SRI VENKATESWARA COLLEGE OF ENGINEERING

COURSE DELIVERY PLAN - THEORY

Department of Applied Chemistry	LP: OC18002 Rev. No: 00 Date: 02.0 1.24
B.E/B.Tech : (Common to CHE&CSE) (Open Elective)Regulation: 2018 Sub. Code / Sub. Name : **OC18002/FUEL CELL CHEMISTRY** Unit : 1	

UNIT 1 BASICSOF FUEL CELL

Basics, History of Fell Cell Technology, Open Circuit Voltage, Efficiency, Basic Principles, Components Reactions for Alkaline, Proton Exchange Membrane, Direct Methanol.

Objective: To gain knowledge on fundamentals of fuel cell technology

Session No *	Topics to be covered	Ref	Teaching Aids
1	Definition of a fuel cell,Components of a Fuel Cell,Need for Fuel Cells, Difference between Electrolysis Battery and Fuel cell.	R9, P 1-9, R12, P 1-15	PPT
2	Conventional route and Fuel cell route for Energy Conversion &History of Fell Cell Technology.	R9,T2 P 1-19	PPT
3	Open Circuit Voltage, Efficiency of fuel cell.Typical polarization curve for a fuel cell (Fuel cell performance)	R10 P 1-12	PPT
4	Types of Fuel Cells, Comparison of the different types of fuel cells.	R11, P 1-15, R12, P 16-20	PPT
5	Advantages and disadvantages of Fuel cell.	R9 P 10-15, R12, P 21-30	PPT
6	Working Principles, Components &Reactions for Alkaline Fuel cell.	R9, P 71-73	PPT
7	Construction and Working Principles of Proton Exchange Membrane Fuel cell.	R9, P 44-46	PPT
8	Components and Reactions for Proton Exchange Membrane Fuel cell.	R9, P 44-46	PPT
9	Working Principles, Components &Reactions for Direct Methanol Fuel cell.	R9, P 68-70	PPT

Content beyond syllabus covered (if any): High Temperature Polymer Electrolyte Membrane (HT-PEM)Fuel Cells.

Sub. Code / Sub. Name: **OC18002/ FUEL CELL CHEMISTRY**

Unit : 2

UNIT 2 CHEMICAL THERMODYNAMICS

Basic Reactions, Heat of reaction,– Enthalpy change of a reacting system - Gibbs free energy of substances - Gibbs free energy change of a reacting system - Efficiency - Power, heat due to entropy change.

Objective: • To make the students to understand the importance of CHEMICAL THERMODYNAMICS

Session No *	Topics to be covered	Ref	Teaching Aids
10	System, Boundary, Surrounding – Types of system – Properties of system	T1/2/113 R8/18/670 R1/16/549	PPT
11	Process and their types – Internal Energy – Enthalpy	T1/2/115-117 R8/18/670	PPT
12	Zeroth Law of Thermodynamics – First law of Thermodynamics	T1/2/115-117	PPT
13	Need of Second law of thermodynamics – Clausius and Kelvin statement	T1/2/115-117 R8/18/670	PPT
14	Entropy - Definition – Mathematical expression of entropy – Significance of entropy – Entropy change in reversible and irreversible process	T1/2/137-140 R8/18/665	PPT
15	Entropy change in an Isothermal expansion of an Ideal gas – Entropy change in Physical transformations	T1/2/137-140 R8/18/665	PPT
16	Spontaneous Process – definition Examples of Spontaneous process Gibbs free energy and spontaneity	T1/2/143 R4/4/90 R5/8/309-315	PPT
17	Helmholtz Work function; Gibbs free Energy – Significance	T1/2/143 R4/4/90 R5/8/309-315	PPT
18	Standard free energy change Gibb's–Helmholtz equation – Significance – Applications	T1/2/145 R8/18/657-672 R1/16/568	PPT

Content beyond syllabus covered (if any): Maxwell relations

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Sub. Code / Sub. Name: **OC18002/ FUEL CELL CHEMISTRY**
Unit : 3

Unit : 3 ELECTROCHEMISTRY

Nernst equation and open circuit potential, pressure effect, temperature effect - Stoichiometric coefficients and reactants utilization - Mass flow rate calculation – voltage and current in parallel and serial connection - Over- potentials and polarizations - Activation polarization

Objective: • To make the students to understand the importance of electrochemistry.

Session No *	Topics to be covered	Ref	Teaching Aids
19	Basic of galvanic cells, electrochemical energy conversion	R8/37	PPT
20	Electrochemical energy storage, dynamics of equivalent circuits, impedance of electrode	R8/60	PPT
21	The Nernst Equation - Significance of the Nernst Equation	R8/44	PPT
22	Two, Three and Four Electrode Experiments	R8/45	PPT
23	Open Circuit Potential (OCP)	R8/22	PPT
24	Stoichiometric Coefficient - Balanced Reactions and Mole Ratios	R8/154	PPT
25	Parallel Circuit vs. Series Circuit	R8/373	PPT
26	Types of over voltages, chemical and electrochemical over potentials	R8/663	PPT
27	Polarizations - Activation polarization	R8/40	PPT
Content beyond syllabus covered (if any): Water splitting: from electrode to green energy			

Sub. Code / Sub. Name: OC18002 / **FUEL CELL CHEMISTRY**

Unit : 4

UNIT4 FUEL SYSTEM DESIGN & OPTIMISATION

Geometries of fuel cells and fuel cell stacks - Fuel Delivery and Crossover Prevention– Water flooding and water management, Thermal Management, Mass Transport/Concentration Losses and current collection - Bipolar plates and cooling plate design - Flow uniformity consideration

Objective: • To gain knowledge of in relation to Applications and Challenges of fuel cell..

Session No *	Topics to be covered	Ref	Teaching Aids
28	Optimization of Channel Geometry in a Proton Exchange Membrane (PEM) single Fuel Cell&Stacks.	R13 P 1-15	PPT
29	Analysis and control of a fuel delivery system.	R14 P 4655–4670	PPT
30	Effect of reactant gas Crossover Prevention in fuel cells	R 15, P 246	PPT
31	Influence ofWater flooding and water management on fuel cels.	R 15,16, P 1-3	PPT
32	Experimental Investigations on Thermal Management of a PEMFC stack.	R 9, R 16, P 115847,R 18 P 16.	PPT
33	Mass Transport/Concentration Losses and current collection-an overview.	R 11,R 9, P 50	PPT
34	Design analysis of PEMFC bipolar plates considering stack manufacturing and environment impact.	R18, P 152.	PPT
35	ANALYSIS OF COOLING PLATE DESIGNS FOR FUEL CELL APPLICATIONS	R18, P 1-10	PPT
36	Enhanced gas flow uniformity across parallel channel cathode flow field of Proton Exchange Membrane fuel cells.	R13, P 40,R 18.	PPT

Content beyond syllabus covered (if any): FUEL SYSTEM DESIGN & OPTIMISATION OF DMFC.

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Sub. Code / Sub. Name: OC18002/ **FUEL CELL CHEMISTRY**
Unit : 5

UNIT5 **APPLICATIONS AND CHALLENGES**

Automotive applications & issues - Micro fuel cells & portable power - Distributed & Stationary power. Cost Reductions, System Integration, Reliability, Technical Issues.

Objective: • To reduce the production cost of fuel cell systems to be used in transport applications.

Session	Topics to be covered	Ref	Teaching Aids
37	Hydrogen PEMFC system for automotive applications.	R 9, P 31	PPT
38	Micro fuel cells principles and applications.	R 20 ,P 67-69	PPT
39	Fuel Cells for Portable power – Distributed Power Application.	R 9, P 19-27	PPT
40	Challenges for PEM Fuel Cell-based uninterrupted power supply (UPS) system.	R 9, P 19-27	PPT
41	Fuel Cells for Stationary power Application.	R 9, P 19-27	PPT
42	An assessment of past and potential cost reductions for fuel cells.	R 9, P 81-83	PPT
43	Overview of Cost reductions in fuel cell technology.	R 9, P 81-83	PPT
44	System Integration and Control of Proton Exchange Membrane Fuel Cells.	R 9.R 11 P 27-38.	PPT
45	Durability and reliability of fuel cells: Challenges and solutions.	R 9.R 11, P 45-63.	PPT
Content beyond syllabus covered (if any): APPLICATIONS AND CHALLENGES OF METHANOL ELECTROLYSIS.			

* Session duration: 50 mins

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. To foundational knowledge of the fuel cell.
2. Understand the way to Fuel system design &optimization.
3. Apply their learned knowledge to develop conventional technologies.
4. Understand the importance of fuel cell applications.
5. The students will acquire knowledge on various fuel cell techniques and their mechanism.

REFERENCES:

TEXT BOOKS:

1. Jain P.C. "Engineering Chemistry- Vol 1, 16th Edition", DhanpatRai Publishing Company (P) Ltd.,New Delhi, 2013 **[T1]**
2. B. Viswanathan and Aulice M. Scibioh, "Fuel Cells: Principles and Applications",Universities Press, 1st Edition 2006. **[T2]**

REFERENCES

1. Puri, Sharma, Pathania., "Principles of Physical Chemistry", Vishal Publishing C., Jalandhar 2004 **[R1]**
2. Sivasankar B., "Engineering Chemistry", Tata McGraw-Hill Publishing Company, Ltd., New
   a. Delhi, 2008. **[R2]**
3. Gowariker V.R., Viswanathan N.V. and JayadevSreedhar, "Polymer Science", New Age International P (Ltd.,), Chennai, 2006. **[R3]**
4. Atkins ..P., J.D. Paula, "Physical Chemistry", Oxford University Press, Oxford, 2002. **[R4]**
5. Agarwal. OP, "Engineering Chemistry", Khanna Publishers, New Delhi, 2010. **[R5]**
6. Jain P.C. and Monica Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company (P) Ltd., New Delhi, 2010 **[R8]**
7. J. Newman, E. Karen Thomas-Alyea, Electrochemical Systems. 3rd Ed.,Wiley-Interscience, 2004
8. A.J. Bard and L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications. 2nd Ed.,Wiley, 2001.
9. Introduction to Fuel CellsContinuing Education and Development, Inc. P: (877) 322-5800 **[R9]**
10. The Open Circuit Voltage of Polymer Electrolyte Membrane Fuel CellsDie Leerlaufspannung von Polymerelektrolyt-Membran-Brennstoffzellen Chapter 1, 2019. **[R10]**
11. Fuel Cells - Challenges Ahead,B. Viswanathan,National Centre for Catalysis Research,Indian Institute of Technology, Madras, Chennai. **[R11]**
12. Fuel Cells and Their Applications,M. Ghouse,King Abdulaziz City for Science and Technology,June 2012. **[R112]**
13. Optimization of channel geometry in a proton exchange membrane (PEM) fuel cellJephanya Kasukurthi,University of Nevada Las Vegas,2009.
14. Analysis and control of a fuel delivery system considering a two-phase anodemodel of the polymer electrolyte membrane fuel cell stack,Journal of Power Sources 196 (2011) 4655–4670.
15. Energy, Volume 179, 15 July 2019, Pages 246-267
16. Water flooding in the proton exchange membrane fuel cellP.K. Bhattacharya,2015.
17. Applied Thermal Engineering,Volume 180, 5 November 2020, 115847
18. Design analysis,Journal of Power Sources 129 (2004) 152–169
19. ANALYSIS OF COOLING PLATE DESIGNS FOR FUEL CELL APLICATIONS, May 2016,Blice Nuchka Okome M'bika,University of Central Oklahoma,Directed by: Dr. Evan Lemley.
20. Micro-fuel cells—Current development and applicationsJournal of Power SourcesVolume 170, Issue 1, 30 June 2007, Pages 67-78

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	Prepared by	Approved by
Signature		02/01/2024.
Name	Dr.N.Nachiappan	Dr.S. Stanly
Designation	Asso. Professor	Prof. & Head
Date	02.01.24	02.01.24
Remarks *:	No change in LP.	

* If the same lesson plan is followed in the subsequent semester/year it should be mentioned and signed by the Faculty and the HOD