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ELECTROCHEMISTRY

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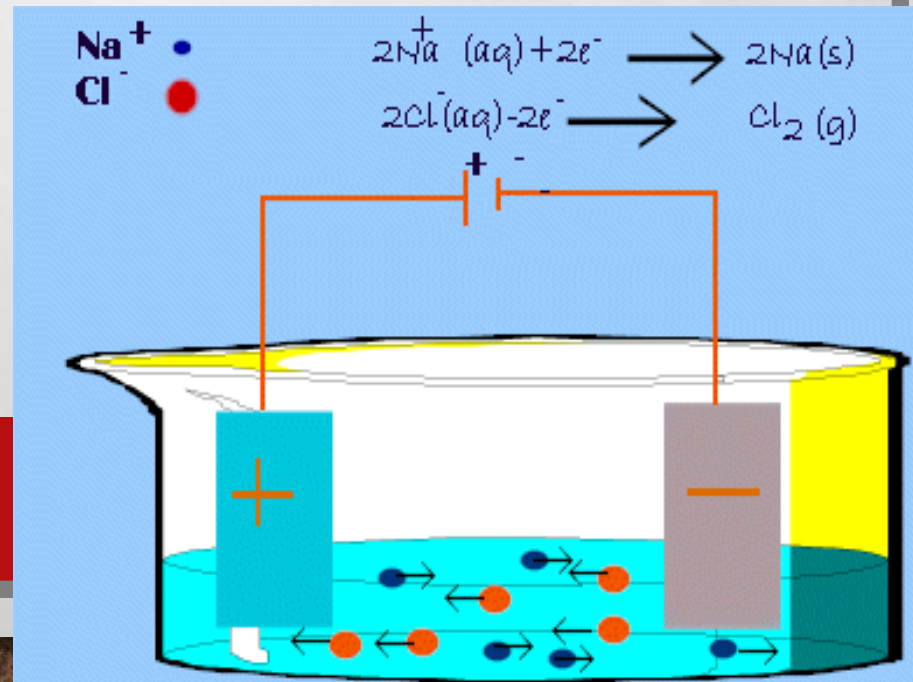
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Medical Chemistry



WHAT IS ELECTROCHEMISTRY

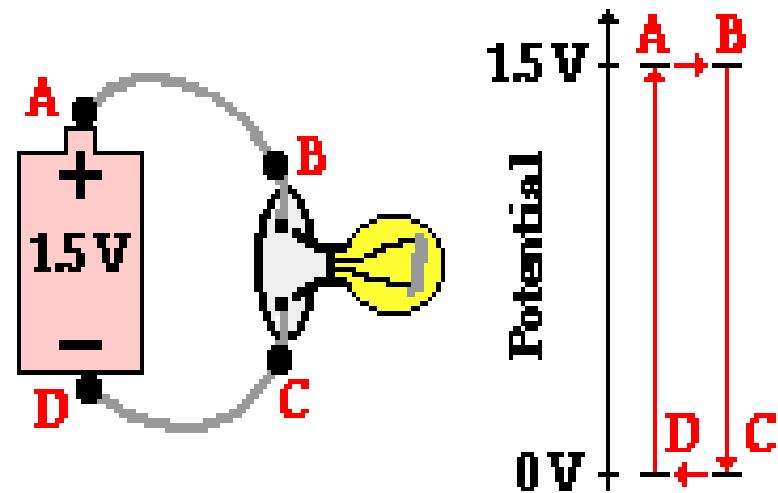
- ELECTROCHEMISTRY IS THE SCIENCE THAT UNITES ELECTRICITY AND CHEMISTRY. IT IS THE STUDY OF THE TRANSFER OF ELECTRONS. IF A CHEMICAL REACTION IS DRIVEN BY AN EXTERNAL APPLIED VOLTAGE, AS IN ELECTROLYSIS, OR IF A VOLTAGE IS CREATED BY A CHEMICAL REACTION, AS IN A BATTERY, IT IS AN *ELECTROCHEMICAL* REACTION.



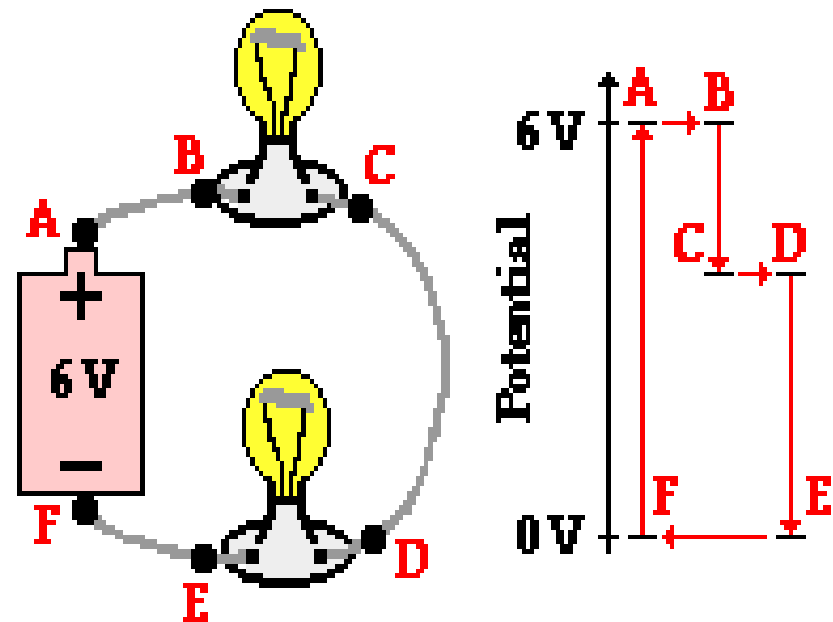
WHAT IS VOLTAGE/CHARGE/CURRENT

- AN ELECTRIC POTENTIAL DIFFERENCE IS CALLED AS VOLTAGE. THE SI UNIT OF VOLTAGE IS VOLTS.

Circuit A



Circuit B



- ELECTRIC CHARGE IS THAT WHICH CAUSES ELECTRONS AND IONS TO ATTRACT EACH OTHER, AND REPEL THE PARTICLES OF THE SAME KIND. COULOMB IS THE UNIT USED TO MEASURE ELECTRIC CHARGE.

- CURRENT IS THE FLOW OF CHARGE PER UNIT OF TIME. AMPERE IS THE SI UNIT OF ELECTRIC CURRENT, EQUAL TO 1C/S .

- ONE JOULE OF ENERGY IS USED WHEN 1C MOVES ACROSS A POTENTIAL OF 1V .

- ENERGY (J) = POTENTIAL (V) X CHARGE (C)

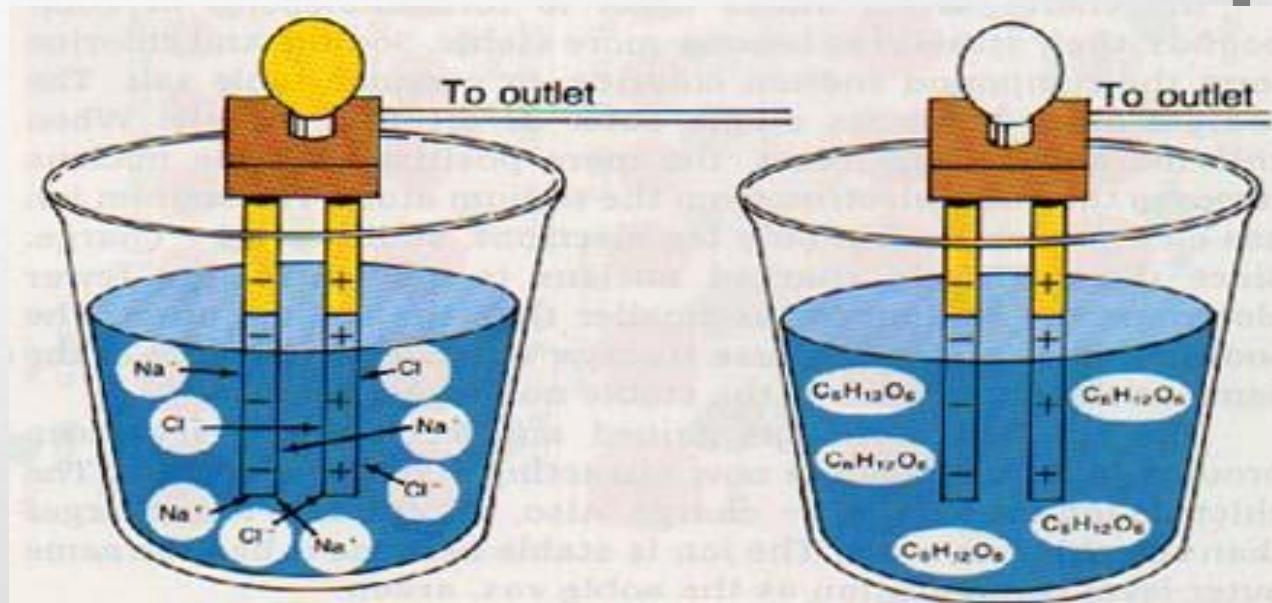
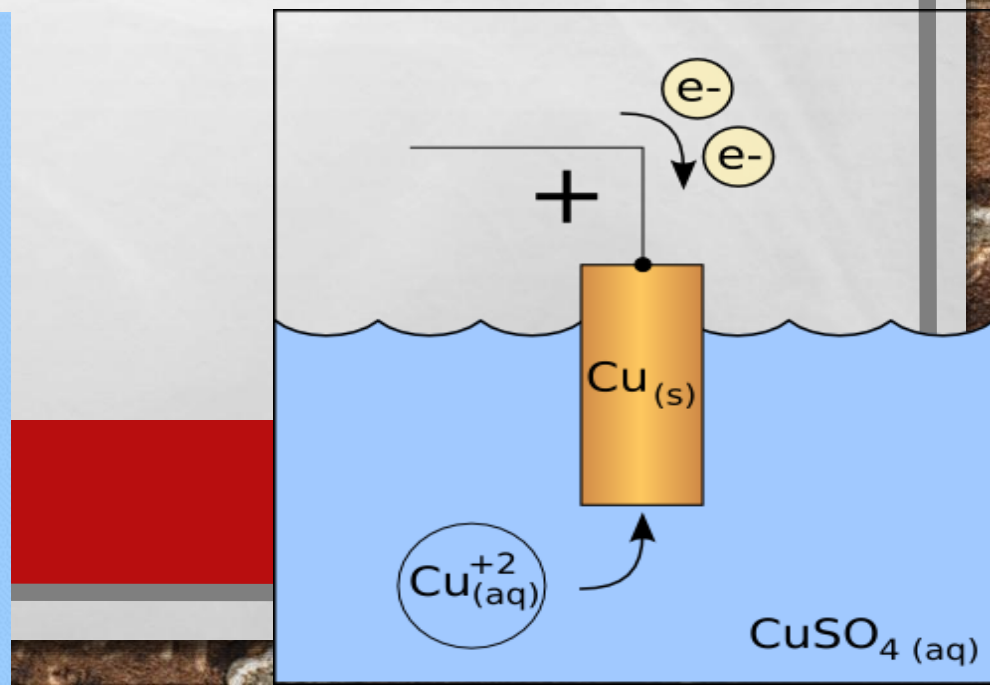
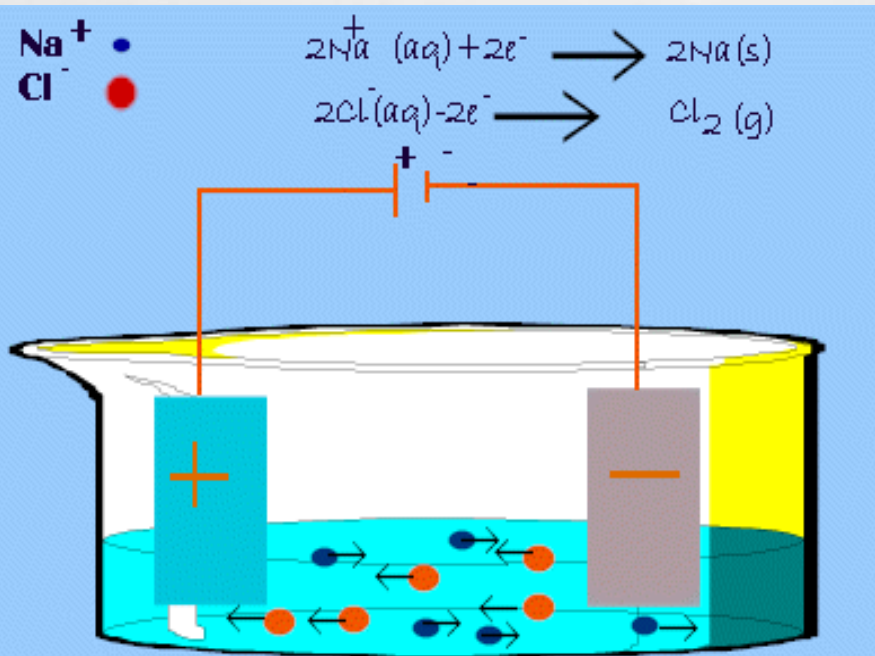


FIGURE 10-10. When salt dissolves, the ions are free to move. Thus, salt conducts an electric current. A molecular substance such as sugar does not conduct since there are no ions in solution.

CATHODE AND REDUCTION

- IF THE ELECTRONIC CONDUCTOR GIVES UP ELECTRONS TO THE IONIC CONDUCTOR THEN THE ELECTRODE IS CALLED AS A CATHODE AND THE REACTION IS CALLED AS A CATHODIC REACTION. THE FLOW OF ELECTRONS AND IONS AT A CATHODE IS SHOWN IN THE FIGURE BELOW. THE COPPER STRIP IS THE ELECTRONIC CONDUCTOR THAT GIVES UP ELECTRONS TO THE IONIC CONDUCTOR WHICH IS THE COPPER (II) SULFATE SOLUTION.

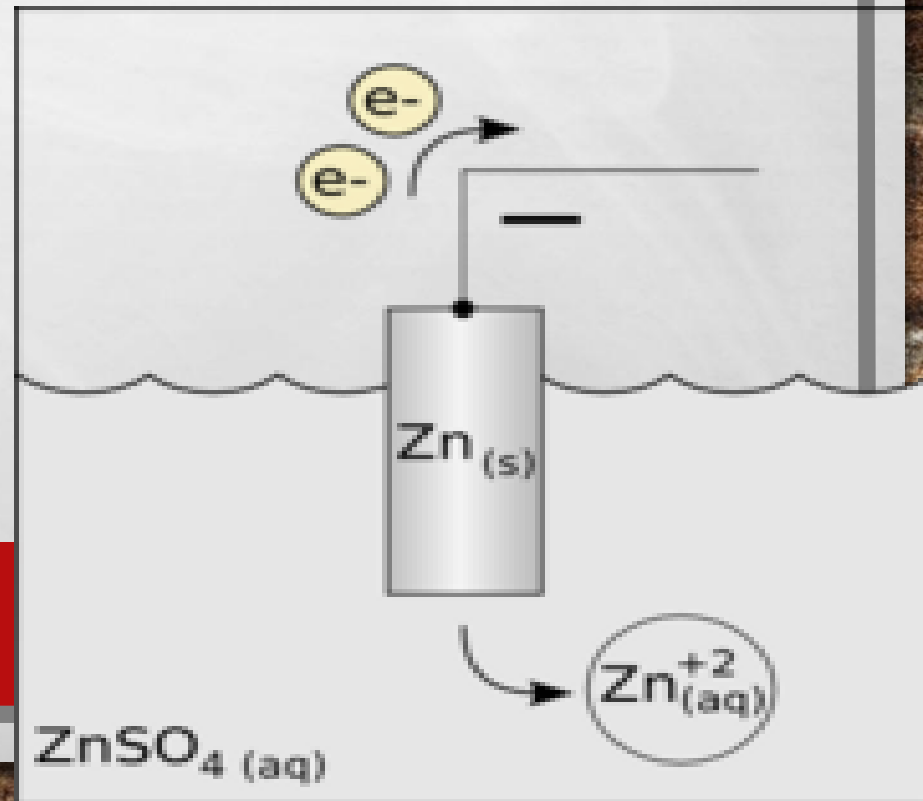


- THE CHEMISTRY THAT TAKES PLACE IN THE CATHODE IS REDUCTION. $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Cu}(\text{s})$
- DURING REDUCTION COPPER IS DEPOSITED ON THE METAL STRIP. SOLID METAL APPEARS AS A PRODUCT.
- THIS PROCESS OF DEPOSITING A METAL ON A CONDUCTIVE SURFACE IS USED IN THE ELECTROPLATING OF SILVER INTO JEWELRY AND FLATWARE.



ANODE AND OXIDATION

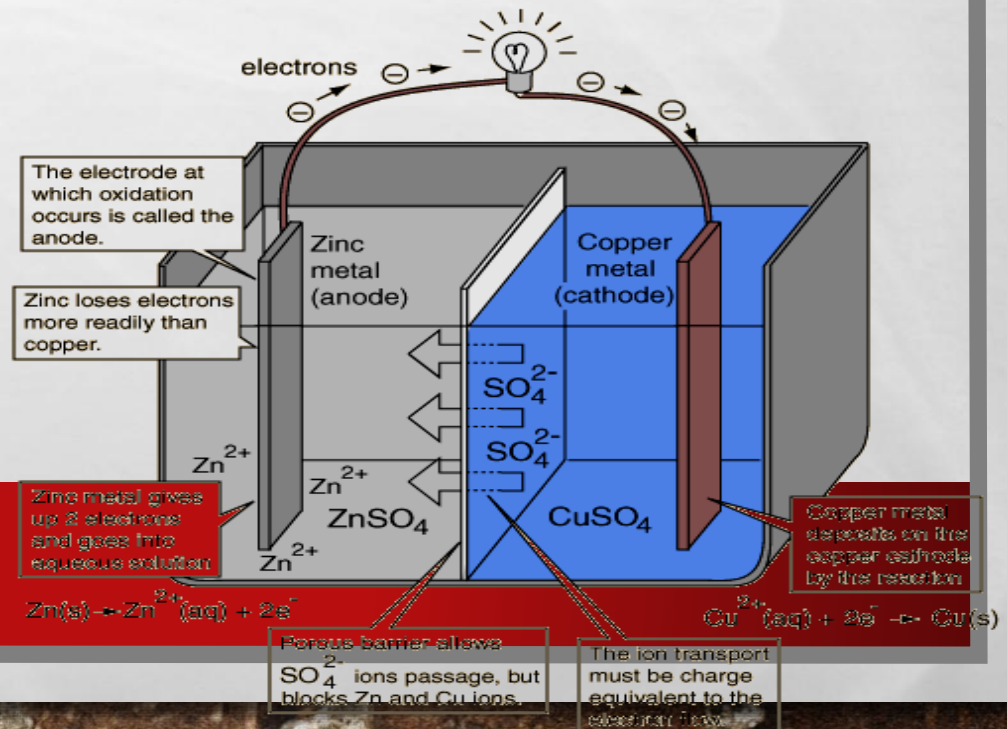
- AN ANODE IS AN ELECTRODE AT WHICH ELECTRONS ARE GENERATED. A REACTION OCCURRING AT THE ANODE IS ANODIC REACTION. ELECTRONS FLOW IN THE OPPOSITE DIRECTION TO THE POSITIVE ELECTRIC CURRENT .THE FIGURE BELOW SHOWS THE REACTION OF ZINC ATOMS TO FORM ZINC IONS.



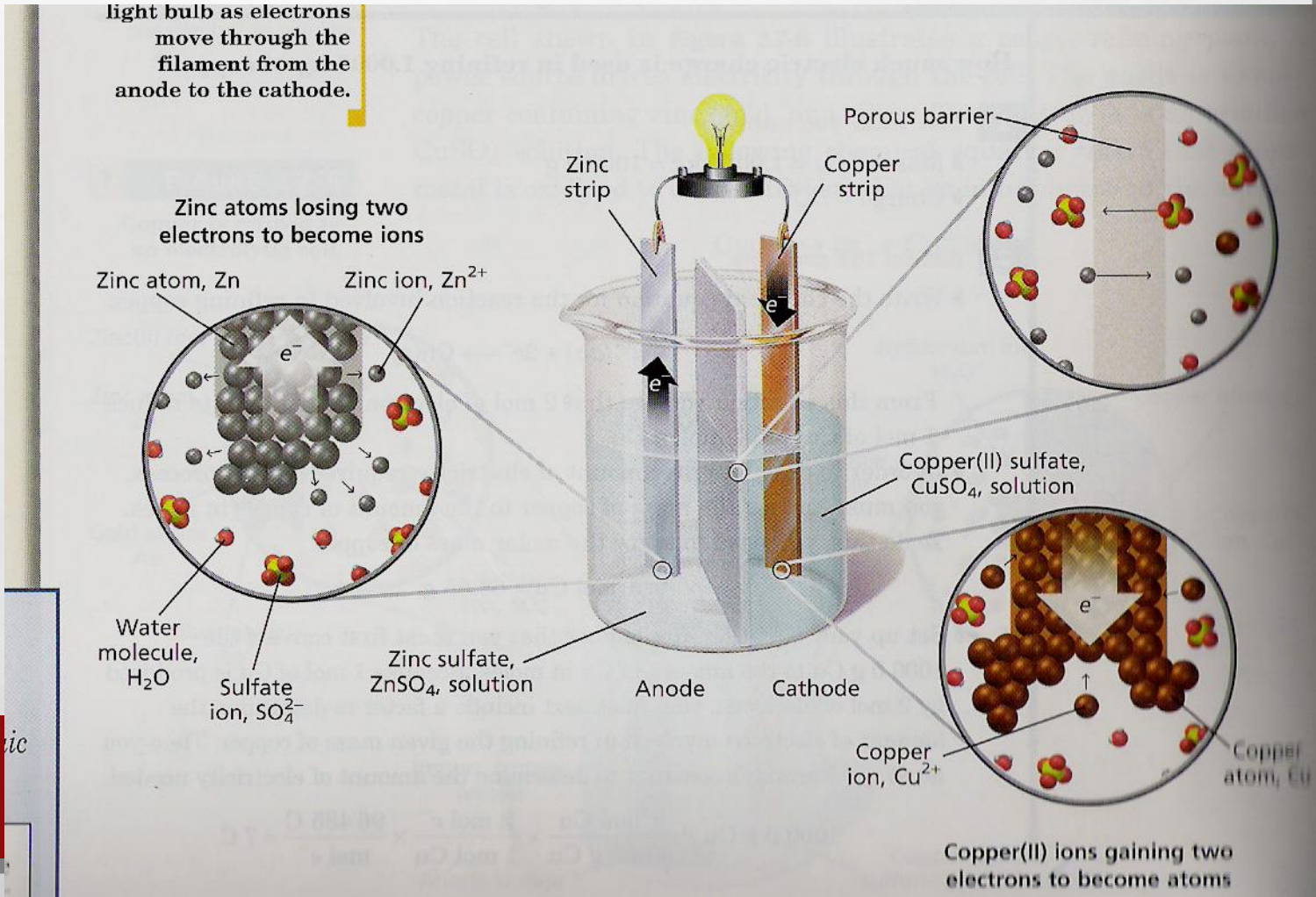
- A REACTION OCCURRING AT AN ANODE IS AN ANODIC REACTION, AND THE RESULTING CHEMICAL CHANGE IS CALLED OXIDATION. ZINC ATOMS ARE OXIDIZED AS THEY LOSE ELECTRONS AT THE ANODE. THE METAL STRIP DISSOLVES AS THE REACTION PROCEEDS.
- REDUCTION REACTIONS ALWAYS OCCUR WITH OXIDATION REACTIONS. THE ELECTRONS USED IN REDUCTION MUST COME FROM AN OXIDATION REACTION. THE OVERALL REACTION IS CALLED AN OXIDATION REDUCTION REACTION, OR REDOX REACTION.

ELECTROCHEMICAL CELL

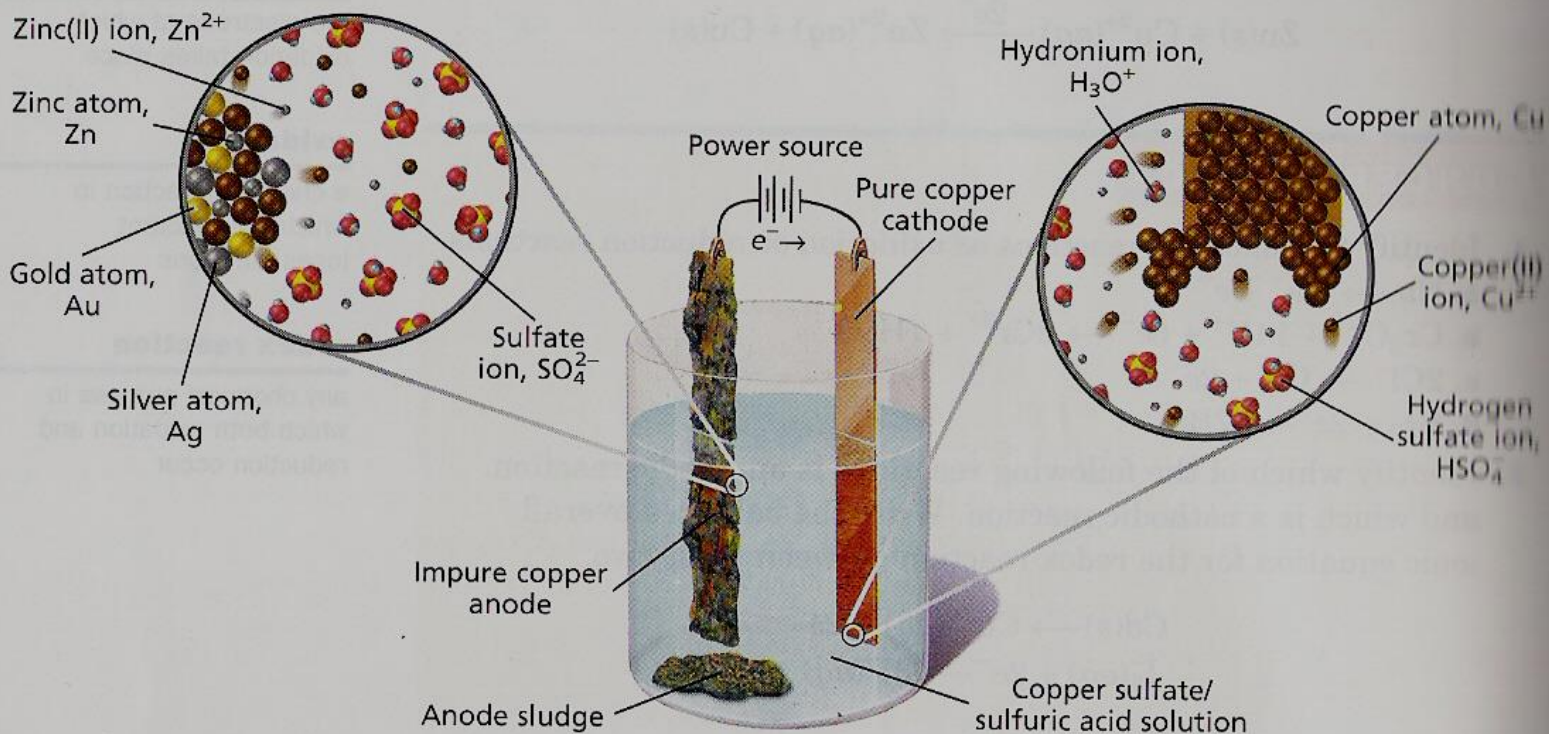
- ELECTRONS PRODUCED BY AN ANODE MUST BE CONSUMED BY A CATHODIC REACTION. THEREFORE AN ANODE MUST BE PAIRED WITH A CATHODE. THE TWO ELECTRODES COMBINE IN AN ELECTROCHEMICAL CELL.
- AN ELECTROCHEMICAL CELL CAN BE CREATED BY PLACING METALLIC ELECTRODES INTO AN ELECTROLYTE WHERE A CHEMICAL REACTION EITHER USES OR GENERATES AN ELECTRIC CURRENT.



• ELECTROCHEMICAL CELLS WHICH GENERATE AN ELECTRIC CURRENT (IN WHICH THE 2 ELECTRODE REACTIONS OCCUR SPONTANEOUSLY) ARE CALLED VOLTAIC CELLS OR GALVANIC CELLS, AND COMMON BATTERIES CONSIST OF ONE OR MORE SUCH CELLS.

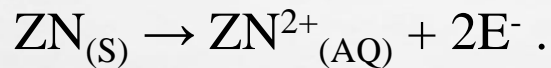


- IN OTHER ELECTROCHEMICAL CELLS AN EXTERNALLY SUPPLIED ELECTRIC CURRENT IS USED TO DRIVE A CHEMICAL REACTION WHICH WOULD NOT OCCUR SPONTANEOUSLY. SUCH CELLS ARE CALLED ELECTROLYTIC CELLS.

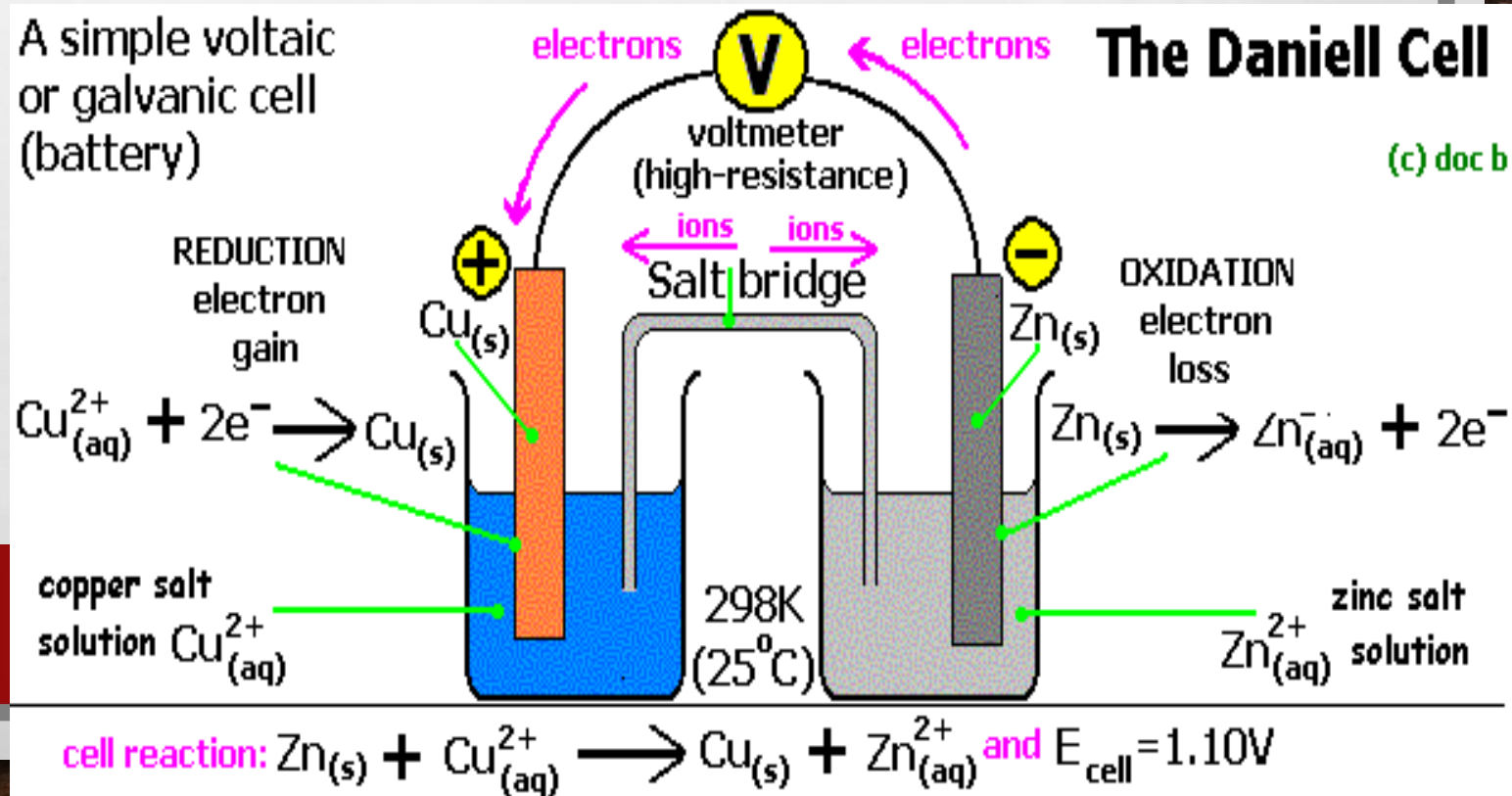


DANIELL CELL

- IN THE DANIELL CELL, COPPER AND ZINC ELECTRODES ARE IMMERSSED IN A SOLUTION OF COPPER (II) SULFATE AND ZINC SULFATE RESPECTIVELY. AT THE ANODE, ZINC IS OXIDIZED PER THE FOLLOWING HALF REACTION:



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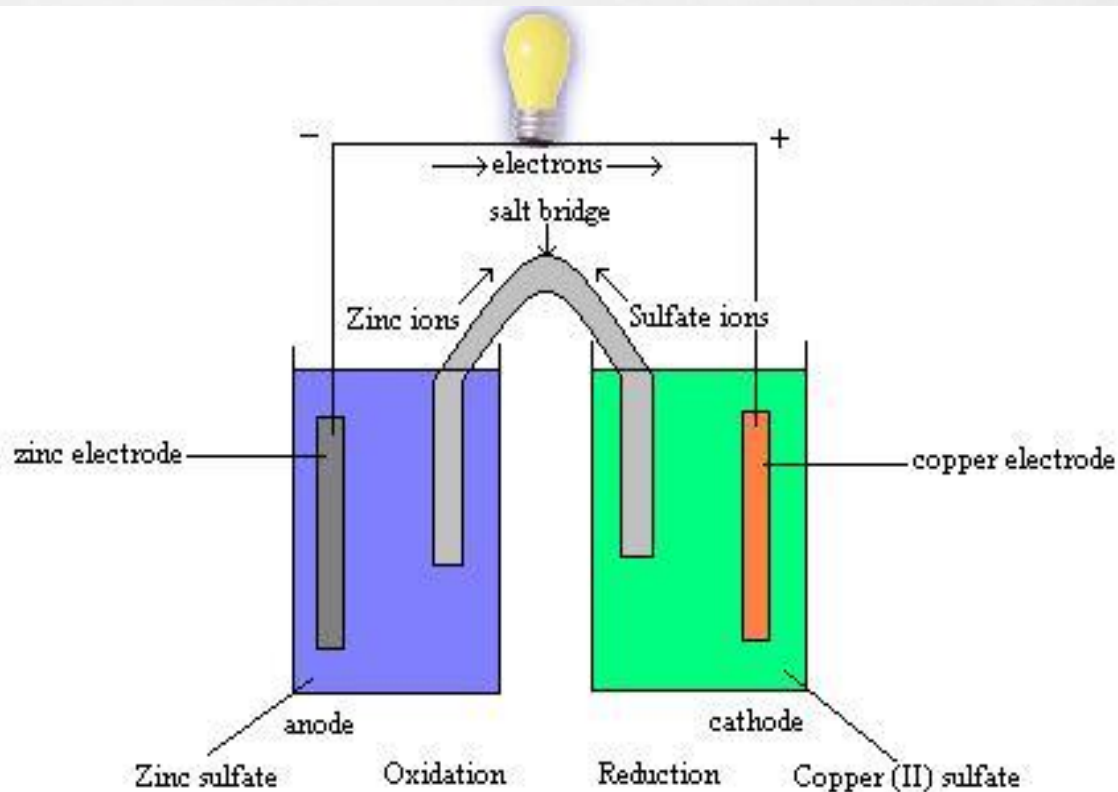


- AT THE CATHODE, COPPER IS REDUCED PER THE FOLLOWING REACTION:

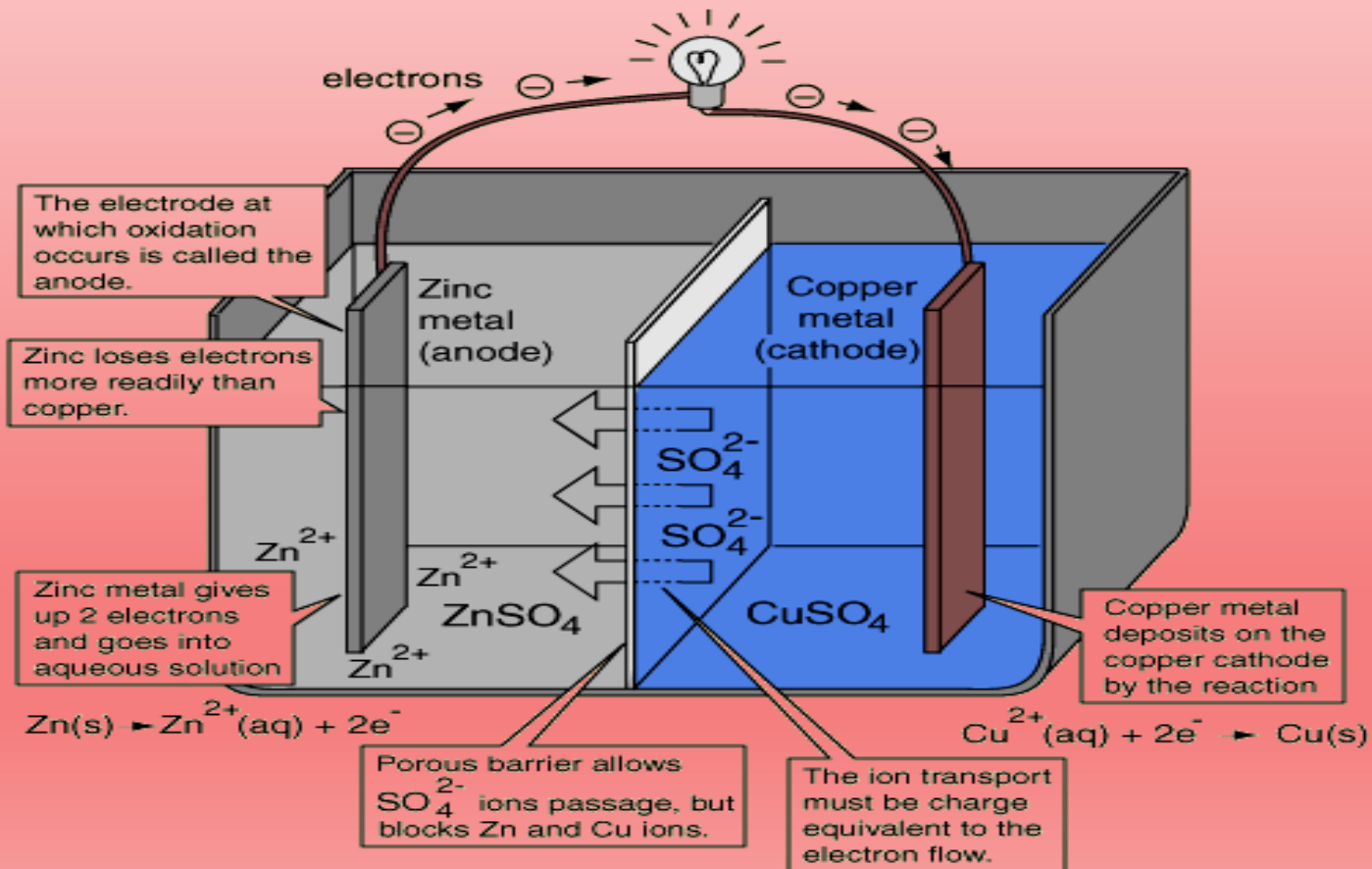


- IN THE DANIELL CELL A WIRE AND LIGHT BULB MAY CONNECT THE TWO ELECTRODES. ELECTRONS THAT ARE “PULLED” FROM THE ZINC TRAVEL THROUGH THE WIRE, WHICH MUST BE A NON-REACTIVE CONDUCTOR, PROVIDING AN ELECTRICAL CURRENT THAT ILLUMINATES THE BULB.

- IN SUCH A CELL, THE SULFATE IONS PLAY AN IMPORTANT ROLE. HAVING A **NEGATIVE CHARGE**, THESE ANIONS BUILD UP AROUND THE ANODE TO MAINTAIN A NEUTRAL CHARGE. AT THE CATHODE THE COPPER (II) CATIONS (**POSITIVELY CHARGED**) ACCUMULATE TO MAINTAIN THIS NEUTRAL CHARGE. THESE TWO PROCESSES CAUSE COPPER SOLID TO ACCUMULATE AT THE CATHODE AND THE ZINC ELECTRODE TO "DISSOLVE" INTO THE SOLUTION.



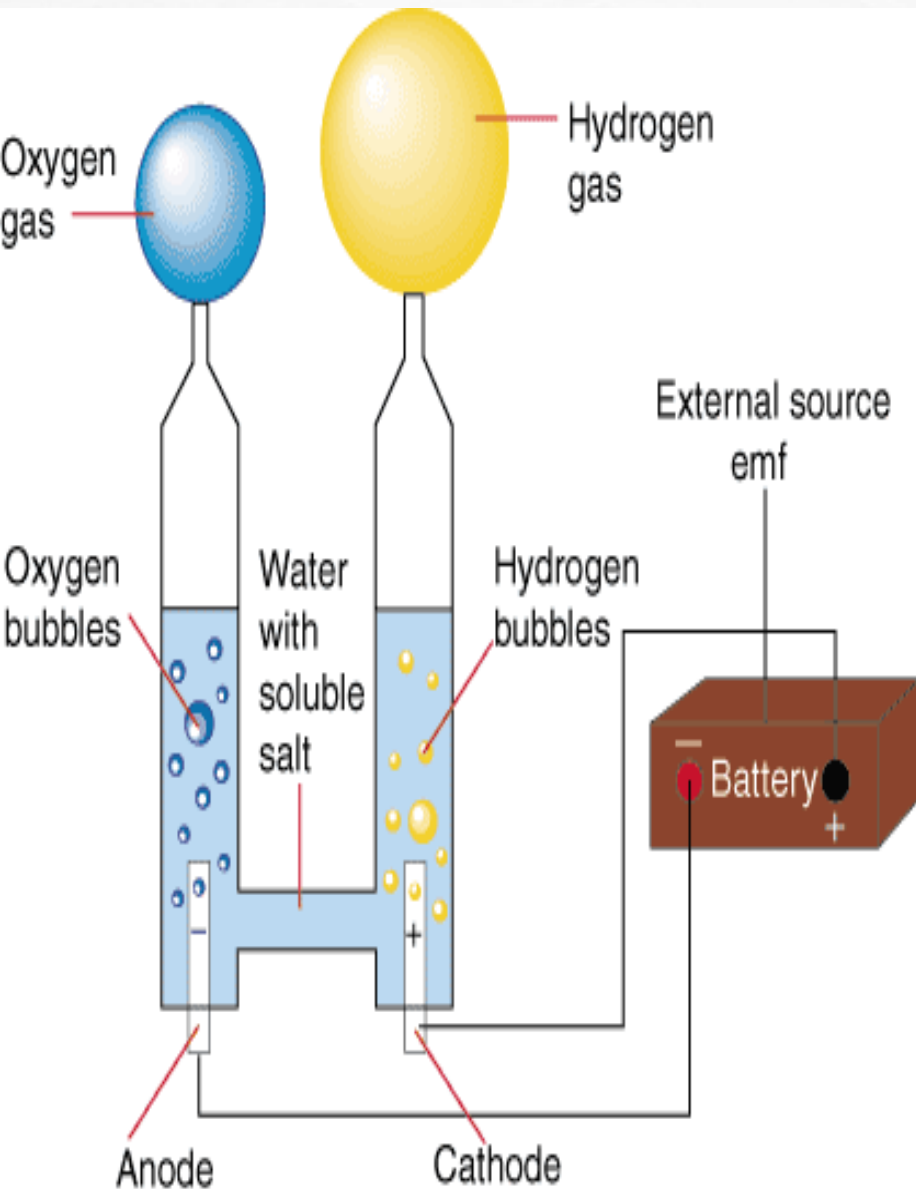
Since neither half reaction will occur independently of the other, the two half cells must be connected in a way that will allow ions to move freely between them. A porous barrier or ceramic disk may be used to separate the two solutions while allowing ion flow. When the half cells are placed in two entirely different and separate containers, a salt bridge is often used to connect the two cells.



ELECTROLYTIC CELL

- **ELECTROLYTIC CELLS** ARE CHEMICAL CELLS COMPOSED OF A VESSEL USED TO DO ELECTROLYSIS, CONTAINING ELECTROLYTE, USUALLY A SOLUTION OF WATER OR OTHER SOLVENTS CAPABLE OF DISSOLVING VARIOUS IONS INTO SOLUTION, AND A CATHODE AND ANODE. THE ELECTROLYTE IN THE CELL IS INERT UNLESS DRIVEN BY EXTERNAL VOLTAGE INTO A REDOX REACTION WITH THE ANODE AND CATHODE.

ELECTROLYSIS OF WATER



By using an electrolytic cell composed of water, two electrodes and an external source emf one can reverse the direction of the process and create hydrogen and oxygen from water and electricity. The reaction at the anode is the oxidation of water to O_2 and acid while the cathode reduces water into H_2 and hydroxide ion. That reaction has a potential of -2.06 V at standard conditions.

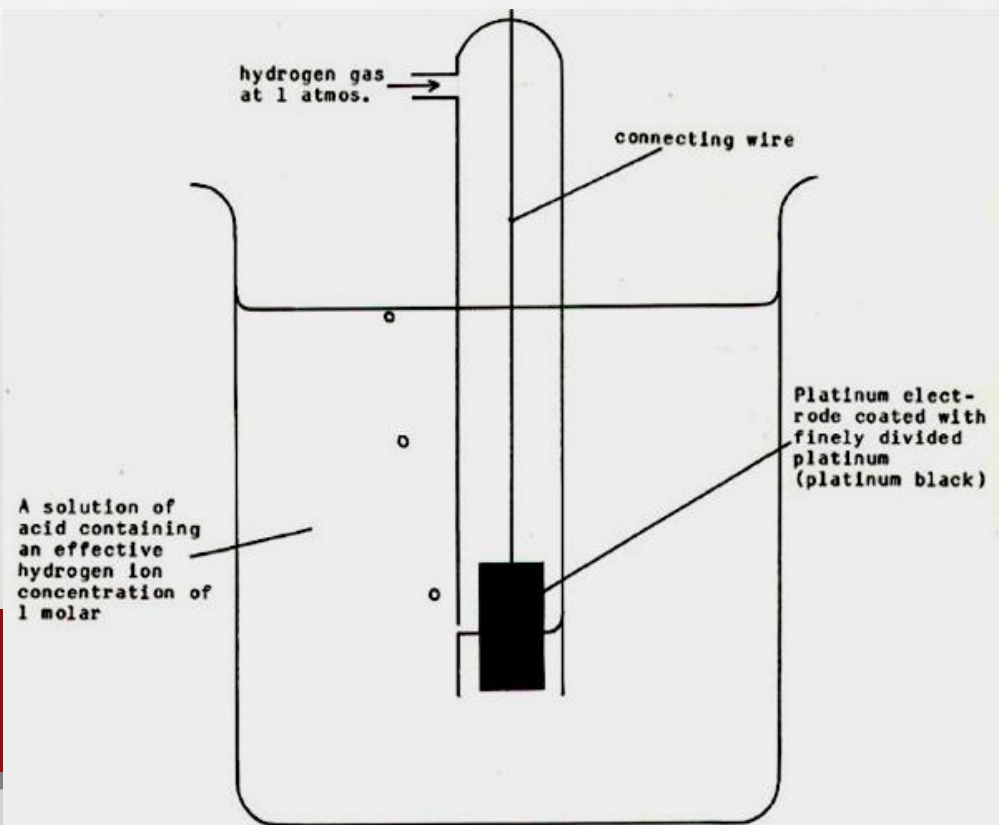
HOW DO BATTERIES WORK

- ELECTROCHEMICAL POWER SOURCES CAN BE DIVIDED INTO PRIMARY CELLS AND SECONDARY CELLS.
- PRIMARY CELLS FUNCTION ONLY AS GALVANIC CELLS. A PRIMARY CELL CAN EITHER BE A FUEL CELL OR A BATTERY. A PRIMARY BATTERY IS THROWN AWAY WHEN ITS ACTIVE MATERIALS ARE USED UP. FAMILIAR PRIMARY CELLS ARE IN FLASHLIGHTS , WATCHES, TOYS AND RADIO.
- SECONDARY CELLS INCLUDE STORAGE CELLS, ACCUMULATORS, OR RECHARGEABLE BATTERIES . SECONDARY CELLS ARE AN ELECTROCHEMICAL CELLS THAT CAN ACT AS A GALVANIC CELL OR, ON RECHARGE, AS AN ELECTROLYTIC CELL. SECONDARY CELLS ARE IN IGNITION, STARTING IN AUTOMOBILES (**CAR BATTERIES**) AND ENGINE GENERATOR SETS.

EQUILIBRIUM CELL VOLTAGE

- THE VOLTAGE OF A CELL AS MEASURED BY A VOLTMETER WHEN NO CURRENT IS FLOWING. ELECTROCHEMICAL VOLTAGE IS GIVEN AS ΔE .

- CELL POTENTIALS ARE MEASURED USING STANDARD HYDROGEN ELECTRODE (SHE).
- SHE IS MADE UP OF AN AQUEOUS SOLUTION OF A STRONG ACID IN WHICH THE EFFECTIVE H_3O^+ CONCENTRATION IS 1.000M. A PLATINUM ELECTRODE IS DIPPED INTO THIS SOLUTION AND A STREAM OF HYDROGEN GAS AT A PRESSURE OF 1 ATM BUBBLES IN .



STANDARD ELECTRODE POTENTIAL

- IT IS THE MEASURED VOLTAGE WHEN AN ELECTRODE UNDER STANDARD CONDITIONS OF TEMPERATURE, PRESSURE, AND CONCENTRATION IS PAIRED WITH A STANDARD HYDROGEN ELECTRODE IN AN EQUILIBRIUM CELL.
- STANDARD ELECTRODE POTENTIALS ARE USUALLY GIVEN IN A TABULAR FORM AND ARE CALLED AS THE ELECTROCHEMICAL SERIES.

Std hydrogen
Electrode

