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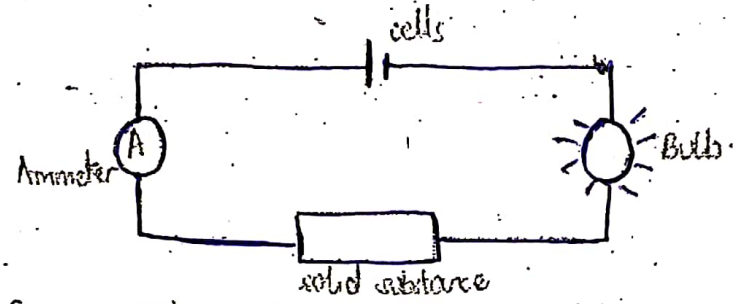
EFFECT OF ELECTRICITY ON SUBSTANCES (electrolysis)

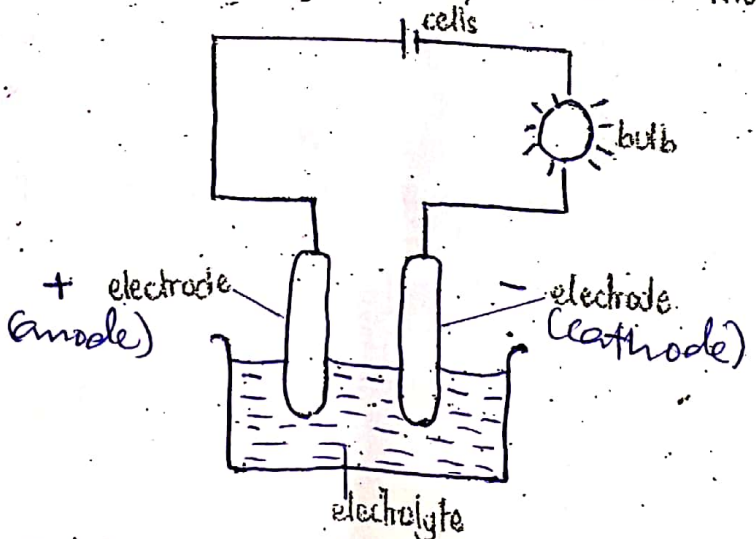
Electric current is the flow of electrons from one point to another through a solid/liquid.



Some solid substances allow current to pass through them, as result, ē bulb gives light. These solids are known as conductors. However, solids like wood, plastics, etc don't allow ē flow i electric current ∴ are therefore called non-conductors/insulators.

⇒ Conductors have free mobile electrons which move about within the solid transferring ē stream ō electrons ie current hence conduction ō electricity.

Solutions ō ionic compounds and molten (liquid) ionic compounds that conduct electricity in ē liquid state are known as electrolytes



Electrolytes use a few mobile ions to transmit the electrons one point to another. Electrolytes include aqueous solutions of copper (II) sulphate, sodium chloride, copper (II) chloride, sulphuric acid, hydrochloric acid, etc and molten salts of lead (II) bromide, sodium chloride, etc.

Liquids which don't conduct electricity are known as non-electrolytes e.g. Carbontetrachloride, benzene etc

ELECTROLYTES

An electrolyte is a compound which conducts electricity in solution or molten states and is decomposed by it.
There are two types of electrolytes.

1. Strong electrolytes

These completely ionise in aqueous solutions and are good conductors of electricity ie

$$BX_{(aq)} \longrightarrow B^{+}_{(aq)} + X^{-}_{(aq)} \quad \text{(solution state)}$$

$$BX_{(s)} \longrightarrow B^{+}_{(l)} + X^{-}_{(l)} \quad \text{(Molten state)}$$

Strong electrolytes include sulphuric acid (dilute), dilute hydrochloric acid, dilute nitric acid, sodium hydroxide solution, copper(II) sulphate soln etc. eg.

$$H_2SO_{4(aq)} \longrightarrow 2H^{+}_{(aq)} + SO^{2-}_{4(aq)}$$

$$HCl_{(aq)} \longrightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$$

$$CuSO_{4(aq)} \longrightarrow Cu^{2+}_{(aq)} + SO^{2-}_{4(aq)}$$

2. Weak electrolytes

These partially ionise therefore they have fewer ions per unit to transmit the electric current. For the above reason, they aren't good conductors. Weak electrolytes include aqueous ammonia, ethanoic acid, carbonic acid, etc.

$$NH_4OH_{(aq)} \rightleftharpoons NH^{+}_{4(aq)} + \bar{O}H_{(aq)}$$

$$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^{-}_{(aq)} + H^{+}_{(aq)}$$

$$H_2CO_{3(aq)} \rightleftharpoons 2H^{+}_{(aq)} + CO^{2-}_{3(aq)}$$

Definitions

1. Electrodes

These are 2 poles of metal/carbon (graphite) at which the electric current enters/leaves the electrolyte.

Anode: This is the positive electrode at which electrons leave electrolyte/enter external circuit

OR Anode is an electrode at which oxidation reaction occurs.

OR Anode is an electrode where at which oxidation reaction takes place/occurs

→ Cathode:- This is ē negative electrode at which electrons leave ē external circuit/ enter ē electrolyte. An electrode at which reduction reaction occurs

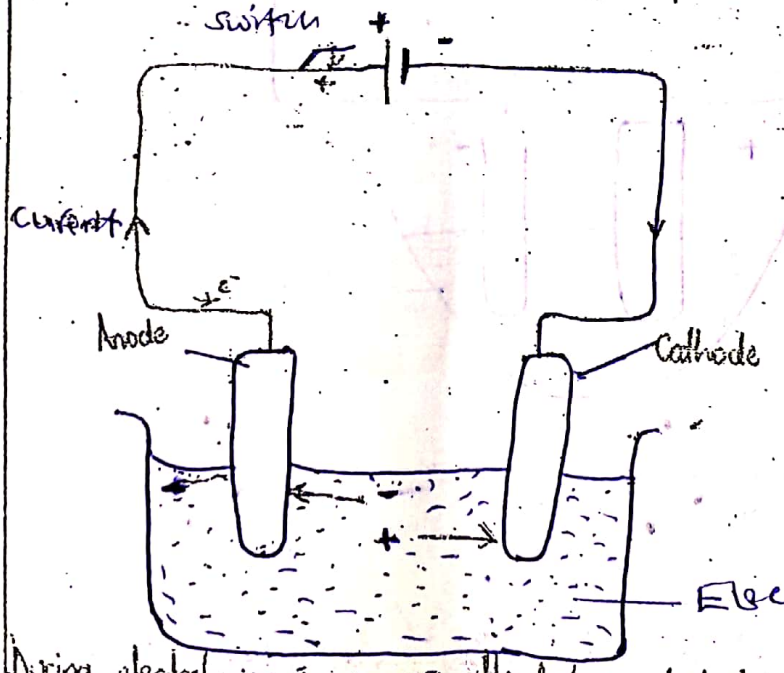
NOTE:- Non-electrolytes don't ionize at all therefore ey exist as molecules.

14/4/11. ## ELECTROLYSIS

This is the decomposition of an electrolyte by passing electric current through it. It only occurs when ē electrolyte is in molten/solution states.

Ionic theory of electrolysis

1. Ionic substances contain negative and positive particles called ions.
2. In ē solid state/concentrated liquid, ē ions are strongly attracted to each other (aren't free to move) hence ē electrolyte doesn't conduct
3. On melting / dissolving ē ionic compound in water, ē ions are separated frm each other. ie ē ions become free and mobile hence ē electrolyte conducts
4. On applying an electric current, ē ions move ā ē opposite ends ō ē electric field. Positively charged ions migrate ā ē negative electrode while negatively charged ions migrate to the positive electrode ie opposite charges attract while like charges repel.



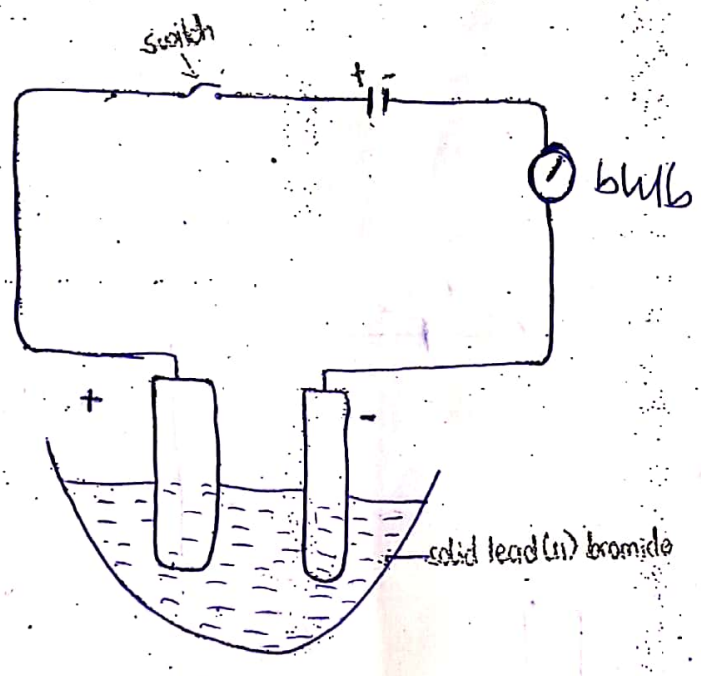
During electrolysis, ē ions are attracted to electrodes of opposite charges ie Cations are attracted to cathode and anions to anode.

At ē cathode	At ē anode
The lead(ii) ions migrate ā ē cathode from where ey gain electrons and are discharged. Observation A grey solid is deposited at ē cathode Eqn ō reaction: $Pb^{2+}_{(l)} + 2e \longrightarrow Pb_{(s)}$	The bromide ions migrate ō ē anode from where ey are discharged by loss ō electrons. Observation: A reddish brown gas is given off at ē anode Eqn ō reaction: $2Br^-_{(l)} - 2e \longrightarrow Br_{2(g)}$

NOTE:
The bulb does not give light when ē lead(ii) bromide is not molten because solid lead(ii) bromide has no mobile ions but as soon as ē lead(ii) bromide melts, ē ions become free ą are able ā conduct ē electric current therefore ē bulb gives light.

Questions

1. A circuit ą ē electrolysis ō lead(ii) bromide was set up as shown below.



a. State what was observed when,
i. Switch was turned on.
No observable change.
ii. Lead(ii) bromide was melted ą ē switch turned on.
Bulb gives light, lead solid " " " " " " anode ^

b. Explain your observations in a(i) & a(ii).

- In a(i), ere is no observable change because solid lead(II) bromide has no mobile ions therefore cannot conduct electricity.
- In a(ii), molten lead(II) bromide has mobile ions which conduct electricity, therefore e bulb gives light. Also e lead(II)ions migrate 2 e cathode 4m where ey are discharged 2 form lead (grey solid) & e bromide ions migrate 2 e anode 4m where ey are discharged as bromine gas.

At e cathode: $Pb^{2+}_{(l)} + 2e \rightarrow Pb_{(l)}$

At the anode: $2Br^-_{(l)} - 2e \rightarrow Br_{2(g)}$

2 Molten lead(II) bromide was electrolysed btn 2 carbon electrodes.

a. State what was observed at e;

i. Anode
A reddish brown gas is given off.

ii. Cathode
A grey solid is deposited.

b. Write eqn for e reaction that took place at;

i. anode
$2Br^-_{(l)} - 2e \rightarrow Br_{2(g)}$

ii. cathode
$Pb^{2+}_{(l)} + 2e \rightarrow Pb_{(s)}$

3. Molten lead(II) bromide was electrolysed btn 2 carbon electrodes.

a. Explain why lead(II) bromide was electrolysed in e molten state and not solid state.
Molten lead(II) bromide has mobile ions which can conduct electric current while in solid lead(II) bromide, e ions aren't free 2 move.

b. State what was observed at e

i. Anode
A reddish brown gas is given off.

ii. Cathode
A grey solid is deposited.

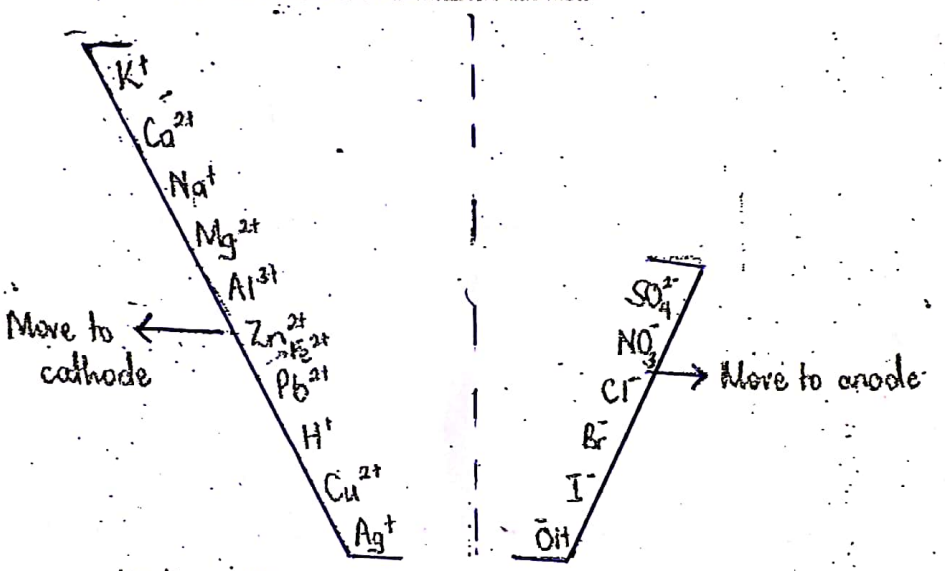
c. Write eqn for e reaction that took place at e anode

$2Br^-_{(aq)} \rightarrow Br_{2(g)} + 2e$ OR $2Br^- - 2e - Br_{2(g)}$

SELECTIVE DISCHARGE OF IONS

When 2/ more ions of with similar charges are present in a solution under similar conditions eg sodium ion & hydrogen ion / hydroxide ion & sulphate ion, one is preferencially discharged & ē electron ō ē ion ẗ be discharged depends on a number ō factors which include;

1. Position ō ē ion in ē electrochemical series.



Given that all ē other factors are constant, an ion will be discharged frm solution in preferrence ẗ those above it in ē electrochemical series. eg Sodium hydroxide solution contains sodium ions & hydrogen ions frm water but when ēse 2 ions migrate ẗ ē cathode, ē hydrogen ions are discharged in preferrance ẗ sodium ions bcz ēy are lower in ē electrochemical series therefy hydrogen is evolved at ē cathode.

ELECTROLYSIS OF COPPER(II) SULPHATE SOLUTION

Procedure

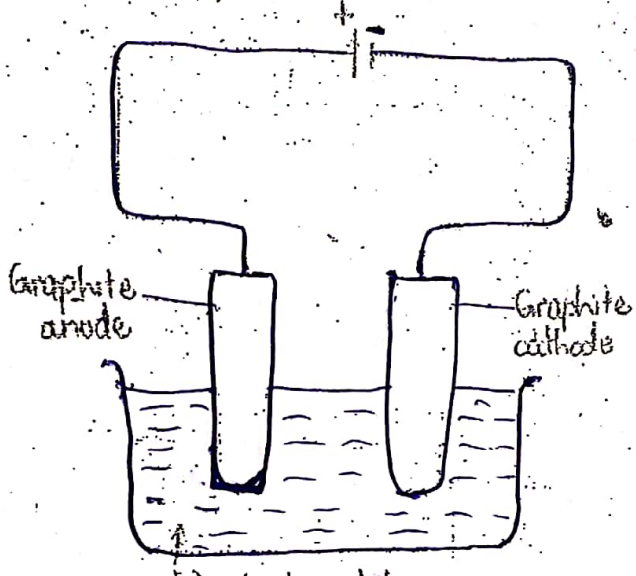
A known mass ō copper(II) sulphate is dissolved in a known volume of water in a beaker. Graphite electrodes are ēn connected to 6 volts direct current supply & dipped in ē beaker containing copper(II) sulphate solution. Electric current is ēn passed thru ē electrolyte.

Na^+ H^+

$KCl \rightarrow$

OH^-

Experimental set up



Ions present

Cu^{2+}, SO_4^{2-}, H^+, OH^-

At the cathode

Copper(II) ions & hydrogen ions migrate to the cathode but ē copper(II) ions are discharged in preference ā ē hydrogen ions because ey are lower in ē electro chemical series.

Observation:

A reddish brown solid is deposited at ē cathode.

Eqn. ō reaction

$Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)}$

pH at ē cathode

ē discharge ō copper(II) ions leads ā ē accumulation ō hydrogen ions at ē cathode. ē presence ō ē hydrogen ions at ē cathode is responsible ā ē acidity ō ē solution around ē cathode ie pH less than 7.

At the anode

The hydroxide ions & sulphate ions migrate to ē anode but ē hydroxide ions are discharged in preferance ā ē sulphate ions bse ey are lower in ē electro chemical series.

Observation

Bubbles ō a colourless gas are given off.

Eqn. ō reaction.

$4OH^-_{(aq)} - 4e \longrightarrow 2H_2O_{(l)} + O_{2(g)}$

pH at ē anode

ē discharge ō hydroxide ions upsets ē ionic equilibrium ō water therefore ē water dissociates ā form hydroxide & hydrogen ions. ē hydroxide ions are discharged but before ē hydrogen ions migrate ā ē cathode, ey do accumulate around ē anode hence making ē soln around ē anode acidic ie pH less than 7.

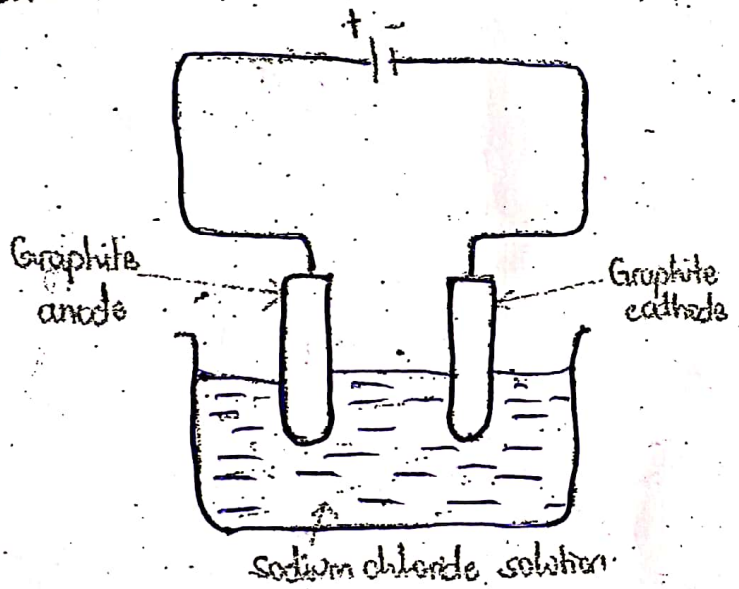
General observations:

1. The overall pH ō ē soln after electrolysis is less than 7 ie ē soln becomes acidic
2. The blue colour ō copper(II) sulphate soln fades as copper is discharged ie ē blue solution turns colourless

ELECTROLYSIS OF DILUTE SODIUM CHLORIDE SOLUTION

Procedure

A known mass ō sodium chloride is dissolved in a known volume ō water in a beaker. Graphite electrodes are ēn connected to a 6 volts direct current power supply & dipped into ē soln in ō ē beaker. Experiment is set up as shown below



Na^+, H^+, Cl^- and OH^-

At the cathode

The sodium ions and hydrogen ions migrate to the cathode but ē H^+ ions are discharged in preferrance to the Na^+ ions b'se ēy ore lower in ē electro chemical series.

Observation:

Bubbles ō a colourless gas are given off.

$2H^+_{(aq)} + 2e \rightarrow H_{2(g)}$

At the anode

ē chloride ions & hydroxide ions migrate ē anode but ē OH^- ions are discharged in preferrance to the chloride ions b'se ēy are lower in ē electro chemical series.

Observation:

Bubbles ō a colourless gas are given off.

Eqn ō reaction:

$4OH^-_{(aq)} - 4e \rightarrow 2H_2O_{(l)} + O_{2(g)}$

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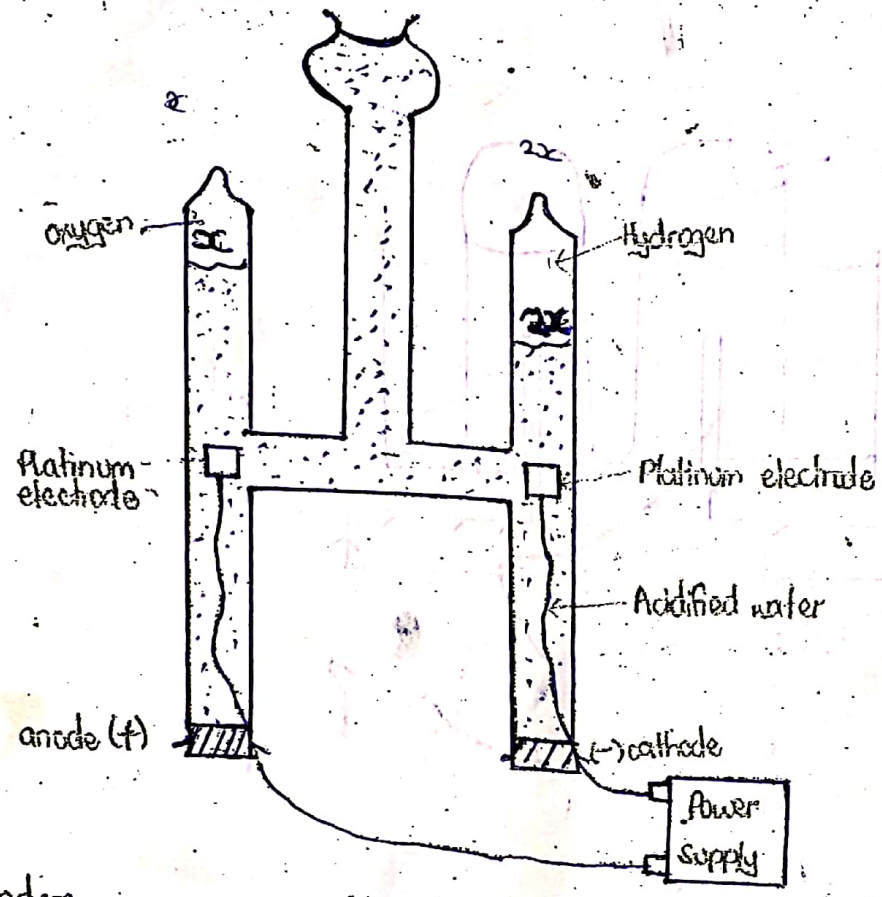
ELECTROLYSIS OF ACIDIFIED WATER

Hofman's Voltmeter



Procedure

Fill the voltmeter with acidified water (acidified with sulphuric acid) and connect the electrolyte to a 6 volts direct current power supply. Pass an electric current through the electrolyte.

Ions present

Hydrogen ions H^+

Hydroxide ions OH^-

Sulphate ions SO_4^{2-}

At the cathode

observation: Bubbles of a colourless gas are given off.

Eqn ō reaction.

$2H^+_{(aq)} + 2e \rightarrow H_{2(g)}$

At the anode

observation: Bubbles of a colourless gas are given off.

Eqn ō reaction:

$4OH^-_{(aq)} - 4e \rightarrow 2H_2O_{(l)} + O_{2(g)}$

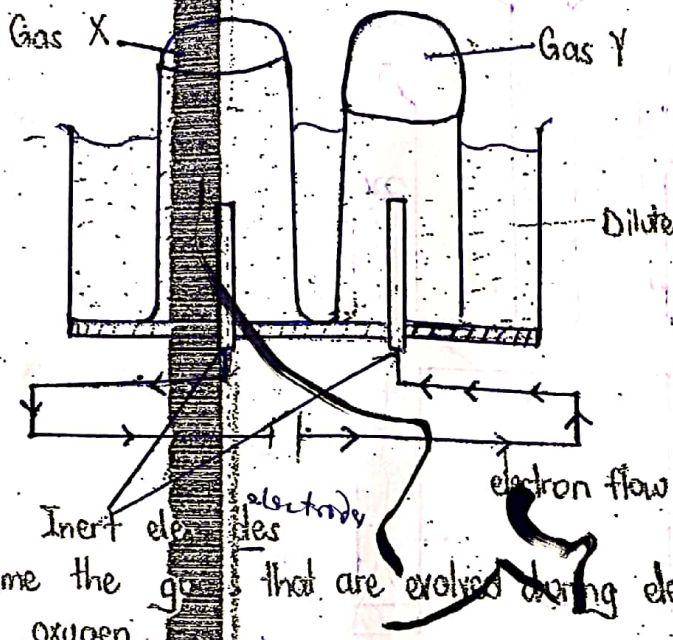
Note:

The volume of hydrogen produced is twice that of oxygen.

Overall eqn ō reaction.

Question:

The diagram below shows an electrolytic cell in which electrolysis of dilute sulphoric acid occurs.



a. Name the gases that are evolved during electrolysis.

X oxygen

Y hydrogen

b. Write equation the reaction that took place at the;

i. Anode

$4OH^-_{(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$

ii. Cathode

$2H^+_{(aq)} + 2e \longrightarrow H_{2(g)}$

c. Indicate the direction of electron flow in the circuit.

d. State 2 industrial applications of electrolysis.

- Extraction of metals.
- Purification of metals.
- prevention of rusting.

2. Concentration of the electrolyte:

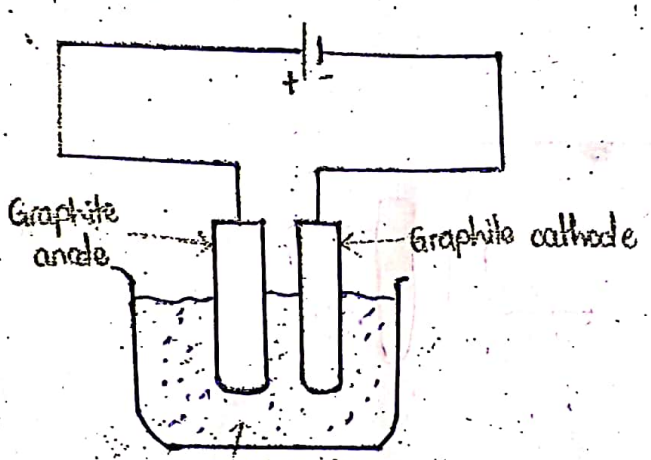
The discharge of an ion is promoted by its increase in concentration. Therefore the ion in a larger concentration is preferentially discharged. Concentrated hydrochloric acid (HCl) contains Cl^- & OH^- ions from water as negative ions. Hence the chloride ions are in a higher concentration they are discharged in preferrance to hydroxide ions.

In dilute hydrochloric acid, the hydroxide ions are in a larger concentration compared to that of the chloride ions. Therefore the hydroxide ions are discharged in preferance to chloride ions.

Electrolysis of concentrated sodium chloride (NaCl) solution.

Procedure

Prepare a conc soln of NaCl. Dip graphite electrodes into the solution and connect the electrodes to a 6 volts direct current power supply. Pass an electric current through the electrolyte.



Ions present

Na^+, Cl^-, H^+, OH^-

At the cathode

The sodium ions and hydrogen ions migrate to the cathode but the Na^+ are discharged in preferance to the H^+ because they are in a higher concentration.

Eqn of reaction.

$Na^+_{(aq)} + e \longrightarrow Na_{(s)}$

The sodium formed is very reactive. It reacts with H_2O to form hydrogen gas.

Observation:

Bubbles of a colourless gas are given off

Eqn of reaction to formation of H_2

$2Na + 2H_2O \longrightarrow 2NaOH + H_2$

At the anode

The chloride ions and hydroxide ions migrate to the anode but the Cl^- are discharged to the preferance of OH^- bse they are in a higher concentration.

Observation

A greenish yellow gas is given off.

Eqn of reaction.

$2Cl^-_{(aq)} - 2e \longrightarrow Cl_{2(g)}$

pH at the anode

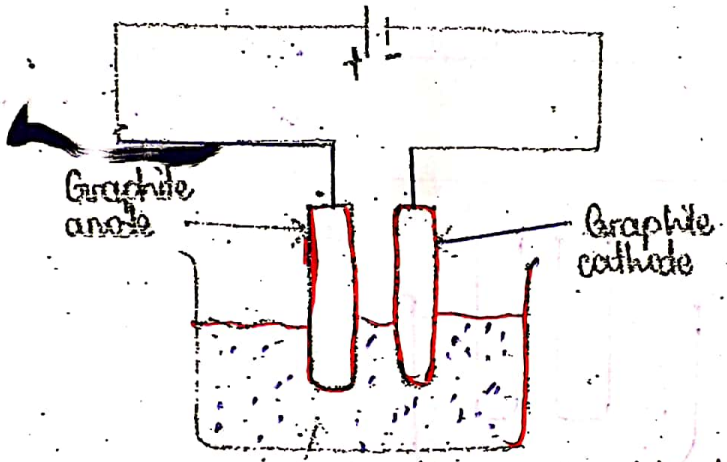
The discharge of chloride ions leaves hydroxide ions around the anode. Therefore the soln at the anode is alkaline. Hence the pH is greater than 7 / Hence the overall pH is greater than 7

cathode is responsible for making the soln alkaline hence a pH greater than 7.

Electrolysis of concentrated copper(II) chloride soln:

Procedure

Prepare a concentrated solution of copper(II) chloride. Dip graphite electrodes into the solution and connect the electrolyte to a 6 volts direct current power supply. Pass an electric current through the electrolyte.



concentrated copper(II) chloride solution.

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Ions present;

copper(II) ions (Cu^{2+}), chloride ions (Cl^-), hydrogen ions (H^+) & hydroxide ions (OH^-).

At the cathode

Copper(II) ions & hydrogen ions migrate to the cathode but the copper(II) ions are discharged in preferance to hydrogen ions because they are in a higher concentration.

Observation

A reddish brown solid is deposited.

$Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$

At the anode

The chloride ions & OH^- migrate to anode but the Cl^- are discharged in preferance to the OH^- because they are in a higher concentration.

Observation

A greenish yellow gas is given off.

$2Cl^-_{(aq)} - 2e \rightarrow Cl_{2(g)}$

3. Nature of the electrode

(i) Electrolysis of copper(II) sulphate solution

a. Using platinum electrodes

Ions present; Cu^{2+}, H^+, SO_4^{2-}, OH^-

At the anode

The OH^- & SO_4^{2-} migrate to the anode but the OH^- ions are discharged in preference because they are lower in the electrochemical series.

Observation:

Bubbles of a colourless gas are given off.

Equation of reaction:

$4OH^-_{(aq)} - 4e \rightarrow 2H_2O_{(l)} + O_{2(g)}$

At the cathode

The Cu^{2+} & H^+ ions migrate to the cathode but the Cu^{2+} are discharged in preference because they are lower in the electrochemical series.

Observation

A reddish brown solid is deposited.

Equation of rxn:

$Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$

b. Using copper electrodes

At the anode

The SO_4^{2-} & OH^- ions migrate to the anode but none of them is discharged instead the copper anode dissolves into the solution (electrolyte) to form copper(II) ions. This is known as electrode ionisation.

Observation:

The anode decreases in size.

$Cu_{(s)} - 2e \rightarrow Cu^{2+}_{(aq)}$

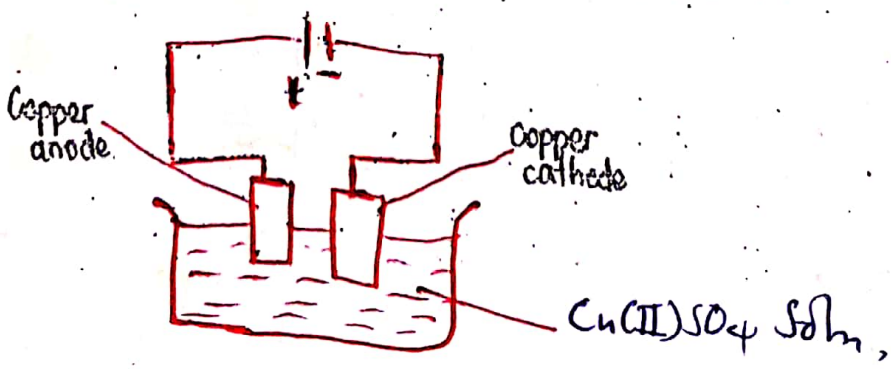
At the cathode:

The Cu^{2+} & H^+ ions migrate to the cathode but the Cu^{2+} ions formed on dissolution of the ions are the ones that are discharged at the cathode.

Observation:

The cathode increases in size as a reddish brown solid is deposited.

$Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$



NOTES;

1. The mass lost by ē anode is equal ẓ ē mass gained by ē cathode
2. The blue colour of copper(ii) sulphate soln is not discharged since copper(ii) ions discharged are formed as a result of the dissolution of the anode

(ii) Electrolysis of concentrated sodium chloride solution (Brine).

a. Using mercury cathode.

Ions present; Na^+, Cl^-, $\bar{O}H$, H^+ ions.

At the cathode Na^+ & H^+ ions migrate to the cathode but ē Na^+ ions are discharged in preferance to the H^+ ions bcse ēy are higher in ē electrochemical series. Eqn ō reaction. $Na^+_{(aq)} + e \rightarrow Na_{(s)}$ The sodium deposited reacts with ē mercury cathode to form sodium amalgam	At the anode Cl^- & $\bar{O}H$ ions migrate ẓ ē anode but ē Cl^- ions are discharged in preferance ẓ ē $\bar{O}H$ ions due ẓ ēr high concentration. Observation A greenish yellow gas is given off Eqn ō reaction. $2Cl^-_{(aq)} - 2e \rightarrow Cl_{2(g)}$

b. Using platinum cathode

At the cathode H^+ & Na^+ ions migrate to the cathode but the Na^+ ions are discharged in preferance. Eqn ō rtn. $Na^+_{(aq)} + e \rightarrow Na_{(s)}$ The Na formed immediately reacts with H_2O to form hydrogen gas. Eqn ō rtn. $2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$ Observation Bubbles of a colourless gas.	At the anode Cl^- & $\bar{O}H$ ions migrate ẓ ō anode but ē Cl^- ions are discharged in preference bcse ēy are in a higher concentration. Observation A greenish yellow gas is given off. Eqn ō rtn. $2Cl^-_{(aq)} - 2e \rightarrow Cl_{2(g)}$

APPLICATIONS OF ELECTROLYSIS.

1- Extraction of metals:

Metals that are on top on ē reactivity series are extracted by electrolysis. These metals include, potassium, sodium, calcium, magnesium & aluminium. The metals can be obtained by electrolysis of their molten salts eg magnesium can be got from molten magnesium chloride, sodium from molten sodium chloride, etc. The solution / molten salts ō ēse ions are used as electrolytes, when ē current is switched on, ō cations gain electrons at ē cathode.

2- Anodising aluminium:

This is the process ō coating objects made of aluminium with a very thin oxide layer to protect ēm from corrosion. This is carried out by electrolysis ō dilute sulphuric acid using ē aluminium object as ō anode.

The $\bar{O}H$ & SO_4^{2-} ions migrate to ē anode but ē $\bar{O}H$ ions are discharged in preferance because ēy are lower in the electrochemical series therefore oxygen gas is given off at the anode.

Equation of reaction;

$$4\bar{O}H_{(aq)} - 4e \longrightarrow 2H_2O_{(l)} + O_{2(g)}$$

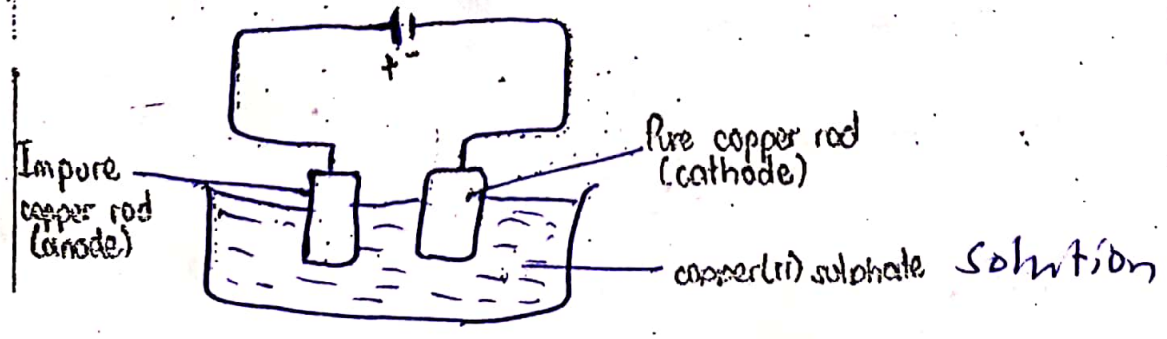
The oxygen gas ēn reacts with ē surface ō ē aluminium object & coats it with a thin invisible but protective coating ō aluminium oxide.

$$4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)}$$

3- Purification of copper:

Copper can be purified by electrolysis ō copper(II) sulphate solution using ē impure copper rod as ē anode & a pure copper rode ar ē cathode.

Experimental setup.



The anode dissolves into ē electrolyte to form copper(II) ions & impurities which collect at ē bottom of ē cell

Eqn for reaction at ē anode

$Cu_{(s)} - 2e \longrightarrow Cu^{2+}_{(aq)}$

The copper(II) ions migrate to ē cathode frm where ey gain electrons & are deposited as copper metal

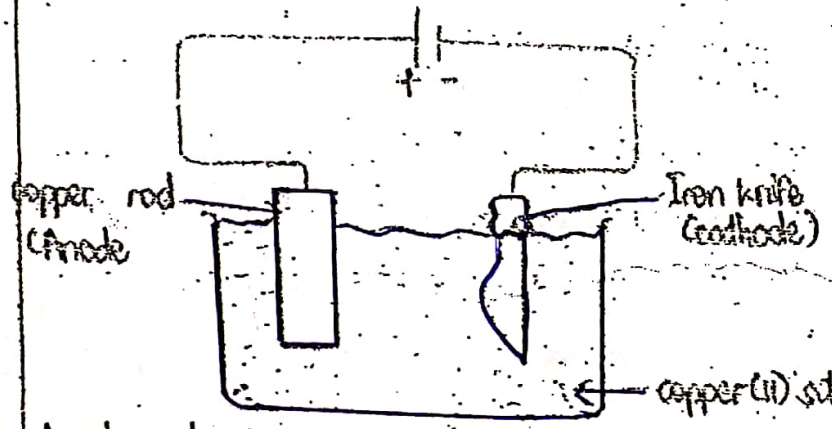
Eqn for reaction at ē cathode

$Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)}$

4. Electroplating metals (copper plating, galvanisation, etc)

This is ē coating ā objects/metals with a layer ō another metal by electrolysis. The object to be electroplated is used as ē cathode/ is made ē cathode will ē metal to be used is made ē anode eg when copper plating an iron knife, ē iron knife is used as ē cathode while ē anode is made ō copper and copper(II) sulphate solution is used as ē electrolyte

Experimental setup



Anode dissolves ē form copper(II) ions which migrate ā ē cathode. At ē cathode, ē copper(II) ions gain electrons & are discharged

$Cu^{2+}_{(aq)} + 2e \longrightarrow Cu_{(s)}$

Copper is deposited on ē knife as a reddish brown coating.

5. Manufacture of chlorine (Review preparation ō chlorine).

6. Manufacture of sodium hydroxide (See ē extraction ō sodium ahead).

Advantages of electroplating metals:

1. To improve on their appearance
2. To protect them from corrosion/rusting.
3. To improve on their tensile strength.

Questions:

1. Copper(II) sulphate solution was electrolysed using carbon electrodes.

a. State what was observed at the;

i. Anode

Bubbles of a colourless gas.

ii. Cathode.

A reddish brown solid is deposited.

b. Explain your answer in a(ii).

The copper(II) ions and hydrogen ions migrate to the cathode but the copper(II) ions are discharged in preferance because they are lower the electrochemical series.

$$Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$$

c. Write eqn for the reaction which took place at the anode

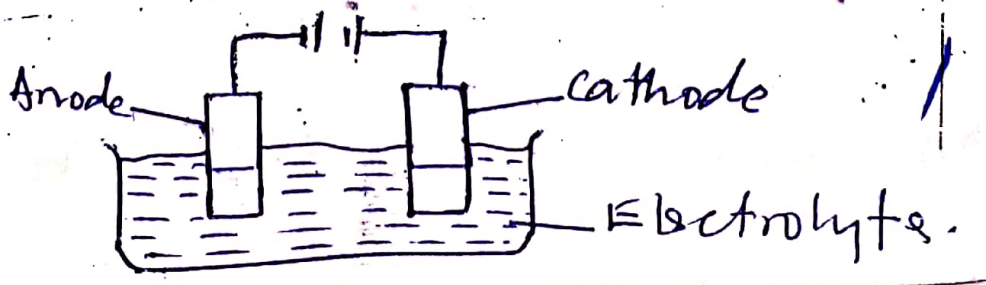
$$4OH^-_{(aq)} - 4e \longrightarrow 2H_2O_{(l)} + O_{2(g)}$$

Refs:

2000 Paper 2 (2)
2008 Paper 2 (4)
1998 Paper 2 (5)
1997 Paper 2 (14)

2000 Paper 2 No. 2:

The diagram in figure 1 shows an arrangement of the apparatus used for the purification of copper.



a) Name the substance used as:

(i) anode

Impure copper rod ✓

(ii) cathode

Pure copper rod ✓

b. Name the electrolyte

Copper(II) sulphate solution ✓

c. Write equation for the reaction that took place at:

(i) anode

Solution:

$Cu_{(s)} - 2e \rightarrow Cu^{2+}_{(aq)}$ ✓✗

ii. cathode

$Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$ ✓✗

2001 Paper 2 No. 4

The cell convention for an electrochemical cell is shown below.

$Zn_{(s)} / Zn^{2+}_{(aq)} // Pb^{2+}_{(aq)} / Pb_{(s)}$

(a) Name two substances that could be used as electrolytes.

Lead(II) nitrate solution

Zinc sulphate solution.

(b) State which one of the electrodes is the anode.

$Pb^{2+}_{(aq)}$

c) Write equation for the reaction at

(i) the anode.

$Pb^{2+}_{(aq)} + 2e \rightarrow Pb_{(s)}$

ii. the cathode.

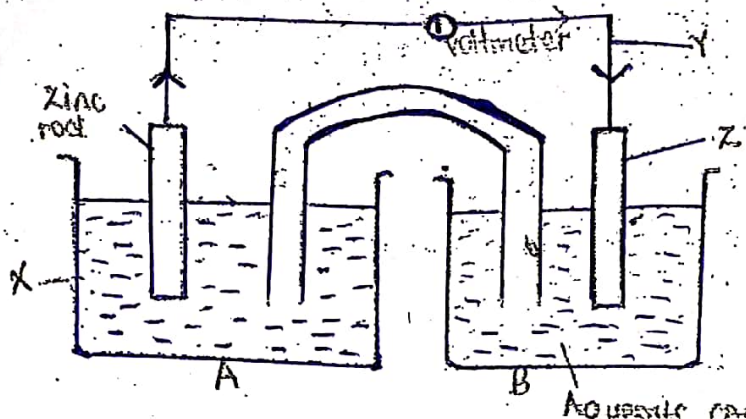
$Zn^{2+}_{(aq)} + 2e \rightarrow Zn_{(s)}$

d) Write equation for the overall cell reaction.

$Zn_{(s)} + Pb^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Pb_{(s)}$

1998 Paper 2 No. 5

Figure 2 below shows a simple voltaic cell.



a (i) Write equations for the reaction taking place at the:

cathode

$Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$

anode

$Zn^{2+}_{(aq)} + 2e \rightarrow Zn_{(s)}$

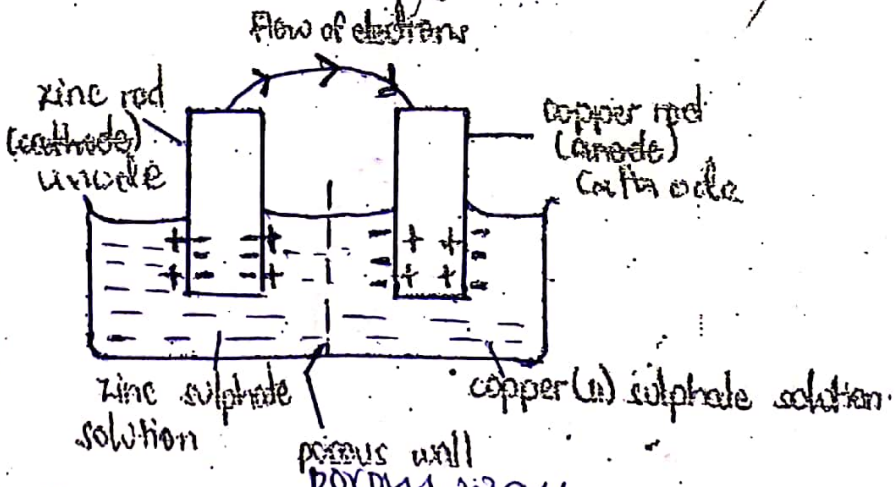
ii. Write the overall equations of the cell reaction.

$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+} + Cu_{(s)}$

b. Draw an arrow on the diagram to show the direction of flow of electrons.

1997 Paper 2 No. 14:

a. Draw a diagram of a Daniell cell consisting of a zinc rod dipped in zinc sulphate and a copper rod dipped in copper sulphate solution, the solutions separated by a porous wall; and the rods connected by a wire.



porous wall.

b. Indicate

i. the charges on each electrode

ii. the direction of electron movement in the wire.

c) Write,

i) equations for reactions at each electrode.

$Zn^{2+}_{(aq)} + 2e \rightarrow Zn_{(s)}$ (for cathode)

$Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$ (for anode)

ii) an equation for the overall reaction.

$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$