CHS6611 – ENVIRONMENTAL CHEMICAL ANALYSIS
ANNOTATED SYLLABUS – FALL 2006
(see SCHEDULE http://www.fau.edu/~blouda/CHS6611-sch.pdf)

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PREFACE: This course is designed for students of varied undergraduate preparation who are pursuing a Masters of Science degree in Environmental Science or a Master of Science in Teaching in Chemistry. It is open to all graduate students. However, this course **cannot** be used as credit towards the M.S. or Ph.D. in Chemistry and Biochemistry without prior approval of the instructor, the student's major professor and committee and the Department. That is, by design, this course lacks the rigors of a true chemistry course. It does, however, have 'a bit' of "real" chemistry in order to provide the requisite operational understanding of chemicals in and their effect upon the environment and its components, including you and me.

COURSE LAYOUT: This course begins with a broad based overview of a few classic divisions of 'chemistry', namely; general, organic, biochemistry and analytical. Each of these topics are covered in about 1-1/2 hours and only the topics, mainly vocabulary, required for the remainder of the course are discussed. Thus, some attention to atomic structure, molecules, organic classes, photosynthesis / respiration and general analytical techniques are covered. Next, a rather extended (8+ sessions) coverage of aquatic chemistry occurs. Lastly, we cover the main environmental chemical issues affected the World today (pollution, pesticides, energy, acid rain, ozone destruction, global warming). There is a field trip to an environmental analytical laboratory so the student may gain an understanding of the monitoring of our environment (gasoline spills, drinking water, etc.).

Pedagogically, the course evolves through a certain amount of rote memorization into mechanism / synergism understanding and finally the student is expected to make basic scenario evaluations (= what happens if---?).

ANNOTATED OUTLINE: (**Sessions 6, 11, 18, and 30 are exams)**.

Refer to the class schedule for exact days / dates of each "session".

NOTE: In this booklet, ~~single~~ or ~~double~~ strikethrough words are provided only as extra information and/or clarification and will not be tested.

SESSIONS 1-2: **Introduction to the course**, how "environmental chemistry" evolved as a distinct discipline (Silent Spring, EPA, DDT &c), description of the various environmental (hydro-, atmos-, geo-, bio-, anthro-) spheres of Earth and more detailed divisions of selected areas (rivers, lakes, the World Ocean, soil, &c.).

SESSION 3: **General Chemistry review**. Metric system, Atomic structure (p^+, n^o , e^-; mass, number, isotopes), electron orbital (filling) up to atomic number 12 (Mg). Essentially covers what is required in order to have an understanding of the generalities of the periodic table

and "why" certain atoms (elements) "want" to exist in a +1, + 2, -1, -2, or other ionic state. This is needed for the basics of REDOX chemistry as it applies to the presence of metals in the environment.

SESSION 4: **Organic and Bio-Chemistry**. This session deals mainly with a moderate amount of *vocabulary*. What is an olefin, an alkane, an alkene, an aromatic, *et cetera.* The biochemistry section is limited to "*short-form*" overviews of photosynthesis and respiration plus some discussion on selected biomolecule classes (lipids, phospholipids, &c.).

SESSION 5: **Introduction of 'Analytical Chemistry'**. Covers some basic tenets of analytical methodology: Precision / accuracy, instrument response, limits of detection, errors, sampling, some definitions of techniques to be covered later in the course and MSDS usage.

SESSION 7-10: These sessions cover **aquatic chemistry** and begin with a description of water itself. Coverage of solution concepts (concentration, hydration, solute/solvent, common ion effect, &c.). Colligative properties (-FP, +BP, osmotic pressure &c.), gases in water (Henry's Law, Clausius-Clapeyron relation: really important in the understanding of CO_2 re global warming, pH & for O_2 in BOD, COD, P/R), pH and acid/base concepts. Carbonic acid equilibrium and alkalinity, analysis of CO_2 and O_2.

SESSION 12: This session briefly goes into the states of **metals (cations) in aquatic systems.** The 'speciation' of iron (Fe^{2+}/Fe^{3+}) is covered in the most depth as it is important in 'rusting', surface coatings / adsorption mechanisms, control of photosynthesis, and other processes. Calcium and 'hardness' are discussed during this period. Chelation ("claw like" binding) of metals by anthropogenic pollutants as well as natural (humic acids &c.) substances is covered as pertaining to transport, source and sink activities.

SESSION 13: **REDOX, aka 'oxidation-reduction'**, reactions are quite important in the environment. This session is likely to scare the chemophobic student at first. However, it is not that difficult and a basic understanding of this process goes a long way in helping one understand why certain metals either leave or enter the dissolved state from the various solid phases in the environment. This is the "why" behind a lot of 'sink *versus* source' considerations pertaining to metals.

SESSION 14: **PHASE INTERACTIONS**. Chemistry in environmental settings does not occur strictly in solution (the world is not test tube). Rather, most reactions, material transfers and other processes occur at the boundary (interface) of 2 or more phases. Examples include the air-sea boundary and water / sediment interfaces. This session covers colloids, clays, silicates, ion-exchange and solid phase adsorption / occlusion mechanisms.

SESSION 15-16: **MINERAL CYCLES**. This session covers the biogeochemical cycling of carbon, nitrogen, sulfur, phosphorous and touches on iron and silica. Here we uncover the Redfield-Richards Model and how it helps in the understanding of eutrophication and phytoplankton succession. Additionally, on a global and historical basis the inverse relation of the carbon and sulfur cycles is revealed. Specifically, on a mass basis if organic (reduced) carbon is buried then sulfides (reduced S) are oxidized. Conversely, if organic matter (reduced C) is oxidized, then S is reduced and buried (metal sulfides, pyrite, &c.). This also applies directly to global warming and postulated (Gaia) whole-earth feedback loops.

SESSION # 17: **WATER POLLUTION & TREATMENT.** This is the area covered as 'industrial waters'. "Trophy" of water systems, BOD, COD, MSDS, the Redfield ratio are all included (covered in earlier sessions) again. Sewerage, drinking water, ground water contamination, and biodegradation are the topics of this session. Treatment of waste waters are emphasized and this prepares the class for the first field trip.

SESSIONS # 19-20: "**HEAVY METALS" and "BIOCIDES**". The first half of session #19 will cover some basic tenets of heavy metals pollution and then cover the (methyl) mercury and organo-tin problems in a bit more detail. Local examples include (methyl)mercury in the Everglades and the Everglades Agricultural Area (EAA). Approximately 1-1/2 sessions are devoted to the huge variety of biocides (pesticides, herbicides, rodenticides, etc-a-cides). Obviously, we start with the DDT story, Rachel Carson's book Silent Spring and the birth of the US-EPA. Various classes of 'biocides' (organochlorine, organophosphate, carbamates, pyrethrins etc.) are surveyed briefly and examples of these compounds in current worldwide and local use are given. At all stages of discussion, the 'benefit *versus* risk' paradox is stressed. As these structures are difficult to learn / memorize, only DDT, its 2 main breakdown products (DDD and DDE) and an analog (methoxychlor) are required structural knowledge. This should help lower the anxiety level of the chemophobe.

SESSIONS # 21-22: "ENERGY TOPICS". This begins with consideration of wood as renewable resource and moves into the 'fossil' fuels: peat, coal, oil shale and petroleum. A quick overview of how coal and petroleum are generated then leads into description of each of these. Here the student will find out the difference between a bituminous coal and anthracite and what each fraction of a crude oil contains. This topic finishes off with discussion of nuclear, solar, wind, fuel cell and other 'alternate' energies.

NOTE: Take home test #4, "NOT a GROUP EFFORT !" is given out at the end of Session #21 and is due to be handed in at the field trip (session # 23).

SESSION #23: FIELD TRIP, Environdyne Analytical Laboratory (map is page iv following here), Boca Raton, Florida. This field trip reveals to the student the actual workings of an environmental analytical laboratory. Here he/she will see in action GC, GC-MS, AA, ICP-MS, and a variety of 'wet-chemical' methods. This is where samples are analyzed for heavy metals, pesticides, herbicides, and other pollutant classes. ***TEST #4, the 'take-home', is DUE.***

SESSIONS # 24-25: "ATMOSPHERIC CHEMISTRY". These 2 sessions cover photochemical SMOG; including a discussion of natural *vs.* anthropogenic components, the ~~infernal~~ internal combustion engine, use of octane boosting and oxygenation additives (methanol, MTBE etc.) as well as ACID-RAIN.

SESSIONS #26-28: These sessions cover the '**OZONE PROBLEM" and "GLOBAL WARMING".** The protection of life (DNA) by the ozone layer is stressed and this is explained using absorption / transmission spectra. The ultraviolet (UV) portion of solar radiation is divided into UVA, UVB and UVC, each with different energies and life damaging effects. Changes in incident solar radiation within the various levels of the atmosphere (covered in sessions # 1-2) are also covered. Global warming is discussed from various angles: (1) is it really happening (= the George W. Bush question), (2) why is it thought to be happening and what are doing to create / stop / reverse this phenomenon, (3) thermohaline circulation within the World Ocean (main CO_2 storage / transport system), and (4) alternate storage / recovery of CO_2, CH_4 and other "GWGs" (global warming gases).

SESSION # 29: The first ½ hour of this last, pre-comprehensive final, session is devoted to the concept of "green chemistry. That is, what are the chemical and associated industries doing to change technologies to more environmentally friendly (thus "green") methods. This is a short film plus some lecture. The last hour is then given over to a review of topics for the final plus Q&A on same.

SESSION #30: ----COMPREHENSIVE FINAL -----