Topics in Physico-Chemical Hydrodynamics and Electrodiffusion (A)SYLLABUS

2 credits

I FUNDAMENTALS OF CONTINUUM TRANSPORT

1. General conservation law, hyperbolic and parabolic diffusion, local mechanical equilibrium, friction theory of diffusion, osmosis, swelling, electric conductance, conductivity of dilute suspensions.
2. Sparse particle movement in a constant force field, sedimentation under gravity, hindered settling.
3. Adsorption and ion exchange column.
4. Kinetics of the first order phase transitions: Ostwald ripening, morphological instability.

II CONVECTIVE DIFFUSION

Forced Convection

1. Diffusion layer
2. Convective diffusion in a thin channel – reduction to one-dimensional diffusion, heat flux curving.
1. Taylor dispersion in a channel.

Free Convection

1. Thermal Rayleigh-Benard and Marangoni convection, the Boussinesq approximation, the Boycott effect in sedimentation in an inclined channel.
2. The loop model of thermal convection.

III ELECTRO-DIFFUSION - PROTOTYPE OF DIFFUSION IN A VARIABLE FORCE FIELD

1. Basic notions: electro-dialysis as a prototypical electro-diffusion phenomenon, local electro-neutrality, local electro-diffusion equilibrium
2. Quasi-equilibrium electric double layer, perm-selectivity.
3. Ion exchange as a non-linear diffusion process; steady-state ionic current, concentration polarization; non-equilibrium electric double layer, extended space charge.
4. Electro-convection in electrolytes: bulk electro-convection; equilibrium, quasi-equilibrium and non-equilibrium electro-osmosis; non-equilibrium electro-osmotic instability; electro-osmotic oscillations.

MATERIALS

BOOKS

1. Probstein, R. F. 1994. *Physicochemical Hydrodynamics*. New York: John Wiley & Sons.
2. Levich, V. G. 1962. *Physicochemical Hydrodynamics*. N.J.: Prentice-Hall.
3. Whitham, G. B. 1974. Linear and Nonlinear Waves. New York: John Wiley & Sons.
4. Maxwell, J. C. 1954 *Treatise on Electricity and Magnetism. Vol.1.* New York: Courier Dover Publications.

5. Tritton, D. J. 1988. *Physical Fluid Dynamics*. Oxford: Clarendon Press.
6. Lifshitz, E. M. and Pitaevskii, L. P. 1981. *Physical Kinetics. Landau and Lifshitz Course of Theoretical Physivs. Volume 10.* Oxford: Pergamon Press.
7. Rubinstein, I. 1990. *Electrodiffusion of Ions.* Philadelphia: SIAM

JOURNAL ARTICLES

1. Maxwell, J.C., On the Dynamical Theory of Gases. *Phil. Trans. Roy. Soc.* **157** (1867) 49-88
2. Truesdell, C., Mechanical Basis of Diffusion. *J. Chem. Physics* **10** (1962) 2336-2344
3. Jeffrey, D. J., Conduction Through a Random Suspension of Spheres. *Proc. Roy. Soc. A***335** (1973) 355-367
4. Kynch, G.J., A Theory of Sedimentation, *Trans. Faraday Soc.* **48** (1952) 166-176
5. Rubinstein, I. and Zaltzman, B., Diffusional Mechanism of Strong Selection in Ostwald Ripening. *Phys. Rev. E* **61** (2000) 709-717
6. Taylor, G. I., Dispersion of Soluble Matter in Solvent Flowing Slowly Through a Tube.*Pros. Roy. Soc. A* **219** (1953) 186-203
7. Keller, J. B., Periodic Oscillations in a Model of Thermal Convection. *Journal of Fluid Mechanics* **26** (1966) 599-606
8. Zaltzman B. and Rubinstein I., Electro-osmotic slip and electroconvective Instability, *Journal of Fluid Mechanics* **579** (2007) 173 – 226

LECTURER:

Prof. Isaak Rubinstein