CHE 464/564 – Fuel Cells

(Fall 2014, O. Talu)

Instructor: Dr. Orhan Talu
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Office Hours: 3:30-5:30 MW (other times by appointment)

Text: Fuel Cell Fundamentals
O'Hayre, Cha, Colella, Prinz
John Wiley & Sons (2006)

Prerequisites: Thermodynamics, Reaction Kinetics, Mass Transfer and permission of the instructor

Topics: This course is for seniors and graduate students. The basics of fuel-cells, particularly MEA's (membrane-electrolyte-assembly), will be covered. It involves electrochemistry, thermodynamics, kinetics, charge transport and mass transfer. Current fuel cell technology will be reviewed briefly. After the course, the students should expect to understand how fuel-cells work, how to improve the performance, what are the opportunities for further research and development.

Organization: 1) Attendance to lectures is mandatory. Inform the instructor as soon as reasonably possible in case of emergency.

2) The students must read the assignments as listed on the schedule. Most classes will be held as open discussions.

3) Homework problems will be assigned and the students will be asked to present their solutions on the black-board. The discussions and student contributions to problem solving constitute 10% of the grade as class participation. No late homeworks will be accepted.

Graduate Credit: Graduate students are required either:

1. To complete a term-paper on a topic of their choosing about fuel-cells. Term paper topics must be approved by the instructor. Some term-papers will be asked to present their work in class.
2. OR, some students can perform experiments on the fuel-cell system in SH 19 and write a report. This option is only open to students who did not receive their B.S. degree at CSU.

Grading:

Homeworks & participation	10%
Midterms (2)	50%
Final	40%
Term paper	10% (extra only for graduate credit)

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Tentative Schedule

Session	Subject	Read (including)
1	Introduction to fuel cells; chemical bond energy, power, advantages, disadvantages, performance, technology	
2	Thermodynamics; internal energy, 1^{st} & 2^{nd} law, potentials, reaction thermodynamics	Ch.1 & 2.3.1
3	Thermodynamics; ΔG & electrical work, electrochemistry, half-cell potential, T,P and c dependence	2.4.3
4	Thermodynamics; concentration cells, efficiency	End of Ch.2
5	**Ch.2-Problems**, thermodynamics review	
6	Kinetics; activation energy, reaction rate, equilibrium rate	3.5
7	Kinetics; galvanic potential, Butler-Volmer Eqn., electrocatalysis	3.8
8	Kinetics; Tafel eqn., catalyst-electrode design, intro. quantum mechanic	End of Ch. 3
9	**Ch.3-Problems**, kinetics review	
10	***MIDTERM-1***	
11	q-transfer; charge flux, Ohm's law, basic electricity, electronic/ionic conductivity**,**	4.5
12	q-transfer; electrolytes, diffusivity-conductivity, driving forces	End of Ch. 4
13	q-transfer; PEM versus SOFC	
14	**Ch.4-Problems**, q-transfer review	
15	Mass transfer; diffusivity, convection	5.2
16	Mass transfer; pressure drop, bipolar plates	End of Ch. 5
17	Mass transfer; total system, additional contributions	
18	**Ch. 5-Problems**, mass transfer review	
19	***MIDTERM-2***	
20	Characterization; in-situ/ex-situ, test stand	7.3.3
21	Characterization; impedance spectroscopy, voltametry	End of Ch. 7
22	**Ch. 7-Problems**, characterization review	
23	Modelling; basic model	6.2.3
24	Modelling; examples	End of Ch. 6
25	**Ch. 6-Problems**, modeling review	
26	Technology; Alkaline, molten carbonate, PEM, SOFC	Ch. 8
27	Technology; Balance of Plant (thermal management, fuel system, power electronics)	Ch. 9
28	Environmental impact; life cycle analysis	Ch. 11
29	**Laboratory Presentations**	
30	Class Review	