CE 697-013, Spring 2011
Advanced Physico/Chemical Processes of Environmental Engineering
MWF 9:30-10:20 AM   CIVL 2113

Instructor: E.R. Blatchley III   CIVL 2129
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Prerequisite: CE 550 or equivalent or instructor consent

Required Texts: AWWA (1999) *Water Quality and Treatment*, 5th Edition, McGraw-Hill, New York.

Cussler, E.L. (1997) *Diffusion: Mass Transfer in Fluid Systems,* Cambridge University Press.

Recommended Texts: Weber, Jr., W.J. and DiGiano, F.A. (1996) *Process Dynamics in Environmental Systems*, John Wiley & Sons, New York.

Stumm, W. and Morgan, J.J. (1996) *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters*, John Wiley & Sons, New York.

J.M. Montgomery, Inc. (2005) *Water Treatment: Principles and Design*, John Wiley & Sons, New York.

Grading Policy: 5 exams @ 15% each; weekly homework assignments 25%.

Overall Course Description

Physico/chemical processes are central to the behavior of most Environmental Engineering systems. Therefore, knowledge of fundamental physico/chemical processes and the principles that govern their behavior is of broad importance in the field. This class has been designed to provide students with advanced knowledge related to five general groups of physico/chemical processes: gas-liquid transfer, solid:fluid transfer, precipitation:dissolution, membranes, and photochemistry/photochemical reactors. The class is divided into five modules of roughly equal length (*ca.* three weeks), each dealing with one process group.

The first four process groups relate to two-phase systems. In each case, lectures will begin with a presentation of fundamental equilibrium and transport principles. These background lectures will be followed by lectures that relate to the dynamic behavior of each system. Each module will conclude with several lectures that relate to specific examples that illustrate relevant governing principles, and techniques used to evaluate them.

The fifth module will focus entirely on photochemistry and photochemical reactor theory. This is a rapidly emerging area that has importance in both engineered and natural systems. Moreover, it is an area where conventional methods of analysis often fail. Lectures in this module will begin with basic principles of photochemistry, followed by materials that relate to system dynamics where photochemistry plays an important role.

For all modules, homework assignments will be given on a (roughly) weekly basis. Each module will conclude with an exam that covers module-related materials.

CE 697 Tentative Course Outline[1]

I. Gas-Liquid Transfer: Equilibrium principles, dynamics, applications.

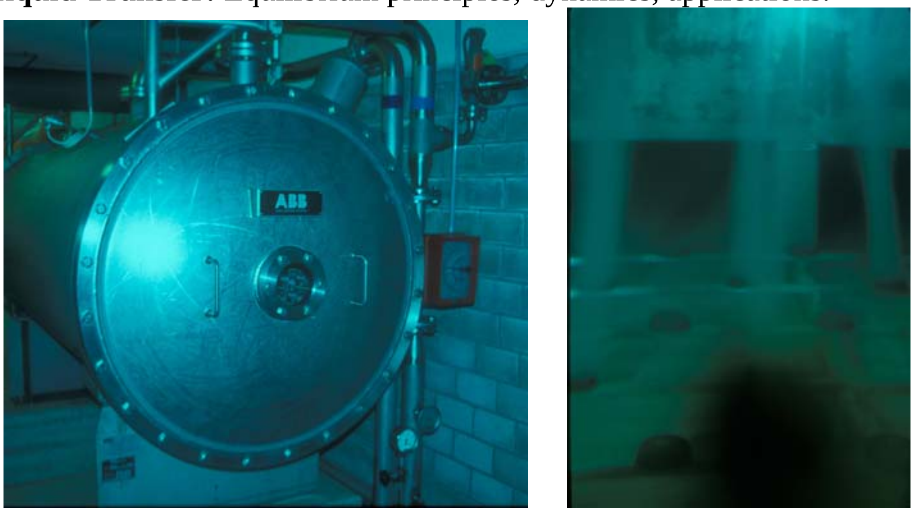

Figure 1. Pictures from an ozone contacting system in Zurich, Switzerland. The image on the left is an ozone generator. On the right is a view of ozonation at the Zurich facility, which is accomplished by introduction of small bubbles containing a mixture of air and ozone through a “diffuser”. The principles that govern the behavior of this system also apply to other gas-liquid transfer scenarios, including oxygen transfer, air stripping, and stream reaeration.

II. Solid-Fluid Transfer: Equilibrium principles, dynamics, applications.

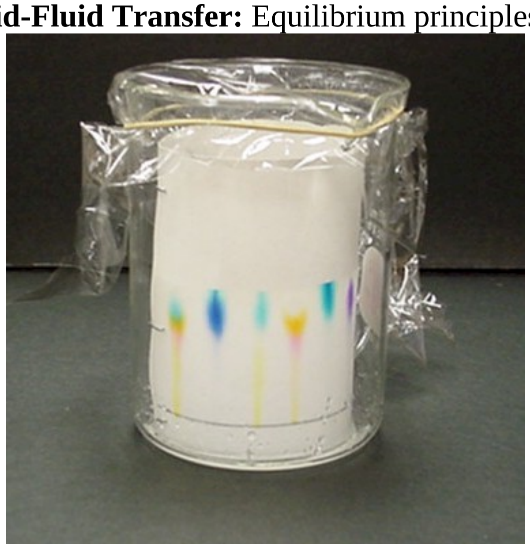

Figure 2. Illustration of paper chromatography. The physico/chemical principles that govern the behavior of this system also dictate many fate/transport processes in the environment, as well as some analytical procedures we use for environmental samples.

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[1] Subject to change.

III. Precipitation/Dissolution: Equilibrium, dynamics, examples.

Figure 3. Examples of chemical precipitation processes. Left image: accumulation of Fe-based precipitant at a quartz:water interface in an ultraviolet (UV) photochemical reactor. Precipitation in this form can virtually occlude all UV radiation, thereby adversely affecting reactor performance. Right image: reactor system used for metal removal from water by chemical precipitation. The principles that govern the dynamics of these processes are also relevant to many other applications, including: softening, Fe and Mn removal, solidification/stabilization, and separation (recovery) of heavy metals.

IV. Membrane Processes: Basic Principles, Membrane Theory, Applications.

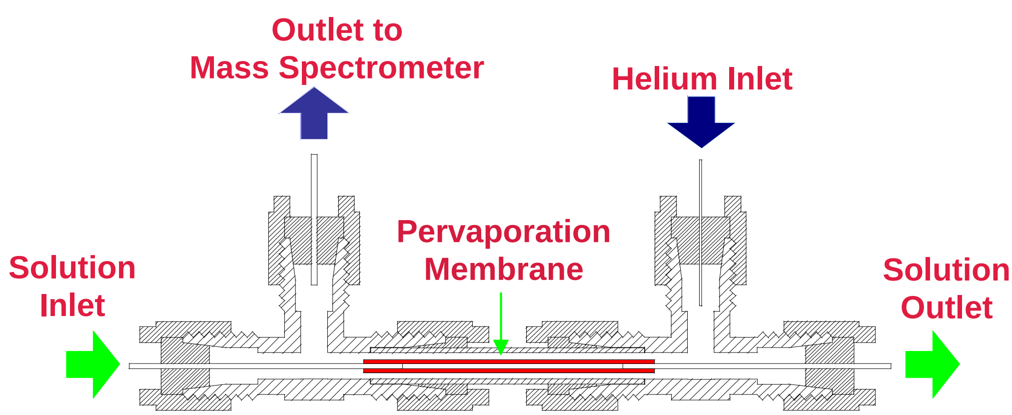
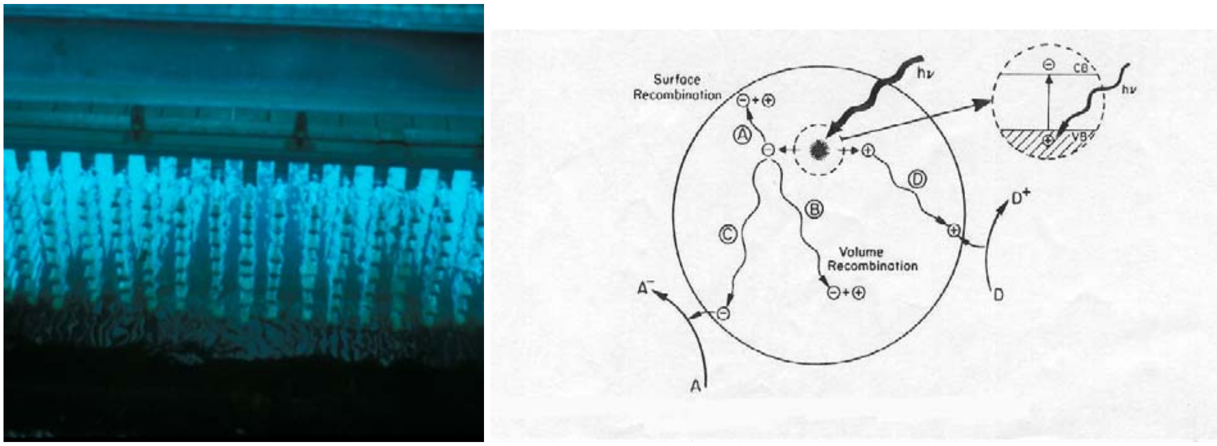


Figure 4. Schematic representation of membrane interface used for membrane introduction mass spectrometry (MIMS). MIMS represents a powerful analytical tool for analysis of fluid mixtures, including water and air. The principles of membrane separations are important in many natural and engineered processes that are relevant in environmental engineering, including reverse osmosis, ultrafiltration, microfiltration, and microbial membranes.

V. Photochemistry/Photochemical Reactors: Basic Principles of Photochemistry, Photochemical Reactor Theory, Applications.



Source: Linsebigler et al., *Chem. Rev.*, **95**, 735, 1995.

Figure 5. Examples of environmentally relevant photochemical processes. Left image: photograph of UV disinfection system used for disinfection of municipal wastewater effluent in East Chicago, IN. This facility, which is located in one of the most industrialized areas of the US, releases treated municipal wastewater to the environment that is sufficiently clean that salmon actually spawn in the outfall from the facility; freshwater sponges also thrive in this same outfall. UV disinfection is also used for drinking water because it is known to be effective for inactivation of many recalcitrant microbial pathogens (*e.g.*, *Cryptosporidium parvum*) and because it generates few, if any disinfection by-products. Right image: schematic representation of photocatalysis by the use of (nano-sized) TiO_2 particles. Photocatalytic processes are being applied with increasing regularity as an approach to treatment of recalcitrant water constituents.