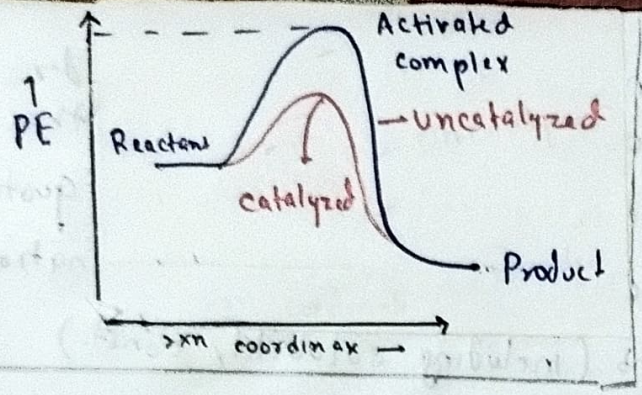


ELECTROCHEMISTRY & CHEMICAL SENSORS

→ Study the relation b/w Electricity and chemical reaction ~~relation~~

Practical Applications:

1. Electrochemical industries
2. Biomedical application
3. Energy conversion & storage
4. Fuel cells
5. Corrosion engineering
6. Environmental remedies

Technologies based on Electrochem.

- Energy storage
- Sensing
- corrosion prevention
- Organic electrosynthesis
- Industrial electrolysis
- Energy conversion

- Electrode potential – Tendency of an electrode to gain/lose e^- when in contact with its ion soln.
- Electrode :- Electrical conductor allowing e^- transfer ~~from~~ to/from a chem. syst.
- Half-Cell – Single electrode in a soln of its ions.
- Oxidⁿ/Redⁿ – Pot. diff. due to metal loosing e^- (oxidⁿ) or gaining e^- (redⁿ)
- Standard Electrode Potential (E°) – Measured under std. condⁿ 298 K, 1 atm, 1M ion concⁿ.
  - Reference : SHE (standard Hydrogen electrode), $E^\circ = 0$ V
- Electrochemical cells :- Two half cells with diff pot. connected
  - galvanic (voltaic) cell.
  - spontaneous redox rxn generates electrical energy.
  - Formula : $\boxed{E_{cell} = E_{cathode} - E_{anode}}$

Nernst Equation :→ determination of cell potential under non-standard cond^n .. It relates the measured cell potential to the rxn quotient and allows the accurate determination constant (including solubility const.)

At eqb^m $Q = K$.

$$\Delta G = \Delta G^\circ + RT \ln Q.$$

$$\Delta G = -nFE_{cell} \quad \text{and} \quad \Delta G^\circ = -nFE^\circ_{cell}$$

Hence, Electrical Potential Energy

$$E_{cell} = E^\circ_{cell} - \frac{RT}{nF} \ln Q$$

$$E_{cell} = E^\circ_{cell} - \frac{0.0257}{n} \ln Q$$

nernst equation

$$E_{cell} = E^\circ_{cell} - \frac{0.0592}{n} \log_{10} Q$$

Applications :
- Electrochemical cells.
- Batteries
- Fuel cells
- corrosion theory,
- anodic / cathodic protection,
- coatings, inhibitors,
- electro plating, electro machining,
- electro winning, electro refining
- green, electro-organic synthesis

* Chemical sensors : devices that detect and measure the presence and the presence and concentration of chemical substances (analytes) in a given sample.

- Chemical sensors in environmental monitoring
  - → Glucose monitoring
  - → Bioimaging
  - → Disease detection
  - → chemical sensing
  - → Environmental monitoring
  - → Org. chem. sensing.

- Types of chemical sensors
  - → Humidity
  - → pH sensors
  - → Biosensors
  - → Gas sensors

ENGINEERING MATERIALS

L used in creation of structures & components & their selection is crucial for successful engg. projects.

Key material properties : density, elasticity, strength, & thermal conductivity

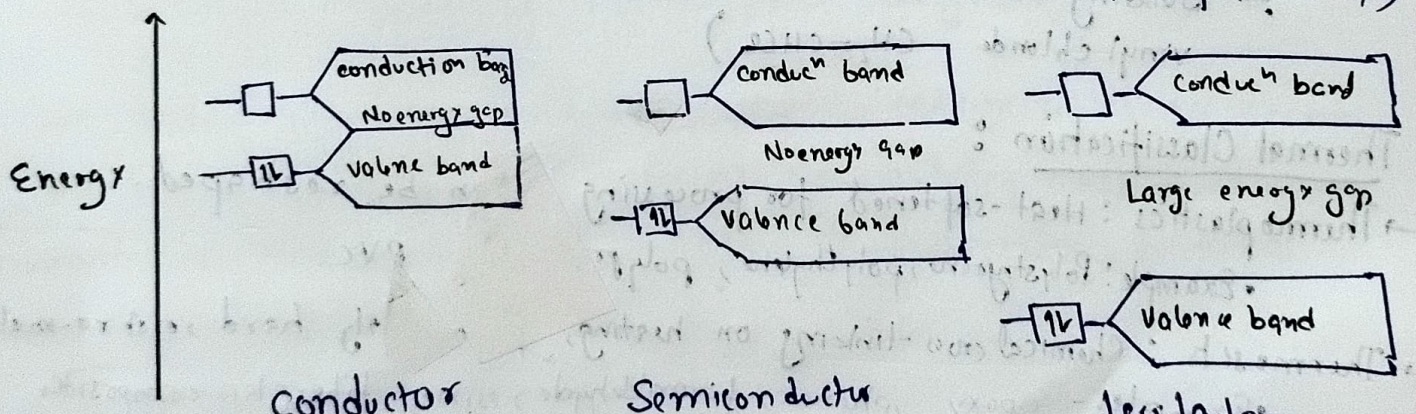
- Classification of Material
  - → Metals
  - → Ceramics
  - → polymers
  - → composites
  - → Smart materials
  - → nanomaterials
  - → Bio material
  - → Semi-conductors
  - → Polymers

* Unique characteristics and applicⁿ across various engg. disciplines

→ Classification of Materials

— Based on Electrical Conductivity

1) conductors (Metals & graphite)
2) semiconductor (Si, GaAs, InP, etc)
3) Insulators (Ceramic oxides, Polymers, Paper)



→ Band theory : As the value of n inc., the energy levels merge into an almost continuous band.

[conductivity of solids, optoelectronic materials, OLED]

Nanotechnology → science and engg. of nanoscale systems, whose critical sizes range from 1 to 100 nm

Application of Nanoparticles

1. Silver nanoparticles have good antibacterial properties, and are used in surgical instruments, refrigerators, air-conditioners, water purifiers etc.
2. Gold nanoparticles are used → catalytic synthesis of si nanowires, sensors, for the detection of tumors, drug delivery cargos.
3. ZnO nanoparticles → electronics, UV light emitters, piezoelectric devices and chemical sensors
4. TiO_2 nanoparticles → photocatalyst & sunscreen cosmetics (UV blocking pigment)
5. Antimony-Tin-Oxide (ATO), Indium-Tin-Oxide (ITO) nanoparticles are used in car windows, liquid crystal displays, and in solar cell preparations

* POLYMERS → Definition: Greek "poly" (many) + "meros" (parts) = long-chain molecule with repeating identical units

- **Monomers**
  - "Building blocks" that combine to form polymers (e.g. ethylene $CH_2=CH_2$ vinyl chloride $CH_2=CHCl$)

Thermal Classification :-

→ Thermoplastics : Heat-softened for processing, can be reshaped.
- Example: Polystyrene, polythylene, polypropylene, PVC.

→ Thermosets : Chemical cross-linking on heating, permanently hard, not re-moldable
- Examples - Epoxy, phenol-formaldehyde resins, fiberglass composites
- Uses - composites, coatings, adhesives

ECOSYSTEMS & BIODIVERSITY

- **Ecosystem** → Living organism + physical env. interaction thru energy/nutrient exch
  - → components :
    - Biotic : Plants, animals, fungi, microorganisms
    - abiotic : Air, water, sunlight, soil, temp., nutrients.

BIODIVERSITY → Types: Genetic, species, ecological diversity from terrestrial/marine/desert ecosystem.

Natural Resources & Human Impact

- Types: Renewable (sunlight, water, forest) v/s Non-renewable (fossil (minerals, fuels)
- Human Impacts: Deforestration, Pollution, over-exploitation, climate change
- Results: Habitat destruction, biodiversity loss, resources depletion

Pollutants & Waste Disposal

Pollutant Effects on Earth's Spheres

→ Atmosphere: Greenhouse gases (CO_2, methane), aerosols → climate change, acid rain, air quality issues.

→ Hydrosphere: Industrial discharge, agricultural runoff, plastics → aquatic life damage, eutrophication, oxygen depletion

→ Geosphere: Mining / Industrial waste → soil contamination, reduced fertility, groundwater pollution.

→ Biosphere: All pollution types → respiratory illness, birth defect, habitat destruction, biodiversity loss.

Waste Disposal Methods

→ Techniques: Landfilling, incineration, recycling, composting, waste-to-~~coast~~ energy.

→ Goal: Minimize environmental impact, maximize resource recovery

→ Waste-to-Energy: (WtE) Convert non-recycling wast → electricity / heat via incineration, pyrolysis, landfill gas recovery.

Environmental Hazards, Sustainability, Ethics & laws

- Environmental Hazards: Cond^n harming environment / human health (pollution, deforestation, Climate change, bio diversity loss)
- Sustainability: Balance ecological, social, economic needs, minimize damage, conserve resources, promote long-term health

→ Environmental Ethics: natur & human rel^n
- Anthropocentrism - Human centered approach
- Ecocentrism: Nature-centered approach

Environmental Laws

- Purpose: Govt rules to protect env. manage resources, mitigate pollution
- Scope: Air / water quality, waste management, conservation

- connection: Ethics inform laws → laws promote sustainability → laws mitigate hazards.
- Example: Emission regulations protect future generations from climate change