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Energy and Environment
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Energy scenario in World and India (demand and consumption), Alternative (Renewable energies).

Fuel cells: Basic principle, history of fuel Cell, different types of fuels and sources, electrochemical cell, different components of fuel cell, cell potential, thermodynamics, and kinetics of fuel cell reactions; different types of fuel cells, various approaches in designing materials as electrodes, applications.

Batteries: History and principles of batteries, Primary and Secondary Batteries, Zn-carbon, alkaline Batteries, Pb-acid, Ni-MH and Li-, Na- and Mg-ion Batteries, Redox flow batteries.

Capacitors and Supercapacitors: history, working principle, different types of capacitors, applications.

CO_2 reduction: Chemistry of CO_2, advantages and disadvantages, greenhouse effect, sources of CO_2, carbon recycling, global warming, photosynthesis, CO_2 capture, CO_2 sequestration, CO_2 reduction using different pathways, chemicals and fuels from CO_2, reaction mechanisms, carbon footprint, zero carbon policy, industrial development.

N_2 reduction: Fundamentals and Applications

Solar cell: What is solar cell? Definition and history of solar cell, Difference between Module and Solar Cell, Photovoltaic effect, Basic physics of solar cell, Solar cell parameters, Solar radiation and AM 1.5, Working principle – light absorption and band alignment, Charge carriers Generation Rate, Diffusion and Drift current, Construction of Si/Perovskite solar cell, Sensitized Solar Cells.

Water splitting and photocatalysis; electronic structure of semiconductors, hetero-structures, charge separation, band gap evolution, Z-scheme, thermo-chemical water splitting, artificial photo synthesis.

Hydrogen generation and storage; chemical processes, hydrogen storage in porous materials.

Thermoelectrics: Electronic structure modulation, resonance state, band convergence, low thermal conductivity, point defect phonon scattering, nano-structuring, intrinsic factors- bonding asymmetry, soft chemical bonding, effect of lone pair and rattling.

Piezoelectronics: Ferroelectric, dielectrics, piezoforce microscopy.

Reference Books:

1. Electrochemical Supercapacitors: Fundamentals and Applications, B E Conway, (Kluwer, 1999.
2. Understanding Batteries, R.M. Dell and D.A.J. Rand (RSC), 2003.
3. Fuel Cell Technology, Sammes Nigel, (Springer), 2006.
4. Renewable Energy, Godfrey Boyle, (Oxford University Press) 2004.
5. Fundamentals of Atmospheric Modeling, Mark Z. Jacobson (RSC Publications, Cambridge), 2004.
6. Carbon Dioxide Sequestration and Related Technologies, Ying Wu, (Wiley) 2011.