<u>CHM3080; ENVIRONMENTAL CHEMISTRY</u>

ANNOTATED SYLLABUS

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<u>Hello</u>: This course is tailored for Chemistry Majors in the ACS certified Baccalaureate of Science (B.S.) program. It will satisfy elective requirements in that program. Additionally, this course is open to any student, regardless of major, providing that they meet the <u>prerequisite requirements</u> (1 year each of General and Organic Chemistry) or make arrangements with the instructor.

<u>Objectives:</u> The main objective of this course is in two parts: First, to provide the student with an understanding of the chemical and physical processes that occur amongst the environments of Earth. Second, to guide the student towards an appreciation of how fragile these systems are and what we can or cannot do to avoid severe negative impacts.

<u>Overview:</u> The course will begin with a description of the environments of Earth for that is where the chemistry we consider occurs. Environmental chemistry differs from "test tube" chemistry. That is, we need to consider extremely heterogeneous mixtures, quite unlike the well-defined recipes of laboratory chemistry. We will also include mathematical description / analysis / modeling of several physical processes (diffusion, kinetics, solubilities, light, *et cetera*).

'Atmospheric' chemistry will be covered as it applies to both the outside and the inside (buildings) world. This then includes such topics as the ozone layer, global warming, radioactivity and the generation of radon, acid rain, photochemical smog and other topics.

Much of the term will be devoted to aquatic chemistry, interactions at phase boundaries (gas/liquid = atmosphere/hydrosphere, liquid/solid = hydrosphere / geosphere, *etc.*), and geochemical cycles, which include; C, N, S, P, Hg, As, CO_2/O_2 and others.

"Fossil Fuel" and Nuclear Energies as well as emerging alternate energy sources (hydrogen, hybrid, solar, geothermal) will be reviewed. Finally, the emerging technologies of "Green Chemistry", ways by which to do "test-tube" chemistry yet use / produce environmentally safe reagents / products, will be covered.

One "field trip", a visit to a local commercial environmental analytical laboratory, is included. Here, the student will gain a much better feel for environmental chemistry in action and how it really applies to our everyday lives.

<u>Course text:</u> G. W. vanLoon and S. J. Duffy (2000) <u>Environmental Chemistry; a global perspective.</u> Oxford University Press, Oxford. 492pp. MSRP = $ 52.95.

<u>Other source materials used by the instructor for the development of this course:</u>

- Fifield, F. W. and Haines, P.J. <u>Environmental Analytical Chemistry</u>. Blackwell Science, Oxford, 490 pp. (an excellent analytical chemistry reference / text).

- Millero, F.J. (1996) <u>Chemical Oceanography</u>. CRC Press, Boca Raton, Fl. 469 pp.

-Wetzel, R. G. (2001) <u>Limnology</u>. Academic Press, San Diego. 1006 pp.

-Reddy, K.R., O'Connor, G.A., and Schelske, C. L., Editors (1999) <u>Phosphorous Biogeochemistry in Subtropical Ecosystems.</u> Lewis, Boca Raton, Fl. 707 pp.

-Livingston, R. J. (2001) Eutrophication Processes in Coastal Systems. CRC Press, Boca Raton, Fl. 327pp.

-Davis, S. M. and Ogden, J.C.; Editors (1994) Everglades; The Ecosystem and Its Restoration. St. Lucie, Press. Delray Beach, FL. 826pp.

-Anderson, A.J.B. (2000) Interpreting Data, Chapman & Hall / CRC, Boca Raton, 223pp.

-Sterner, R.W. and Elser, J.J. (2002) Ecological Stoichiometry, Princeton University Press, Princeton, 439pp.

-Wagner, R.E. *et al.*, Editors (1996) Guide to Environmental Analytical Methods, 3rd. Ed., Genium Publishing Corp., Schenectady. >100pp.

-Howard, A.G. (1998) Aquatic Environmental Chemistry. Oxford Science, Oxford. 90pp.

-Garrels, R.M. and Christ, C.L. (1965) Solutions, Minerals, and Equilibria. Freeman, Cooper & Co., SanFrancisco. 450pp.

Grading: A total of 700 points is possible.

These points are distributed as follows; 3 tests at 100 points each (300pts), 1 take-home test / project (scenario development / analysis) at 200 points, and a cumulative final worth 200 points. Major grade breakpoints (the so-called 'vanilla' scale) are 90% (630+/A), 80% (560-629/B), 70% (490-559/C), 60% (420-489/D), <60% (0-419/ F). These "break points" *may* be curved down at the discretion of the instructor but they will not be increased.

Syllabus: Please note that this is tentative and, while efforts are expended to 'stay to schedule', the instructor retains the right to alter (→ indicates continual sessions on related topics) this schedule during the term to adapt to student progress, natural and man made disruptive events, and the-like.

Session #1: Introduction to the course. *Silent Spring* and the start of global environmental awareness. Beginning of description of "environments*"

Session #2: Environments continued (*geosphere, hydrosphere, atmosphere, soil profiles, lake and ocean physiography, *et cetera*).

Session #3: Chapter 1; History of Earth (importance of photosynthesis and the development of an oxygen rich atmosphere and $Fe^{2+} \rightarrow Fe^{3+}$ *etc.*), the mathematics of chemistry (rapid review of units, the System International, metric, scientific notation, residence times, etc.).

Session #4: Start of Atmospheric Chemistry: Review of atmospheric layering and major processes, air *per se*, electromagnetic radiation (ionizing *vs.* non-ionizing radiation, energy/wavelength/frequency, *etc.*), free energy considerations.

Session #5: **TEST #1**

Session #6: Ozone issues [Chp. #3] Electromagnetic radiation (Esp. UVA/UVB?UVC) and the formation of ozone (photochemical rate equations), free energy. →

Session #7: Ozone cont.: catalytic decomposition reactions (hydroxyl, nitrous oxide, chlorine radicals, CFCs, HCFCs, dross etc.) and the ozone hole.→

Session #8: Tropospheric chemistry-smog, acid rain and indoor air [Chpts. #4-7]. Smog, photochemical smog, volatile organic compounds (VOCs), the internal combustion engine.→

Session #9: Tropospheric chemistry-cont. Rain and acid rain. NOx and SOx species, day versus nighttime chemistries. Controls of NOx and SOx (fluidized coal bed, SONOX). →

Session #10: Tropospheric chemistry-cont. Atmospheric particulates, urban and indoor air quality, the Radon issue (radioactive decay processes, half life, etc.).→

Session #11: "Greenhouse" and Global Warming [Chpt. 8 plus handouts] The concept of Earth as a 'greenhouse'; icehouse / greenhouse cycles in geologic time, CO2 / O2 feedback and Lovelock's Gaia hypothesis, oceanic conveyor belt. →

Session #12: "Greenhouse" and Global Warming cont. Measuring CO_2 (IR spectroscopy, Beer-Lambert relations), sources and sinks, alternative storage / disposal technologies. →

Session #13: Energy; Fossil fuels, nuclear, solar, wind, alternate.

Session #14: **TEST #2**

Session #15: Aquatic Chemistry ('hydrosphere'): Water, Speciation (α, fractional concentration) of dissolved species, residence times (τ = [x]/(dx/dt)), dissociation of Bronsted-Lowry acids (mono-/di-/tri-protic) and calculation of constants →

Session #16: pE / pH diagrams (Pourbaix system) and prediction of chemical behavior, measurement of pE (Nernst equation and principles), SHE (Standard Hydrogen Electrode). →

Session #17: Gases (Henry's Law, Clausius-Clapeyron relationship). Carbonic acid equilibrium (influences of photosynthesis, respiration, temperature etc.), alkalinity.→

Session #18: Organic matter in water (fulvic and humic acids, chelation theory, source and sinks of metals), alteration of photic transmissivity, etc.. →

and **(ASSIGNMENT OF TAKE-HOME "TEST / PROJECT" due at Session # 26)**

Session #19: Metals: Hydration (aquo complexes), iron speciation (return to pE/pH and redox concepts), additional metal-humic discussion, mercury and arsenic methylation (Archaebacterial), man introduced ligands and influence on natural metal cycling.→

Session #20: Colloids, clays, interfacial exchange (Langmuir relation, Freundlich relation, octanol / water partition and applicability to bioaccumulation). Soils [Chp.18] overview and interpretation only as it applies to interfacial exchanges. →

Session #21: Biogeochemical cycles [Chpt. 15] Abiotic vs. biotic "worlds", photosynthesis / respiration, →

Session #22: Cycles cont.: carbon, nitrogen, sulfur, oxygen, water and 'other' cycles.

Session #23: **TEST #3**

Session #24: Chemistry of waste, waters [Chpt. 16]. Waste water treatment and recycle, analytical parameters (BOD, COD, TSS, TP, TN, DO, pH etc.). and Film on Wakodahatchee Wetlands.→

Session #25: Chemistry of waste, solids [Chpt. 19] Sludges, landfills (membrane, gases, etc.), TCLP (Toxicity Characteristic Leachate Procedure) →

Session #26: Biocides [Chpt. 20] The DDT story and all of the chlorinated hydrocarbons since. Use of natural products (pyrethrins etc.) or natural product mimics in order to decrease harmful side effects.

(**TAKE HOME TEST / PROJECT DUE, -5 points per day late**)

Session #27: **FIELD TRIP** (Environmental Analytical Laboratory); see GC, GC-MS, ICP, ICP-MS, BOD, AA, etc. in action and how it applies to the 'real world'.

Session #28: "Green Chemistry": How man can "do chemistry" in an environmentally friendly manner (alternate solvents, reagents, etc.) and produce more benign (rapid breakdown after discarding / use) products.

Session #29: **FINAL (yes it is a comprehensive final, just like life!)**