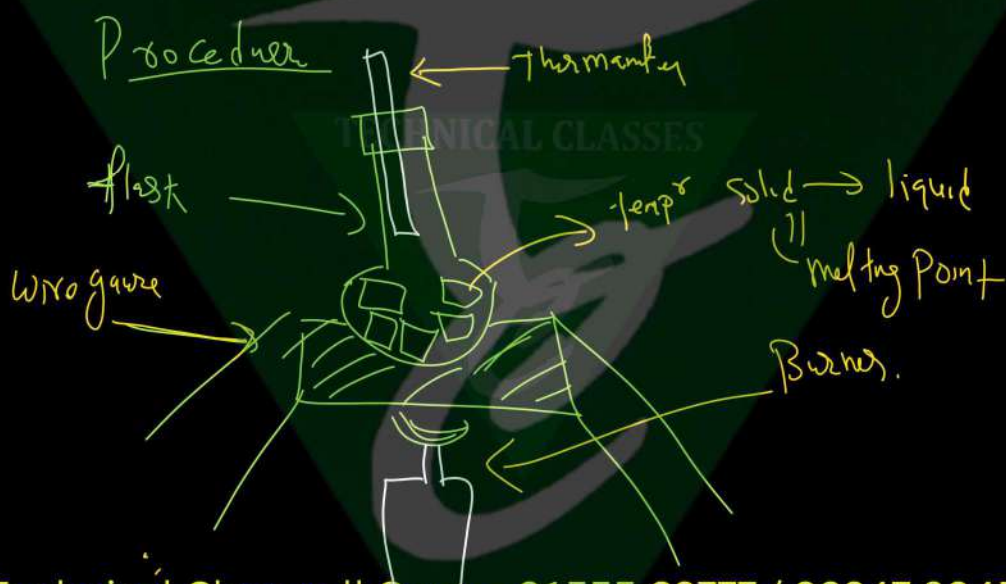
Technical Classes || Cont. - 91555 63777 / 93347 89450



Material required

- (i) Crystalline Solid
- (ii) Capillary tube
- (iii) Melting Point apparatus
- (iv) Thermocouple
- (v) Heat source

Technical Classes || Cont. - 91555 63777 / 93347 89450



Technical Classes || Cont. - 91555 63777 / 93347 89450

TECHNICAL CLASSES

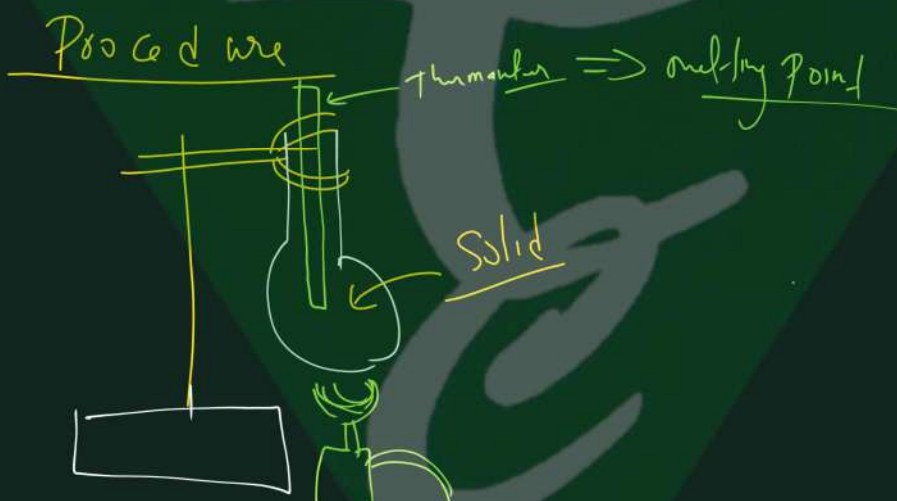


Technical Classes || Cont. - 91555 63777 / 93347 89450



Kjeldahl's method

~~The~~ Kjeldahl's method is quantitative chemical analysis technique used to determine the nitrogen content in organic compound but it also used some to determine melting point of crystalline solid.



Q which of the following is a characteristic of crystalline solids?

- (a) irregular arrangement of particles
- (b) sharp melting point
- (c) Isotropic nature
- (d) No long range order



Q Which type of solid is held together by Vander Waals forces?

- (a) ionic solid $\Rightarrow$ non polar ✓
- ~~(b) Molecular solid $\Rightarrow$ polar~~
- (c) Metallic solid
- (d) Covalent bond

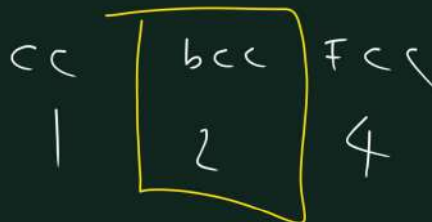
TECHNICAL CLASSES

Q An example of a metallic solid is

- (a) NaCl $\Rightarrow$ ionic solid
- (b) Diamond $\Rightarrow$ Network solid
- ~~(c) Iron $\Rightarrow$ metallic solid~~
- (d) Iodine

Q In BCC unit cell, how many atoms are present per unit cell

- (a) 1
- (b) 2
- (c) 4
- (d) 6





Q Which type of defects is known as a stoichiometry defect

- (a) Frenkel defect
- ☒ (b) Schottky "
- (c) Impurity "
- (d) Interstitial "

TECHNICAL CLASSES

Q Frenkel defect is common in

- (a) NaCl
- ☒ (b) ZnS
- (c) KCl
- (d) CsCl

Q Band theory explain

- (a) Crystal shape
- (b) Melting point
- ☒ (c) Electrical conductivity
- (d) Magnetism.



Q X-ray diffraction is used to

- (a) molecular weight
- (b) Density
- (c) Crystal structure
- (d) Melting Point

TECHNICAL CLASSES

Q Which method is used for the determination of melting point in crystalline solid?

- (a) Tollen's method
- (b) Kjeldahl method
- (c) Biuret "
- (d) Dumas "

Q What is relation given by Bragg's law

- (a) $n\lambda = 2d \sin \theta$
- (b) $E = mc^2$
- (c) $PV = nRT$
- (d) $\lambda = \frac{h}{mv}$



Q A material which show temporary magnetism is the presence of an external magnetic field

(a) Ferromagnetic

(b) Paramagnetic

(c) Diamagnetic

(d) Ferri magnetic

TECHNICAL CLASSES

Subjective Questions (short types Questions)

Q Define Crystalline solids and amorphous solids with example?

Q Explain the classification of crystalline solids with examples.

Q What is crystal lattice? Describe the primitive, BCC and FCC unit cells.

Q Explain the Frenkel and Schottky defects in solids. with example



My Suggestion

If ask difference between any two
or three things

eg Frenkel | Schottky

TECHNICAL CLASSES

Q Write difference between crystalline
and amorphous solid

Q Differentiate between metallic
and covalent solid

metallic solid	covalent solid
# Definition	Definition

eg-

eg-

Metallic solid

(1) Such a types of
crystalline solids
in which constituent
particles are metal and
they are bonded with
metallic bond
eg Fe(s) Zn(s) etc

Covalent solid

Such a types of crystalline
solid



Subjective Questions (Long types)

Q Explain the classification of crystalline solids into molecular, ionic, metallic and covalent solid.

TECHNICAL CLASSES

Q Describe the magnetic properties of solids with example of Ferromagnetism, paramagnetism, diamagnetism, ferrimagnetism.

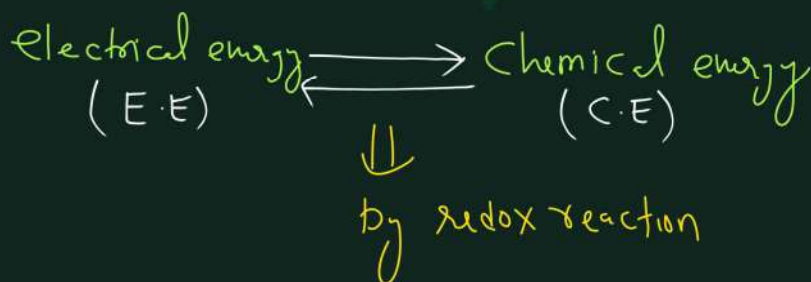
Q Discuss the imperfections in solids. explain stoichiometric defects, impurity defects, and non stoichiometry defects in detail.

Electrochemistry

The branch of chemistry in which we study about change in electrical energy into chemical energy and chemical energy into electrical energy by redox reaction.

TECHNICAL CLASSES

Electrochemical cell — A cell which convert electrical energy into chemical energy and chemical energy into electrical energy by redox reaction.





as we know

Redox = $\frac{\text{Redox}}{\text{Reduction} \quad \text{Oxidation}}$

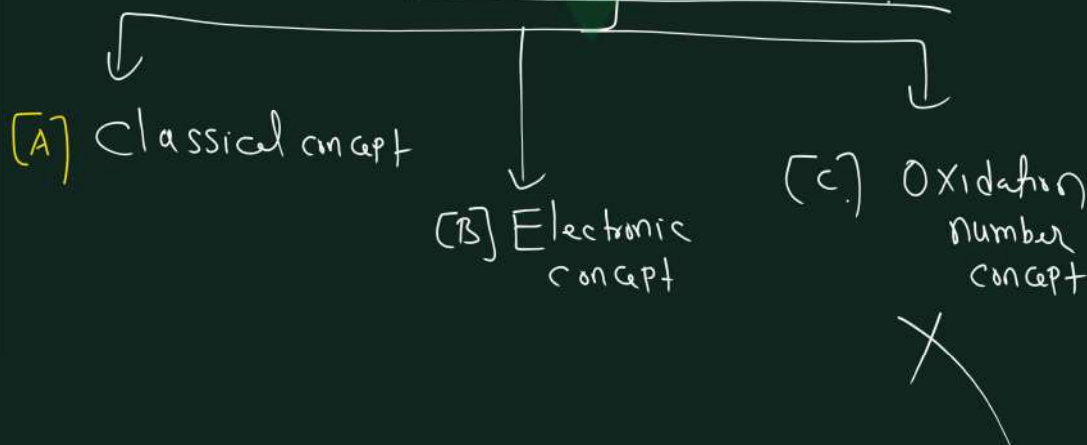
Redox reaction is also known as reduction oxidation reaction.

TECHNICAL CLASSES

Redox reaction

Those reactions in which Oxidation and Reduction occurs at same time.

Concepts of Redox reaction





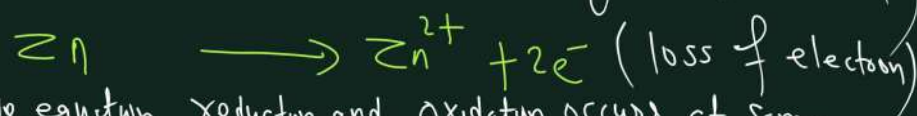
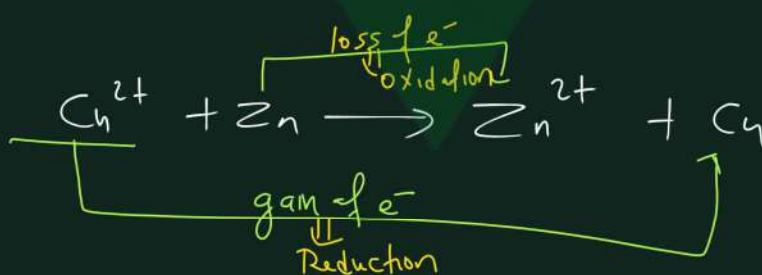
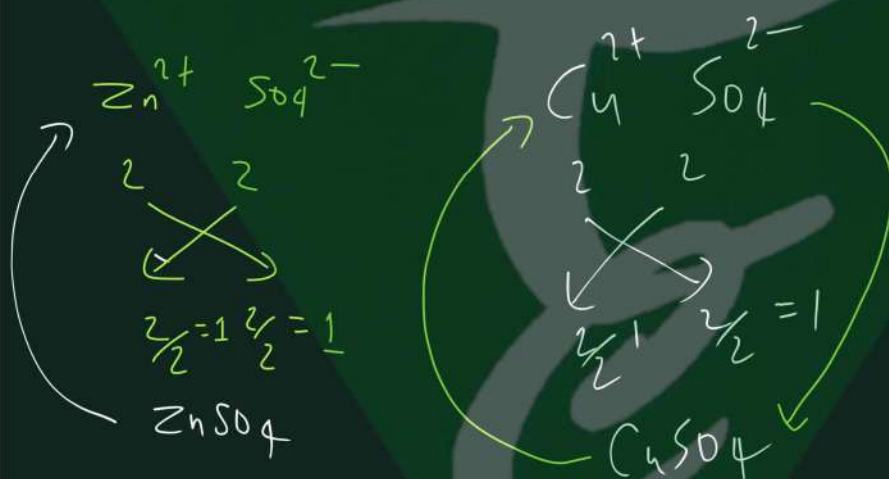
change above equation into ionic equation.



ionic
equation.



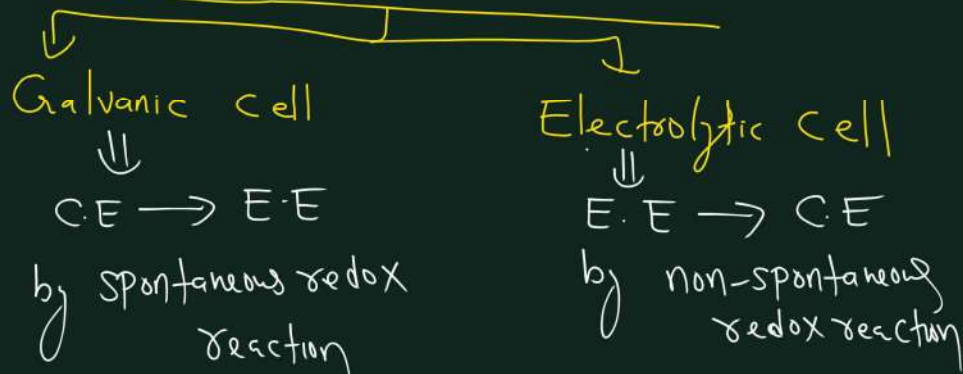
TECHNICAL CLASSES



In above equation reduction and oxidation occurs at same time so it is a redox reaction.



Types of Electrochemical cell



TECHNICAL CLASSES

Spontaneous process — not need external help

Non spontaneous process — need of external help

Some important terms

Conductors — those substance which conduct electric current

Types of conductor

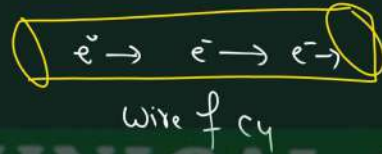
- (i) Electronic conductor (metallic conductor)
- (ii) Electrolytic conductor



Electronic Conductor (metallic conductor)

Those conductor which conduct electric current due to flow of an electron.

For example - Metals like, Silver, Cu, Au etc

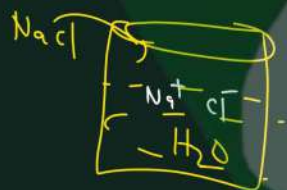


TECHNICAL CLASSES

② Electrolytic conductor

Those types of conductor which conduct electric current due to flow of ions.

For example - CuSO_4 , NaCl , ZnSO_4 etc



in aqueous NaCl , Na^+ and Cl^- ions conduct electric current

Difference between electronic
and
electrolytic conductor.



Electronic conductor (metallic conductor)

- (I) Conduct electric current due to flow of electrons.
- (II) Matter is not transfer

Electrolytic conductor

- (I) Conduct electric current due to flow of ions.
- (II) Matter is transferred

TECHNICAL CLASSES

Metallic conductor

- (III) Faraday's law not follow
- (IV) it is only a physical change not chemical changes

Electrolytic conductor

- (III) Faraday's law is follow
- (IV) both physical and chemical changes occurs.

Metallic conductor

- (V) Conductivity decreases with increase in temperature

Electrolytic conductor

- (V) Conductivity increases with increase in temperature.



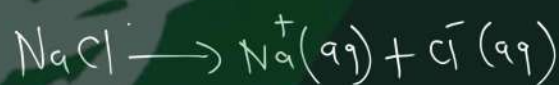
Electrolytes and non electrolytes

Electrolytes — Those substance which dissociated in molten and aqueous state to conduct electric current. is called electrolytes.

TECHNICAL CLASSES

for example NaCl(s)

NaCl



ions conduct electric current

aqueous — Any substance dissolve in water.

aqueous and non aqueous

aqueous word

comes from aqua(water)

Any substance dissolve in water is called its aqueous state

non aqueous
 (//) (//)
 not in water

Any substance not dissolve in water



Types of electrolytes

(I) Strong electrolytes — those electrolytes which completely decompose in molten and aqueous state and gives high concentration of ions.

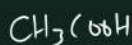
for example — NaCl , KCl , HCl , H_2SO_4 , CuSO_4 , ZnSO_4

TECHNICAL CLASSES

Strong electrolytes have high conductivity because it decompose completely and gives high concentration of ions, as we know high concentration of ions conduct high amount of electric current.

(II) Weak electrolytes — Those electrolytes which do not decompose completely and gives low concentration of ions.

for example — CH_3COOH (acetic acid)
 HCOOH (formic acid)



+

H^+

low concentration of ions formed
So weak electrolytes conduct low amount
current.

TECHNICAL CLASSES

Factors affecting Conductivity of electrolytic Conductor / Electrolytes

- (I) Nature of electrolytes — Conductivity depends upon nature of electrolytes for example, strong electrolytes conduct high amount of electric current but weak are not.
- (II) Temperature — If Temperature increase degree of ionisation increases so conductivity also increases.
- (III) Concentration of solution — Conduction of electric current decreases by increase in concentration



(iv) Nature of Solvent — in polar solvent
(like water) conductivity high
as compared to non polar solvent

TECHNICAL CLASSES

Strong acids are strong electrolytes
eg HCl , H_2SO_4 etc

Weak acids are weak electrolytes
eg - CH_3COOH (acetic acid)
 HCOOH (formic acid)



Galvanic cell — Those types of electrochemical cell which convert chemical energy into electrical by spontaneous redox reaction.
It is also known as voltaic cell

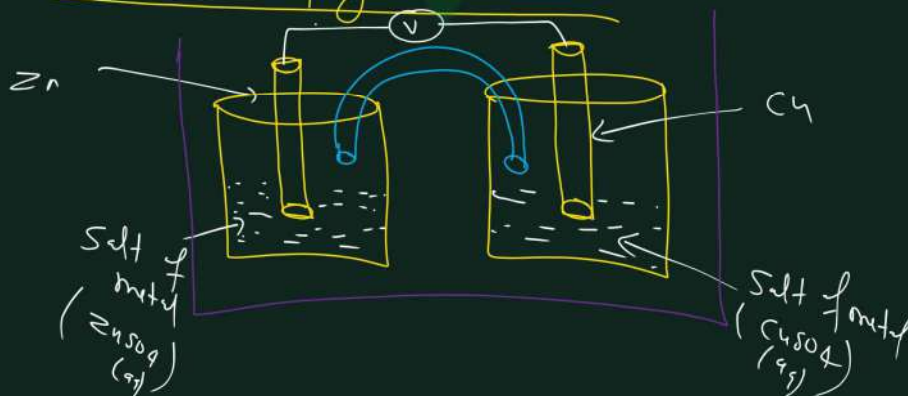
TECHNICAL CLASSES

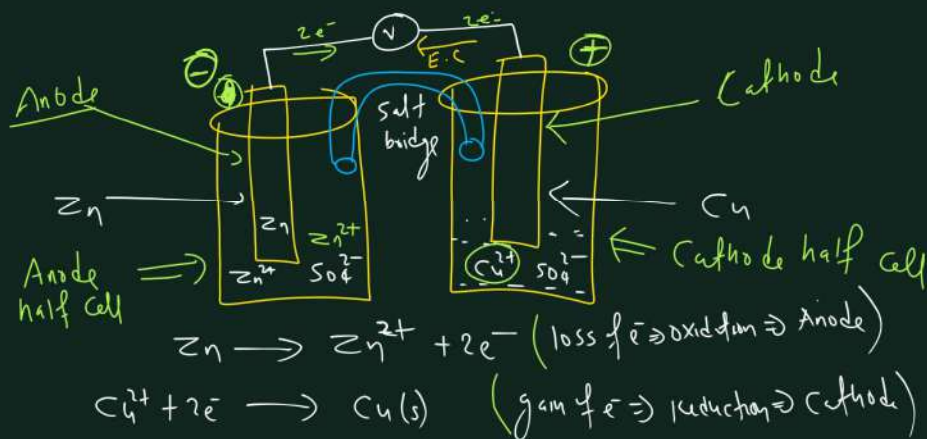
Example

Daniell cell

it is a galvanic cell in which anode and cathode made by Zn and Cu respectively

Function of galvanic cell





TECHNICAL CLASSES

The direction of electric current (E.C) is opposite to the flow electron

Reactivity series of metal

K
 Na
 Ca
 Mg
 Al
Zn
 Fe
 Sn
 Pb
 H
 Cu

more reactive $\leftarrow$

Electrodes — An electrodes is a conductor through which electric current enters or leaves an electrochemical cell. It allows to flow of electrons between the electrolyte and external circuit.



Types of electrodes

Anode - Those type of electrode where oxidation occurs.

Cathode - Those type of electrode where reduction occurs.

TECHNICAL CLASSES

Note

In Galvanic Cell

Flow of electron = Anode to Cathode

Direction of electric current = Cathode to Anode

Salt bridge



← Inverted U shape

Salt bridge is a inverted U shaped glass tube filled with inert electrolyte mixed with substance like agar-agar or gelatin which makes it Jelly-like.

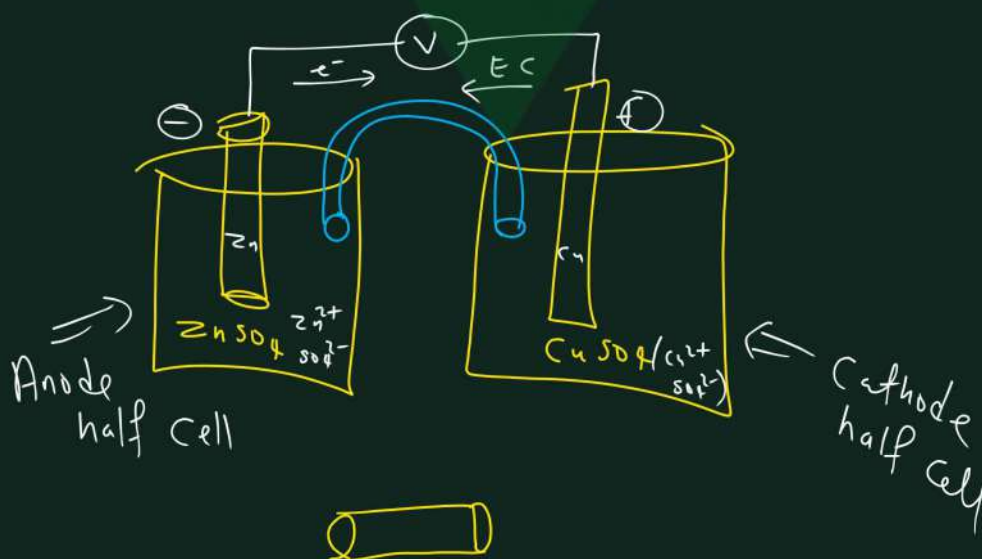


Inert electrolytes

It is a type of electrolyte which gives ions in solution and conduct electric current but not participated in cell reaction in galvanic cell

TECHNICAL CLASSES

Most common inert electrolytes used in Salt bridge





Anode = -ve

Cathode = +ve

TECHNICAL CLASSES

Function of salt bridge

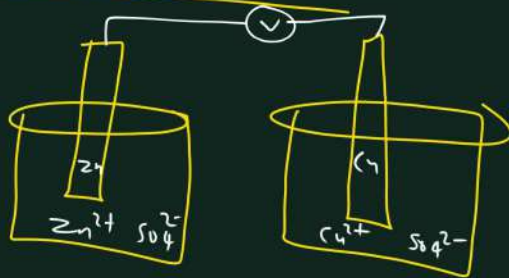
- # Salt bridge completes the electrical circuit in galvanic cell
- # It maintains the electrical neutrality of electrolytes in two half cell

It prevents diffusion of the solution from one half cell to another half cell

Diffusion means intermixing



Cell Reaction



at Anode = $\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$ (Oxidation)

at Cathode $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$ (Reduction)

TECHNICAL CLASSES

Q Write reaction at cathode and
Anode half cell also write
Cell reaction and representation
for Daniell cell.

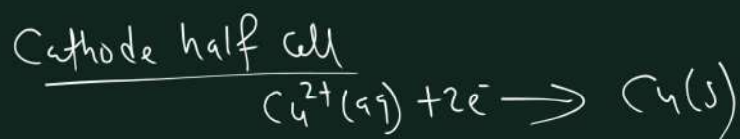
Ans for Daniell cell

Reaction at :-

Anode half cell

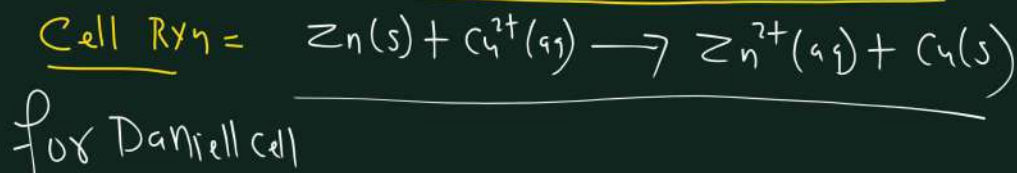
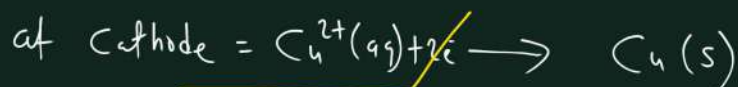
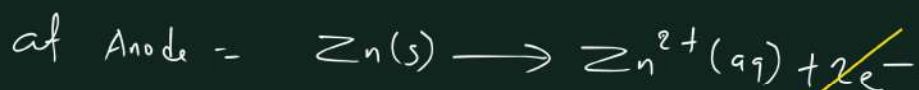


Cathode half cell





Cell reaction for Daniell cell

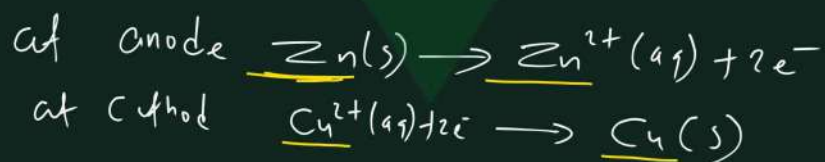


TECHNICAL CLASSES

eg-①



eg-②



for Representation of cell

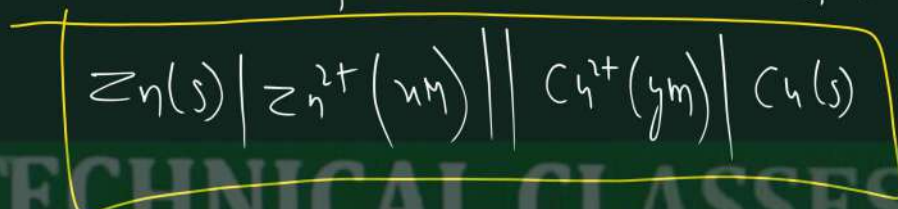
A B C
(Anode) Salt bridge Cathode



Representation
of Daniell cell



Where c_1 and c_2 is the concentration of Zn^{2+} and Cu^{2+} respectively.



Difference between Galvanic and electrolytic cell

<u>Galvanic cell</u>	<u>Electrolytic cell</u>
(i) Spontaneous redox reaction occurs.	(i) Non spontaneous redox reaction occurs.
(ii) Anode = -ve cathode = +ve	(ii) Anode = +ve cathode = -ve

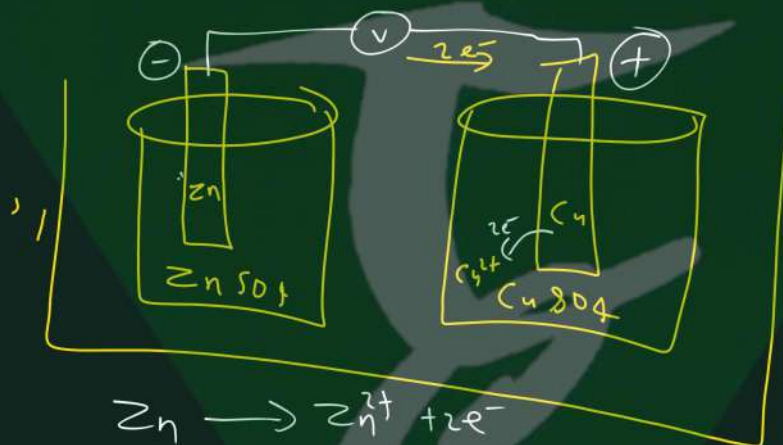
<u>Galvanic cell</u>	<u>electrolytic cell</u>
(iii) ΔG (change in Gibbs free energy) = -ve	(iii) $\Delta G = +ve$
(iv) $E_{\text{cell}} = +ve$	(iv) $E_{\text{cell}} = -ve$
(v) In general chemical energy into electrical energy	(v) Change E.E into C.E



Gibbs free energy — The amount of energy in a system that is available to do useful work

ΔG = change in Gibbs free energy

TECHNICAL CLASSES



Electrodes —

- Anode (Oxidation occurs)
↓
loss of electron
- Cathode (Reduction)
↓
gain of an electron



Some Important Points

Electrode Potential (E)

The tendency of an electrode to either lose or gain electrons

The tendency to get either oxidised or reduced

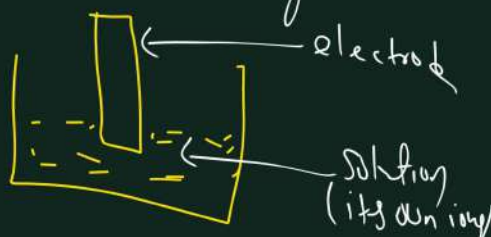
TECHNICAL CLASSES

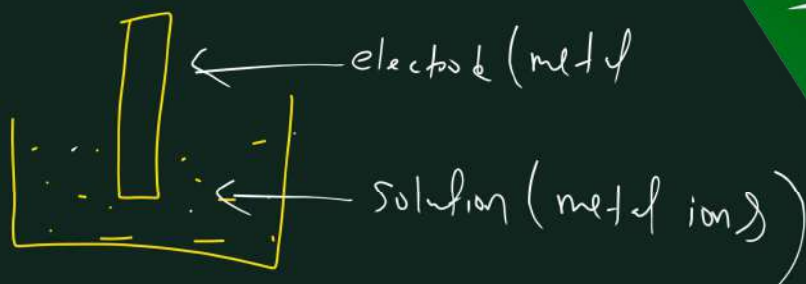
When it is in contact with a solution of its own ions is known as Electrode Potential



Oxidation $\Rightarrow$ tendency
 $\Downarrow$
 Electrode Potential.

The potential difference set up between metal and its ions in the electrolytic solution surrounding the electrode





TECHNICAL CLASSES

factors affecting magnitude of electrode potential

- (i) Nature of electrodes
- (ii) Concentration of ions in solution
- (iii) Temperature
- (iv) Pressure (gaseous electrode)

Types of electrode potential

- (i) Oxidation Potential
- (ii) Reduction Potential



① Oxidation Potential — The potential difference between electrodes and own solution where oxidation occurs.

The electrode potential ^{ox} of the electrode where oxidation occurs.

TECHNICAL CLASSES

Reduction Potential — The electrode potential of electrode where reduction occurs.

Relation between Oxidation potential ($E_{\text{Oxidation}}$) and Reduction Potential ($E_{\text{Reduction}}$)

$$E_{\text{Oxidation}} = -E_{\text{Reduction}}$$

$$E_{\text{Reduction}} = -E_{\text{Oxidation}}$$

for example ^{suppose} $E_{\text{Reduction}} = -0.76\text{V}$

$$E_{\text{Reduction}} = -E_{\text{Oxidation}}$$

$$-0.76\text{V} = -E_{\text{Oxidation}}$$

$$E_{\text{Oxidation}} = +0.76\text{V}$$



Standard electrode potential (E°)

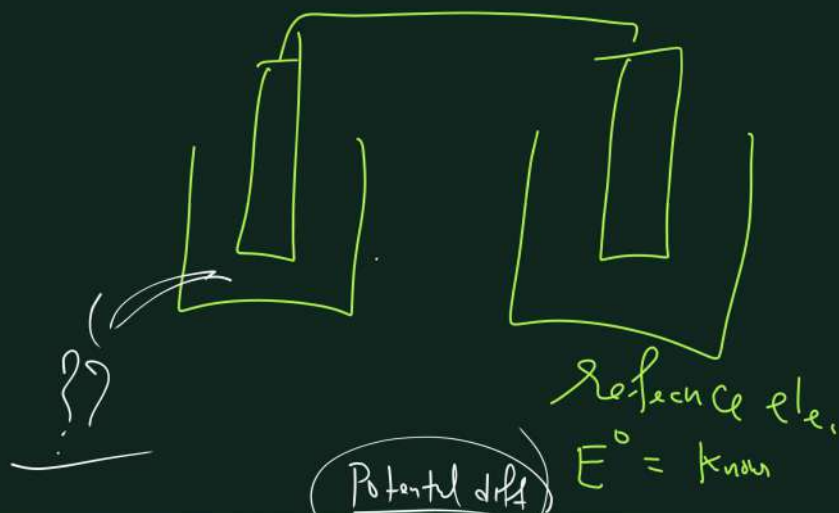
The electrode potential measured at unit concentration at 298 K Temperature or 1 atm pressure

TECHNICAL CLASSES

Electrode potential (E)	Standard electrode potential (E°)
at any T & P	$T = 298 \text{ K}$ $P = 1 \text{ atm}$

Measurement of electrode potential

Standard electrode potential of single electrode cannot be determined because any half cell reaction can't take place alone. But we can measure a potential difference between the electrode by using reference electrode.



TECHNICAL CLASSES

Q Which of the following is a strong electrolytes?

- (a) Acetic acid
- (b) Urea
- (c) NaCl
- (d) Glucose.

(a) acetic acid - CH_3COOH weak acid

(b) Urea (NH_2CONH_2) - covalent molecule

☒ (c) NaCl ionic compound $\Rightarrow$ easily dissociated into ions.

(d) Glucose $\Rightarrow$ covalent molecule = do not form ions.



Oxy acid

Which contain hydrogen as well as oxygen with other elements
 e.g. $\text{CH}_3\text{COOH} - \text{C, H, O}$
 $\text{HCOOH} - \text{C, H, O}$
 $\text{H}_2\text{SO}_4 - \text{H, O, S}$

Hydra acid

Which contain hydrogen not oxygen with other elements
 e.g. $\text{HCl} - \text{H, Cl}$
 $\text{HI} - \text{H, I}$

TECHNICAL CLASSES

Q Which of the following conducts electricity by movements of electron?

- (a) Aqueous NaCl
- (b) Molten KCl
- (c) Copper metal
- (d) Dilute HCl

Conductor

metallic / electronic



e.g. metal

electrolytic

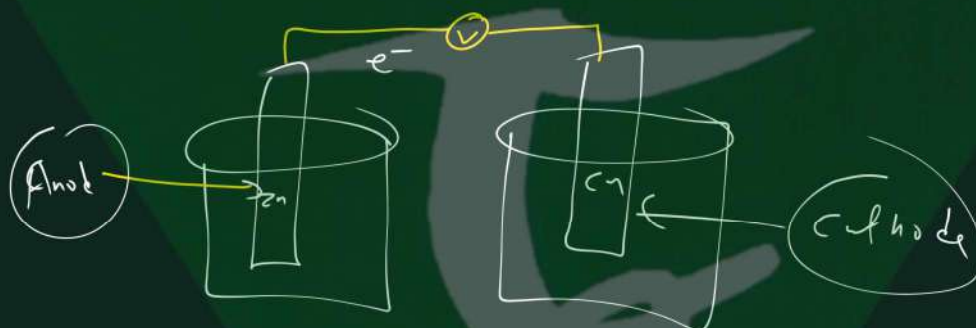
e.g. - ions forming salts





Q In a galvanic cell, electrons flow from

- (a) Cathode to Anode
- (b) Electrolyte to Salt bridge
- (c) Anode to Cathode
- (d) Cathode to Solution



flow of electrons - Anode to Cathode

flow of electricity - Cathode to Anode.

Q Which of the following is a non electrolyte?

- (a) $\text{NaOH} \rightarrow \text{Na}^{+} + \text{OH}^{-}$
- (b) $\text{HCl} \rightarrow \text{H}^{+} + \text{Cl}^{-}$
- (c) Glucose $\rightarrow$ do not form ions
- (d) $\text{KNO}_3 \rightarrow \text{K}^{+} + \text{NO}_3^{-}$



Q Electrolytic Conduction is due to the movement of

- (a) electron only
- (b) ions only
- (c) Atoms
- (d) holes.

TECHNICAL CLASSES

Q which one of the following factors increase electrolytic conductance?

- (a) increase viscosity of solvent
- (b) Decrease temperature
- (c) Increase concentration indefinitely
- (d) Increase temperature

Q Which of the following substances will show maximum conductance in solution?

- (a) CH_3COOH (Weak electrolyte)
- (b) H_2SO_4 (Strong acid)
- (c) NH_4OH
- (d) H_2O (covalent molecule)



Q In metallic conduction, the charge is carried by

- (a) Cation
- (b) Anion
- ☒ (c) Electrons (e^-)
- (d) Molecule

Q Which of the following statements is true for metallic conductors?

- (a) Conductivity increases with temperature
- ☒ (b) Conductivity decreases with temperature
- (c) No free electrons involved
- (d) Ions are responsible for conduction

Q A weak electrolyte is one which

- (a) Dissociates completely
- (b) Does not dissociate at all
- ☒ (c) Dissociates partially
- (d) Conducts like a metal



TECHNICAL CLASSES

Measurement of electrode potential

- # absolute electrode potential cannot be measured directly.
- # Hence, electrode potentials are measured relative to a reference electrode.
- # most commonly the standard hydrogen electrode is used (SHE).

Reference electrode

- A Reference electrode is an electrode which has a known, stable, and reproducible electrode potential.
- # It is used as a standard to measure the electrode potential of other electrodes under investigation.



Advantage of reference electrodes

- # Stable potential over time
- # Easy to construct and maintain
- # Chemically inert towards the system being studied

TECHNICAL CLASSES

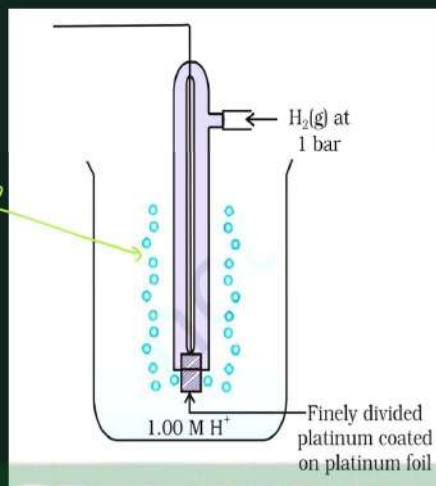
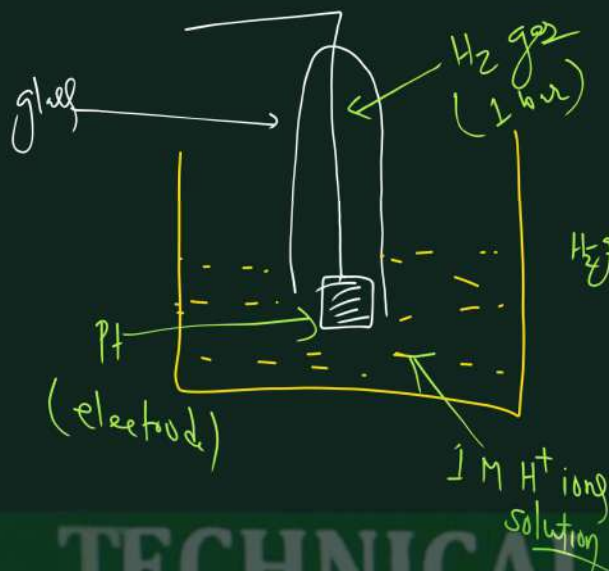
Types of Reference electrodes

- (i) Standard hydrogen electrodes (SHE)
- (ii) Calomel electrodes (Mercury-mercurous chloride electrode)
- (iii) Silver-silver chloride electrode

Standard hydrogen electrodes

Construction

- # A Platinum electrode Coated with Platinum black
- # Dipped in a 1M H^+ ion solution
- # hydrogen gas in bubbled over the electrode at 1 atm pressure.



TECHNICAL CLASSES

Q in the construction of a SHE which gas is bubbled over the platinum electrode?

- (a) Oxygen ~~not~~ hydrogen
(b) Nitrogen (d) carbon dioxide.

Q The pressure of hydrogen gas maintained in a SHE is

- (a) 0.5 atm
(b) 1 atm
(c) 2 atm
(d) 10 atm.



Q The temperature maintained for standard conditions in a SHE is

(a) 0°C (b) 100°C

(c) 25° (d) 50°C

TECHNICAL CLASSES

Q Which of the following acts as the inert electrodes in SHE?

(a) Gold (c) Platinum

(b) Silver (d) Copper.

Q In SHE the electrolyte used should have a concentration of H^{+} ions equal to

(a) 0.1M (b) 1M

(c) 2M (d) 0.5M

Q SHE Can act as which type of electrode depending on the cell it is connected to?

- (a) only anode (b) only cathode
(c) Both Anode and cathode
(d) None of these.

Q In SHE, what is the role of Platinum black?

- (a) acts as catalyst
(b) acts as reactants
(c) changes color at end point
(d) Reduces over potential.

Platinum black

Platinum black is a finely divided, powdered form of platinum metal that appears black in color.

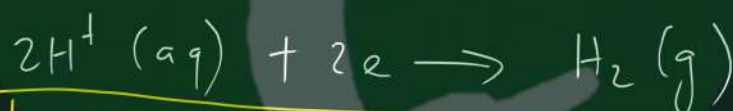


Advantage of Platinum black

- # It is high reactive so behave as catalyst
- # high surface area

TECHNICAL CLASSES

Reactions of SHE



Standard Electrode Potential = 0 V

Disadvantage

- # Difficult to maintain hydrogen gas and pressure.

EMF (electromotive force) of a cell

- # EMF (E_{cell}°) is the potential difference between two electrodes of a cell under Standard condition



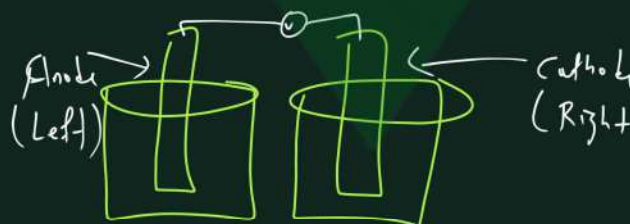


EMF of the cell is also known
as cell potential.

$$\# \text{ EMF} = \left(\text{Reduction Potential of Cathode} \right) - \left(\text{Reduction Potential of anode} \right)$$

TECHNICAL CLASSES

Left $\longrightarrow$ Right
L $\longrightarrow$ R



$$E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}}$$

E_{cathode} = Reduction potential of cathode

E_{anode} = " " " " Anode

$$E_{\text{cell}} = E_{\text{Right}} - E_{\text{Left}}$$



E (Electrode Potential)

Reduction Potential
(E (Reduction))

Oxidation Potential
(E (Oxi))

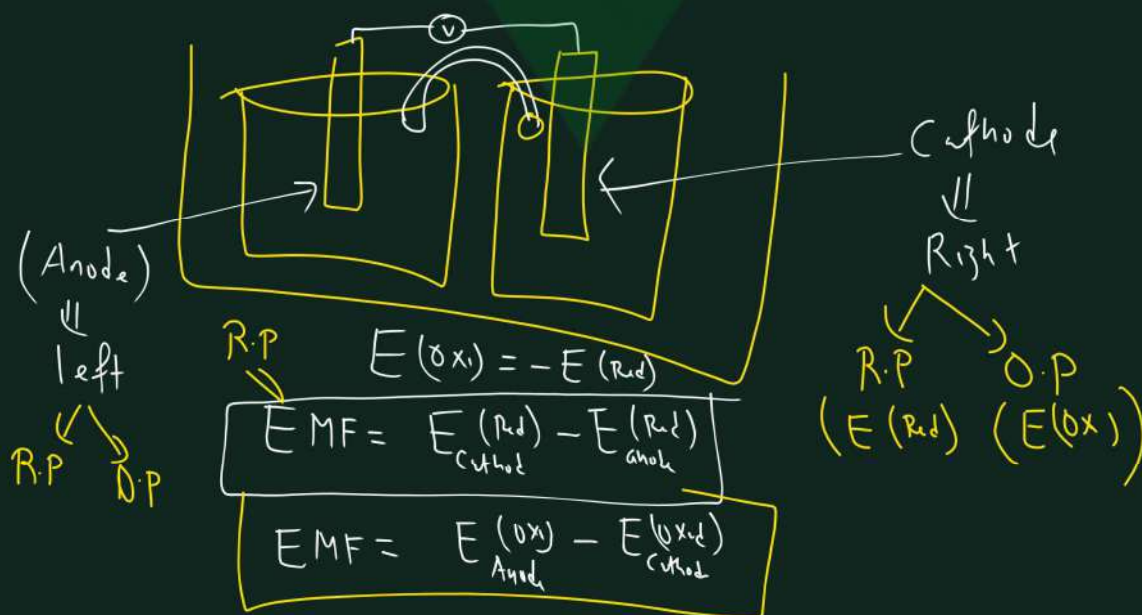
$$E(\text{Red}) = -E(\text{Oxi})$$

TECHNICAL CLASSES

$$EMF = \left(\text{Oxidation Potential of Anode} \right) - \left(\text{Oxidation Potential of Cathode} \right)$$

$$EMF = E(\text{Oxi})_{\text{Anode}} - E(\text{Oxi})_{\text{Cathode}}$$

$$EMF = E(\text{Oxi})_{\text{left}} - E(\text{Oxi})_{\text{right}}$$



Q What does a positive EMF indicate?

Ans — A positive EMF indicate the reaction is spontaneous and the galvanic cell produce electric current.

for example = $E_{\text{cell}} = +0.34\text{V} \Rightarrow \text{spontaneous}$

TECHNICAL CLASSES

Galvanic cell

$E_{\text{cell}} / \text{EMF} = +ve$

Q calculate the EMF of a cell
 $\text{Zn} | \text{Zn}^{2+} || \text{Cu}^{2+} | \text{Cu}$

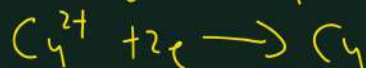
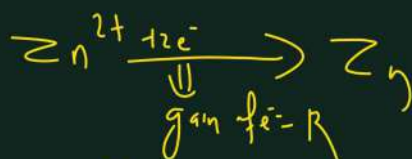
$$E_{\text{Zn}^{2+} | \text{Zn}}^{\circ} = -0.76\text{V}$$

$$E_{\text{Cu}^{2+} | \text{Cu}}^{\circ} = +0.34\text{V}$$

Ans $\xrightarrow{\text{R.P.}} E_{\text{Zn}^{2+} | \text{Zn}}^{\circ} = -0.76\text{V}$

$$\boxed{E_{\text{Cu}^{2+} | \text{Cu}} = +0.34\text{V}}$$

R.P.



$$E_{\text{Cu} | \text{Cu}^{2+}} = -0.34\text{V}$$

$$E_{\text{cell}} = E_{\text{cathode}} - E_{\text{Anode}}$$

$$0.34 - (-0.76\text{V})$$

$$= 0.34 + 0.76\text{V}$$

$$= 1.10\text{V}$$



$$E_{\text{Cell}}^{\circ} = E_{\text{Cathode}}^{\circ}(\text{R.P}) - E_{\text{Anode}}^{\circ}(\text{R.P})$$

$$E_{\text{Cell}}^{\circ} = E_{\text{Anode}}^{\circ}(\text{O.P}) - E_{\text{Cathode}}^{\circ}(\text{O.P})$$

Limitation - these formulas are applicable only
at Standard conditions
Concⁿ - 1M

TECHNICAL CLASSES

Nernst equation

The Nernst equation is used to calculate
the electrode potential of a half cell
or the EMF of a cell under non
Standard conditions (i.e. when ion concentrations
are not 1M)

Electrochemical Series

- # A list of elements arranged in the
order of their Standard electrode potential.
- # more Negative potential - higher tendency
to lose electron.



More Positive Potential - higher tendency
to gain electron

Used to predict

- Feasibility of redox reaction
- EMF of a cell
- Reactivity of metal

TECHNICAL CLASSES

Electrochemical series

A list of elements arranged
in the order of their Standard
electrode potential

More negative Potential - higher tendency
to lose electron

more positive potential - higher tendency
to gain electron

Table 2.1: Standard Electrode Potentials at 298 K

Ions are present as aqueous species and H_2O as liquid; gases and solids are shown by g and s.

Reaction (oxidized form + ne ⁻ → reduced form)	E°/V
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	2.87
$Co^{3+}(aq) + e^- \rightarrow Co^{2+}(aq)$	1.81
$H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$	1.78
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	1.51
$Au^{3+} + 3e^- \rightarrow Au(s)$	1.40
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	1.36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	1.33
$O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O$	1.23
$MnO_2(s) + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	1.23
$Br_2 + 2e^- \rightarrow 2Br^-(aq)$	1.09
$NO_3^- + 4H^+ + 3e^- \rightarrow NO(g) + 2H_2O$	0.97
$2Hg^{2+} + 2e^- \rightarrow Hg_2^{2+}$	0.92
$Ag^+ + e^- \rightarrow Ag(s)$	0.80
$Fe^{3+} + e^- \rightarrow Fe^{2+}(aq)$	0.77
$O_2(g) + 2H^+ + 2e^- \rightarrow H_2O_2$	0.68
$I_2 + 2e^- \rightarrow 2I^-(aq)$	0.54
$Cu^+ + e^- \rightarrow Cu(s)$	0.52
$Cu^{2+} + 2e^- \rightarrow Cu(s)$	0.34
$AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$	0.22
$AgBr(s) + e^- \rightarrow Ag(s) + Br^-(aq)$	0.10
$2H^+ + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+} + 2e^- \rightarrow Pb(s)$	-0.13
$Sr^{2+} + 2e^- \rightarrow Sr(s)$	-0.14
$Ni^{2+} + 2e^- \rightarrow Ni(s)$	-0.25
$Fe^{2+} + 2e^- \rightarrow Fe(s)$	-0.44
$Cr^{3+} + 3e^- \rightarrow Cr(s)$	-0.74
$Zn^{2+} + 2e^- \rightarrow Zn(s)$	-0.76
$2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83
$Al^{3+} + 3e^- \rightarrow Al(s)$	-1.66
$Mg^{2+} + 2e^- \rightarrow Mg(s)$	-2.36
$Na^+ + e^- \rightarrow Na(s)$	-2.71
$Ca^{2+} + 2e^- \rightarrow Ca(s)$	-2.87
$K^+ + e^- \rightarrow K(s)$	-2.93
$Li^+ + e^- \rightarrow Li(s)$	-3.05

1. A negative E° means that the redox couple is a stronger reducing agent than the H^+/H_2 couple.
2. A positive E° means that the redox couple is a weaker reducing agent than the H^+/H_2 couple.

Handwritten notes on the table:

- Non metal $\Rightarrow F$ (pointing to F_2)
- tending to gain $\leftarrow$ (pointing to positive E° values)
- half cell rxn (pointing to the table)
- tendency to loss electron $\Rightarrow$ metal (pointing to negative E° values)
- Li, K, Ca, Na (pointing to the bottom of the table)
- 3.05 (pointing to the value for Li^+/Li)
- +2 (pointing to the value for F_2/F^-)

Q Which of the following metals is the most reactive according to the electrochemical series.

(a) Cu (b) Ag (silver)

(c) K (d) Au (gold)

Q Which Statement is true about the electrochemical series?

X (a) it arranges metal based on their atomic weight

(b) it help predict the direction of redox reaction

X (c) it only applies to non metal

X (d) it ranks substances by their melting point

TECHNICAL CLASSES

Table 2.1: Standard Electrode Potentials at 298 K

Ions are present as aqueous species and H₂O as liquid; gases and solids are shown by g and s.

Reaction (Oxidised form + ne ⁻)	Reduced form	E°/V
F ₂ (g) + 2e ⁻	→ 2F ⁻	2.87
Co ³⁺ + e ⁻	→ Co ²⁺	1.81
H ₂ O ₂ + 2H ⁺ + 2e ⁻	→ 2H ₂ O	1.78
MnO ₄ ⁻ + 8H ⁺ + 5e ⁻	→ Mn ²⁺ + 4H ₂ O	1.51
Au ³⁺ + 3e ⁻	→ Au(s)	1.40
Cl ₂ (g) + 2e ⁻	→ 2Cl ⁻	1.36
Cr ₂ O ₇ ²⁻ + 14H ⁺ + 6e ⁻	→ 2Cr ³⁺ + 7H ₂ O	1.33
O ₂ (g) + 4H ⁺ + 4e ⁻	→ 2H ₂ O	1.23
MnO ₂ (s) + 4H ⁺ + 2e ⁻	→ Mn ²⁺ + 2H ₂ O	1.23
Br ₂ + 2e ⁻	→ 2Br ⁻	1.09
NO ₃ ⁻ + 4H ⁺ + 3e ⁻	→ NO(g) + 2H ₂ O	0.97
2Hg ²⁺ + 2e ⁻	→ Hg ₂ ²⁺	0.92
Ag ⁺ + e ⁻	→ Ag(s)	0.80
Fe ³⁺ + e ⁻	→ Fe ²⁺	0.77
O ₂ (g) + 2H ⁺ + 2e ⁻	→ H ₂ O ₂	0.68
I ₂ + 2e ⁻	→ 2I ⁻	0.54
Cu ⁺ + e ⁻	→ Cu(s)	0.52
AgCl(s) + e ⁻	→ Ag(s) + Cl ⁻	0.34
AgBr(s) + e ⁻	→ Ag(s) + Br ⁻	0.22
2H ⁺ + 2e ⁻	→ H ₂ (g)	0.00
Pb ²⁺ + 2e ⁻	→ Pb(s)	-0.13
Sn ²⁺ + 2e ⁻	→ Sn(s)	-0.14
Ni ²⁺ + 2e ⁻	→ Ni(s)	-0.25
Fe ²⁺ + 2e ⁻	→ Fe(s)	-0.44
Cr ³⁺ + 3e ⁻	→ Cr(s)	-0.74
Zn ²⁺ + 2e ⁻	→ Zn(s)	-0.76
2H ₂ O + 2e ⁻	→ H ₂ (g) + 2OH ⁻ (aq)	-0.83
Al ³⁺ + 3e ⁻	→ Al(s)	-1.66
Mg ²⁺ + 2e ⁻	→ Mg(s)	-2.36
Na ⁺ + e ⁻	→ Na(s)	-2.71
Cu ²⁺ + 2e ⁻	→ Cu(s)	-2.87
K ⁺ + e ⁻	→ K(s)	-2.93
Li ⁺ + e ⁻	→ Li(s)	-3.05

TECHNICAL CLASSES

Handwritten Notes:

- Cathode:** Indicated by a downward arrow on the right side of the table.
- Anode:** Indicated by an upward arrow on the left side of the table.
- Increasing strength of oxidising agent:** Indicated by an upward arrow on the left side of the table.
- Increasing strength of reducing agent:** Indicated by a downward arrow on the right side of the table.
- More positive:** Indicated by an upward arrow on the right side of the table.
- More negative:** Indicated by a downward arrow on the right side of the table.
- More tendency to gain e⁻:** Indicated by an upward arrow on the right side of the table.
- More tendency to lose e⁻:** Indicated by a downward arrow on the right side of the table.

Diagram:

Q The most negative the standard electrode potential, the greater is the tendency to

- Gain electrons
- lose electrons
- Remain inert
- Act as oxidizing agent



Nernst equation

It is used to calculate electrode potential at non standard conditions.

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0591}{n} \log Q_c$$

n = no. of electron involved in R_{xy}

TECHNICAL CLASSES



Where

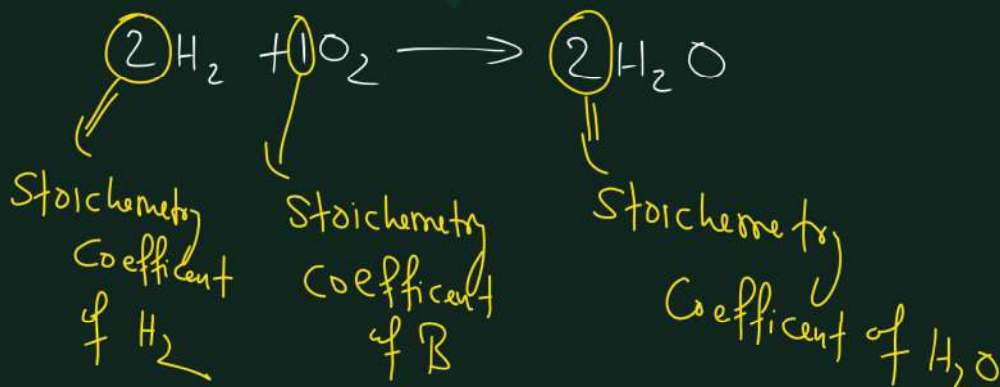
A & B are reactant

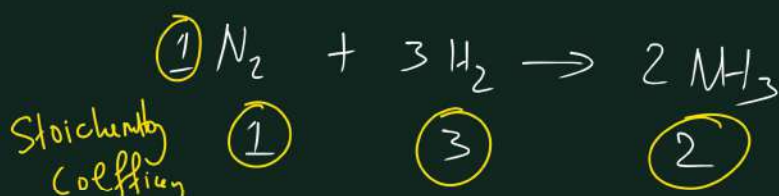
C & D are product

a & b are stoichiometry coefficient of A and B

c & d are " " " (and D)

for reaction





in chemistry

$$\text{Concentration} = []$$

$$[A] = \text{concentration of A}$$

$$[B] = \text{concentration of B}$$



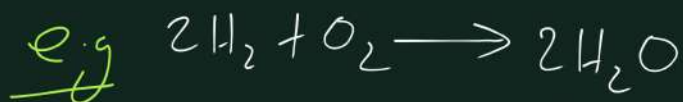
$$Q_c = \text{Reaction Quotient}$$

// it is ratio of concentration of reactant and product to the power its Stoichiometry Coefficient

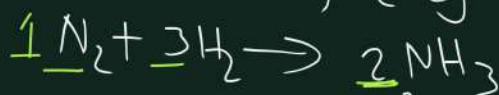


$$Q_c = \frac{[\text{Product}]^{\text{Stoi}}}{[\text{Reactant}]^{\text{Stoi}}}$$

$$Q = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$



$$Q_c = \frac{[H_2O]^2}{[H_2]^2 [O_2]}$$



$$Q_c = \frac{[NH_3]^2}{[N_2] [H_2]^3}$$

Cancel

TECHNICAL CLASSES

K_c = equilibrium const

Reversible reaction



γ_f = rate of forward reaction ($R \rightarrow P$)

γ_b = rate of backward reaction ($P \rightarrow R$)

equilibrium = $\boxed{\gamma_f = \gamma_b}$

at equilibrium

$$\boxed{Q_c = K_c}$$

equilibrium const



Nernst equation

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0591}{n} \log Q_c$$

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0591}{n} \log K_c$$

at equilibrium

TECHNICAL CLASSES

for Questions

$$0.0591 \approx 0.06$$

log

Formula (याद रखें)

$$\log(A \times B) = \log A + \log B$$

$$\log \frac{A}{B} = \log A - \log B$$

$$\log A^B = B \log A$$



उदाहरण

$$\log 1 = 0$$

$$\log 2 = 0.3010$$

$$\log 3 = 0.4771$$

$$\log 4 = 0.6020$$

$$\log 5 = 0.6989$$

$$\log 6 = 0.7781$$

$$\log 7 = 0.8450$$

$$\log 8 = 0.9030$$

$$\log 9 = 0.9542$$

$$\log 10 = 1$$

TECHNICAL CLASSES

for example

$$\textcircled{Q} \log 10^6 = 6 \log 10$$

$$= 6 \times 1 = 6$$

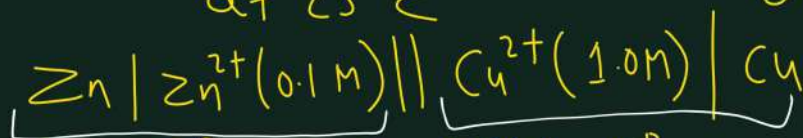
$$\textcircled{Q} \log 2 \times 10^4 = \log 2 + \log 10^4$$

$$= \log 2 + 4 \log 10$$

$$= 0.3010 + 4 \times 1 = 4.3010$$

Questions based on Nernst equation

Q Calculate EMF of the following cell at 25°C



$$\text{Given } E^\circ_{\text{Zn}^{2+}/\text{Zn}} = -0.76\text{V} \quad E^\circ_{\text{Cu}^{2+}/\text{Cu}} = +0.34\text{V}$$



$$E_{cell} = E_{cell}^{\circ} - \frac{0.06}{n} \log Q_c$$

Annotations: $1.10V$ (pointing to E_{cell}), Q_c (circled), n (circled), and "required" (written under each term).

$$E_{Zn^{2+}/Zn}^{\circ} = -0.76V$$

Annotation: R (written below the half-cell notation).

$$Cathode = Cu$$

$$Anode = Zn$$

$$E_{Cu^{2+}/Cu}^{\circ} = +0.34V$$

Annotation: R (written below the half-cell notation).

$$E_{cell}^{\circ} = E_{cathode}^{\circ} - E_{anode}^{\circ}$$

$$= +0.34V - (-0.76V)$$

$$= 1.10V$$

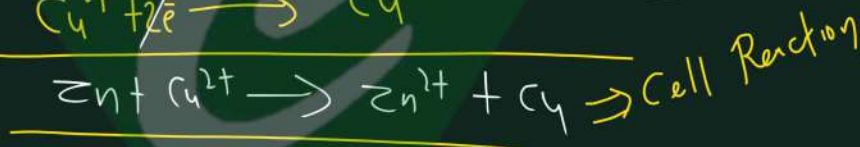
in Question Given



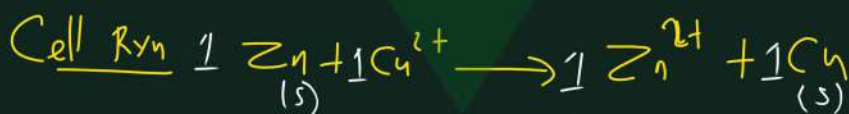
At anode
(Oxidation)



at Cathode
(Reduction)



$n=2$



$$Q_c = \frac{[Product]^{Stoic}}{[Reactant]^{Stoic}}$$

$$Q_c = \frac{[Zn^{2+}]^1 [Cu]^1}{[Zn]^1 [Cu^{2+}]^1}$$

Annotations: $[Cu]$ and $[Zn]$ are crossed out with a diagonal line, and 1 is written below $[Zn]$.

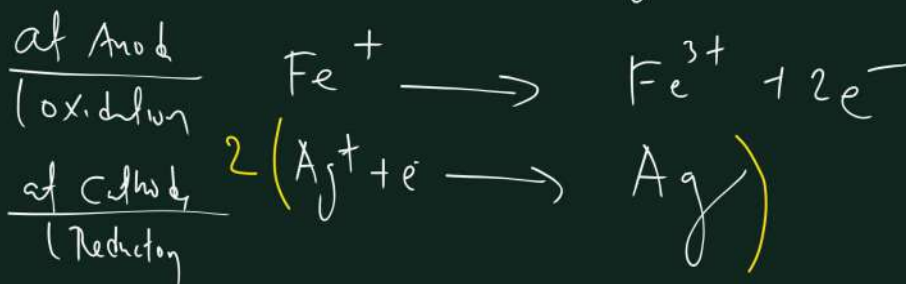
Concn Solid
in electrochemistry
consider 1

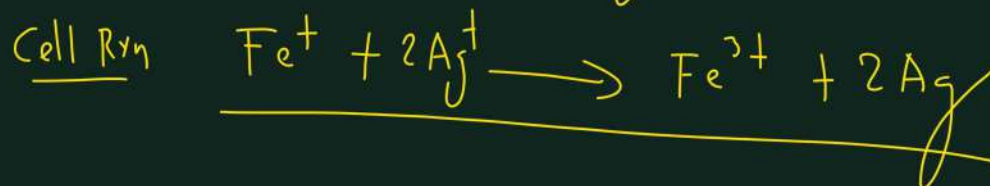
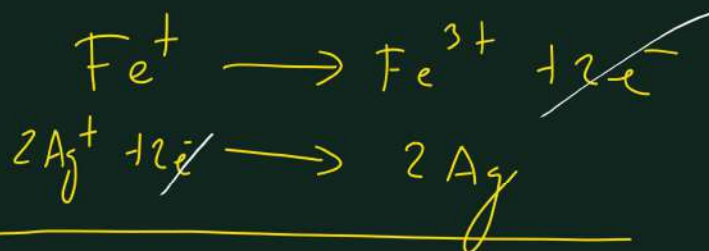


$$Q_c = \frac{[Zn^{2+}]}{[Cu^{2+}]}$$

$$\begin{aligned} E_{\text{cell}} &= E_{\text{cell}}^{\circ} - \frac{0.06}{n} \log Q_c \\ &= 1.10 - \frac{0.06}{2} \log \frac{[Zn^{2+}]}{[Cu^{2+}]} \\ &= 1.10 - 0.03 \log \frac{0.1 \text{ M}}{1.0 \text{ M}} \end{aligned}$$

$$\begin{aligned} &= 1.10 - 0.03 \log \frac{0.1}{1.0} \\ &= 1.10 - 0.03 \log \frac{1}{10} \\ &= 1.10 - 0.03 \log 1 - \log 10 \\ &= 1.10 - 0.03 (0 - 1) \\ &= 1.10 - 0.03(-1) \\ &= 1.10 + 0.03 = 1.13 \text{ V Avg} \end{aligned}$$





TECHNICAL CLASSES

Relation between E_{cell} and ΔG

$$\boxed{\Delta G = -nFE_{\text{cell}}} \quad \boxed{\Delta G^\circ = -nFE_{\text{cell}}^\circ}$$

Where

ΔG = Change in Gibbs free energy

n = no. of electron transfer

F = Faraday constant (96,485 C/mol)

Note ~~XXX~~

$$\left. \begin{array}{l} E_{\text{cell}} > 0 \quad / \quad E_{\text{cell}} = +ve \\ \Delta G < 0 \\ \Delta G = -ve \end{array} \right\} \text{Spontaneous Rxn}$$

$$\left. \begin{array}{l} \text{If } E_{\text{cell}} < 0 \\ E_{\text{cell}} = -ve \end{array} \right\} \begin{array}{l} \text{than } \Delta G > 0 \\ \Delta G = +ve \end{array} \quad \text{Non spontaneous.}$$



Q Calculate the ΔG° for a cell having $E^\circ = 1.10\text{V}$ and $n = 2$ (use $F = 96485\text{ C/mol}$)

Ans
$$\Delta G^\circ = -nFE_{\text{cell}}$$

$$= -2 \times 96485 \times (1.10)$$

$$= -212267\text{ J/mol}$$

TECHNICAL CLASSES

Q if a cell has a ΔG° of -237.1 kJ/mol and transfer 2 electrons, find the standard electrode Potential (E°) (use $F = 96485\text{ C/mol}$)

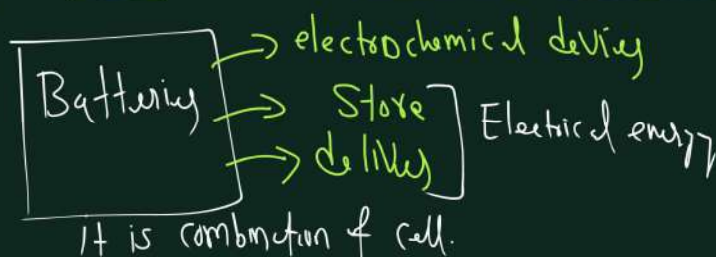
Ans
$$\Delta G^\circ = -nFE_{\text{cell}}$$

$$+237.1 = -2 \times 96485 (E_{\text{cell}})$$

$$E_{\text{cell}} = \frac{237.1 \times 1000}{2 \times 9648} = 1.23\text{V}$$

Batteries

Batteries are electrochemical devices that store and deliver electrical energy.





Types of Batteries or cell

- (i) Primary cell / Batteries
- (ii) Secondary cell
- (iii) fuel cell

TECHNICAL CLASSES

(i) Primary cell - It is a non rechargeable cell

It is once discharged, cannot be reused.

Example - Dry cell

In this cell, chemical energy is converted into electrical energy as long as the chemical components active

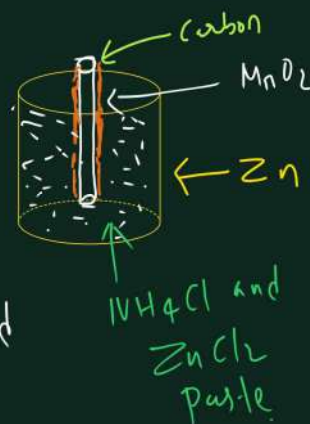
Example of dry cell

Important point

Anode - Zn container

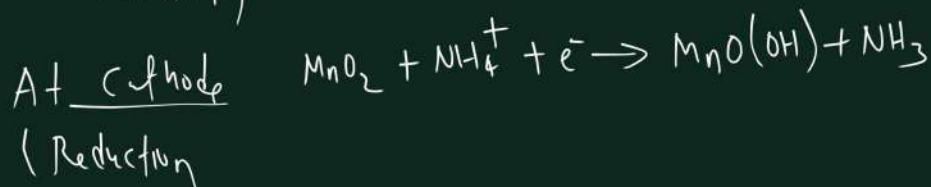
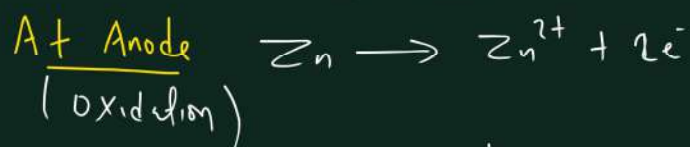
Cathode - Carbon rod surrounded with MnO_2

Electrolyte - NH_4Cl and $ZnCl_2$ paste





Reaction in Dry cell



TECHNICAL CLASSES

Feature (Dry cell)

- # It is compact and portable
- # Short life due to zinc corrosion

Uses Common use - Flashlights, radios, toys, etc.

Characteristics of Primary cell

- # Irreversible reaction
- # Lightweight and portable
- # Low cost
- # Limited shelf life and energy capacity
- # Cannot be recharged.



Some other primary cell

⇒ Alkaline battery

- # It is improved version of dry cell
- # Anode Zn powder
- # Cathode MnO_2
- # Electrolyte KOH (Alkaline not acidic like NH_4Cl)

TECHNICAL CLASSES

Advantage

- # Longer life
- # Steady Voltage
- # Better Performance under heavy load.

Mercury cell

- # It is a primary cell which used in watches, hearing aids.

Anode - Zinc

Cathode - HgO



Reaction



TECHNICAL CLASSES

Silver oxide cell

- # Used in calculator, hearing aids
- # Anode - Zn
- # Cathode - Ag_2O
- # Electrolyte - KOH or NaOH

Reaction



Advantage

- # High energy to weight ratio
- # Stable Voltage.



Secondary cell

It is rechargeable electrochemical cell that converts chemical energy into electrical energy during discharge and electrical energy into chemical energy during charging.

TECHNICAL CLASSES

Important Points about Secondary cell

- # Reversible redox reaction
- # Can be used multiple time
- # Use — mobile phone, laptops, UPS, electrical vehicles.

Characteristics of Secondary cells

- # Rechargeable
- # High efficiency and Capacity.
- # Long cycle life
- # Higher initial cost than Primary cells.
- # Used for high drain application.



Types of Secondary cell

Lead Acid Battery (Lead Storage battery)

Use — Automobiles, inverters.

Anode — Lead (Pb)

Cathode — Lead dioxide (PbO_2)

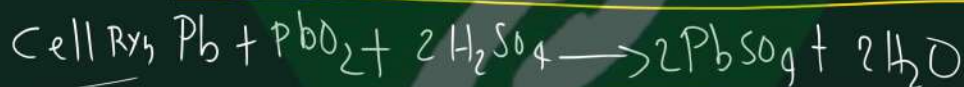
Electrolyte — Sulphuric acid (H_2SO_4)

Discharging reaction

at
Anode



at
Cathode



Charging reverses the above reaction

Maintenance free battery

It is a type of sealed lead acid battery that does not require water refilling or frequent maintenance.



Some Important points

- # Sealed construction
- # No topping up — No need to add distilled water.
- # leak-proof
- # Longer shelf life

TECHNICAL CLASSES

Nickel Cadmium battery (Ni-cd)

Use — Cordless phone, tools.

Anode — Cadmium (Cd)

Cathode — Nickel oxide hydroxide ($\text{NiO}(\text{OH})$)

Electrolyte — KOH

Discharging Rxn

at Anode



at cathode





Lithium ion battery

Use - Laptop, Smartphone, electric Vehicles.

Anode - Graphite (Carbon)

Cathode - Lithium metal oxide

Electrolyte - Lithium salt in organic solvent

TECHNICAL CLASSES

Working

During discharge - Li ions move from anode to cathode.

During charge - Li ions move back from cathode to anode.

Advantage of Li ions battery

High energy density

Light weight

Long cycle life



Fuel cell

A Fuel Cell is an electrochemical device that converts the chemical energy of a fuel directly into electricity.

for example- H_2-O_2 fuel cell

TECHNICAL CLASSES

Working Principle

The fuel cell consists of anode, cathode and electrolyte.

hydrogen gas is supplied to the anode, where it is oxidized to produce
 $H \rightarrow H^+ + e^-$ Proton (H^+) and electron (e^-)

oxygen gas is supplied to the cathode, where it reacts with protons (from the electrolyte) and electron (from the external circuit) to form water.

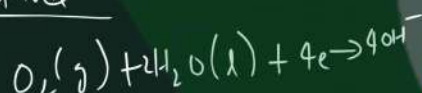


The movement of electrons through the external circuit generates electric current.

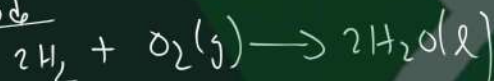
TECHNICAL CLASSES

Reactions

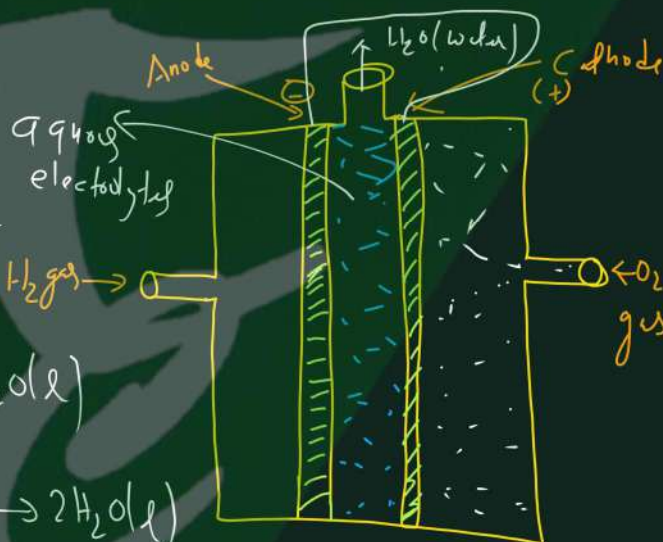
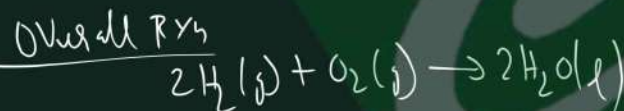
Cathode



Anode



Overall Rxn



Advantage of fuel cell

- # High efficiency
- # Environmentally friendly - because it gives only water as a product



Application / Uses

- # Power Sources — Apollo mission (by NASA)
- # Space Craft and Submarines

TECHNICAL CLASSES

Questions

Q. What is the main fuel used in most fuel cell

- (a) Methane
- ✓ (b) Hydrogen
- (c) Carbondioxide
- (d) Nitrogen

Q. What is the main by product of hydrogen-oxygen fuel cell?

- (a) Carbondioxide
- (b) Methane
- ✓✓ (c) Water
- (d) Ammonia



Q Which part of the fuel cell allows only protons to pass through?

- (a) Cathode
- (b) Anode
- (c) ~~electrolyte~~
- (d) collector

TECHNICAL CLASSES

Q In hydrogen fuel cell, hydrogen is oxidized at the

- (a) Cathode
- (b) ~~Anode~~
- (c) ~~Electrolyte~~
- (d) collector

Q What type of energy conversion takes place in a fuel cell?

- (a) Mechanical to electrical
- (b) Electrical to chemical
- (c) Thermal to mechanical
- (d) ~~Chemical to electrical~~



Q Which of the following is a Secondary cell.

- (a) Dry cell
- (b) Mercury cell
- ☒ (c) Lead-acid battery
- (d) Fuel cell

TECHNICAL CLASSES

Q What is the main advantage of Secondary cell over Primary cell?

- (a) Lightweight
- (b) Single use only
- ☒ (c) Rechargeable
- (d) Non-toxic

Q In a lead acid battery, the active material of the negative plate is

- (a) PbO_2
- ☒ (b) Pb
- (c) H_2SO_4
- (d) $PbSO_4$



Q What is the electrolyte used in a lead acid battery?

- (a) Sodium chloride
- (b) Potassium hydroxide
- (c) Sulfuric acid
- (d) Ammonium chloride.

Q Which of the following is not a type of Secondary cell?

- (a) Nickel Cadmium battery
- (b) Lithium ion battery
- (c) Alkaline battery
- (d) Lead acid battery.

Q Which of the following is a Primary cell

- (a) Lead acid battery
- (b) Nickel Cadmium cell
- (c) Dry cell
- (d) Lithium-ion cell



Q Primary cells are

- (a) Rechargeable
- ☒ (b) Non-rechargeable
- (c) Reusable
- (d) Used in cars.

TECHNICAL CLASSES

Q What is the electrolyte used in a dry cell?

- (a) Sulfuric acid
- (b) Potassium hydroxide
- ☒ (c) Ammonium chloride
- (d) Sodium chloride

Q In a Leclache dry cell, the cathode is made of

- (a) Zinc
- (b) Copper
- ☒ (c) Manganese dioxide
- (d) Lead.



Q What is the anode material in a dry cell?

- (a) Copper
- (b) Carbon
- ☒ (c) Zinc
- (d) Lead

Q Primary cells are commonly used in

- (a) Laptops
- (b) Electric vehicles
- ☒ (c) Flashlights and remote controls
- (d) mobile phones.

Types of fuel cell

(1) PEMFC (Proton exchange membrane fuel cell)

Uses - Used in Vehicles.



(II) SOFC (Solid Oxide fuel cell)

— used at high temperature, industrial use

~~XXX~~
(III)

AFC (Alkaline fuel cell)

Use in Spacecraft

TECHNICAL CLASSES

(IV) MCFC (Molten carbonate fuel cell)

For power plant

(V) PAFC (phosphoric acid fuel cell)

used in stationary power generation

Primary cell

vs

Secondary cell

(I) A cell that cannot be recharged once discharged

(II) Not reusable i.e. it is single use.

(I) A cell that can be recharge

(II) Reusable i.e. it is multiple times used.



Primary cell

- (III) electrochemical reaction is irreversible
- (IV) it is generally cheaper in cost
- (V) generate more waste

Secondary cell

- (III) electrochemical reaction is reversible.
- (IV) more expensive than primary cell.
- (V) generate less waste due to reusability.

TECHNICAL CLASSES

Primary cell

- (VI) example - Dry cell, mercury cell, Alkaline cell
- (VII) used in clocks, remote, torches.

Secondary cell

- (VI) Lead acid battery
Lithium ion battery
Ni-cd cell
- (VII) used in laptops, mobiles, electric vehicle.

EMF (Electromotive force)

(VS)

Electrode potential

- (I) E°_{cell} or E_{cell} is EMF
- (II) The maximum potential difference between two electrodes of a cell when no current flows.

- (I) E° or E

- (II) The potential of a single electrode in contact with its ion solution



EMF

vs

Electrode Potential

(III) It measured between two electrode (i.e. Cathode and Anode) of the Cell

(III) It measured between Electrode and Standard hydrogen electrode (SHE) or other reference electrode.

TECHNICAL CLASSES

EMF

vs

Electrode Potential

(IV) It depends upon electrode potential of both electrode

(IV) It depends upon Concentration, temperature and pressure.

(V) measure in complete electrochemical cell

(V) measured in half cell only.

Electrolytic Cell

It is a types of electrochemical cell in which electrical energy converted into chemical energy through a non spontaneous redox reaction (electrochemical reaction)

Some Important Points about electrolytic cell

- (i) Anode (+)
Cathode (-)
- (ii) Required external electrical energy.
- (iii) electron flow from Anode to Cathode

TECHNICAL CLASSES

- (iv) example - Electrolysis of molten NaCl
or aqueous CuSO_4
- (v) in electrolytic cell non spontaneous redox reaction occurs.

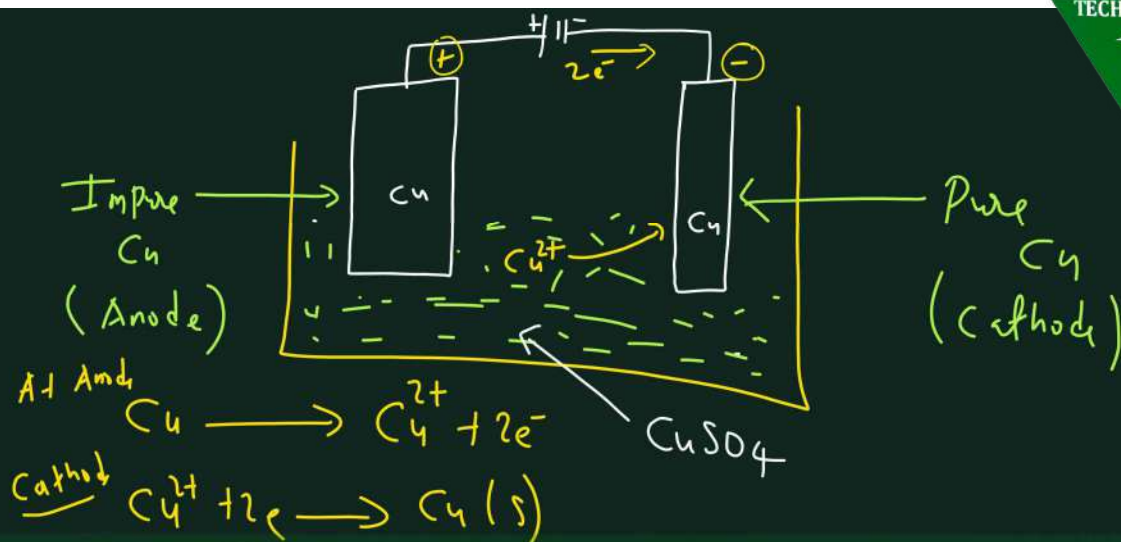
Working of Electrolytic cell

for example - electrorefining of Cu

Anode - Impure Cu

Cathode - Pure Cu

Electrolyte - CuSO_4



TECHNICAL CLASSES



Q Which of the following is true about electrolytic cell?

- (a) Electrical energy is converted into chemical energy
- (b) it works spontaneously
- (c) Anode is positive and cathode is negative
- ☒ (d) Both A and C



Q In electrolytic Cell, the flow of electron is

- ☒ (a) Anode to Cathode through external circuit
- (b) from Cathode to Anode through external circuit
- (c) from Cathode to Anode through electrolyte
- (d) from Anode to Cathode through electrolyte

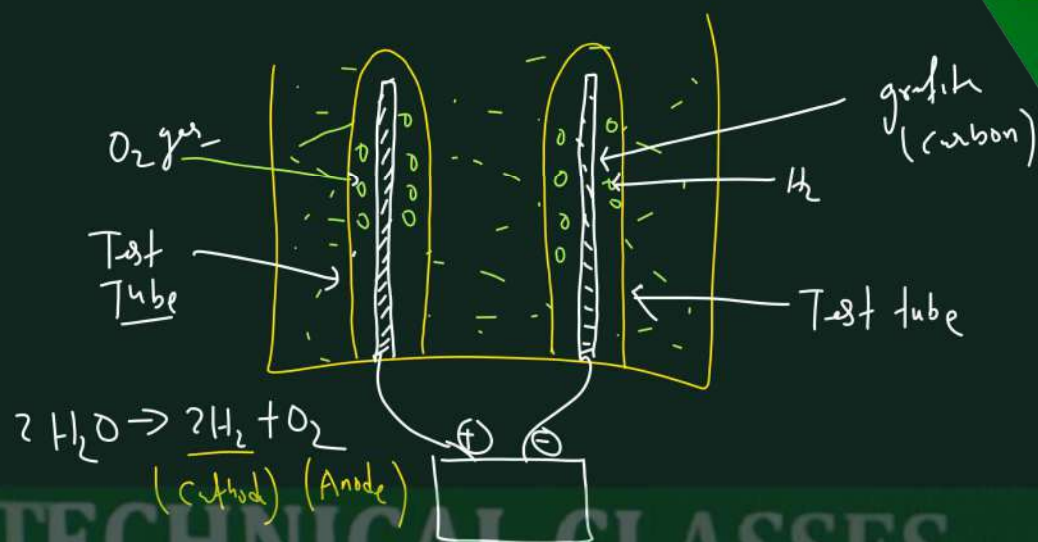
TECHNICAL CLASSES

Q Which of the following is deposited at the cathode during electrolysis of aqueous CuSO_4

- (a) Oxygen
- (b) Sulfate ion
- ☒ (c) Cu
- (d) H

Q Electrolysis of water produce hydrogen gas at

- (a) Anode
- ☒ (b) Cathode
- (c) both electrode
- (d) it does not produce H_2



TECHNICAL CLASSES

Q Electrochemical equivalent (Z) is defined as

- (a) Mass of substance deposited per ampere
- (b) Mass per equivalent weight
- ☒ (c) Mass deposited per coulomb
- (d) Current $\times$ time

Electrochemical equivalent

it is defined as mass deposited per
Coulomb of electrode



Q In electrolysis, the amount of substance liberated is proportional to

- (a) volume of electrolyte
- ~~(b) Time and current~~
- (c) Concentration of solution
- (d) Temperature only

TECHNICAL CLASSES

Factors affecting electrolysis

- (i) Nature of electrolyte
- (ii) Concentration of electrolyte
- (iii) Nature of electrodes
- ~~(iv) Voltage applied (external potential)~~
- (v) Temperature
- (vi) Types of solvent
- (vii) Surface area of electrodes
- (viii) Time of electrolysis.

Q Electrolysis of molten NaCl produces

- (a) Na at anode, Cl_2 at cathode
 (b) Na at cathode, Cl_2 at Anode
 (c) NaCl at both electrodes
 (d) Cl_2 at cathode, Na at anode

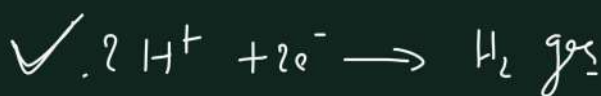
TECHNICAL CLASSES

Electrolysis of NaCl

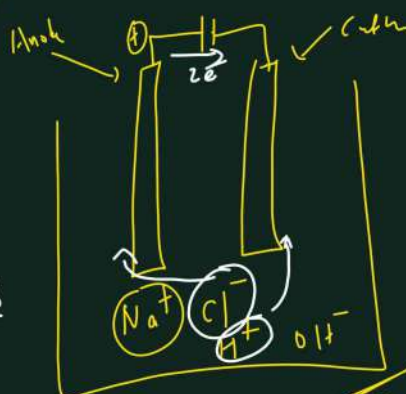
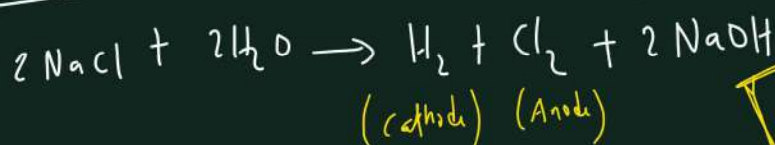
at Cathode



at Anode



Overall Rxn

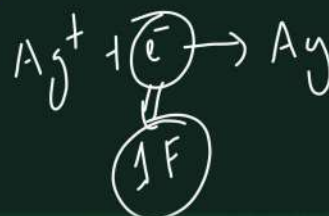


Cathode - H_2 & Na^+
 Anode - Cl_2



Q How much charge is required to deposit 1 mole of Silver
 $(Ag^+ + e^- \rightarrow Ag)$

- (a) 1 C
 (b) 96500 C
 (c) 48250 C
 (d) 193000 C



Q Which law states that the mass deposited is proportional to equivalent weight?

- (a) Faraday's first law
 (b) Faraday's second law
 (c) Ohm's law
 (d) Kohlrausch's law

Faraday's law of electrolysis

Faraday gives laws for the process of electrolysis which used to understand the process of electrolysis of different compounds.

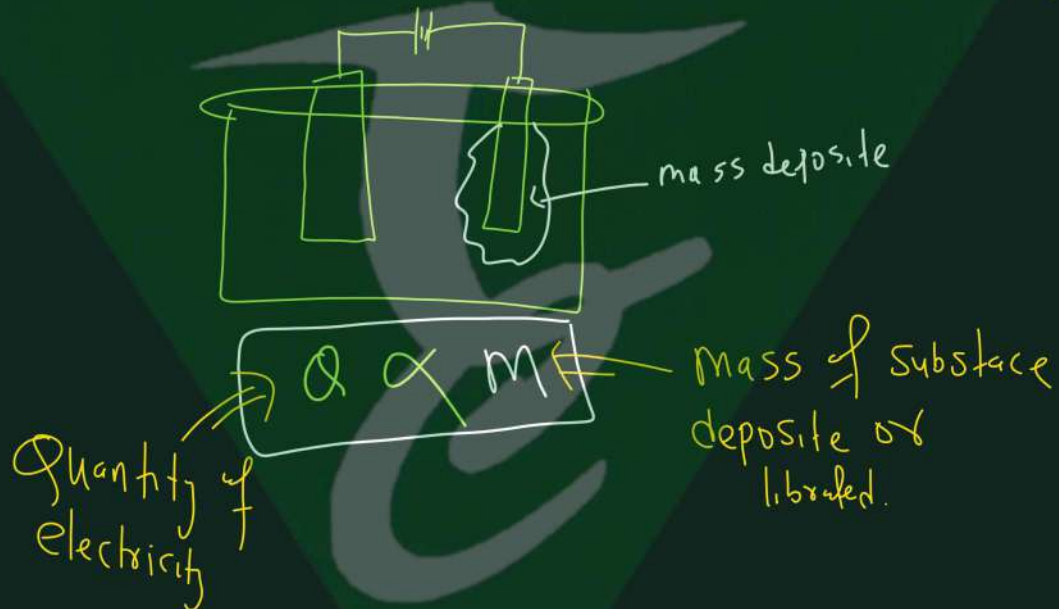


Faraday's first law

According to Faraday's first law

" The mass (m) of substance deposited or liberated at an electrode is directly proportional to quantity of electricity (Q) passed.

TECHNICAL CLASSES



$$m \propto Q$$

$$m = ZQ$$

Where

m = mass of substance

Z = electrochemical equivalent

Q = Quantity of electricity



$$m = Z Q$$

$$Q = I t$$

$$m = Z I t$$

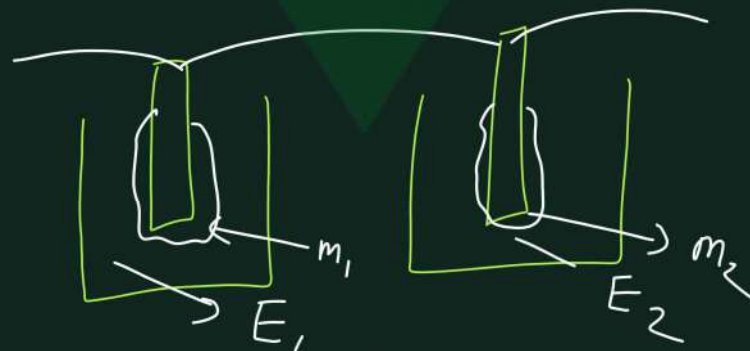
I = Current (A)

t = time (s)

TECHNICAL CLASSES

Second law of electrolysis

According to Faraday 'when the ^{same} quantity of electricity is passed through different electrolytes, the mass of substance deposited are proportional to their chemical equivalent (equivalent weight)



$$\frac{m_1}{E_1} = \frac{m_2}{E_2} = \frac{m_3}{E_3} \dots$$

m = mass of substance E = equivalent weight



Q According to Faraday's first law of electrolysis, the mass of a substance deposited is directly proportional to

- (a) volume of electrolyte
- (b) atomic mass of substance
- (c) Quantity of electricity passed
- (d) Temperature of the solution

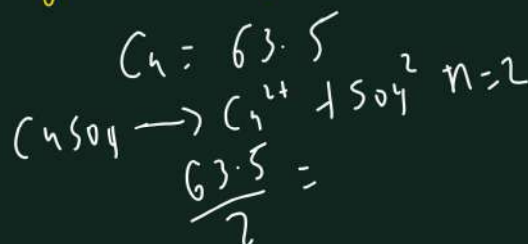
TECHNICAL CLASSES

Q One Faraday is equal to

- (a) 1 Coulomb
- (b) 96500 C
- (c) 1 Ampere
- (d) 965 Coulomb.

Q How many grams of copper will be deposited by passing 1 Faraday of electricity through CuSO_4 solution

- (a) 63.5 g
- (b) 31.75 g
- (c) 1 g
- (d) 127 g







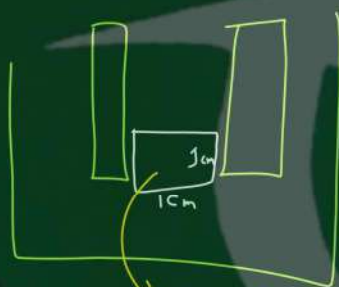
Some Important Topics

Specific Conductivity (κ - Kappa)

It is the conductance of a solution between two electrodes 1 cm apart, having 1 cm² cross-section area.

Unit $S\ cm^{-1}$

TECHNICAL CLASSES



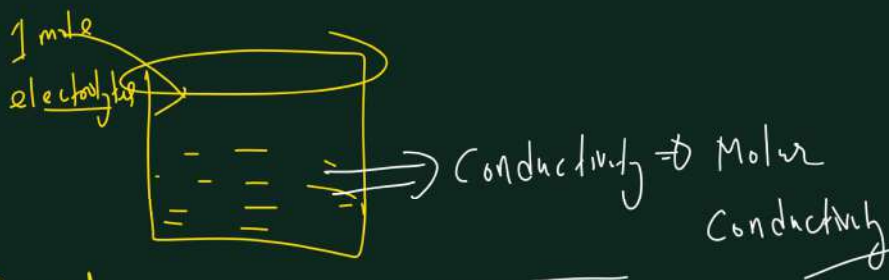
1 cm² $\Rightarrow$ Conductance

$\Downarrow$
Specific conductance.

Molar Conductivity (Λ_m)

It is the conductivity of all the ions produced by one mole of an electrolyte in solution

Unit - $S\ cm^2\ mol^{-1}$



Formula

$$\lambda_m = \frac{k \times 1000}{C}$$

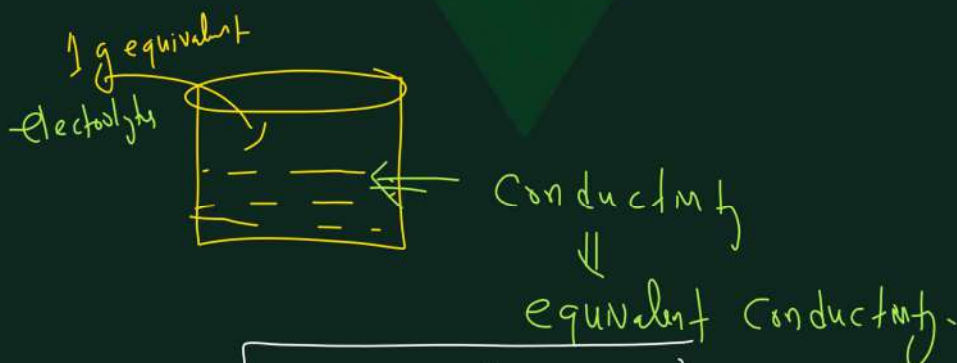
λ_m ← Lambda
 k = Specific Conductivity
 C = Molar concentration (mol/L)

TECHNICAL CLASSES

Equivalent Conductivity (λ_{eq})

it is defined as Conductivity of all the ions produced by one gram equivalent of an electrolyte in solution

$$\text{Unit} = \text{S cm}^2 \text{eq}^{-1}$$



$$\lambda_{eq} = \frac{k \times 1000}{N}$$

N - Normality of solution



Molar Conductivity (λ_m)

Conductivity shows due to one mole electrolyte

$$\lambda_m = \frac{\kappa \times 1000}{M}$$

Unit =

Equivalent Conductivity (λ_{eq})

Conductivity shows due to one gram equivalent electrolyte.

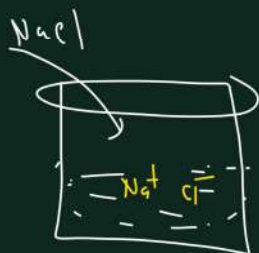
$$\lambda_{eq} = \frac{\kappa \times 1000}{N}$$

Unit =

Kohlrausch's law of Independent migration of ions

At infinite dilution, molar conductivity of an electrolyte is equal to the sum of the individual ionic conductivities of ions.

$$\lambda_m^{\circ} = \lambda_+^{\circ} + \lambda_-^{\circ}$$



$$\lambda_m^{\circ}(\text{NaCl}) = \lambda_{\text{Na}^+}^{\circ} + \lambda_{\text{Cl}^-}^{\circ}$$

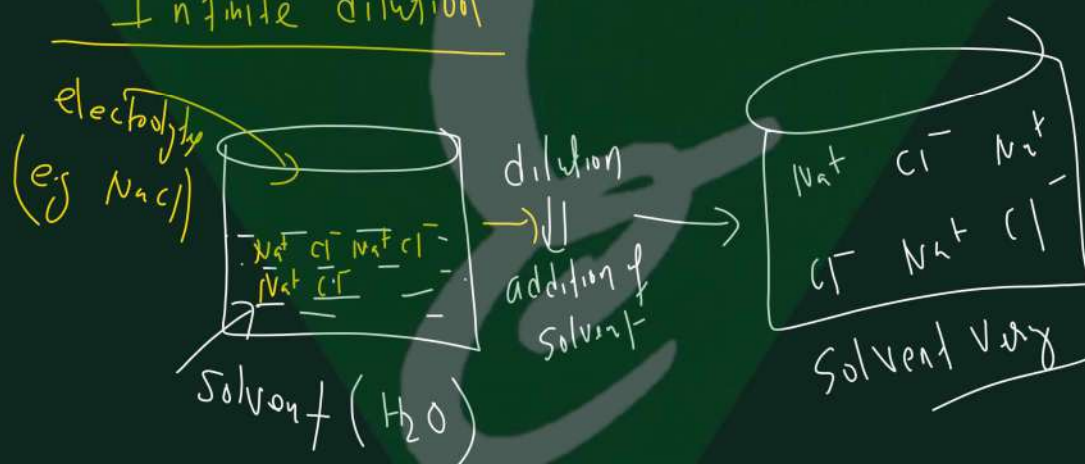


Application

To Determination of λ_m° of weak electrolytes (like CH_3COOH)

TECHNICAL CLASSES

Infinite dilution



Infinite dilution

Infinite dilution refers to the hypothetical condition where an electrolyte is dissolved in such a large amount of solvent

in case of infinite dilution concentration of solution approaches zero

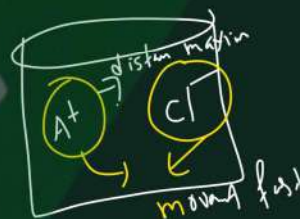
Q What is the unit of molar conductivity

- (a) S m^{-1}
- (b) $\text{S cm}^2 \text{mol}^{-1}$
- (c) $\text{mol} \cdot \text{S} \cdot \text{cm}^{-1}$
- (d) $\text{cm}^2 \text{S}^{-1}$

TECHNICAL CLASSES

Q At infinite dilution molar conductivity becomes

- (a) Zero
- (b) maximum
- (c) minimum
- (d) equal to specific conductivity.



Q Which law helps to determine molar conductivity of weak electrolytes

- (a) Raoult's law
- (b) Henry's law
- (c) Kohlrausch's law
- (d) Faraday's law



Q Which of the following statement is true for Kohlrausch's law

- (a) valid only for weak electrolyte
- (b) valid at all concentrations
- (c) valid only at infinite dilution
- (d) not applicable for ionic compounds.

TECHNICAL CLASSES

Q if λ_m of CH_3COOH at a certain dilution is $405 \text{ cm}^2 \text{ mol}^{-1}$ and $\lambda_m^\circ = 390.5 \text{ S cm}^2 \text{ mol}^{-1}$. what is degree of ionization?

- (a) 0.1 (c) 0.15
- (b) 0.5 (d) 0.9

Degree of ionisation (α)

~~***~~

$$\alpha = \frac{\lambda_m}{\lambda_m^\circ}$$

$$\alpha = \frac{40}{390.5} = 0.102 = 0.1$$



Q for a weak electrolyte, the degree of dissociation increases when

- (a) concentration increases
- (b) Temperature decreases
- ☒ (c) Solution is diluted
- (d) pressure increases.

Q Equivalent conductivity and molar conductivity are equal for

- (a) Diprotic acid
- (b) Monoprotic acid
- (c) Nonelectrolyte
- ☒ (d) electrolyte with one equivalent per mole

Q The equivalent conductivities at infinite dilution of Na^+ and Cl^- are 50.1 and $76.3 \text{ S cm}^2 \text{ eq}^{-1}$ calculate $\lambda_{\text{eq}}^\circ$ (NaCl)

Ans

$$\begin{aligned}\lambda_{\text{eq}} &= (\lambda_{\text{Na}^+}) + (\lambda_{\text{Cl}^-}) \\ &= 50.1 + 76.3 = 126.4 \text{ S cm}^2 \text{ eq}^{-1}\end{aligned}$$



Q Given the following data

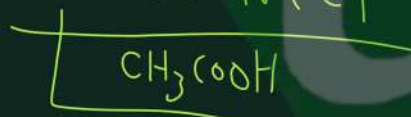
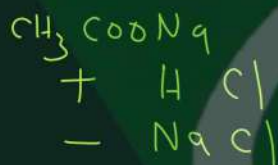
$$\lambda_m^\circ(\text{CH}_3\text{COONa}) = 91 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\lambda_m^\circ(\text{HCl}) = 426 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\lambda_m^\circ(\text{NaCl}) = 126 \text{ S cm}^2 \text{ mol}^{-1}$$

Calculate $\lambda_m^\circ(\text{CH}_3\text{COOH})$

Rough



Ans

$$\lambda_m^\circ(\text{CH}_3\text{COOH}) = \lambda_m^\circ(\text{CH}_3\text{COOH}) + \lambda_m^\circ(\text{HCl})$$

$$- \lambda_m^\circ(\text{NaCl})$$

$$= 91 + 426 - 126$$

$$= 391 \text{ S cm}^2 \text{ mol}^{-1}$$



Corrosion

Corrosion is a gradual degradation or destruction of metal and alloys due to chemical or electrochemical reactions with their environment.

TECHNICAL CLASSES

Types of Corrosion

① Dry Corrosion (chemical corrosion)

Dry corrosion occurs due to the direct reaction of metal with gases (usually oxygen or halogen - F, Cl, Br, I)

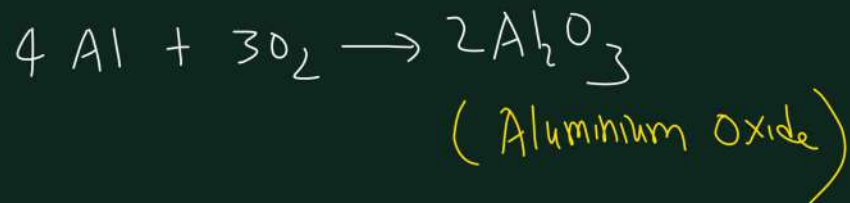
Mechanism (steps)

- # Metal react with dry gases at high temperature
- # formation of an oxide layer on metal surface.
- # This layer can be protective or non protective



for example

Oxidation of aluminum



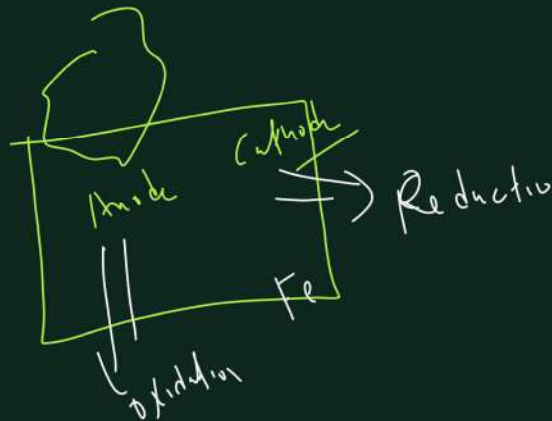
TECHNICAL CLASSES

Characteristics

- # occurs at high temperature
- # forms a corrosion product layer
- # Can be protective (like Al_2O_3 on Al) or non protective (like Fe_2O_3 on Fe)

2 Wet Corrosion

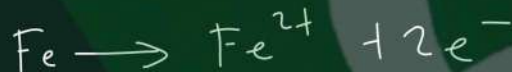
Wet corrosion occurs to the presence of an electrolyte (moisture acid, or salt solution), leading to an electrochemical reaction between anodic and cathodic area on metal surface.



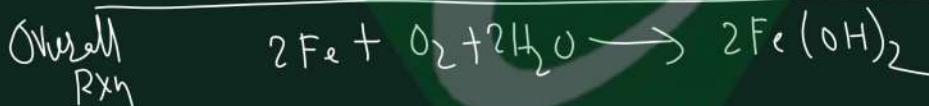
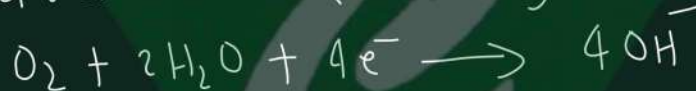
TECHNICAL CLASSES

Mechanism

Anode reaction (Oxidation)



Cathode reaction (Reduction)



$\text{Fe}(\text{OH})_2$ further oxidizes to
 $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$ (Rust)



Prevention of Corrosion

- (1) Surface Coating — a layer form on the surface on the metal.

TECHNICAL CLASSES

Surface Coating may be

- (1) Metallic Coating — A layer of less reactive metal form on surface of metal

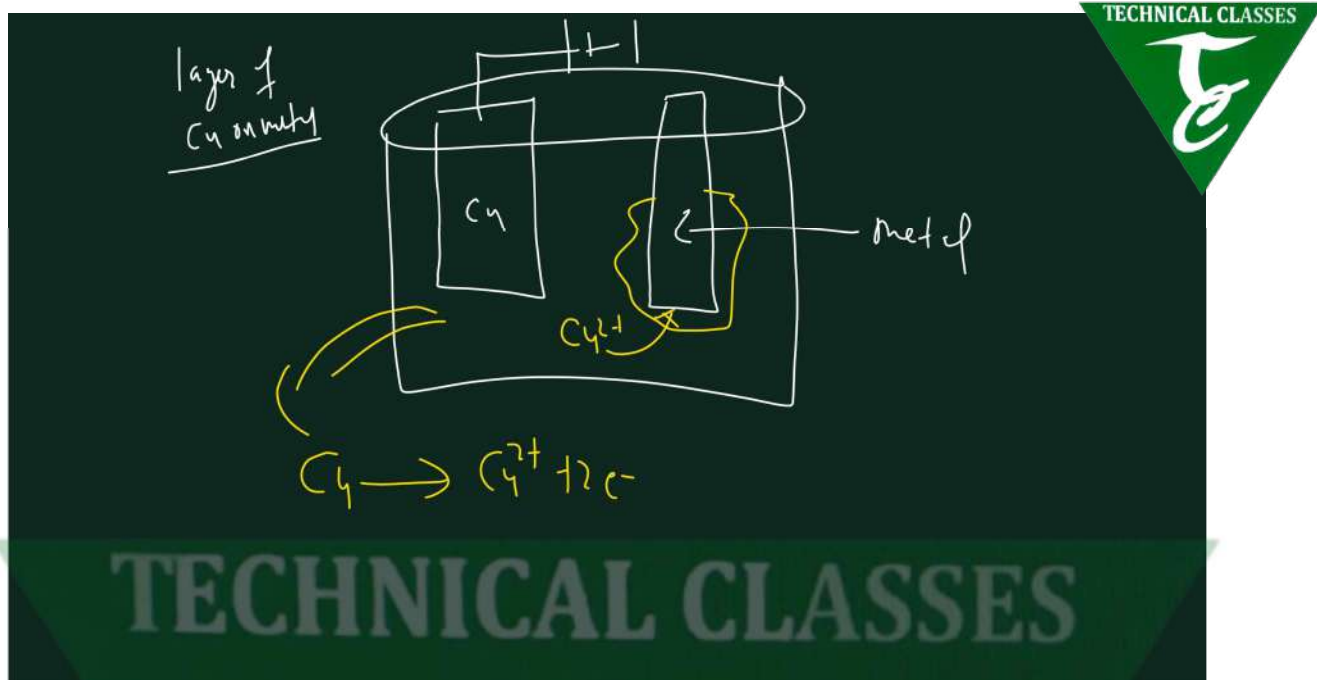
for exampl, Coating iron with Zn (Galvanization)
Tinning — Coating with tin

by using Paints

Used inhibitors

for example — phosphates, chromates.

layer of oil





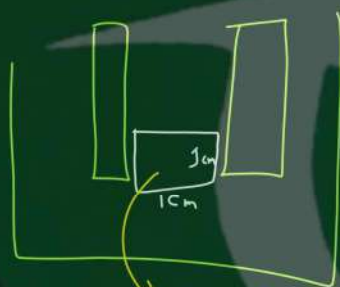
Some Important Topics

Specific Conductivity (κ - Kappa)

It is the conductance of a solution between two electrodes 1 cm apart, having 1 cm² cross-section area.

Unit $S\ cm^{-1}$

TECHNICAL CLASSES



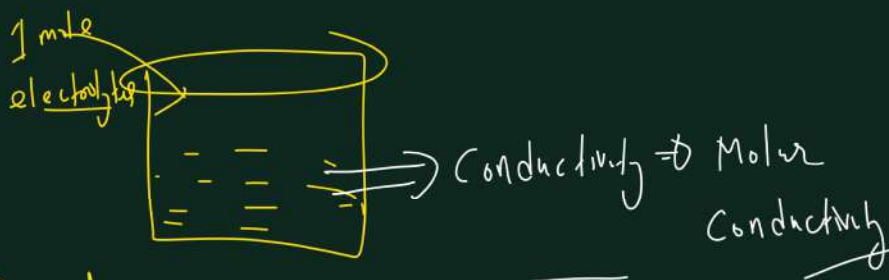
$1\ cm^2 \Rightarrow$ Conductance

$\Downarrow$
Specific conductance.

Molar Conductivity (λ_m)

It is the conductivity of all the ions produced by one mole of an electrolyte in solution

Unit - $S\ cm^2\ mol^{-1}$



Formula

$$\lambda_m = \frac{k \times 1000}{C}$$

λ_m is labeled as λ_m (Molar Conductivity)

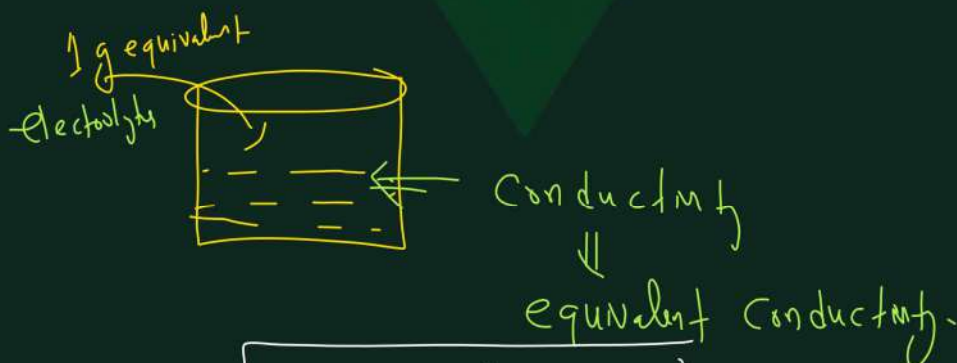
k = Specific Conductivity
 C = Molar concentration (mol/L)

TECHNICAL CLASSES

Equivalent Conductivity (λ_{eq})

it is defined as Conductivity of all the ions produced by one gram equivalent of an electrolyte in solution

$$\text{Unit} = \text{S cm}^2 \text{eq}^{-1}$$



$$\lambda_{eq} = \frac{k \times 1000}{N}$$

N - Normality of solution



Molar Conductivity (λ_m)

Conductivity shows due to one mole electrolyte

$$\lambda_m = \frac{\kappa \times 1000}{M}$$

Unit =

Equivalent Conductivity (λ_{eq})

Conductivity shows due to one gram equivalent electrolyte.

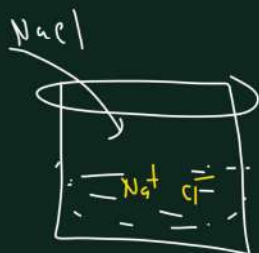
$$\lambda_{eq} = \frac{\kappa \times 1000}{N}$$

Unit =

Kohlrausch's law of Independent migration of ions

At infinite dilution, molar conductivity of an electrolyte is equal to the sum of the individual ionic conductivities of ions.

$$\lambda_m^{\circ} = \lambda_+^{\circ} + \lambda_-^{\circ}$$



$$\lambda_m^{\circ}(\text{NaCl}) = \lambda_{\text{Na}^+}^{\circ} + \lambda_{\text{Cl}^-}^{\circ}$$

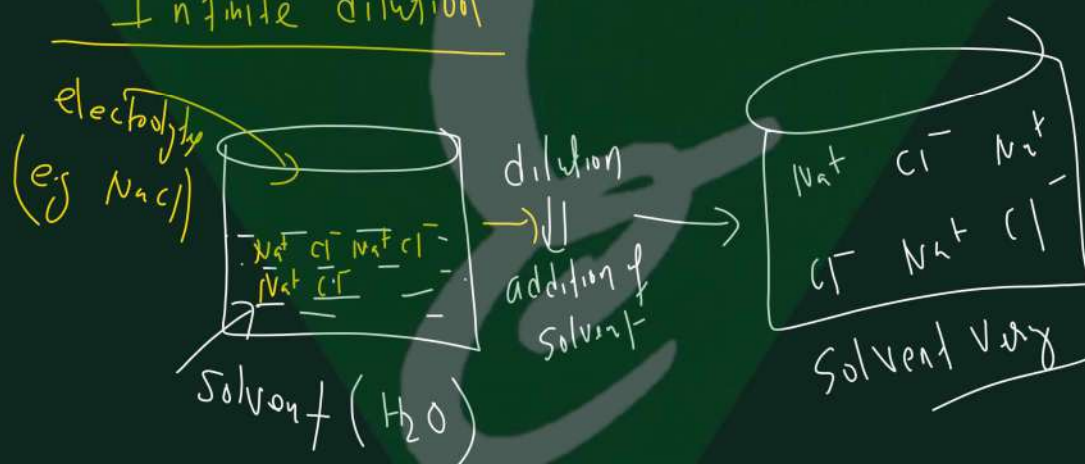


Application

To Determination of λ_m° of weak electrolytes (like CH_3COOH)

TECHNICAL CLASSES

Infinite dilution



Infinite dilution

Infinite dilution refers to the hypothetical condition where an electrolyte is dissolved in such a large amount of solvent

in case of infinite dilution concentration of solution approaches zero

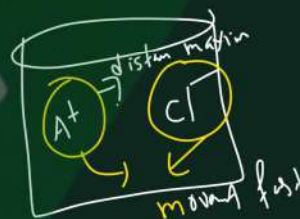
Q What is the unit of molar conductivity

- (a) S m^{-1}
- (b) $\text{S cm}^2 \text{mol}^{-1}$
- (c) $\text{mol} \cdot \text{S} \cdot \text{cm}^{-1}$
- (d) $\text{cm}^2 \text{S}^{-1}$

TECHNICAL CLASSES

Q At infinite dilution molar conductivity becomes

- (a) Zero
- (b) maximum
- (c) minimum
- (d) equal to specific conductivity.



Q Which law helps to determine molar conductivity of weak electrolytes

- (a) Raoult's law
- (b) Henry's law
- (c) Kohlrausch's law
- (d) Faraday's law



Q Which of the following statement is true for Kohlrausch's law

- (a) valid only for weak electrolyte
- (b) valid at all concentrations
- (c) valid only at infinite dilution
- (d) not applicable for ionic compounds.

TECHNICAL CLASSES

Q if λ_m of CH_3COOH at a certain dilution is $405 \text{ cm}^2 \text{ mol}^{-1}$ and $\lambda_m^\circ = 390.5 \text{ S cm}^2 \text{ mol}^{-1}$. what is degree of ionization?

- (a) 0.1 (c) 0.15
- (b) 0.5 (d) 0.9

Degree of ionisation (α)

~~***~~

$$\alpha = \frac{\lambda_m}{\lambda_m^\circ}$$

$$\alpha = \frac{40}{390.5} = 0.102 = 0.1$$



Q for a weak electrolyte, the degree of dissociation increases when

- (a) concentration increases
- (b) Temperature decreases
- ☒ (c) Solution is diluted
- (d) pressure increases.

Q Equivalent conductivity and molar conductivity are equal for

- (a) Diprotic acid
- (b) Monoprotic acid
- (c) Nonelectrolyte
- ☒ (d) electrolyte with one equivalent per mole

Q The equivalent conductivities at infinite dilution of Na^+ and Cl^- are 50.1 and $76.3 \text{ S cm}^2 \text{ eq}^{-1}$ calculate $\lambda_{\text{eq}}^\circ$ (NaCl)

Ans

$$\lambda_{\text{eq}} = (\lambda_{\text{Na}^+}) + (\lambda_{\text{Cl}^-})$$

$$= 50.1 + 76.3 = 126.4 \text{ S cm}^2 \text{ eq}^{-1}$$



Q Given the following data

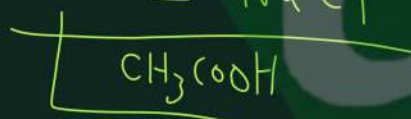
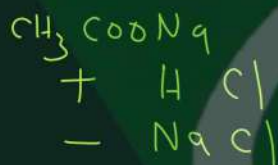
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Rough



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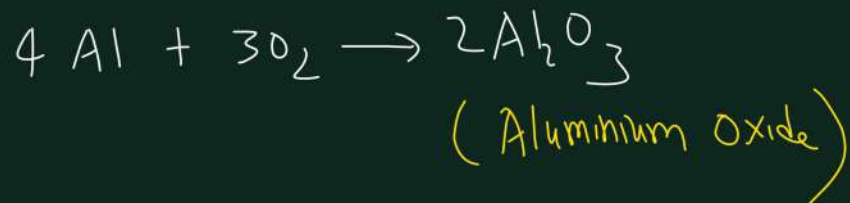
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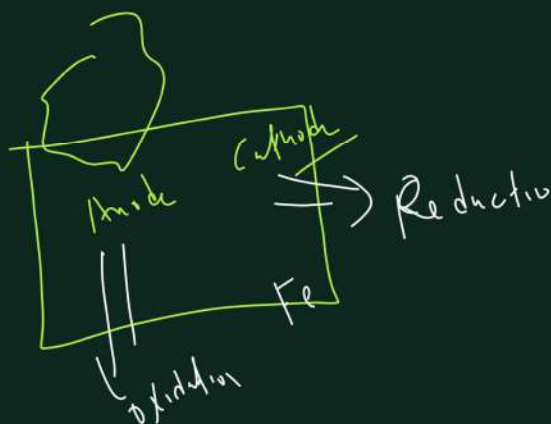
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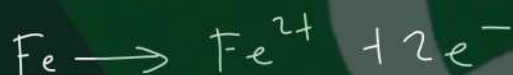
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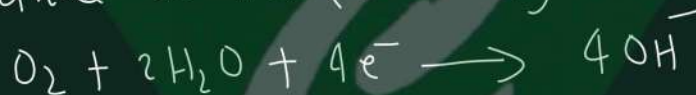
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Mechanism

Anode reaction (Oxidation)



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Overall
Rxn



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