

Electrochemistry

Wed 10:00am – 12:30pm

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03.15. Wed

- Attendance Check
- 03.08. Wed Introduction Review
- Survey Review
- Electrochemistry Preface

23.03.08. Student Activity

Q2. How “Climate change” is related to global carbon dioxide reduction efforts?

👉 0308_lecture1.pptx slide #10, “Cause and Effect of Climate Change”

- “Climate change” is the reason of the “global carbon dioxide reduction efforts”



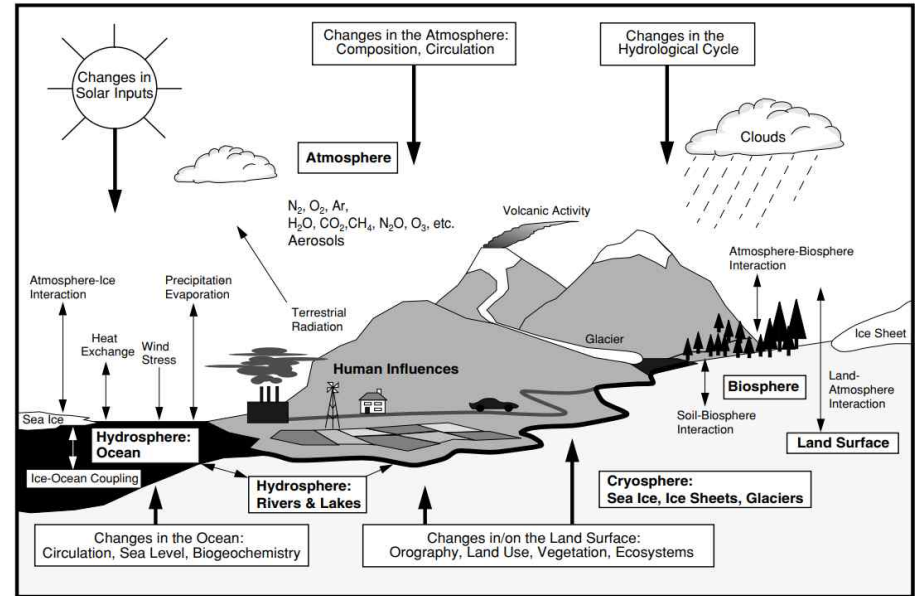
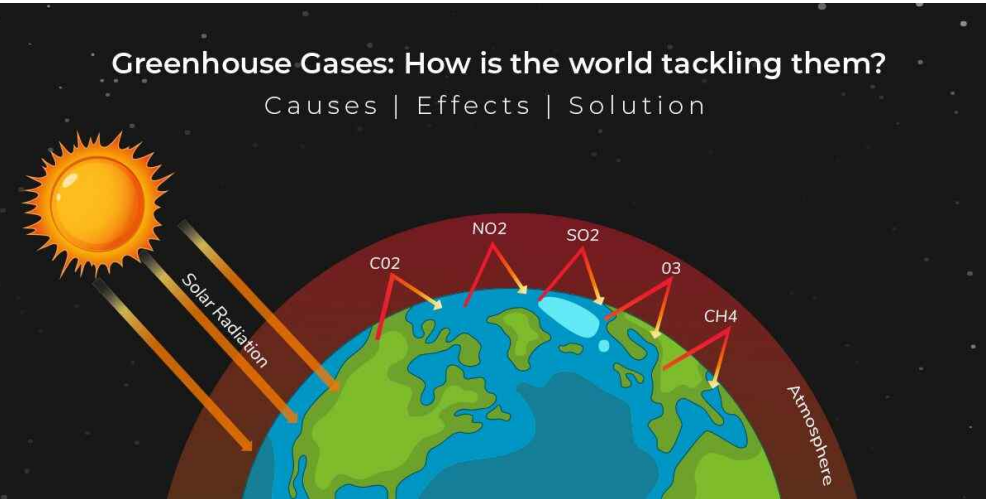
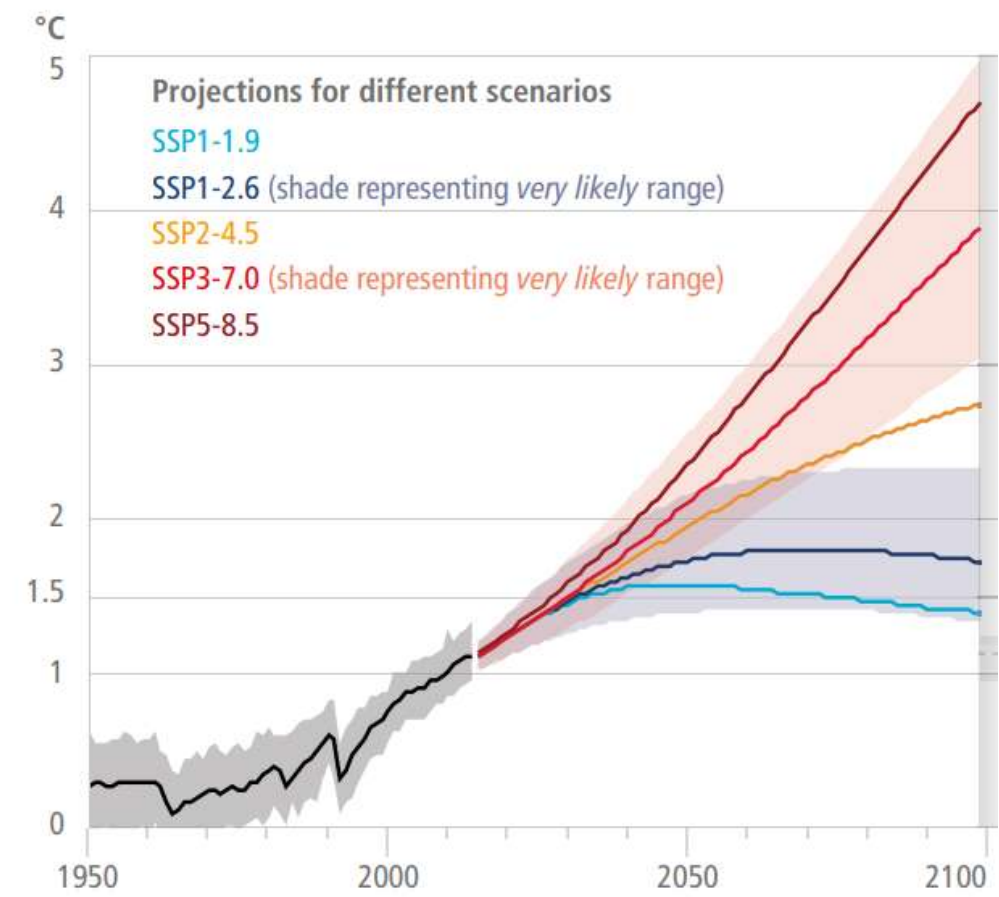


Figure 1.1: Schematic view of the components of the global climate system (bold), their processes and interactions (thin arrows) and some aspects that may change (bold arrows).



(a) Global surface temperature change
Increase relative to the period 1850–1900 **IPCC 6th Report**



[What is Greenhouse Effect & Its Gases, Causes, Solution? | Prana Air](https://www.pranaair.com/blog/what-is-greenhouse-effect-its-gases-causes-solution/)

<https://www.pranaair.com/blog/what-is-greenhouse-effect-its-gases-causes-solution/>



United Nations
Climate Change



Climate change is expected to exacerbate health problems that already pose a major burden to vulnerable populations

The report shares at least five major insights:

1. **Certain groups have higher susceptibility to climate-sensitive health impacts** owing to their age (children and elderly), gender (particularly pregnant women), social marginalization (associated in some areas with indigenous populations, poverty or migration status), or other health conditions like HIV. The socioeconomic costs of health problems caused by climate change are considerable.
2. **Many infectious diseases, including water-borne ones, are highly sensitive to climate conditions.** Figure 1 illustrates the correlation between temperature and diarrhea. A main concern in both developed and developing countries was the increase in and increased geographical spread of diarrhoeal diseases, the report found.

<https://unfccc.int/news/climate-change-impacts-human-health>

1-1. 용어정리

- **IPCC** (Intergovernmental Panel on Climate Change)

“We advance human dignity and protect the planet through our work on transformative issues critical to humanity’s shared future. We strive to defend progress already made and unlock the collective promise of the Sustainable Development Goals (SDGs) across interconnected issues, including climate, health, gender equality, human rights, data and technology, peace, and humanitarian response.

As a strategic partner of the United Nations, we bring together fresh thinking and diverse voices around innovative ideas to drive progress and tackle problems. We build communities of support and nurture initiatives to advance the dignity and well-being of people and planet.”

<https://unfoundation.org/what-we-do/>

SUSTAINABLE DEVELOPMENT GOALS



<https://sdgs.un.org/goals>



United Nations

Climate Action

Home Raising Ambition » The Science » Actors, Actions, Solutions » Act Now
UN and Climate Change » Press Materials Digital Library » Recovering Better Renewable Energy
Loss and Damage

now • Starting now • Starting now • Starting now • Starting now

Net Zero
#ItsPossible

▶ 0:23 / 0:23



For a livable climate: Net-zero commitments must be backed by credible action

What is net zero?

Put simply, net zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance.

Why is net zero important?

The science shows clearly that in order to avert the worst impacts of climate change and preserve a livable planet, global temperature increase needs to be limited to 1.5°C above pre-industrial levels. Currently, the

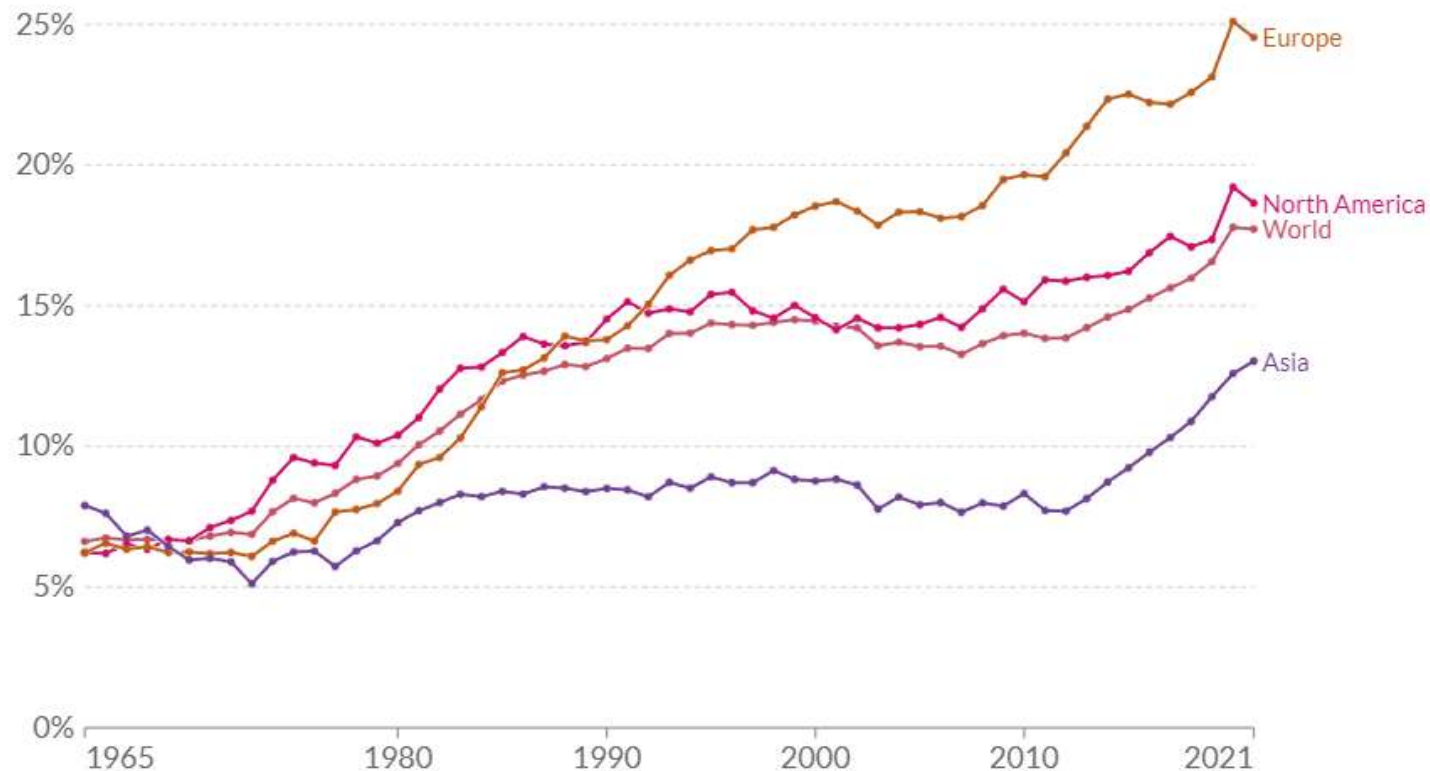
[Net Zero Coalition | United Nations](https://www.un.org/en/climatechange/net-zero-coalition)
<https://www.un.org/en/climatechange/net-zero-coalition>

Share of primary energy from low-carbon sources

Our World
in Data

Low-carbon energy is defined as the sum of nuclear and renewable sources. Renewable sources include hydropower, solar, wind, geothermal, wave and tidal and bioenergy. Traditional biofuels are not included.

+ Add country



Source: Our World in Data based on BP Statistical Review of World Energy (2022)

OurWorldInData.org/energy • CC BY

Note: Primary energy is calculated using the 'substitution method', which accounts for the energy production inefficiencies of fossil fuels.

▶ 1965 2021

CHART

MAP

TABLE

SOURCES

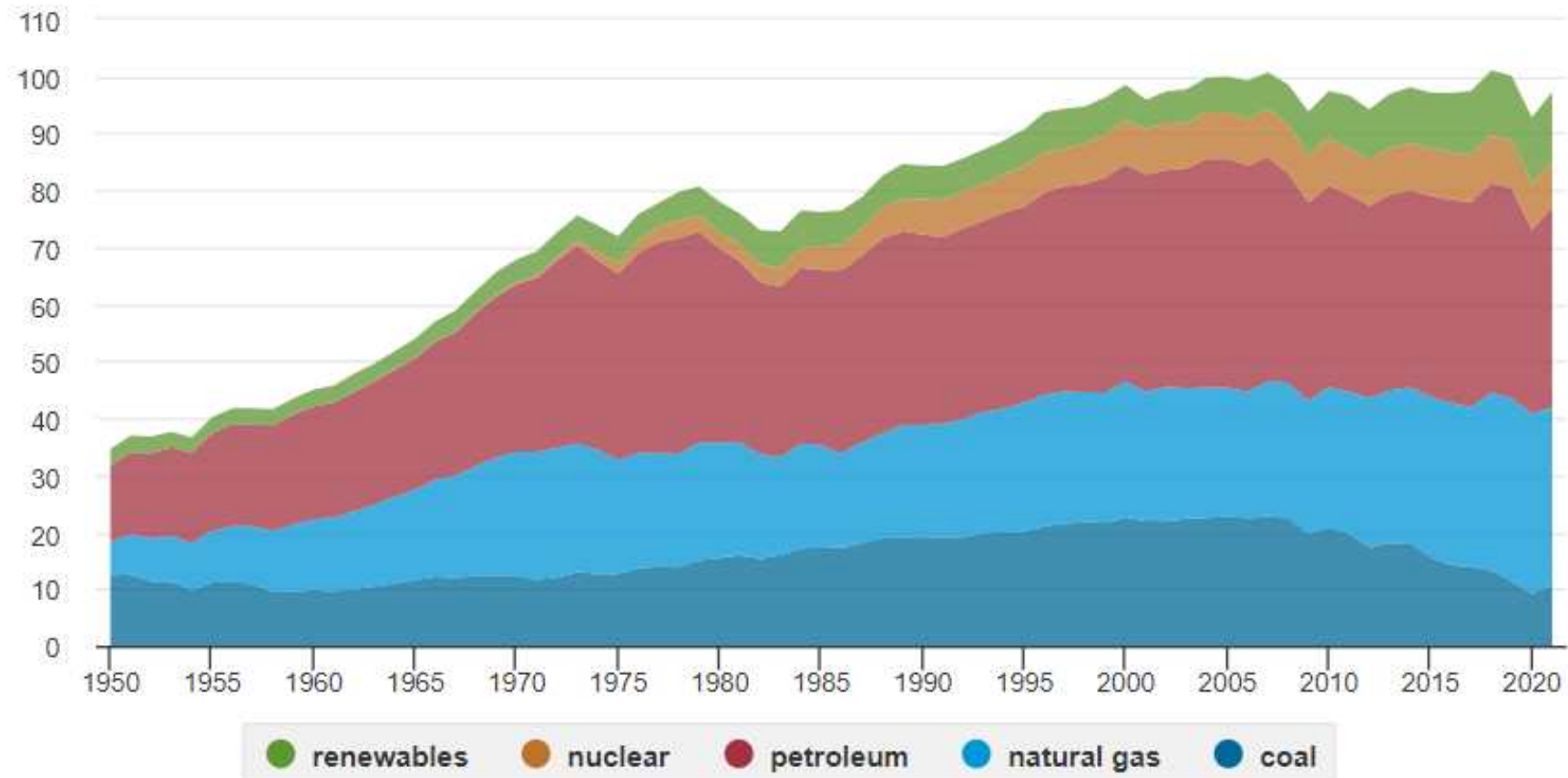
DOWNLOAD



U.S. primary energy consumption by major sources, 1950-2021



quadrillion British thermal units



Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3, April 2022, preliminary data for 2021



Note: Petroleum is petroleum products excluding biofuels, which are included in renewables.

NetZero Effort Example – Solar Power

- How a Solar Cell Works

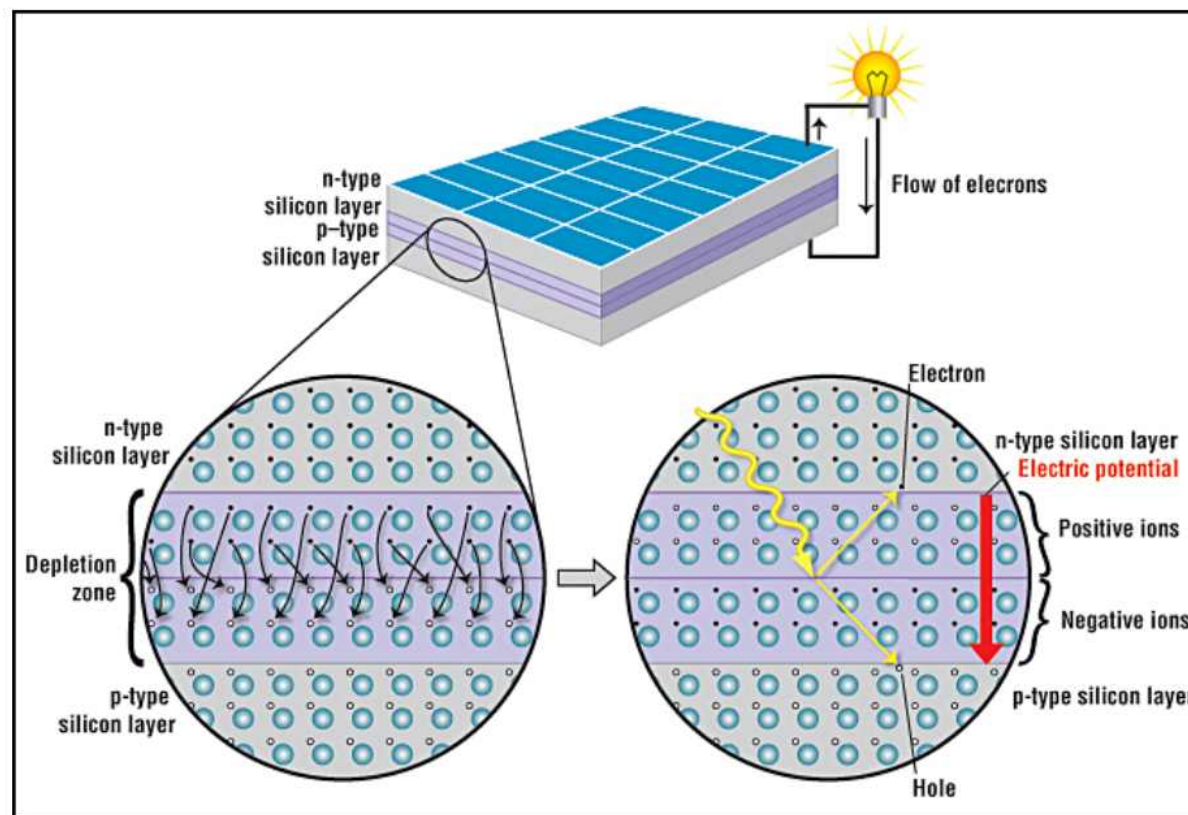
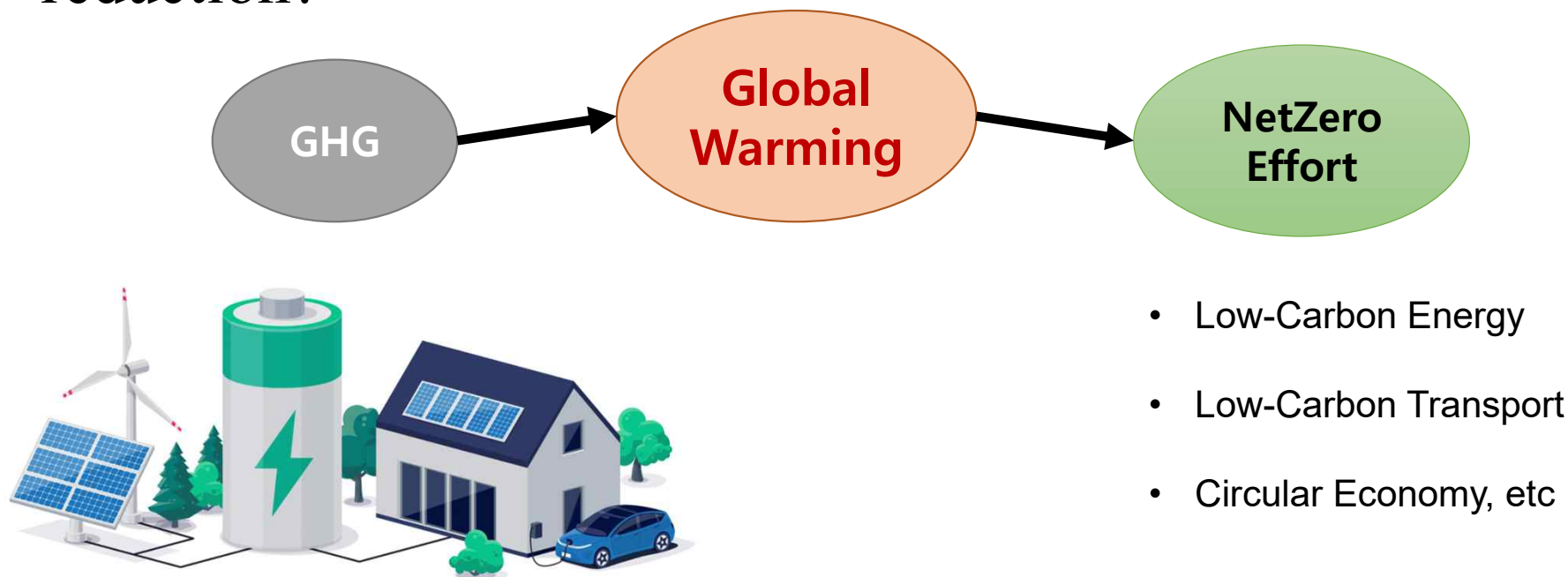


Figure 1. Schematic representation of a solar cell, showing the n-type and p-type layers, with a close-up view of the depletion zone around the junction between the n-type and p-type layers.

<https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2013-2014/how-a-solar-cell-works.html>

23.03.08. Student Activity

Q3. What is the role of “Electrochemistry” on carbon dioxide reduction?



Q3. What is the role of “Electrochemistry” on carbon dioxide reduction?



- Low-Carbon Energy
- Low-Carbon Transport
- Circular Economy, etc

“The individual renewable energy technologies are enabled by many other technologies and areas of science.

One of the most critical enabling areas is **electrochemistry**,

The interfacial science that studies the intersection between chemistry and electricity.

Knowledge of electrochemistry is necessary to understand

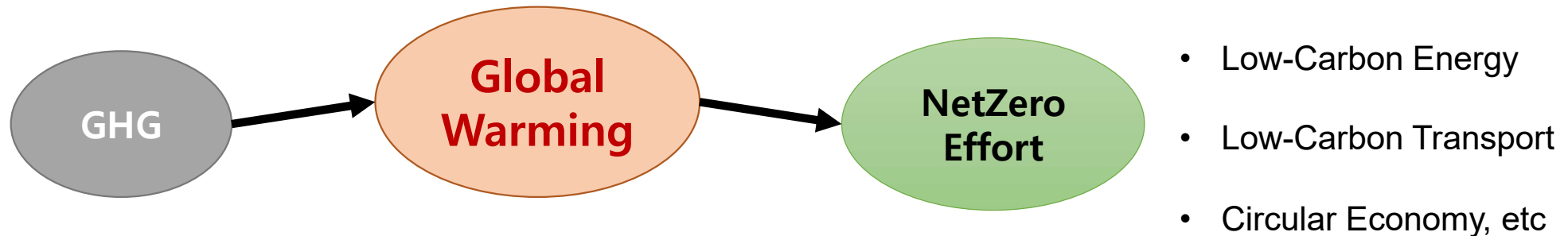
And design **energy storage systems, batteries, fuel cells, electrochemical supercapacitors, and hydrogen technologies.**

It is also important for understanding the mechanism of **solar photovoltaic** device.”*

*Electrochemistry Crash Course for Engineers (2021), Slobodan Petrovic, Springer, pp.4.



Q3. What is the role of “Electrochemistry” on carbon dioxide reduction?



Answer Example:

Electrochemistry takes part in the technologies, which make global NetZero effect possible.

For example, Electrochemistry studies the storage system part of “low-carbon energy” like wind turbine and solar panel.

Because of the intermittency characteristics of the wind turbine and solar panel, the battery system is important.

Moreover,

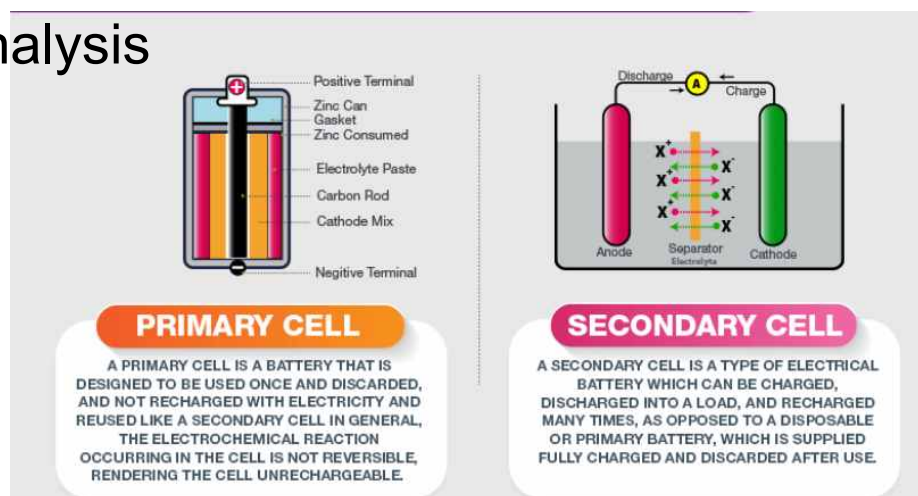
the electrochemistry studies the storage system of the electric cars.



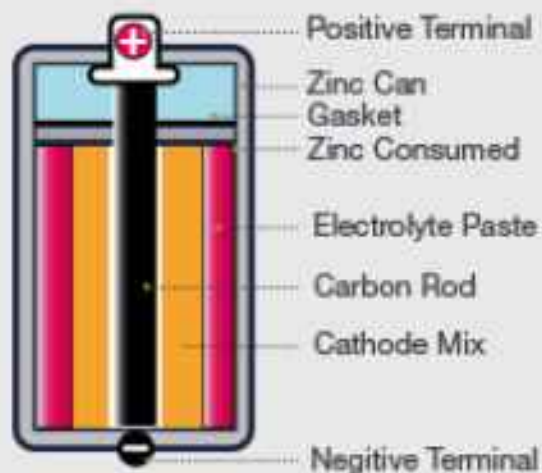
<https://knowhow.distrelec.com/energy-and-power/the-importance-of-batteries-in-renewable-energy-transition/>

Electrochemistry in Industry

- One of the most important sciences in present-day economy
- A basis for significant processes in primary, secondary batteries and fuel cells.
- Electrowinning of metals, electroplating, electro-machining
- The study and prevention of corrosion
- Numerous types of sensors and electroanalysis

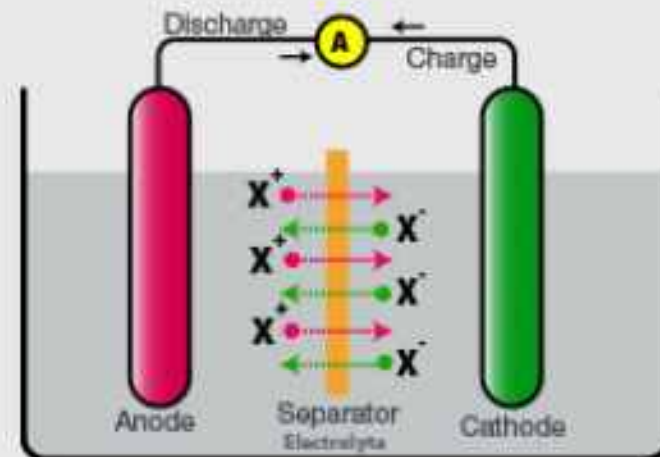


<https://byjus.com/chemistry/difference-between-primary-cell-and-secondary-cell/>



PRIMARY CELL

A PRIMARY CELL IS A BATTERY THAT IS DESIGNED TO BE USED ONCE AND DISCARDED, AND NOT RECHARGED WITH ELECTRICITY AND REUSED LIKE A SECONDARY CELL IN GENERAL, THE ELECTROCHEMICAL REACTION OCCURRING IN THE CELL IS NOT REVERSIBLE, RENDERING THE CELL UNRECHARGEABLE.



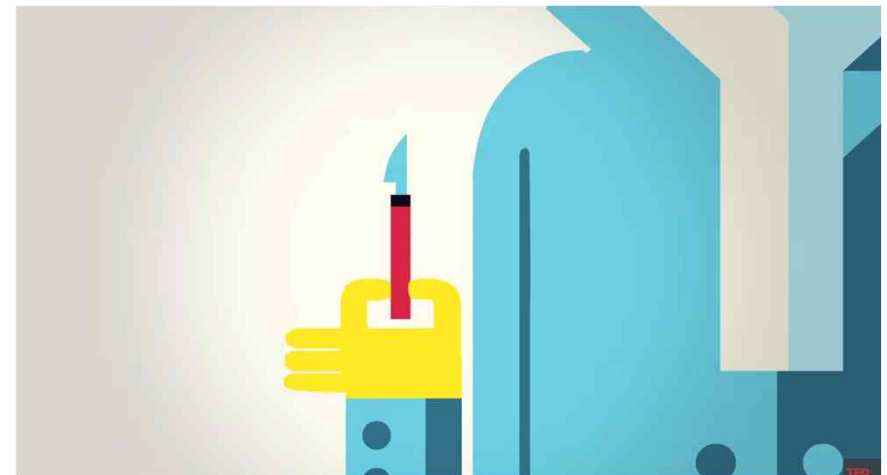
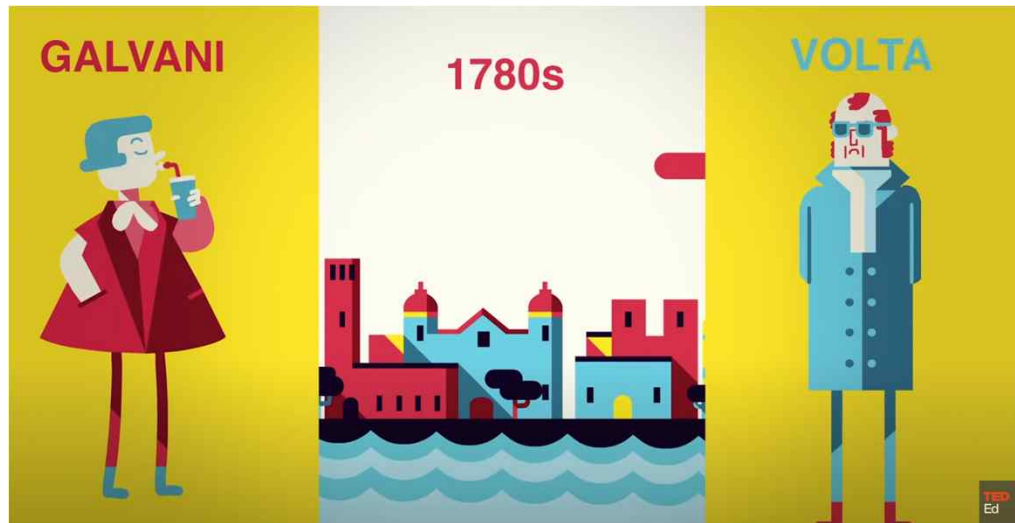
SECONDARY CELL

A SECONDARY CELL IS A TYPE OF ELECTRICAL BATTERY WHICH CAN BE CHARGED, DISCHARGED INTO A LOAD, AND RECHARGED MANY TIMES, AS OPPOSED TO A DISPOSABLE OR PRIMARY BATTERY, WHICH IS SUPPLIED FULLY CHARGED AND DISCARDED AFTER USE.

Electrochemistry in Industry

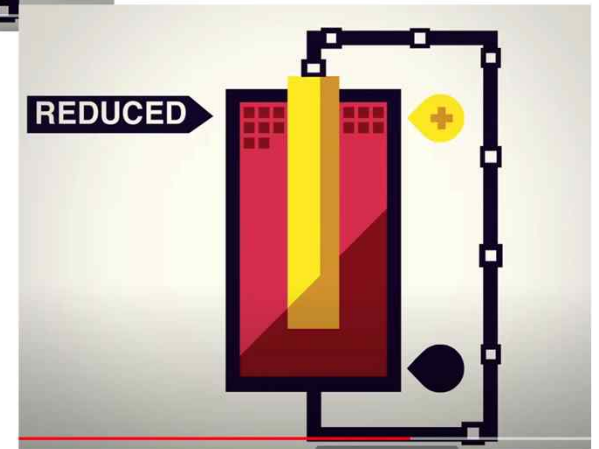
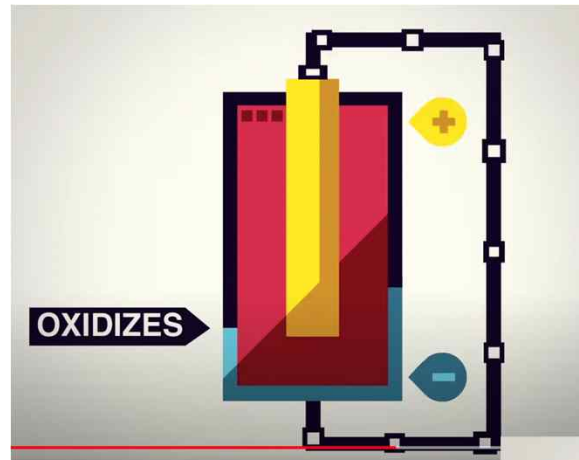
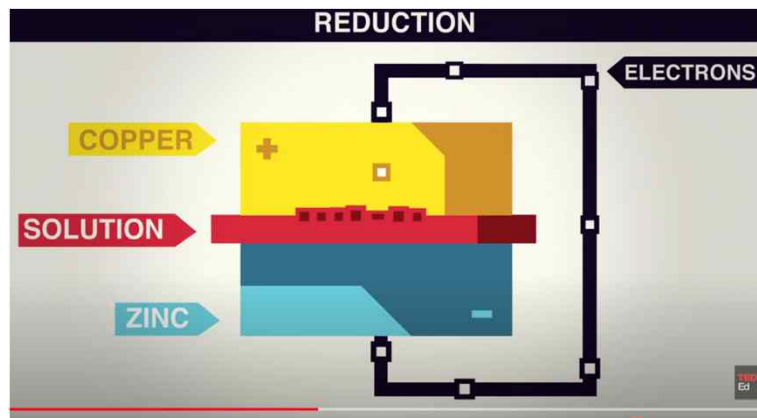
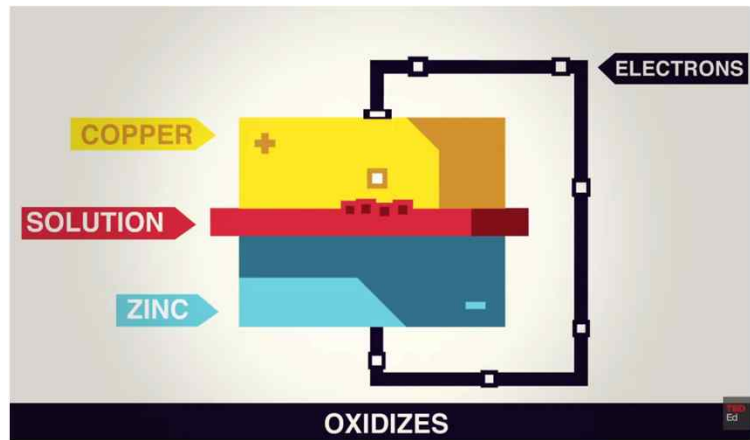
- It comprises 1/3 of the entire chemical industry
→ Electrochemistry is a very significant area
of science intersecting with technology
- <https://www.chemistryworld.com/opinion/electrochemistry-on-an-industrial-scale/4012730.article>

Electrochemistry History

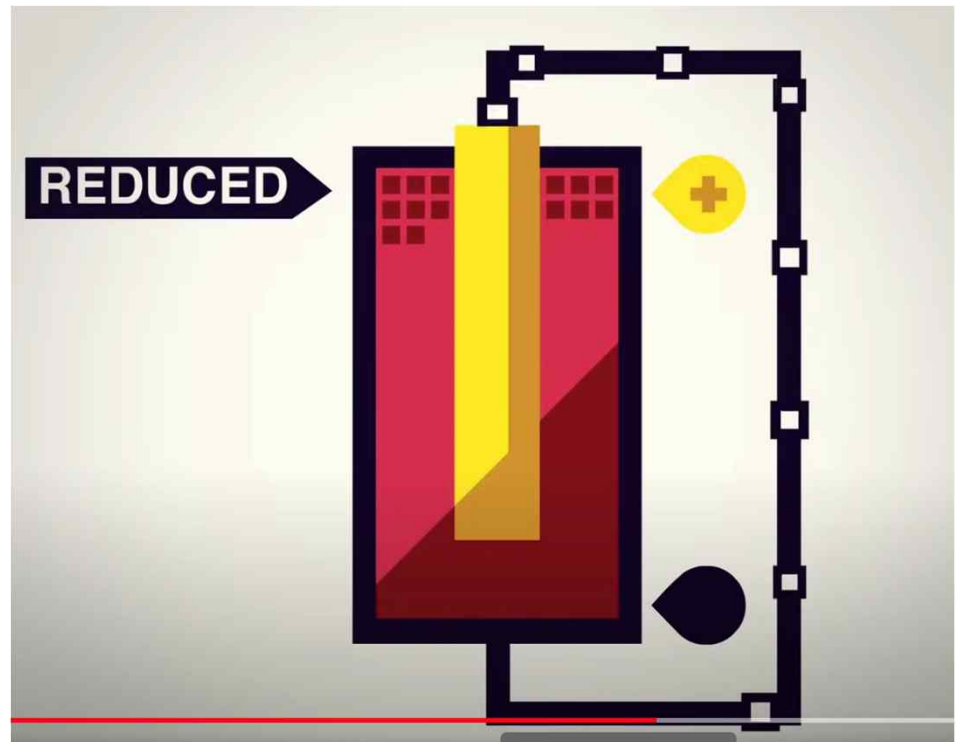
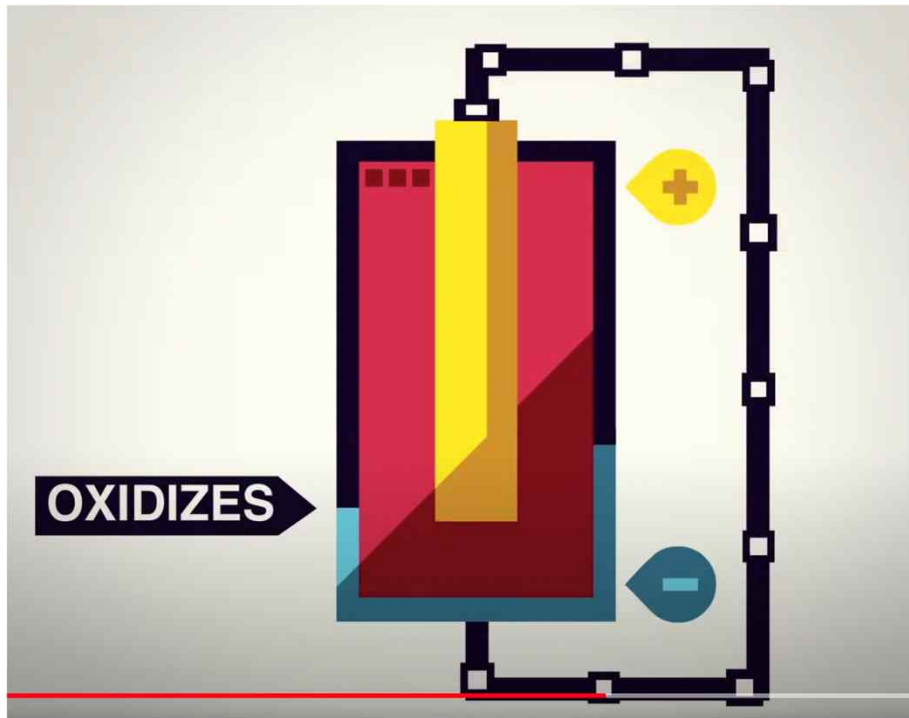


<https://www.youtube.com/watch?v=9OVtk6G2TnQ>

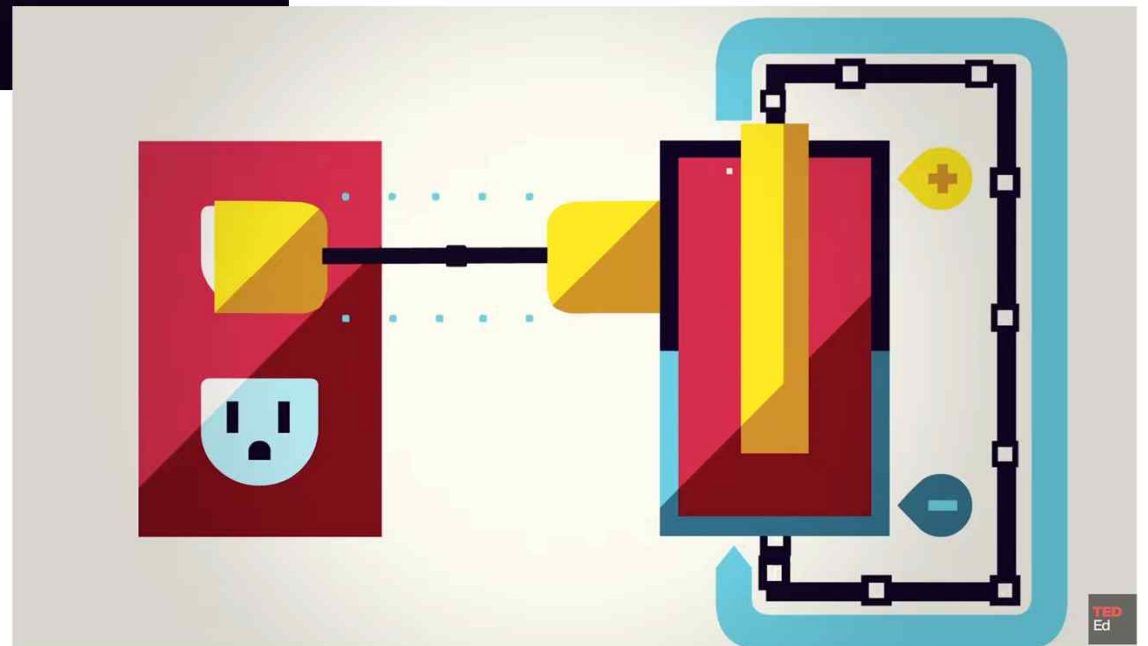
Q4. Can you understand the principle of battery?



Q4. Can you understand the principle of battery?



RECHARGEABLE BATTERIES



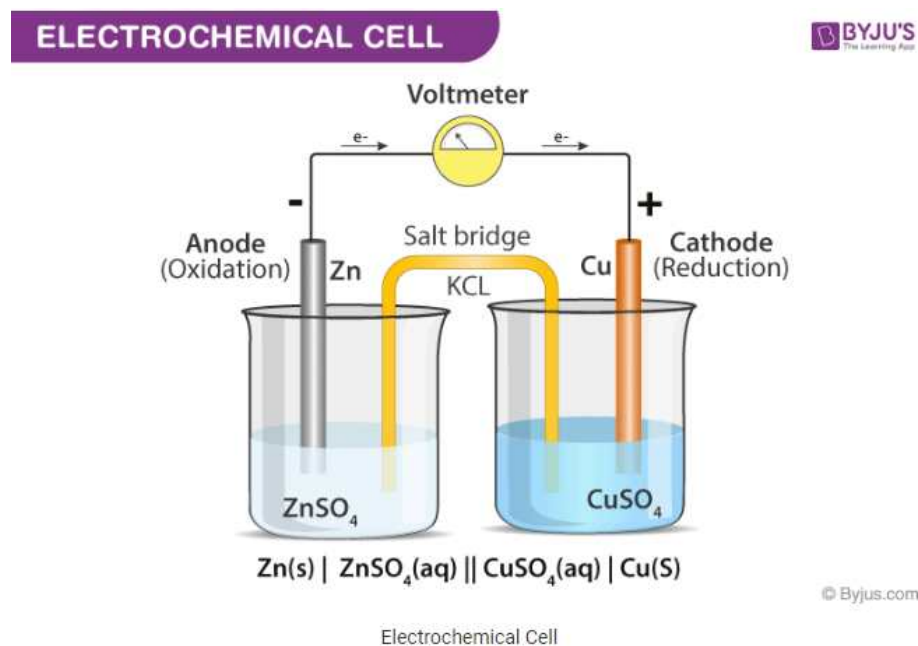
Q5. What do you want to learn the most?

Q6. Are you fine with c.a. 4 times of online classes?

Electrochemistry Basic

Definition

- An interfacial science between chemistry & electricity
- The phenomena and processes of the chemical processes which produces the electricity or when the electricity causes the chemical reaction to occur.



Electrochemistry Basic

Definition

- Study the reactions in which ions cross the interface between a solid (electrode) and a solution or electrolyte.
- The reactions are influenced by the potential difference between the electrode and the solution.
- they are thermodynamically and kinetically controlled.

Electrochemistry Basic

Electrochemical Cell (1)

- It consists of two electrically conductive electrodes immersed in electrolyte
- The electrodes are electronic conductors : they conduct electrons

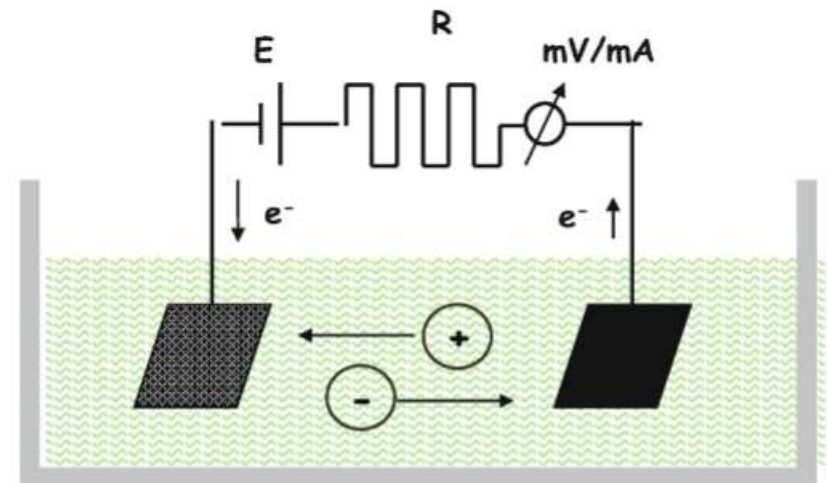


Fig. 1 Schematic of an electrochemical cell

Electrochemistry Basic

Electrochemical Cell (1)

- Electrolyte contains ions which engage in heterogeneous reactions on electrodes surfaces
→ result in the transfer of electrons to or from the conductive electrodes

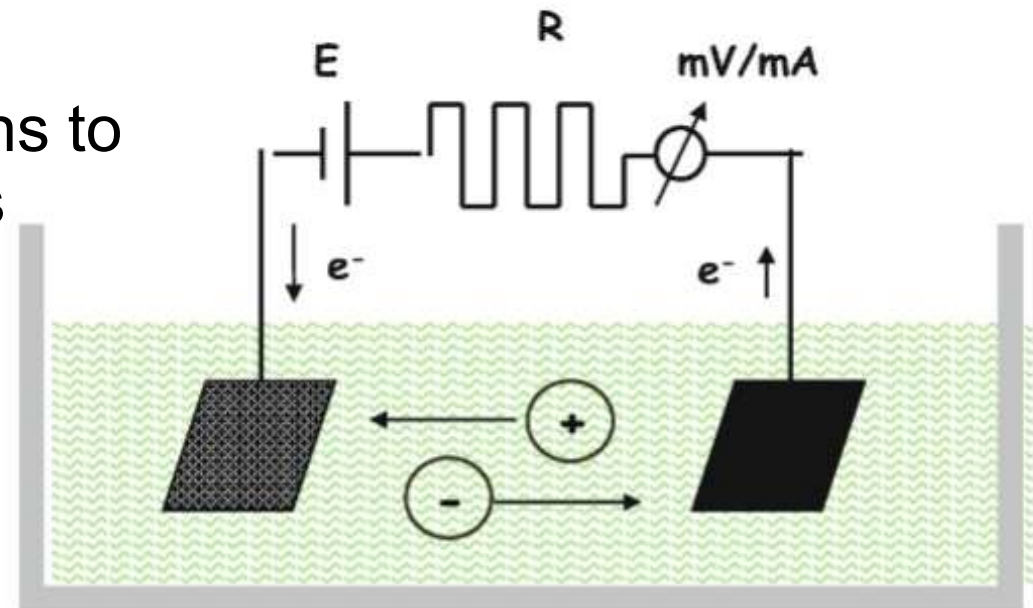


Fig. 1 Schematic of an electrochemical cell

Electrochemistry Basic

Electrochemical Cell (2)

- Two electrodes immersed in solution
- While positive and negative ion carry charge in the electrolyte

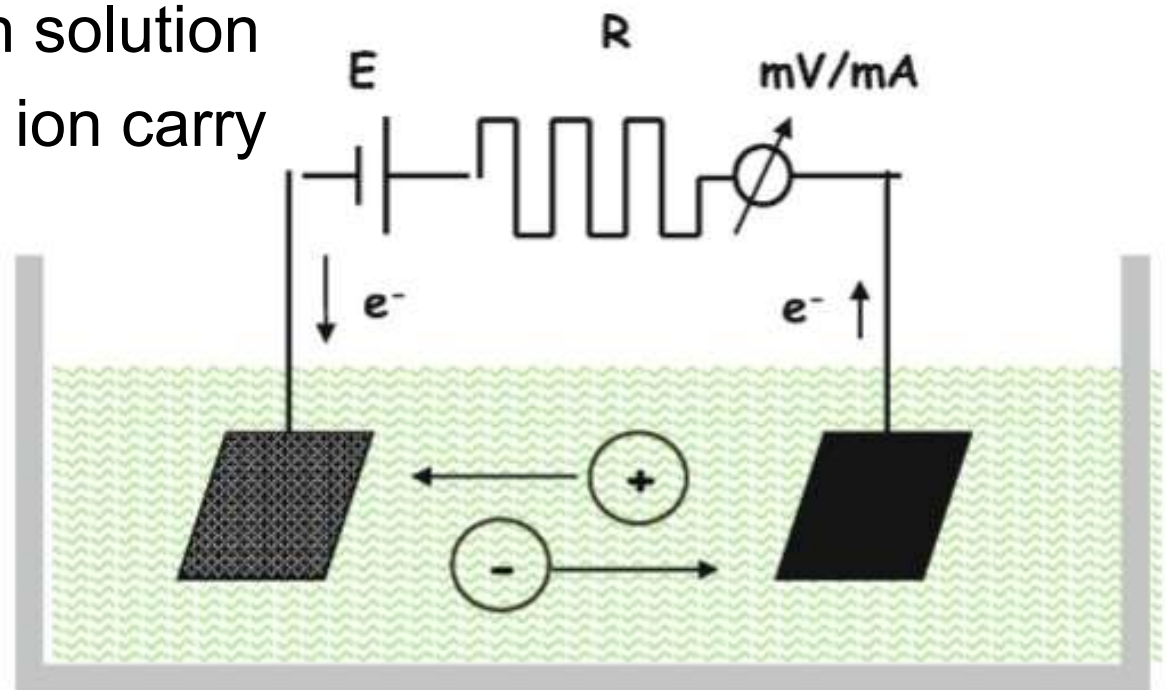


Fig. 1 Schematic of an electrochemical cell

Electrochemistry Basic

Electrochemical Cell (2)

- The electrons are shown to move through the external circuit
- Enter the electrode :
at which reduction occurs
- Leaves the electrode :
at which oxidation take place

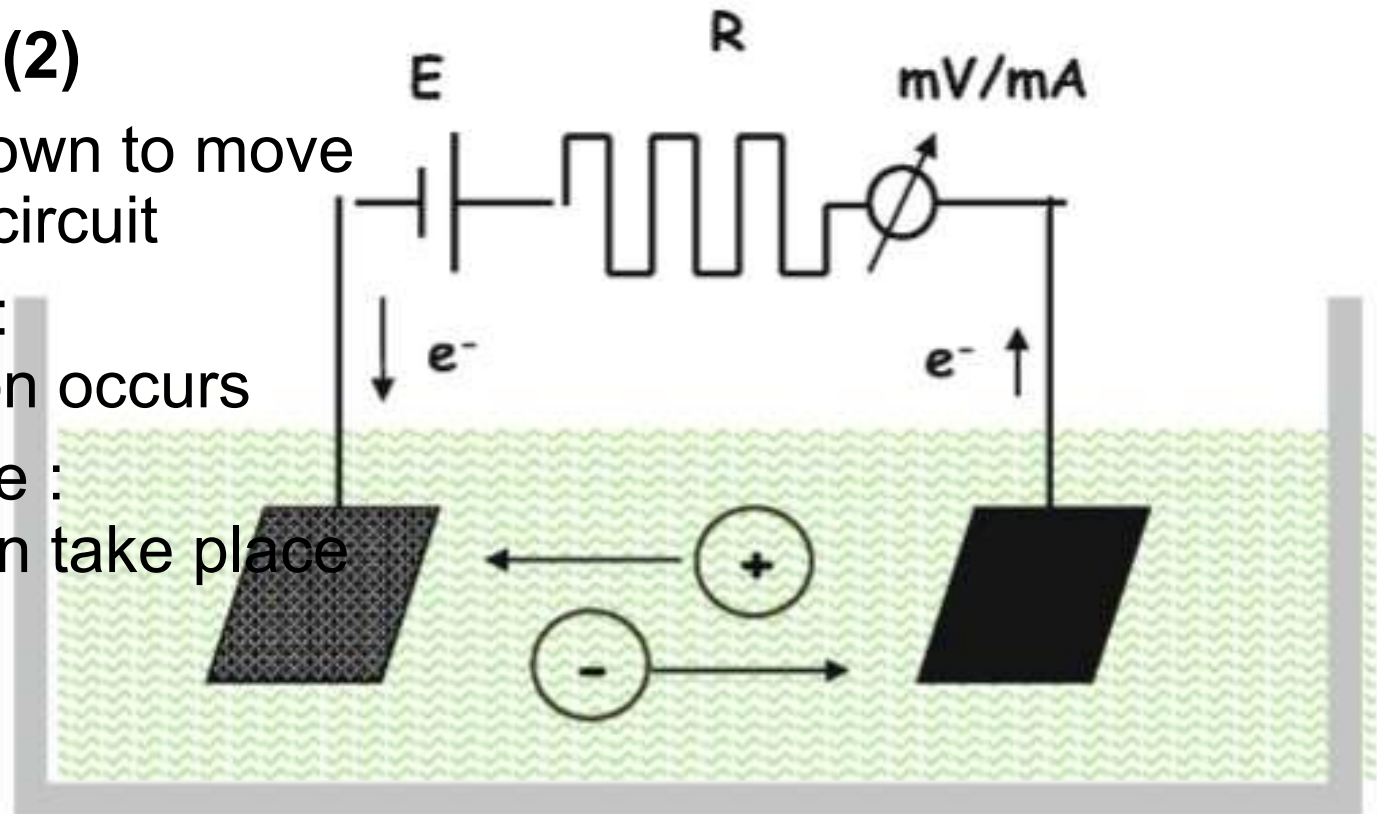


Fig. 1 Schematic of an electrochemical cell

Electrochemistry Basic

Cathode

- The electrons enter from the outside circuit
- Reduction takes place on the cathode

Ex. The reduction of oxygen gas and chlorine gas
(that takes place in a fuel cell)

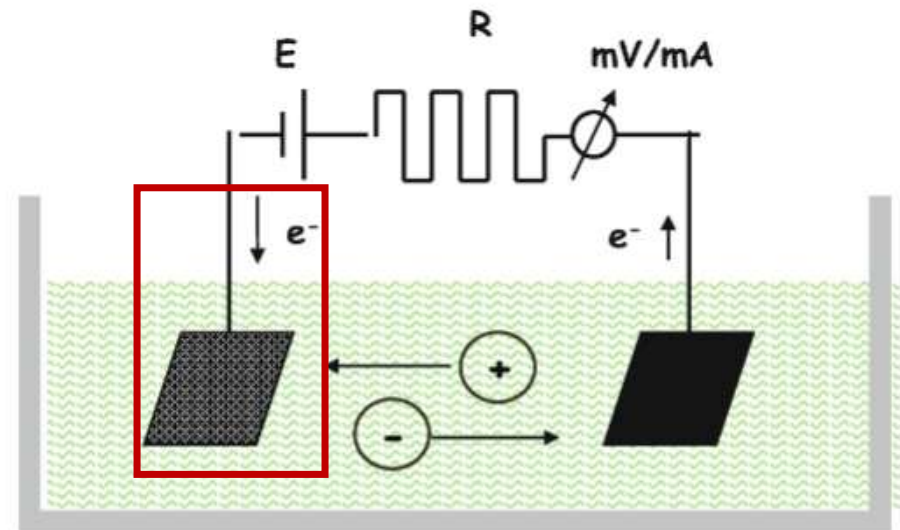


Fig. 1 Schematic of an electrochemical cell

Electrochemistry Basic

Anode

- The electrode from which electrons leave
- Oxidation takes place on the anode
- The electrons are the reaction products
- The production of chlorine gas and oxidation of hydrogen (that takes place in a fuel cell)

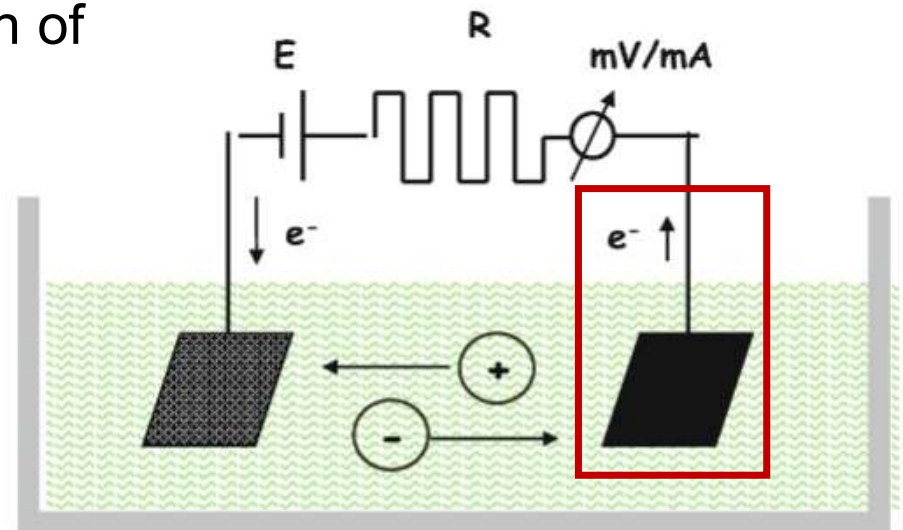


Fig. 1 Schematic of an electrochemical cell

Oxidation & Reduction

- Active Watching
- <https://www.youtube.com/watch?v=IQ6FBA1HM3s>

Electrochemistry Basic

Electronic Conductivity

- The movement of electrons in a metallic conductor
- Electrons conduct electricity in solid conductors,
it can't exist in solutions

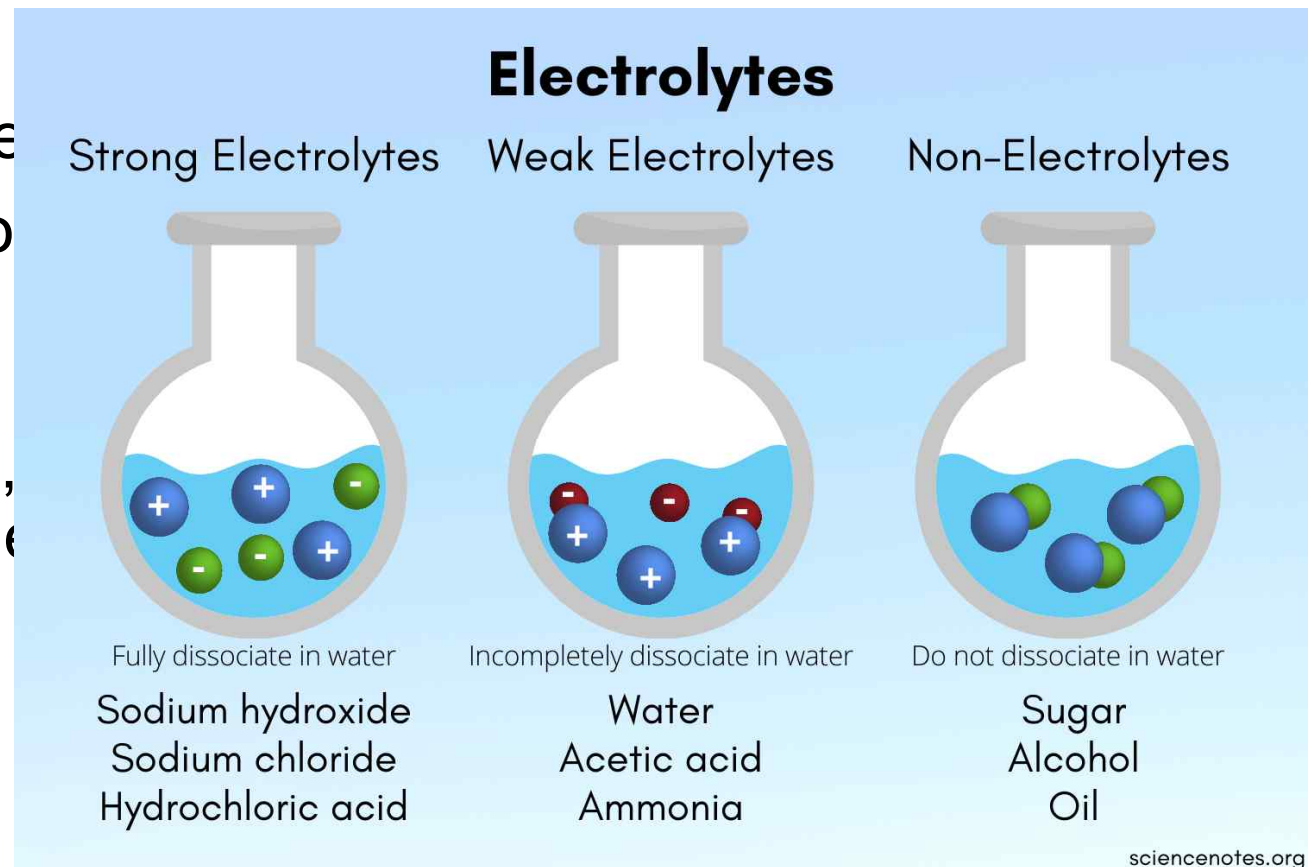
Ionic Conductivity

- The movement of ions through an electrolyte
- Ions conduct electricity in solutions,
can't conduct electricity through solid conductors

Electrochemistry Basic

Electrolyte

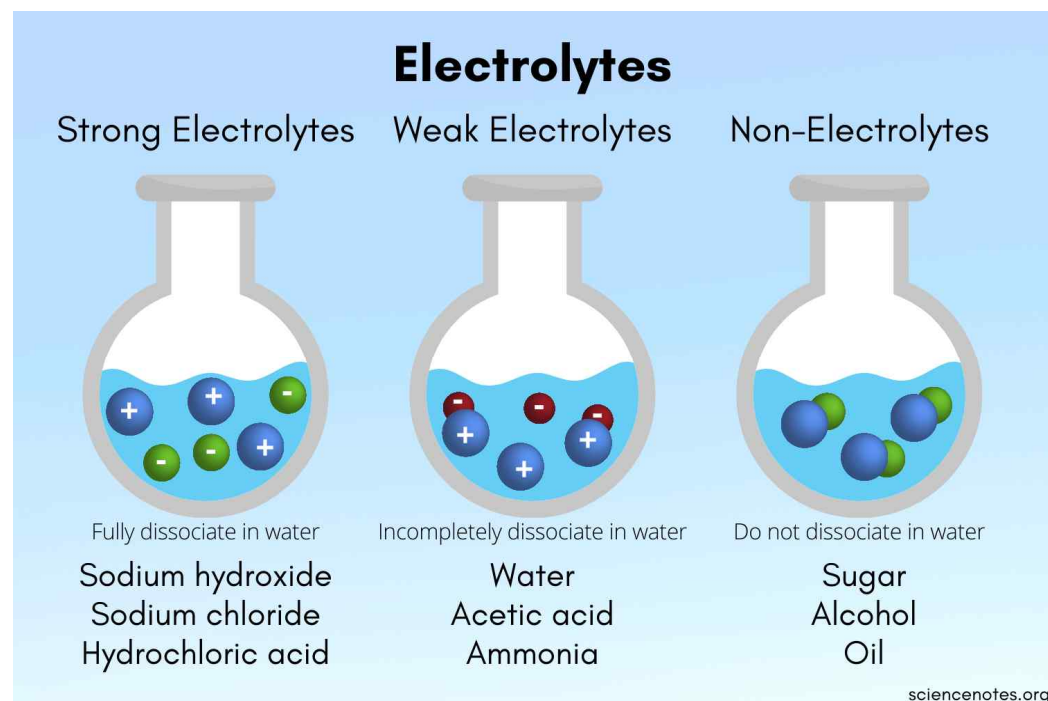
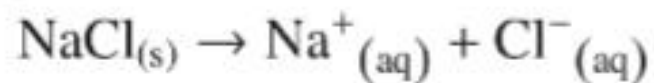
- An ionically conductive
- It contains ions that carry electrical charge
- A liquid solution
(It can also be a solid, substance, or a polymer)



Electrochemistry Basic

Electrolyte

- Liquid electrolytes are most commonly aqueous solutions of acids, bases, or salts
- The process called solvation, the compounds dissociate into ions.

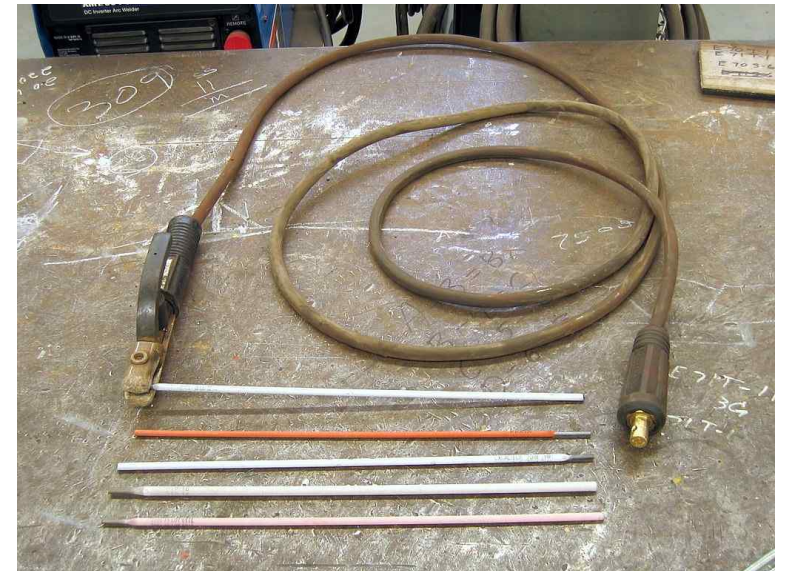


<https://www.exprii.com/t/electrolytes-definition-overview-8653>

Electrochemistry Basic

Electrodes

- An electrode is an electrical conductor used to make contact with a nonmetallic part of a circuit.
- It can consist of a variety of materials depending on the type of battery.

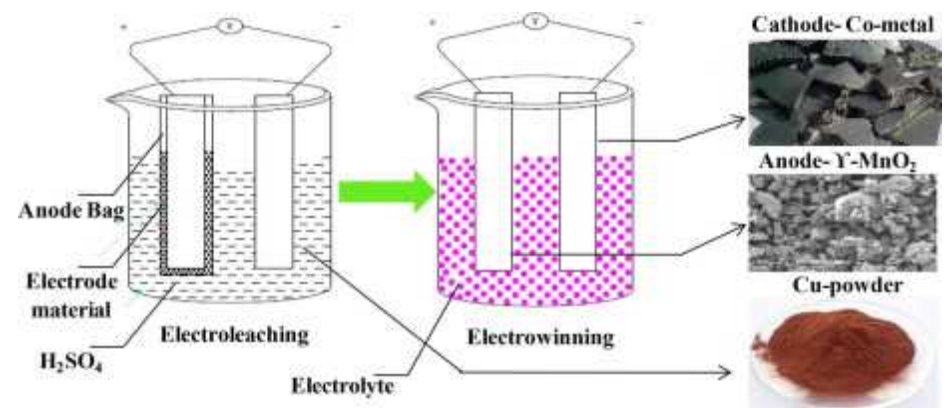


<https://en.wikipedia.org/wiki/Electrode>

Electrochemistry Basic

Electrodes

- Various conducting and semi-conducting elements have been used as electrodes:
 - solid metals (Pt, Au, Ag, etc), liquid metals (Hg, amalgam), metal oxides (MoO₂, MnO₂, CoO₂, etc), carbons (graphite, diamond, graphene, etc), semiconductors (ITO, Si, etc)

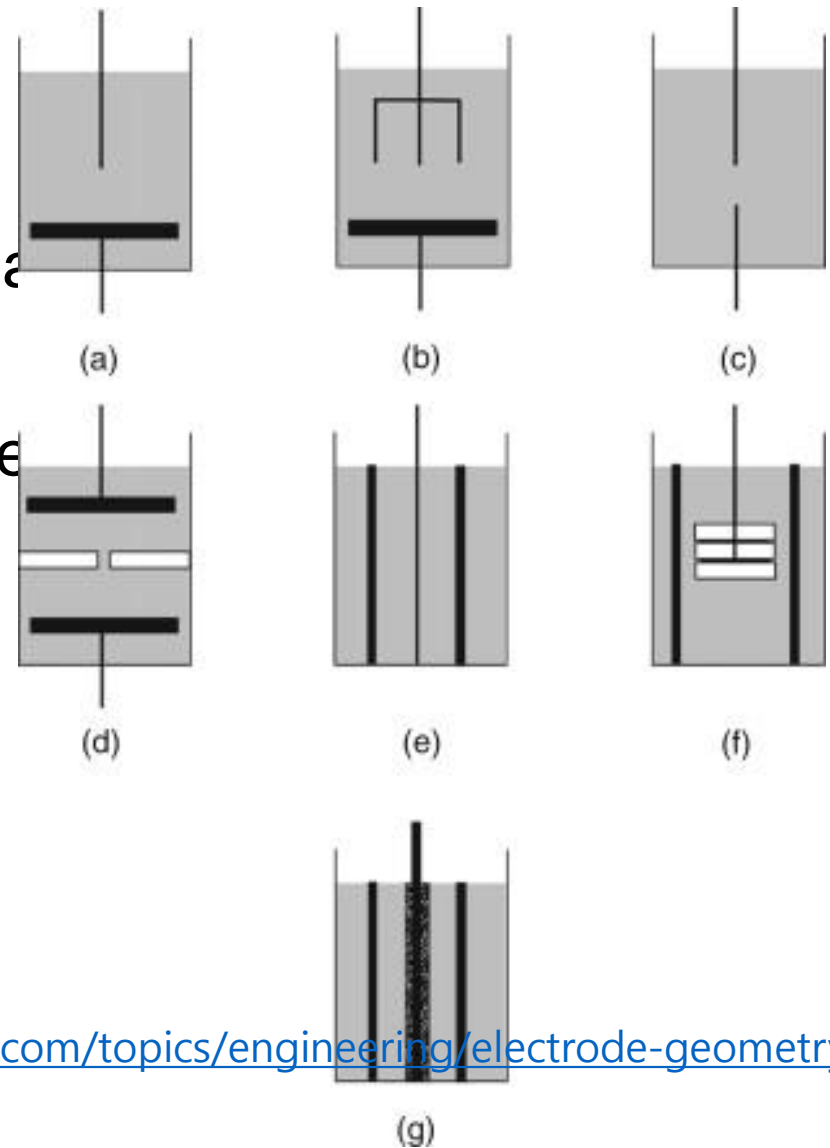


<https://www.sciencedirect.com/science/article/pii/S0956053X17304993>

Electrochemistry Basic

Electrodes

- Electrode geometry varies and can be a number of the following:
flag, disk, cylinder, wire, mesh, thin layer, finely dispersed layer,...

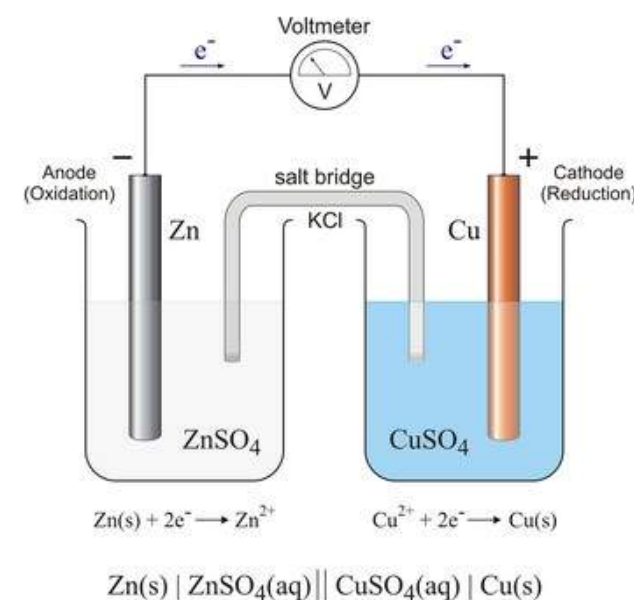


<https://www.sciencedirect.com/topics/engineering/electrode-geometry>

Electrochemistry Basic

Voltaic cells (Galvanic cells)

- Electrochemical cells that produce electricity from the reactions on the electrodes
- The electrochemical system releases energy in this process
- Example of Voltaic cells : Batteries and Fuel Cells

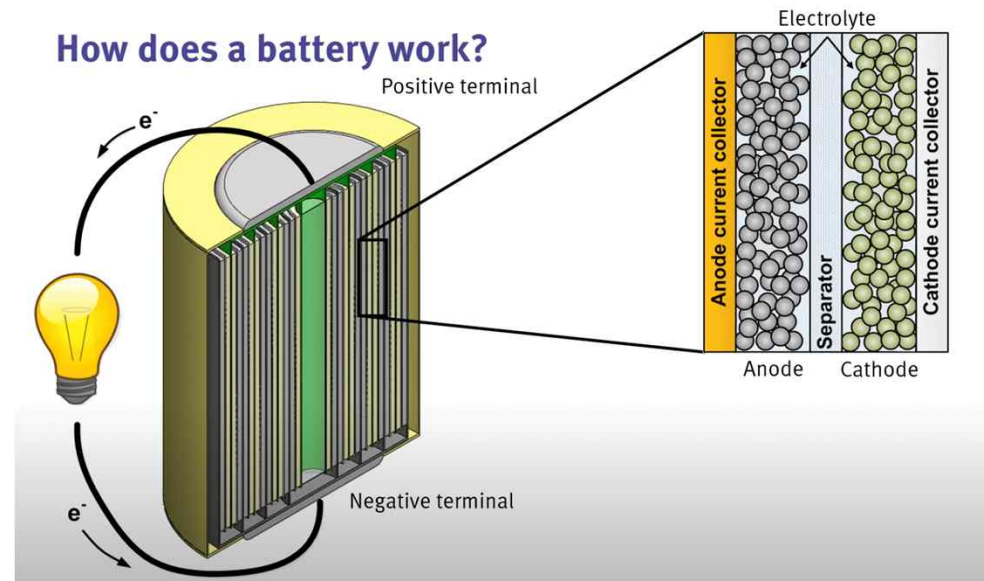


<https://glossary.periodni.com/glossary.php?en=galvanic+cell>

Lithium-ion Battery Explained

- Active Watching!

<https://www.youtube.com/watch?v=DBLHaLhyo2w>



Electrochemistry Basic

Electrolytic Cells

- Electrolytic cells use electricity from external source to cause chemical reactions and produce desired chemicals
- **Reaction at Cathode:** $[\text{Na}^+ + \text{e}^- \rightarrow \text{Na}] \times 2$
- **Reaction at Anode:** $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
- **Cell Reaction:** $2\text{NaCl} \rightarrow 2\text{Na} + \text{Cl}_2$

