Syllabus

Ben-Gurion University of the Negev

Albert Katz International School for Desert Studies

Electro-Diffusion of Ions and Membrane Desalination Processes

Course # 001-24012

3 credits

Isaak Rubinstein

Semester A, Year 2008/09

Course Description:

This course concerns the theory of electro-diffusion – a nonlinear transport process whose essence is diffusion of charged particles, combined with their migration in a self-consistent electric field. Applications of this theory range from classical chemical engineering and electrochemistry, through environmental technologies, such as desalination, soil remediation and alternative energy sources, to micro-fluidics in biotechnology and biomedical engineering.

Course Objectives:

The objective of this course is to illustrate in the context of electro-diffusion that general approach to applied mathematics which views it as a study of correspondence between the mathematical phenomena and those of the surrounding world. This approach also determined the major difference between the chosen presentation style and that in the existing texts: few topics are addressed but the calculations are carried out in detail.

Course Structure:

Lecture: 13 frontal lectures Total # of Points: 3

Course requirements: *(Include required pre-courses, compulsory attendance, etc.)*

Basic Calculus, Introduction to Ordinary and Partial Differential Equation

Structure of Final Course-Grade:

	Component	Weight
1.	Final test	100%

Lecturer Details:

Reception hours: Tuesday, 12:00-14:00, Zonnenfeld Building, Room 112
E-mail: robinst@bgu.ac.il Telephone: 08-6596924

Description of Meetings

Meeting	Date	Subject(s)	Details (as necessary)	Chapters (in course textbook)
1		**Introduction**	**Electrodialysis as a prototypical electro-diffusion process**	**I.R., Chapter 1**
2		**Basic notions of electro-diffusion**	**Nernst-Planck Poisson Equations, Local Electroneutrality, Electric Current**	**I.R., Chapter 1**
3		**Characteristic space and time scales in electro-diffusion**	**Electrochemical potential, electric double layer, Debye length**	**I.R., Chapter 1**
4		**Equilibrium perm-selectivity of a charged membrane and ambipolar diffusion**	**Permeation through a potential barrier, diffusion potential, and electro-diffusion hierarchy**	**I.R., Chapter 1**
5		**Nonlinear effects in electro-diffusional equilibrium**	**The Poisson-Boltzman equation, electric field and force saturation, counterion condensation**	**I.R., Chapter 2**
6		**Locally electro-neutral electro-diffusion**	**Slow and fast diffusion in ion-exchange, membrane potential**	**I.R., Chapter 3**

		without electric current		
7		**Stationary current with local electro-neutrality**	**Multiple steady states in one-dimensional electro-diffusion, concentration polarization**	**I.R., Chapter 4**
8		**None-equilibrium space charge I**	**Space charge in liquid junction**	**I.R., Chapter 5**
9		**None-equilibrium space charge II**	**Space charge in concentration polarization**	**I.R., Chapter 5, B.Z.&I.R.JFM07**
10		**None-equilibrium space charge III**	**Non-equilibrium electric double layer**	**B.Z.&I.R.JFM07**
11		**Electro-convection I**	**Two types of electro-convection: bulk electro-convection and electro-osmosis**	**B.Z.&I.R.JFM07**
12		**Electro-convection II**	**Non-equilibrium electro-osmotic instability, bulk electro-convective instability**	**B.Z.&I.R.JFM07, B.S.,B.Z.&I.R.07**
13		**Electro-convection III**	**Electro-osmotic oscillations**	**I.R., Chapter 6**

References:

A. Course textbook

1. Rubinstein, I. 1990. *Electrodiffusion of Ions.* Philadelphia: SIAM (I.R.)

B. Other References

1. Newman, J and Karen E. Thomas-Alyea, K. E. 2004. *Electrochemical*

Systems. John Wiley & Sons, Inc, Hoboken NJ

2. B. Zaltzman and I. Rubinstein, Electro-osmotic slip and electroconvective Instability, *Journal of Fluid Mechanics* **579** (2007) 173 – 226 (B.Z.&I.R.JFM07)
3. B.D. Storey,B. Zaltzman and I. Rubinstein, Bulk electroconvective instability at high Peclet numbers, *Phys. Rev. E* **76** (2007) 041501 (B.S.,B.Z.&I.R.07)