Electrolysis

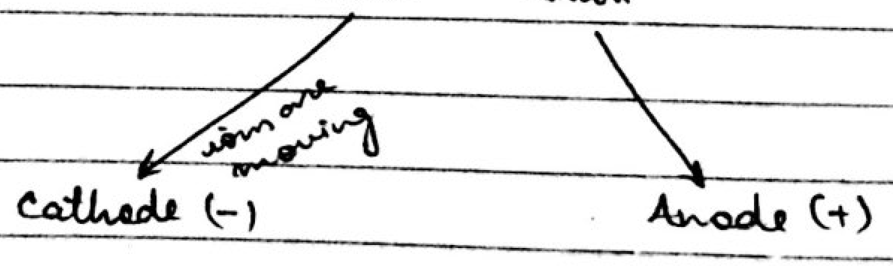
Electro: Electric
Lysis: Breaking

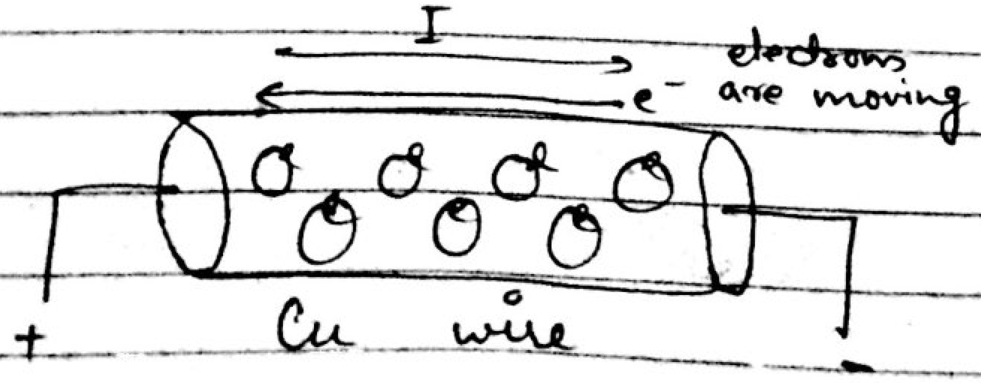
Electrolytes: Those chemical compound which ~~electrolyte~~
i) conducts electric current in aqueous state or molten state
ii) which undergoes chemical decomposition on passing electric current.

Ques) Electrolytes are conductor and copper is also a conductor. How are the two different.

$CuSO_4 \rightleftharpoons Cu^{2+} + SO_4^{2-}$

Ionic — dissociates — cation — Anion

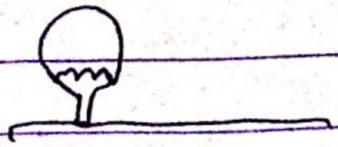




	Cu wire	$CuSO_4$ solution
Temp.	Temp ↑ Conduction ↑	Temp ↑ Conduction ↓
~~Ohm's law~~		
Ohm's law	May or may not be obeyed	Always obeyed.
	solid state	liquid or molten state
	physical process	chemical process

Non-electrolytes : which do not conduct ~~[illegible]~~ current in pure state. Also does not decompose at the electrodes.

Ex: Distilled water, alcohol, benzene(C_6H_6), Carbon disulphide (CS_2), Carbon tetrachloride(CCl_4), Sugar solution, Kerosene,

Strong Electrolytes	Weak Electrolyte.
• 100% Dissociate/Ionise	partially ionise
• Very good conductor	bad conductor
• ~~Ionises~~	
• Ions	Ions & molecules
•  bulb glows brightly	bulb glows dim.

Strong ~~base~~ acid: HCl, HNO_3, H_2SO_4, H_3PO_4, HBr.

Strong base: KOH, NaOH, ~~[illegible]~~

Strong Salts: NaCl, KCl, $PbBr_2$, $CuSO_4$, $CuCl_2$, ~~[illegible]~~

~~Strong~~ Weak acid: H_2CO_3, Acetic Acid

~~Strong Weak acid~~:

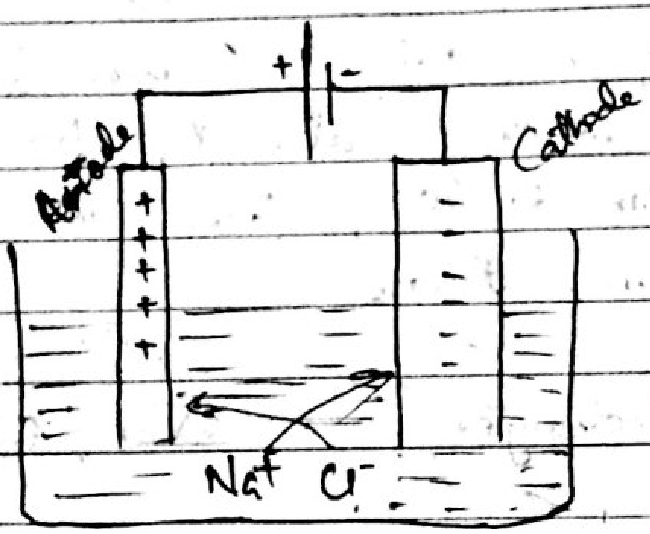
Weak base: $Ba(OH)_2$, $Ca(OH)_2$, NH_4OH

Salts: Pb $(HCOO)_2$, (Na, K, Ca, NH_4) CO_3

Electrolytic cells:
Converts Electric energy into chemical energy

$NaCl \xrightarrow{\text{dissociate}} Na^+ + Cl^-$
(conc) Ionic Cation Anion.

Electrolytic cell



cathode: (-ve) NCR.
$Na^+ + e^- \longrightarrow Na$
Charge Discharge

Anode: (+ve)
$Cl^- \longrightarrow e^- + Cl$ PAO.
Charge Discharge

Electrolysis is an example of redox reaction.

The no. of electrons ~~gained~~ lost from cathode, gained by anode
Cathode → e → Anode

Arrhenius and Modern concept

Arrhenius believed that water has some magical power to break ~~ions~~ a compound into ions. ~~Electrodylysis & Elect~~

Modern concept: Electrolysis is possi~~ble~~ble in molten state.

Conduction in Ionic & Polar Covalent Compound

Ionic ~~Polar~~

1) solid state:
NaCl do not conduct electricity as ions are tightly bounded by electrostatic force
No free electrons.

(ii) / Molten state

$NaCl \xrightarrow{\text{Thermal dissociation}} Na^+ + Cl^-$
Free ions

Heat energy se force ko tod diya

(iii) In aqueous solution :

$H^{\delta+} \rightarrow O^{\delta-} \leftarrow H^{\delta+}$

NaCl

$Na^+ + Cl^-$

Water has very high dielectric constant which breaks $NaCl \rightarrow Na^+ + Cl^-$
81 times of air.

$$\underset{(aq.)}{NaCl} \underset{\text{Dissociation}}{\overset{99.999\%}{\rightleftharpoons}} Na^+ + Cl^-$$

POLAR COVALENT COMPOUND.

1) H-Cl No ions
dry gaseous → Bad conductor

2) aqueous solution

HCl

$^{\delta+}H - O^{\delta-} - H^{\delta+}$

$$HCl \underset{\text{Ionisation}}{\rightleftharpoons} H^+ + Cl^-$$

Free ions

due to high dielectric constant of water (81)
conduct

Scanned by CamScanner

lead Bromide, $CuSO_4$, H_2O

Electrolysis of $PbBr_2$

Electrolyte: molten $PbBr_2$ (Heat)

Cell: Silica cell

↓

Sand

SiO_2

- Bad Conductor of Heat & Current
- Non-reactive
- It can withstand heat.

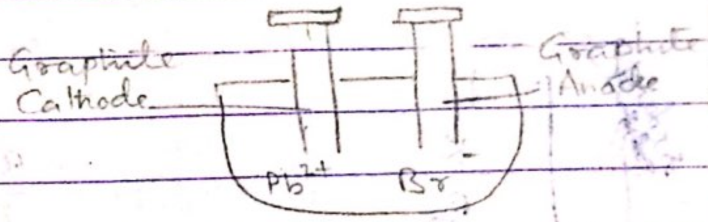
Electrodes:

Graphite (carbon)

(good conductor)

non-reactive

Inert



Q) Why Pt. not used as electrodes → Inert ?

A) Pt is affected by Br_2 vapours.

DC (Direct Current) of 3 amp.

Voltage of 12 volt.

Cautions: Low current for long time.

$$PbBr_2 \rightleftharpoons Pb^{2+} + 2Br^-$$

molten solution — Cation — Anion

Cathode : NCR

↓Graphite $Pb^{2+} + 2e^- \longrightarrow Pb$ (silver, gray, white)

Greyish white lead deposited at — lead deposited.

Anode : PAO

Primary change : $2Br^- \longrightarrow 2e^- + 2Br$.

(Reddish brown bromine gas)

Secondary change:

$2Br \longrightarrow Br_2$ (Reddish brown bromine gas).

Why we cannot used aqueous PbBr.

selective discharge :

Electro-chemical series.

reducing agent ↑

Li
K
Ba
Sr
Ca
Na
Mg
Al
Zn Mn
Zn
Cr
Fe
Co
Ni
Pb
H
Cu
Hg wants to get reduced
Ag wants to discharge at cathode
Au
Pt

↓ oxidising agent

aq $PbBr_2 \rightleftharpoons Pb^{2+} + 2Br^-$

$H_2O \rightleftharpoons H^+ + OH^-$

Cation

71

① Eng

lang lit

70/80 66/74

② Hindi

64 66

③ HCG

64/60 84/80

④ Comp.

70 81

⑤ Sci

55/87 80/87 66/78

⑥ Maths

76 88

Selective Discharge: If two or more cation are present in solution, only one will gets discharged at cathode which is placed ~~[struck]~~ lower in the series.

If two or more anions are present in the solution, only one will get discharged at anode which is placed lower in the series.

~~SOR~~ SU	SO_4^{2-}	Tendency to get discharged at Anode ↓
NO	NO_3^{1-}	
काली	Cl^-	
बर	Br^-	
आइथो	I^-	
	OH^-	

Exception: If one ion is in excess, then don't follow this rule. Example:

① $CuSO_4$ (aq) $\rightleftharpoons$ Cu^{2+} + SO_4^{2-}
✓cathode

H_2O $\rightleftharpoons$ H^+ + OH^-
✓Anode

② NaCl (aq) $\rightleftharpoons$ Na^+ + Cl^-

H_2O $\rightleftharpoons$ H^+ + OH^-
✓cathode ✓Anode

$NaCl \rightleftharpoons Na^+ + Cl^-$

(conc.) $\quad$ 90% $\quad$ 90%

$H_2O \rightleftharpoons H^+ + OH^-$

10% $\quad$ 10%

Rule 3: If electrode is active, then don't follow above

Electrodes of the same metal which is present in the solution.

~~Copper used in~~

Ex: Fe is used in $FeSO_4$.

Ni in $NiSO_4$

Ag in sodium argento cyanide $Na[Ag(CN)$

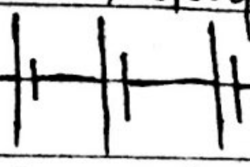
- Electrode ka ka hoga oxidition, Electrode ka hoga reduction.
- ~~Electrode~~

Electrolysis of Aqueous $CuSO_4$ using Pt. electronium - Inert.

Electrolyte : aq. $CuSO_4$

Electrode : Pt / Graphite.

Battery :



Voltage : 12 V, Current : 3A.

$CuSO_4 \rightleftharpoons Cu^{2+} + SO_4^{2-}$

Dissociate

$H_2O \rightleftharpoons H^+ + OH^-$

Cation

Cathode (-ve)

$Cu^{2+} + 2e^- \longrightarrow Cu$

Reduction — Fresh pink, Reddish brown, Brick Red, Brownish.

Anode:

$4OH^- \longrightarrow 4OH + 4e^-$

$2OH + 2OH \longrightarrow 2H_2O + 2O$

$+ \quad O + O \longrightarrow O_2$

$4OH^- + 4OH + 2O \longrightarrow 4OH + 4e^- + 2H_2O + 2O + O_2$

$4OH^- \longrightarrow 4e^- + 2H_2O + O_2$

Oxygen gas.

$$4OH^- \longrightarrow 4OH^{\circ} - 4e^-$$
$$2OH + 2OH \longrightarrow 2H_2O + 2O$$
$$O + O \longrightarrow O_2$$

$$4OH^- \longrightarrow 4e^- + 2H_2O + O_2$$

At anode:

$$Cu^{2+} + 2e^- \longrightarrow Cu$$
$$2Cu^{2+} + 4e^- \longrightarrow 2Cu$$

Observation:

Pink coloured metal is deposited at cathode.

Mass of cathode increases.

No change in mass at anode.

V.V.I. Blue colour of the solution fades away with time.

Ques) What will happen when all Copper has been deposited.

$$\times Cu^{2+} + SO_4^{2-}$$
$$H^+ + OH^-$$

↓ cathode

$$2H^+ + 2e^- \longrightarrow 2H$$

$H + H \longrightarrow H_2$ will be liberated at cathode

Electrolysis of $CuSO_4$ (aq.) with active electrode.

$CuSO_4 \rightleftharpoons Cu^{2+} + SO_4^{2-}$

$H_2O \rightleftharpoons H^+ + OH^-$

Cathode:

$Cu^{2+} + 2e^- \longrightarrow Cu$

Reduction — deposit

Pink, Reddish brown, brownish

Anode: Oxidation.

$\longrightarrow 2e^- + Cu^{2+}$ (in solution)

Observation:

Anode decreases in mass.

Cathode increases in mass.

Blue of solution does not fade.

Q) Why sometimes we add dil. H_2SO_4 to $CuSO_4$ solution?

A) To increase the conductivity of solution.

$4OH^- \longrightarrow 4OH^{\bullet} - 4e^-$

$2OH + 2OH \longrightarrow 2H_2O + 2O$

$O + O \longrightarrow O_2$

$4OH^- \longrightarrow 4e^- + 2H_2O + O_2$

At anode :

$Cu^{2+} + 2e^- \longrightarrow Cu$

$2Cu^{2+} + 4e^- \longrightarrow 2Cu$

Observation :

Pink coloured metal is deposited at cathode.

Mass of cathode increases.

No change in mass at anode.

V.V.I. Blue colour of the solution fades away with time.

Ques) What will happen when all Copper has been deposited.

$\times Cu^{2+} + SO_4^{2-}$

$H^+ + OH^-$

↓ cathode

$2H^+ + 2e^- \longrightarrow 2H$

$H + H \longrightarrow H_2$ will be liberated at cathode

Electrolysis of $CuSO_4$ (aq.) with active electrode

$CuSO_4 \rightleftharpoons Cu^{2+} + SO_4^{2-}$

$H_2O \rightleftharpoons H^+ + OH^-$

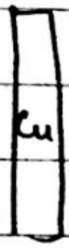
Cathode :

$Cu^{2+} + 2e^- \longrightarrow Cu$

Reduction — deposit

Pink, Reddish brown, brownish

Anode: Oxidation.



$\longrightarrow 2e^- + Cu^{2+}$ (in solution)

Observation:

Anode decreases in mass.

Cathode increases in mass.

Blue of solution does not fade.

Q) Why sometimes we add dil. H_2SO_4 to $CuSO_4$ solution?

A) To increase the conductivity of solution.

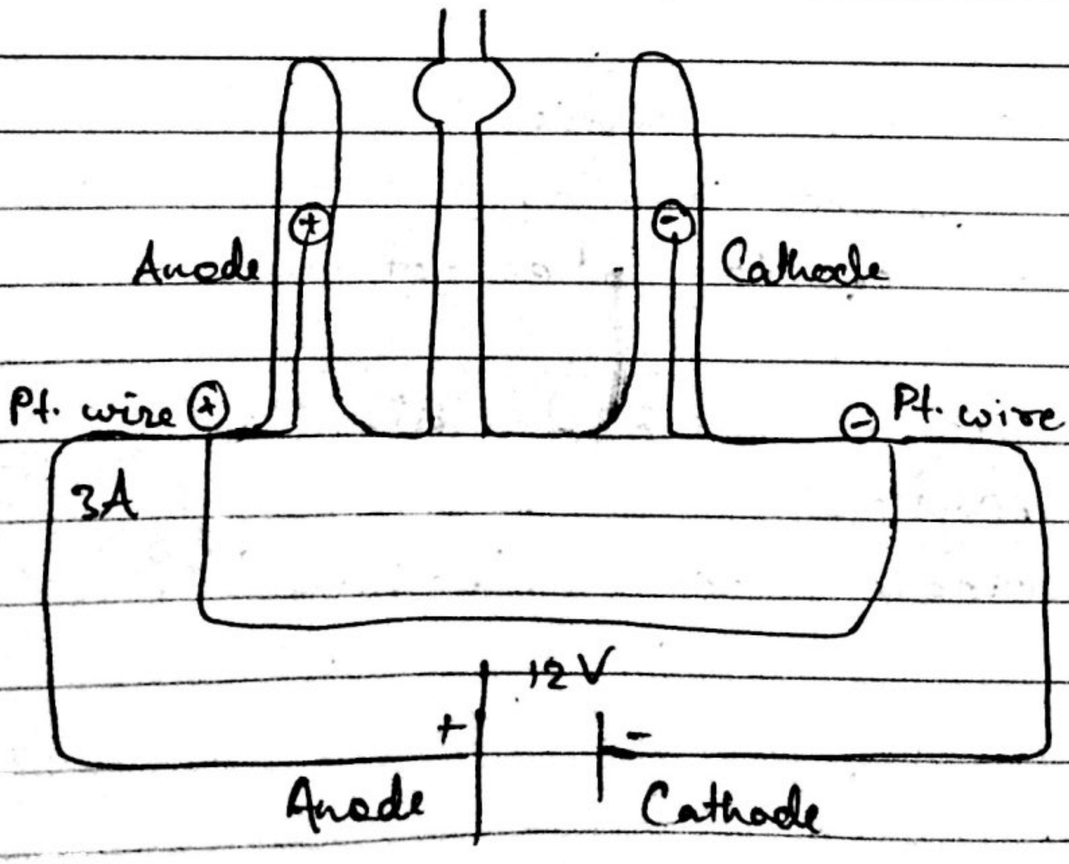
Electrolysis of water:

Pure water is a bad conductor of electricity.
So we add dil. H_2SO_4 which acts as catalyst.
This is an example of catalysis.

Electrolytic cell:
Hoffman Voltameter.

Catalyst: Dil. H_2SO_4
Role of H_2SO_4: It ionises the polar water molecule

Hoffman's Voltameter
Electrode: Pt. wire



$$H_2O \rightleftharpoons H^+ + OH^-$$

$$H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$$

Cathode Cations — Anions Anode

NCR Cathode : Discharge

$$2H^+ + 2e^- \longrightarrow H_2$$

Gain of e^- = Reduction

Anode :

$$4OH^- \longrightarrow 4e^- + 2H_2O + O_2$$

$$4OH^- \longrightarrow 4OH + 4e^-$$

$$2OH + 2OH \longrightarrow 2H_2O + 2O$$

$$O + O \longrightarrow O_2$$

$$4OH^- + \cancel{4OH} + \cancel{2O} \longrightarrow \cancel{4OH} + 4e^- + 2H_2O + \cancel{2O} + O_2$$

$$4OH^- \longrightarrow 4e^- + 2H_2O + O_2$$

Cathode :

$$4H^+ + 4e^- \longrightarrow 2H_2$$

Ratio – $H_2 : O_2$

2 : 1

$$2H_2O \xrightarrow{\text{electric spark}} 2H_2\uparrow + O_2\uparrow$$

Applications of Electrolysis:

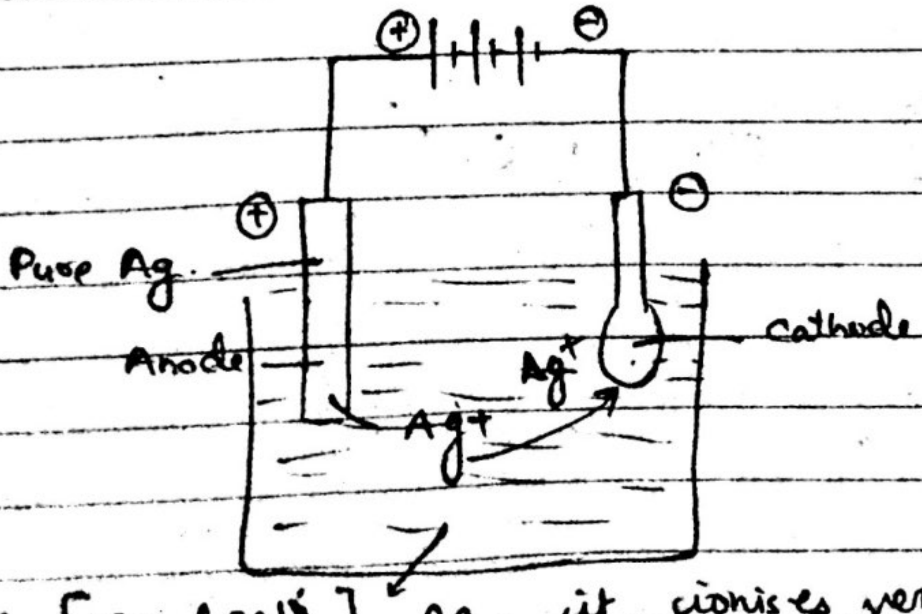
1) Electroplating:
for decorative purpose -

for prevention against corrosion -

~~Rooc~~ Metal to be deposited - Anode
Metal on which electroplating is to be done ⟹ Cathode.

Electrolytic solution: Any solution containing metal ions.
Current: DC current of small magnitude - for uniform deposition low current for long time is used.

Example:
① Electroplating a spoon with silver.



$Na[Ag(CN)_2]$ aq. it ionises very slowly.

Why Not used AgNO₃ ⟶ ionise rapidly ⇒ uneven deposition.

$$Na[Ag(CN)_2] \rightleftharpoons Na^+ + Ag^+ \quad 2CN^-$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Cathode: $Ag + e^- \longrightarrow Ag.$

$Ag^+ + e^- \longrightarrow Ag$
Deposition.

Anode : OH^- / CN^-

$Ag - e^- \longrightarrow Ag.$

$\longrightarrow e^- + Ag^+$
(into solution).

(4) (i) Complex salt

(ii) It ionises ~~which~~ very slowly but ~~to~~ $AgNO_3$ ~~so~~ ionises rapidly which causes uneven deposition.

(iii) low current for long time

H.W. Electrolysis Assignment.

Electroplating with Nickel:

Electrolyte : $NiSO_4$ (acidified)
(about 50% conc)
Cathode : Iron bar
Anode : Nickel bar

$$NiSO_4 \rightleftharpoons Ni^{2+} + SO_4^{2-}$$
$$H_2SO_4 \rightleftharpoons H^+ + SO_4^{2-}$$

Cathode : mass increase.
$$Ni^{2+} + 2e^- \longrightarrow Ni$$
Anode : oxidation
$$Ni \longrightarrow Ni^{2+} + 2e^-$$
$\downarrow$ mass decrease