

الكيمياء الكهربية

Electrochemistry

CHEM 344- 3

وصف المقرر Course Description

<i>Course Title</i>	<i>Course Number</i>	<i>Contact Hours (CH)</i>		<i>Credit unit (CU)</i>	<i>Year</i>	<i>Level</i>	<i>Pre-requisite</i>
		<i>Lec.</i>	<i>Prac.</i>				
<i>Electrochemistry</i>	<i>CHEM 344</i>	<i>2</i>	<i>1</i>	<i>3</i>	<i>3</i>	<i>8</i>	<i>none</i>

Course objectives: They are to
identify the following.

1. *Types of conductor*
2. *Classification of electrolytic cells*
3. *Measuring EMF*
4. *Applications of electrochemistry*

2- Blue Print

Course Name		ELECTROCHEMISTRY						
Course Code		344 CHEM						
PLOs	K1	K2	S1	S2	S3	S4	V1	V2
CLOs	1.1	1.2	2.1	2.2	2.3	2.4	3.1	3.2
Marks	15	21	34	22	4	--	4	---
Learning Domain	PLOs	CLOs	Assessment Type	Assessment Tool	No of Questions	Marks of the Assessment	Weight of the Assessment	
Knowledge & understanding	K1	1.1 (15M)	Quiz	MCQ	2	2	1	
			Mid term	MCQ	6	6	3	
			Final Exam	MCQ	11	11	11	
	K2	1.2 (21M)	Quiz	Q&A	2	2	1	
			Mid term	Q&A	5	5	5	
			Final Exam	Q&A	5	5	15	
Skills	S1	2.1 (34M)	H.W	Solving Problems & chart analysis	4	4	2	
			Quiz	Solving Problems & chart analysis	1	1	1	
			Mid term	Solving Problems & chart analysis	2	2	7	
			Final Exam	Solving Problems & chart analysis	6	6	24	
	S2	2.2 (22M)	Practical Sheet	MCQ	6	6	3	
				Q&A	2	2	2	
			Lab Report	Lab report rubric	10	10	10	
			Final Lab Exam	1 Task experiment	1	1	7	
	S3	2.3 (4M)	Safety Exam	MCQ	8	8	4	
Value	V1	3.1 (4)	Continuous assessment	Group evaluation rubric	-	4	4	
TOTAL		100						100

Electrochemistry is a branch of physical chemistry deals with the interactions of electrical energy with chemical species.

It is divided into two categories, namely

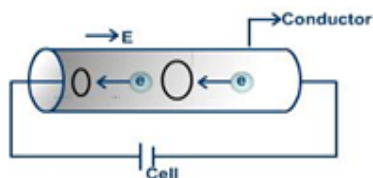
- (i) production of electric current from chemical and
- (ii) Chemical reaction occurs by the electric current.

1. Electrolytic and Non-electrolytic conductors

Electrical conductors or simply conductors:

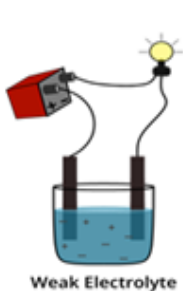
Substances which allow the passage of electric current through them

(i) Metallic or electronic conductors

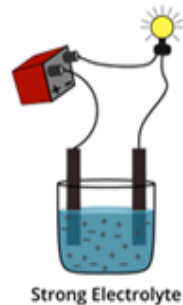


copper, silver, Aluminum

(ii) Electrolytic conductors:



aqueous solutions of acids, bases and salts



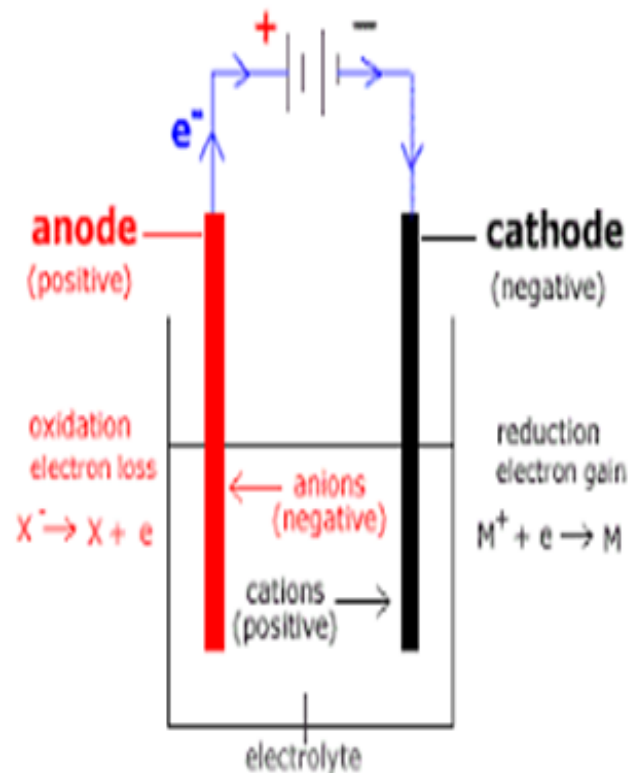
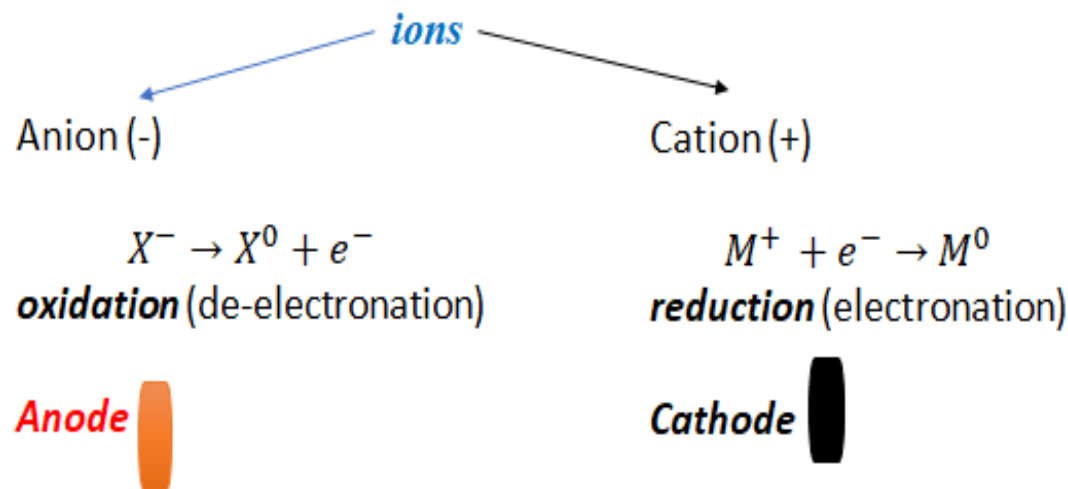
sugar, glycerine, alcohol

non-electrolytes



Passing current I

- An electrolytic conductor (aqueous solution or fused electrolyte),
- Two rods or plates (**electrodes**) (metallic conductors)
- Battery.
- The electrolytic solution conducts electricity by the movement of charged particles called **ions** towards the respective oppositely charged electrodes

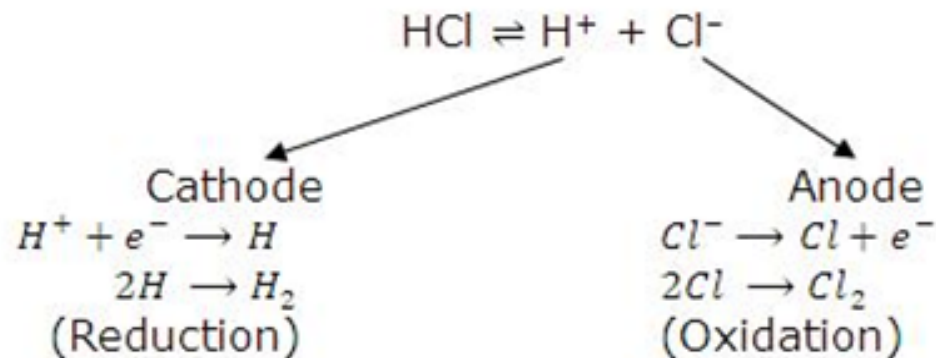


Distinction between metallic and electrolytic conduction

Metallic conduction	Electrolytic conduction
• Electric current flows by movement of electrons. • No chemical change occurs. • It does not involve the transfer of any matter. • Ohm's law is followed. • Resistance increases with increase of temperature. • Faraday law is not followed.	• Electric current flows by movement of ions. • Ions are oxidized or reduced at the electrodes. • It involves transfer of matter in the form of ions. • Ohm's law is followed. • Resistance decreases with increase of temperature. • Faraday law is followed.

Chemical decomposition of an electrolyte

- Molecules of an electrolyte when dissolved in water split up into ions, i.e., into *cations* and *anions*.
- On passing current, these ions move towards oppositely charged electrodes.
- On reaching the electrodes the ions lose their charge either by accepting electrons or losing electrons and thereby deposited at the respective electrodes or undergo a secondary change



electrolytic cell

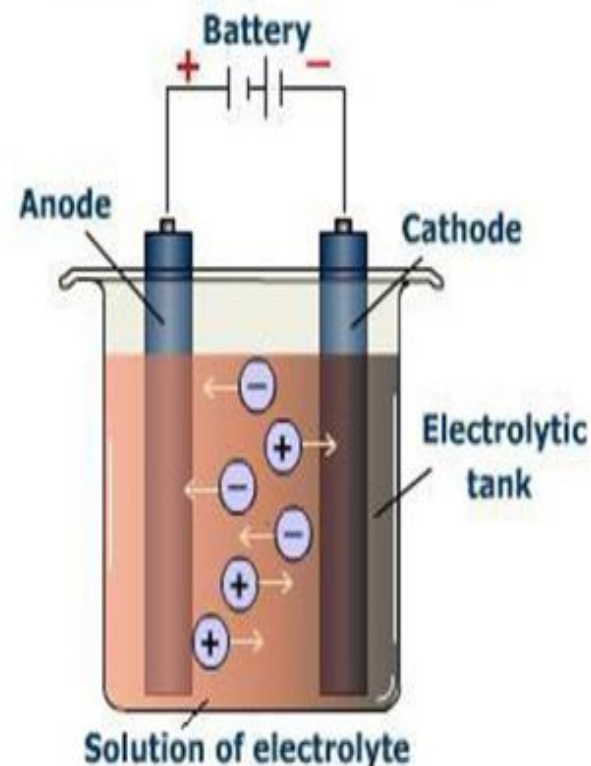
The device in which electrolysis (chemical reaction involving oxidation and reduction) is carried out by using electricity.

The device in which conversion of electrical energy into chemical change is done .

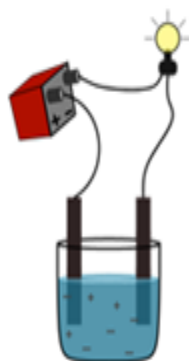
An electrolytic cell consists of

- A vessel for the electrolytic solution or fused electrolyte
- Two metallic electrodes (**Inert** electrodes)
- A source of electric current.

Electrolytic Cells



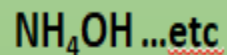
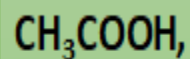
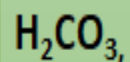
Types of Electrolytes



Weak Electrolyte

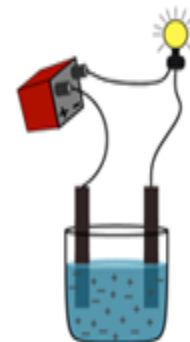
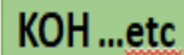
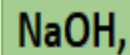
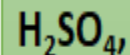
Weak electrolytes are only feebly ionized in the solution.

Examples are



Strong electrolyte are highly ionized in the solution.

Examples are



Strong Electrolyte

Preferential Discharge Theory

If more than one type of ions is attracted towards a particular electrode, then the one discharged is the ion which requires **least energy**.

The potential at which the ion is discharged is called **discharge or deposition potential**.

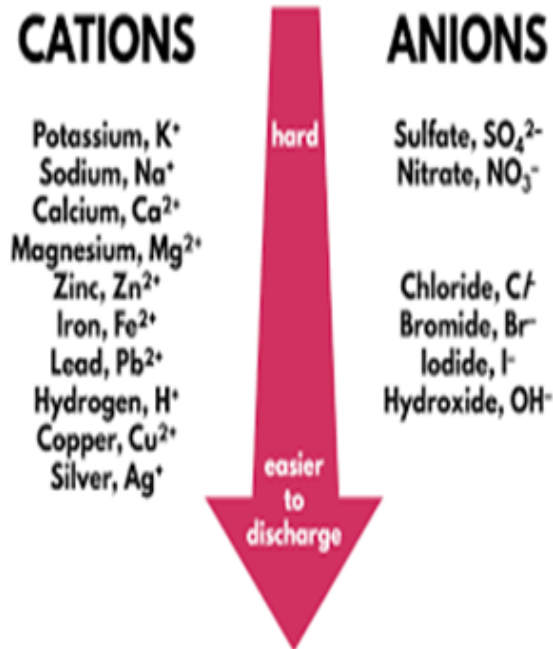
The values of discharge potential are different for different ions

the electrolysis of a solution of NaCl yields

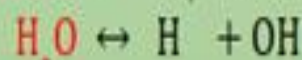
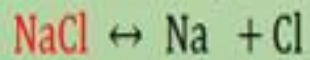
H_2 at the cathode and

Cl_2 at the anode

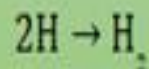
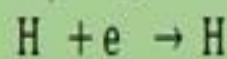
less preferred" ions Na^+ and OH^- form the base NaOH



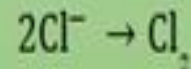
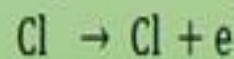
Electrolysis of sodium chloride *NaCl* solution



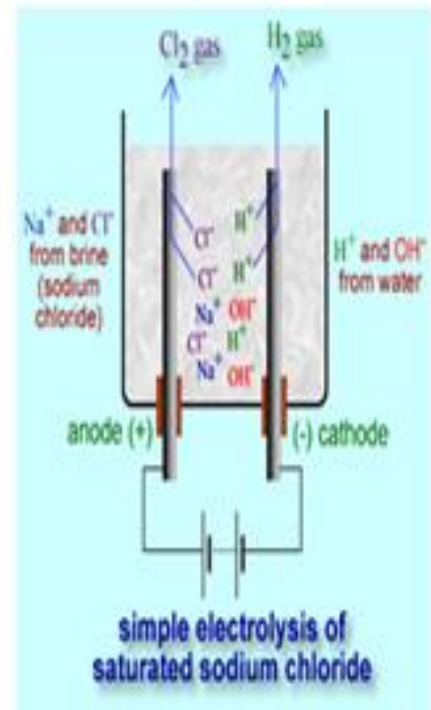
At cathode



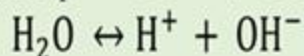
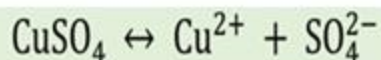
At Anode



- Discharge potential of H^+ ions are lower than Na^+ ions.
- Cl^- ions are discharged in preference to OH^- ions.
- Na^+ and OH^- ions remain in solution and the solution when evaporated yields crystals of sodium hydroxide.

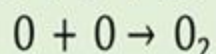
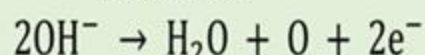
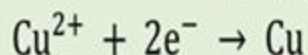


(ii) Electrolysis of CuSO_4 solution using platinum electrodes:



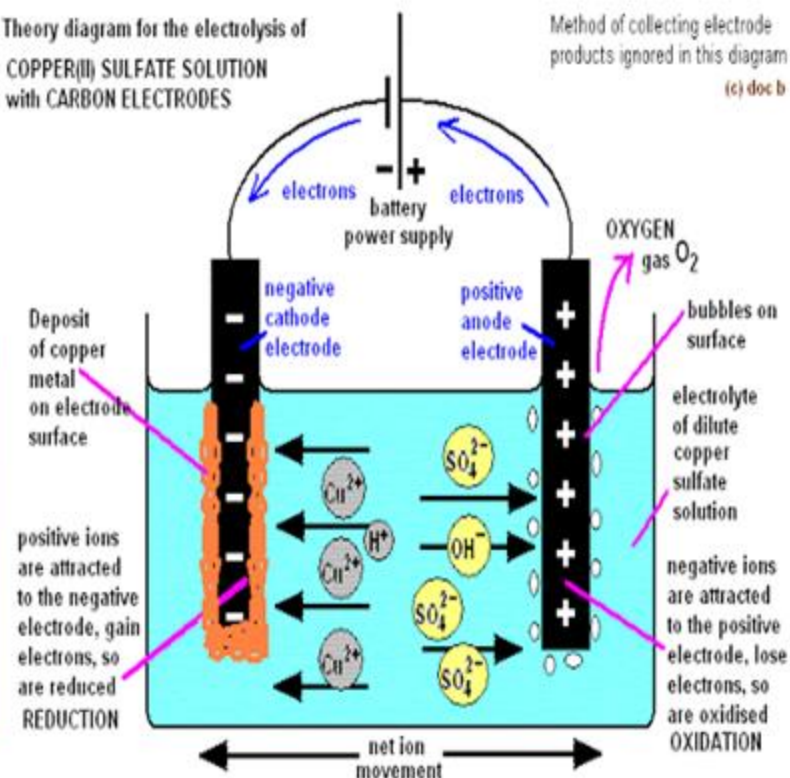
At cathode

At Anode

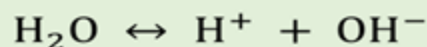
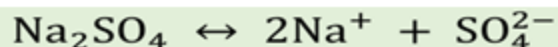


- Cu^{2+} ions have **lower** discharge potential than H^+ ions.
- OH^- ions are discharged at anode as these have **lower** discharge potential than SO_4^{2-} ions.
- Thus, copper is deposited at cathode and oxygen gas is evolved at anode.
- The "less preferred" ions H^+ (from H_2O) and SO_4^{2-} (from CuSO_4) form sulfuric acid H_2SO_4

Theory diagram for the electrolysis of COPPER(II) SULFATE SOLUTION with CARBON ELECTRODES

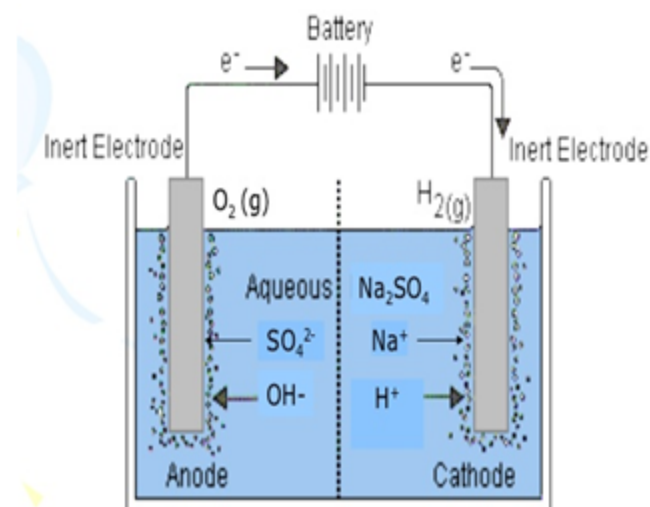
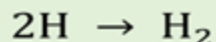
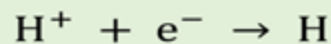


Electrolysis of Na_2SO_4 solution using inert electrodes



At cathode

At Anode



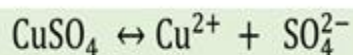
- H^+ is discharged at cathode as H^+ ions have lower discharge potential than Na^+ ions.
- OH^- ions are discharged at anode as these have lower discharge potential than SO_4^{2-} ions.
- Thus, hydrogen is evolved at cathode and oxygen is evolved at anode, i.e., the net reaction describes the electrolysis of water. The ions of Na_2SO_4 conduct the current through the solution and take no part in the overall chemical reaction.

The decreasing order of discharge potential or the increasing order of deposition of some of the ions is given below:

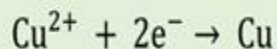
For cations: K^+ , Na^+ , Ca^{2+} , Mg^{2+} , Al^{3+} , Zn^{2+} , H^+ , Cu^{2+} , Hg^{2+} , Ag^+

For anions: SO_4^{2-} , NO_3^- , OH^- , Cl^- , Br^- , I^-

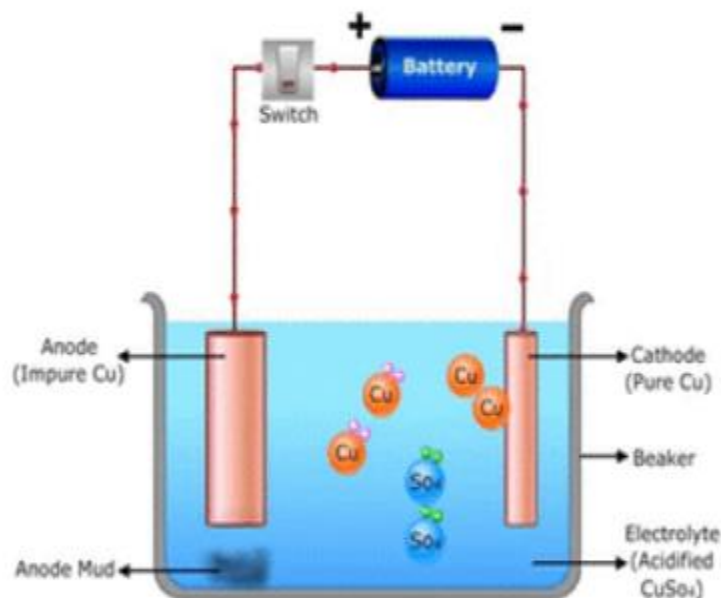
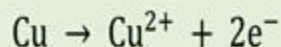
Electrolysis of copper sulphate solution using copper electrodes



At cathode, copper is deposited.



At anode, the copper of the electrode is oxidised to Cu^{2+} ions or ions solution dissolve equivalent amount of copper of the anode.



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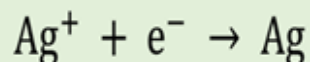
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Thus, during electrolysis, copper is transferred from anode to cathode

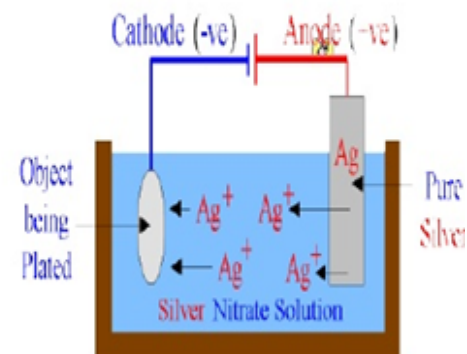
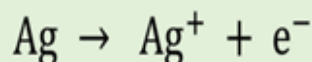
Electrolysis of silver nitrate solution using silver electrodes



At cathode, silver is deposited.



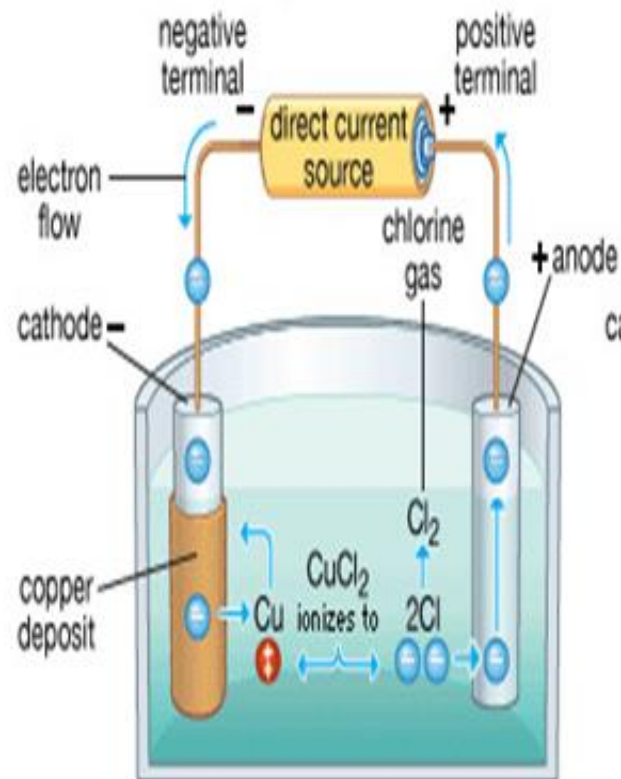
At anode, the silver of the electrode is oxidised to Ag^+ ions which go into the solution or ions dissolve equivalent amount of silver of the electrode.



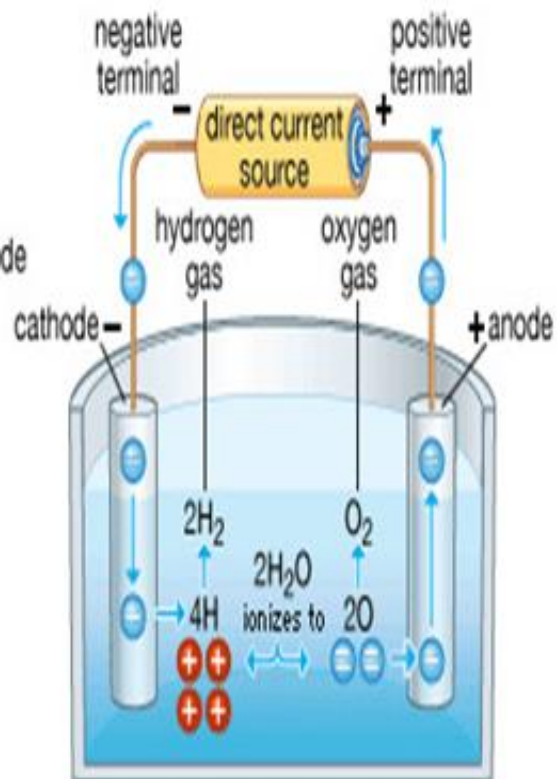
Some more examples of electrolysis

Electrolyte	Electrode	Cathodic reaction	Anodic reaction
Aqueous acidified CuCl_2 solution	Pt	$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$	$2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
Molten PbBr_2	Pt	$\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb}$	$2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$
Sodium chloride solution	Hg	$2\text{Na}^+ + 2\text{e}^- \rightarrow 2\text{Na}$	$2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
Silver nitrate solution	Pt	$\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$	$2\text{OH}^- \rightarrow \frac{1}{2} \text{O}_2 + \text{H}_2\text{O} + 2\text{e}^-$
Sodium nitrate solution	Pt	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	$2\text{OH}^- \rightarrow \frac{1}{2} \text{O}_2 + \text{H}_2\text{O} + 2\text{e}^-$

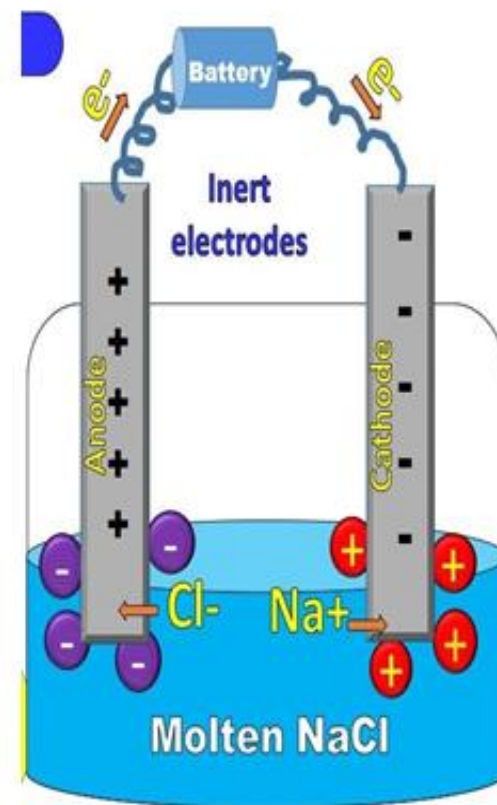
Examples of electrolytic cells



electrolysis of CuCl_2 (copper electroplating)

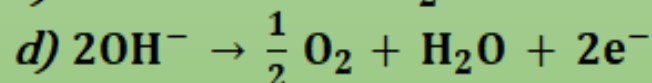
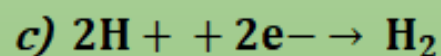
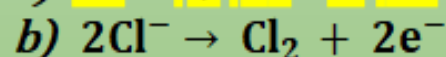
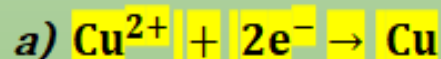


electrolysis of water



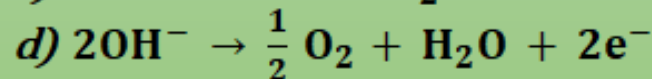
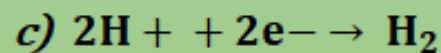
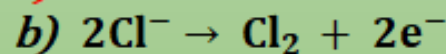
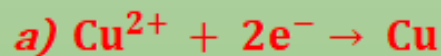
I/ Choose the correct answer

1. Electrolysis of acidified CuCl_2 on Pt electrodes give ($\text{Cu} - \text{H}_2 - \text{O}_2 - \text{Cl}_2$) at cathode.
2. Electrolysis of acidified CuCl_2 on Pt electrodes give ($\text{Cu} - \text{H}_2 - \text{O}_2 - \text{Cl}_2$) at Anode.
3. The reaction done at cathode when acidified CuCl_2 is electrolysis



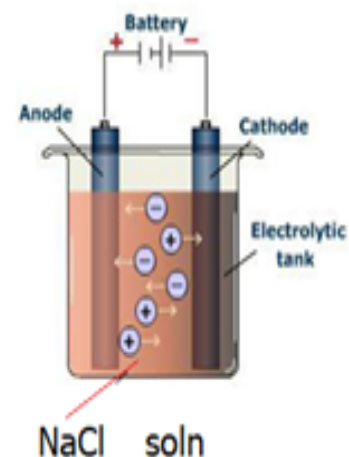
I/ Choose the correct answer

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2. Electrolysis of acidified CuCl_2 on Pt electrodes give ($\text{Cu} - \text{H}_2 - \text{O}_2 - \text{Cl}_2$) at Anode.
3. The reaction done at cathode when acidified CuCl_2 is electrolysis



II/ Use the following Figure, Complete the following

1. The cell is called cell.
2. **Positive** ions in the electrolytic tank are and
3. **Negative** ions in the electrolytic tank are and
4. At Anode is evolved .
5. At Cathode is evolved.



II/ Use the following Figure, Complete the following

1. the cell is called **electrolytic** cell.
2. Positive ions in the electrolytic tank are **Na⁺** and **H⁺** .
3. Negative ions in the electrolytic tank are **OH⁻** and **Cl⁻** .
4. At Anode **Cl₂** is evolved .
5. At Cathode **H₂** is evolved.

•Complete

1. Electrochemical cells are composed of an and in two separate solutions.
2. An electric current consists of a flow of
3. The electrode where oxidation occurs is called the and the electrode where reduction occurs is called the
4. In electroplating, the object to be plated is made the

•Complete

1. Electrochemical cells are composed of an **anode** and **cathode** in two separate solutions.
2. An electric current consists of a flow of **charged particles (ions)**.
3. The electrode where oxidation occurs is called the **anode** and the electrode where reduction occurs is called the **cathode**.
4. In electroplating, the object to be plated is made the **cathode**.

Which of the following is **not** a strong electrolyte?

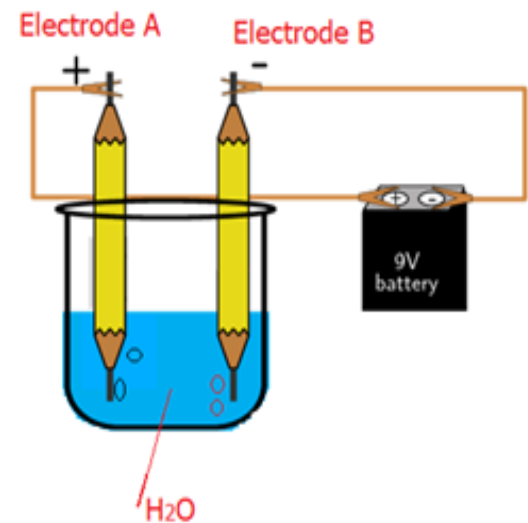
- a) CH_3COOH
- b) NaClO_4
- c) KNO_3
- d) KCl

Complete:

- 1. The electronic conductance depends on , ... , ...
- 2. The conductivity of electrolytic solution depends upon , ...

In the Figure

- 1. Electrode A is called Where electrode B is called
- 2. H_2O is electrolyzed to and
- 3. At electrode A, the reaction Take place.
- 4. At electrode B, the reaction Take place.
- 5. Oxidation occur at electrode Where reduction occur at electrode





Products of electrolysis :

Electrolyte	Products		Reactions involved	
	At cathode	At anode	At cathode	At anode
Molten NaCl	Na metal	Cl ₂ gas	$\text{Na}_{(l)}^{+} + e^{-} \longrightarrow \text{Na}_{(l)}$	$\text{Cl}_{(l)}^{-} \longrightarrow \frac{1}{2} \text{Cl}_{2(g)} + e^{-}$
Aqueous NaCl	H ₂ gas	Cl ₂ gas	$\text{H}_2\text{O}_{(l)} + e^{-} \longrightarrow \frac{1}{2} \text{H}_{2(g)} + \text{OH}_{(aq)}^{-}$	$\text{Cl}_{(aq)}^{-} \longrightarrow \frac{1}{2} \text{Cl}_{2(g)} + e^{-}$
Dil. H ₂ SO ₄	H ₂ gas	O ₂ gas	$\text{H}_{(aq)}^{+} + e^{-} \longrightarrow \frac{1}{2} \text{H}_{2(g)}$	$2\text{H}_2\text{O}_{(l)} \longrightarrow \text{O}_{2(g)} + 4\text{H}_{(aq)}^{+} + 4e^{-}$
Conc. H ₂ SO ₄	H ₂ gas	S ₂ O ₈ ²⁻	$\text{H}_{(aq)}^{+} + e^{-} \longrightarrow \frac{1}{2} \text{H}_{2(g)}$	$2\text{SO}_{4(aq)}^{2-} \longrightarrow \text{S}_2\text{O}_{8(aq)}^{2-} + 2e^{-}$