THE CATHOLIC UNIVERSITY OF AMERICA

ENGINEERING 408 / CHEMISTRY 308: BATTERIES, FUEL CELLS, AND ENERGY STORAGE

http://chemistry.cua.edu/courses/energystorage.cfm

Our world is driven by energy produced primarily by burning fossil fuels. Yet, over the last decade, we have been in the midst of a clean energy revolution. New environment-friendly renewable technologies have become increasingly cost-competitive. For example, energy yield of land-based wind power plants in the US increased 10-fold over the last ten years; wind accounted for 41% of all new generation capacity installed in 2015. Solar photovoltaic energy generation increased from below 1 GW in 2008 to 26 GW in 2015. However, wind blows when is chooses and sun shines only on sunny days. In calm weather or at night these methods of energy generation produce nothing. To make them competitive on a larger scale, one needs to further develop efficient technologies for ENERGY STORAGE.

This CUA course on Energy Storage is unique in a sense that it provides a broad overview of energy storage technologies used for a wide variety of applications, from grid-sized facilities to hand-held devices. No equivalent undergraduate courses are offered in other universities in the DC area. All teaching materials have been designed specifically for this course and are distributed to enrolled students free of charge.

The course covers the basic theory and methods of energy storage, with emphasis on electrochemical storage technology. Topics include introductory electrochemistry, chemical principles of operation and design of batteries and fuel cells, individual battery types (primary and secondary; lead-acid, nickel-cadmium, nickel-metal hydride, lithium ion, sodium-sulfur, flow batteries, and others), hydrogen and non-hydrogen fuel cells, operational issues of batteries and fuel cells, and selected non-chemical methods of energy storage.

Starting with 2017, the course will be offered in Spring semesters of alternate academic years (e.g., 2017, 2019, etc.). It is co-listed as ENGR 408 / CHEM 308; whether you register for the Engineering or the Chemistry version, it will be the same class. Although the course is primarily oriented towards the needs of Engineering students, due to its multidisciplinary nature, it has also been taken by other science and non-science majors. The ENGR 408 version qualifies as an elective course in some of the Engineering departments (check with your adviser). Prerequisites include introductory General Chemistry (one semester of lecture and lab) and introductory Calculus courses.

Course chapters

1. Introduction
2. Mechanical methods of energy storage
3. Magnetic and thermal methods of energy storage
4. Basics of chemical thermodynamics
5. Chemical equilibrium
6. Chemical reactions in aqueous solutions
7. Oxidation-reduction (Redox) reactions
8. Basics of electrochemistry
9. Principles of battery operation, operational issues
10. Individual battery types
11. Battery charging and modeling. Hybrid vehicles
12. Fuel cells and fuel cell thermodynamics
13. Fuel cell kinetics and voltage losses
14. Individual types of H_2 and non- H_2 fuel cells
15. Hydrogen supply and hydrogen storage
16. Electric capacitors and supercapacitors

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Average course evaluations (2011 – 2016): course: 6.3 out of 7 teacher: 6.8 out of 7