Electrochemistry

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Electrochemistry

Electrochemistry is the use of electricity to bring amount a chemical reaction.

Electrolysis is the use of electricity to bring about a chemical reaction in an electrolyte.

i.e. a chemical is produced when an electric current is passed through an electrolyte

An electrolyte is a compound which when molten or dissolved in waer will conduct an electric current.

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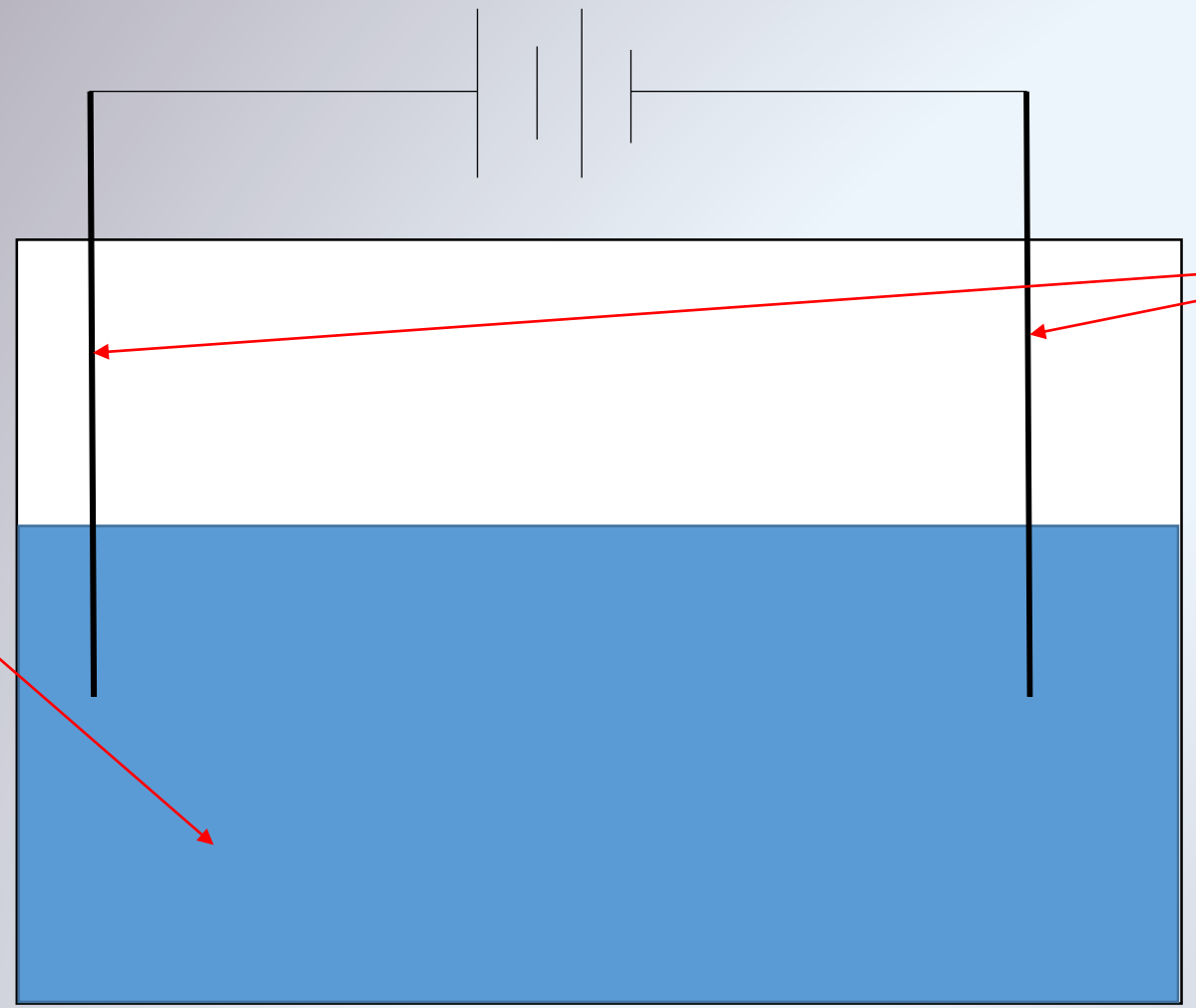

Electrodes
-usually made of carbon or platinum (because they are unreactive)
-Cathode (negative)
-Anode (positive)

Electrolyte

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Types of electrodes

Inert electrodes: electrodes that do not react with electrolyte in which they are dipped e.g. Graphite / Platinum

Active Electrodes: in some cases the electrodes react with the electrolyte. Such electrodes are called active e.g. Copper & Iron

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Electrolysis

Battery ‘pumps’ electrons on to the negative electrode (cathode) where they are gained by some species i.e. reduction occurs at the negative electrode.

At positive electrode (anode) a chemical reactions involving the loss of electrons i.e. oxidation reaction occurs

In electrolysis reactions oxidation occurs as the positive electrode (anode) and reduction occurs at the negative electrode (cathode).

OPRN: Oxidation at Positive, Reduction at Negative

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Experiment 1: Passing Electric Current through Potassium Iodide using Platinum Electrodes: { Phenolphthalein Indicator}

Negative Electrode: $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

Phenolphthalein turns pink as OH^- ions are present. Bubbles of H_2 observed.

Positive Electrode: $2I^- \longrightarrow I_2 + 2e^-$

Negative iodide ions are attracted to positive electrode.

Build up of iodine around positive electrode = brown colour.

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Experiment 2:
Investigate electrolysis of acidified water using platinum electrodes.

Electric current is passed through acidified water. H_2SO_4 is added to the water to conduct electricity. A Hofmann Voltameter is used.

Water is split into the two gases i.e. hydrogen & oxygen (2:1)

Negative Electrode: $2H^+ + 2e^- \longrightarrow H_2$
H^+ ions from sulphuric acid are attracted to negative electrode. Each H^+ ion accepts an electron to form H atom (reduction).

Positive Electrode: $H_2O \longrightarrow 2H^+ + O_2 + 2e^-$
Electrons are removed from the water molecules (oxidation). This destabilises the H_2O molecule & causes it to break down

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Experiment 3:
Investigate electrolysis of sodium sulfate using platinum electrodes.

Electric current is passed through a dilute solution of sodium sulfate using platinum electrodes. Few drops of universal indicator solution are added to the sodium sulfate. This indicator is red in acid & blue in base. It turns red at positive electrode & blue at negative electrode.

Negative Electrode: $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$
Indicator turns blue at the negative electrode, implies that OH^- ions are formed. Bubbles of H_2 gas is observed at this electrode.

Positive Electrode: $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$
At positive electrode as a red colour is observed H^+ ions are formed. Bubbles of O_2 gas observed.

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Experiment 4:

Investigate the electrolysis of $CuSO_4$ using copper electrodes.

In this experiment we are using active electrodes

As the electrolysis proceeds the copper plate connected to –ive end of battery gains weight & gets a fresh coating of Cu metal deposited on the plate.

Negative Electrode: $Cu_2+ + 2e^- \longrightarrow Cu$

Each Cu ion accepts two electrons to form Cu atom. Cu atom is plated on to negative electrode.

Positive Electrode: $Cu \longrightarrow Cu2+ + 2e-$

Cu atoms lose 2 electrons & go into solution as $Cu2^+$ ions. Driving force for this is need to replace $Cu2^+$ ions being removed at negative electrode. positive electrode is slowly eaten away.

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Experiment 5:
Demonstrate the movement of ions under influence of electric field

In this experiment a salt is dissolved in water so that the ions are free to move & attached to electrodes. We normally use ions of different colours. Example a green solution made of blue $CuSO_4$ & yellow CrO_4^{2-} dissolved in concentrated ammonia

Negative electrode: gathers blue Cu^{2+} ions.

Positive electrode: gathers yellow CrO_4^{2-} ions.

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Electroplating

Electroplating is a process where electrolysis is used to put a layer of one metal on the surface of another.

Electroplating is done to

- reduce costs as cheaper metals can be coated in precious metals e.g. jewelry
- prevent corrosion

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To electroplate any object the following conditions must be fulfilled:

1. Object to be plated must be connected to negative terminal of battery.
2. Electrolyte must be the salt of the metal that is being plated.
3. Positive electrode must be same metal as that being plated out.

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Silver Plating

Negative Electrode: $Ag^+ + e^- \longrightarrow Ag$

Ag^+ ions from silver nitrate are attracted to negative terminal. Each Ag ion accepts an electron to form Ag atom, thus Ag metal is plated onto negative electrode.

Positive Electrode: $Ag \longrightarrow Ag^+ + e^-$

Ag metal of positive electrode dissolves in electrolyte to form silver ions. They replace negative ions removed at negative terminal and it is slowly eaten away.

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Electrochemical Series

Chemists use the term electrode potential to describe the tendency of a metal to lose electrons i.e. tendency for metal to be oxidised.

The electrochemical series is a list of elements in order of their standard electrode potentials.

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The series is used to predict the result of displacement reactions.

Metals will displace any of the metals below it from a solution of that metal's ions

e.g. magnesium will displace copper from a solution of copper ions

Potassium
Calcium
Sodium
Magnesium
Aluminium
Zinc
Iron
Lead
Hydrogen
Copper
Mercury
Silver
Gold

Decreasing reactivity

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