DALHOUSIE UNIVERSITY

Faculty of Science Course Syllabus
Department of Oceanography
OCEA 4130/5130
Chemical Oceanography
Fall 2016

Instructor:	Prof. *Doug Wallace*		*dwallace@dal.ca*	*SOSB 2-35*
Assistant:	*Dr. Rebecca Langlois*		*rebecca.langlois@dal.ca*	*SOSB 2-34*

Lectures:	*M*	*8:35-10:25*	*LSC Oceanography 3655*
	F	*9:35-10:25*	*LSC Oceanography 3655*

Tutorials: *3-4 sessions to review problem sets (TBA)*

Office hours: *By appointment only. E-mail: rebecca.langlois@dal.ca .*

Course Description

This course covers the major and minor constituents of sea water, the controls on its chemical composition, nutrient cycling, gas exchange and the influence of the oceans on atmospheric chemistry. Other topics included are chemical tracers, and radiochemical dating methods, stable isotope studies, chemical speciation and chemical models of sea water.

Course Prerequisites

OCEA 2000
OCEA 3002

Course Objectives/Learning Outcomes

At the end of this course students should be able to:

- *Identify the components of seawater and their distributions in the world's oceans*
- *Identify the processes that affect chemical composition in seawater*
- *Integrate concepts of physical and chemical processes to describe nutrient and chemical cycles in the ocean, particularly the carbon cycle*
- *Apply learned content to answer real-world chemical oceanography questions*
- *Organise learned content into concise, scientifically-supported theories*

Course Materials

- *Recommended textbooks are:*
  - *Emerson and Hedges: **Chemical Oceanography and the Marine Carbon Cycle**. Cambridge University Press.*
  - *Libes: **An Introduction to Marine Biogeochemistry**. Wiley.*

- *Pilson:* ***An Introduction to the Chemistry of the Sea****. Cambridge University Press.*
- *Berner and Berner:* ***Global Environment: Water, Air and Geochemical Cycles****. Prentice-Hall.*

- *Additional and out of print required reading materials will be provided and will also be available on the OCEA 4130/5130 Brightspace site.*

Course Assessment

Students will be evaluated on quizzes, problem sets, a mid-term exam, and a final exam. Students should be prepared to work independently and as a group. The problem sets include short answer questions, essays, calculations, and word problems. Students will have one week to complete problem sets. In-class quizzes on the reading material will be given regularly. The in-class mid-term will consist of multiple choice questions, short answer questions, and calculations. The final exam will be scheduled by the registrar and have multiple choice, short answer questions, and calculations. As graduate and undergraduate students are completing the same assignments, undergraduates' final marks will be scaled by 10%.

Component	**Weight (% of final grade)**	**Date**
Quizzes	*10%*	*weekly*
Mid-term exam	*20%*	*26 October (tentative)*
Final exam	*40%*	*(Scheduled by Registrar)*
Assignments	*30% (total or best of 3)*	
Problem Set 1	*10%*	*28 September (tentative)*
Problem Set 2	*10%*	*6 October (tentative)*
Problem Set 3	*10%*	*10 November (tentative)*
Problem Set 4 (tentative)	*10%*	*25 November (tentative)*

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D	(50-54)
A (85-89)	B (73-76)	C (60-64)	F	(<50)
A- (80-84)	B- (70-72)	C- (55-59)		

Course Policies

Collaboration- *Students are encouraged to discuss assignments in groups. However, each student must write and submit their own answers, rationale, and solutions to the problem sets.*

Late assignments- *Students will lose 5 points per day an assignment is handed in late. An assignment is considered late if it is not handed in at the beginning of the lecture period that it is due.*

Missed mid-term exam- *There is no additional mid-term exam. In case of serious illness, students must submit proper documentation per departmental and faculty regulations. Only in such a case the final exam will count for 60% of the final grade.*

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Electronic devices- *No recording devices are allowed without prior written permission from the instructor. All cell phones are to be silent during lectures. No cell phones or graphing calculators are allowed during exams.*

Course Content

The following is a chronological flow of the course. Material that was not covered in one lecture session will be continued in the following session. An updated version of the course time table will be posted on the Brightspace website.

Week 1 (09 Sept.): *Introduction*

Week 2 (12, 16 Sept.): Lecture 1: Introduction to Chemical Oceanography
Lecture 2: Water and Seawater- *water structure; ions in seawater; units; steady-state vs. equilibrium; 1-box model; residence time*
Recommended reading: Libes Chapter 3, Pilson Chapter 2.1

Week 3 (19, 23 Sept.): Lecture 3 & 4: Water and Seawater- *why is the sea salty; sources of materials; rainfall and river chemistry; weathering; salinity; seawater major ions; rain to river to sea; aerosol; cyclic salt*
Recommended reading: Berner and Berner Chapters 4 and 7

Week 4 (26*, 30 Sept.):Guest Lecturer*, Dr. Dariia Atamanchuck- *SeaCycler*
Lecture 5: Esutaries, Clays, Evaporites- *estuarine processes; interactions with clay minerals; evaporates*
Lecture 6: Hydrothermal sources
Recommended reading: Berner and Berner Chapters 7 and 8; Van Dover 2011
Assignment: Problem Set 1

Week 5 (3, 7 Oct.): Lecture 7: Biogenic Fluxes- *Biogeochemical reactions, rain ratio, sedimentation*
Recommended reading: Berner and Berner Chapter 8; Redfield 1934; Redfield 1958
Assignment Due: Problem Set 1

Week 6 (14 Oct.): (Note: 10 Oct.- Holiday) Lecture 7: Biogenic Fluxes- *sedimentary sinks; $CaCO_3$ precipitation; $CaCO_3$ dissolution in deep ocean; $CaCO_3$ sediment distribution*
Recommended reading: Pilson Chapter 7.3; Broeker and Peng pg. 8-28
Assignment: Problem Set 2

Week 7 (17*, 21 Oct.): Lecture 8: Redox and Sulfate Removal- *removal of sulfate; redox reactions; reactions in sediments; summary of sources/sinks*
Guest Lecturer*, Lecture 9: Nitrogen- *major nutrients; chemical forms; nitrogen cycle; vertical and temporal nutrient distributions*
Recommended reading: Libes Chapter 7; Emerson and Hedges Chapter 3; Pilson Chapters 8 and 9
Assignment Due: Problem Set 2

Week 8 (24, 28 Oct.): Lecture 10: Phosphate- *temporal distribution in surface water; remineralization; 2-box model of nutrient cycling; nutrient limitation concept*
Recommended reading: Redfield Revisited; Weber and Deutsch 2012
Mid-term Exam: 26 Oct.

Week 9 (31 Oct., 4 Nov.):Lecture 11: Silicon- *dissolution; vertical and horizontal distribution; remineralization*
Lecture 12: Gases- *concentrations; partial pressures and mole fraction; composition of the atmosphere; gas solubility and Henry's Law*
Recommended reading: Sarmiento, GCB; Emerson and Hedges Chapter 10; Broeker and Peng Chapter 3 pg. 110-161

Study Break (7-11 Nov.)

Week 10 (14, 18 Nov.): Lecture 12: Gases (cont.)- *seawater dissolved gas composition; simple gases; sources and sinks of simple dissolved gases; exchanges at the boundaries; air-sea gas exchange kinetics; circulation of the atmosphere*
Recommended reading: Nightingale 2009
Assignment: Problem Set 3

Week 11 (21, 25 Nov.): Lecture 13: O_2- *internal sources; processes creating non-equilibrium; photosynthesis / respiration*
Recommended reading: Emerson and Hedges Chapter 4; Dickson Goyet Chapter 2; CO_2 Review
Assignment Due: Problem Set 3

Week 12 (28 Nov., 2 Dec.): Lecture 14: *Intro to CO_2- Keeling Curve; records of CO2; latitudinal distributions; seasonal/annual variations; sources and sinks*
Lecture 15: CO_2 Systems- *reactions in seawater; measuring the CO2 system; processes affecting CO2 speciation; anthropogenic CO2*
Recommended reading: Hansen et al 2007; Climate Change History; *The Anthropocene*
Assignment: Problem Set 4

Week 13 (5, 6 Dec.): Lecture 15: CO_2 Systems- *pCO_2, global cycling of carbon species, effects of anthropogenic CO_2*
Lecture 16: *Stable and radioactive isotopes (if time permits)*
Recommended reading: Pilson Chapter 10, Devries 2014
Assignment Due: Problem Set 4

ACCOMMODATION POLICY FOR STUDENTS

Students may request accommodation as a result of barriers related to disability, religious obligation, or any characteristic protected under Canadian Human Rights legislation. The full text of Dalhousie's

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Student Accommodation Policy can be accessed here:
http://www.dal.ca/dept/university_secretariat/policies/academic/student-accommodation-policy-wef-sep--1--2014.html

Students who require accommodation for classroom participation or the writing of tests and exams should make their request to the **Advising and Access Services Centre (AASC)** prior to or at the outset of the regular academic year. More information and the ***Request for Accommodation*** form are available at www.dal.ca/access.

ACADEMIC INTEGRITY

Academic integrity, with its embodied values, is seen as a foundation of Dalhousie University. It is the responsibility of all students to be familiar with behaviours and practices associated with academic integrity. Instructors are required to forward any suspected cases of plagiarism or other forms of academic cheating to the Academic Integrity Officer for their Faculty.

The Academic Integrity website (http://academicintegrity.dal.ca) provides students and faculty with information on plagiarism and other forms of academic dishonesty, and has resources to help students succeed honestly. The full text of Dalhousie's ***Policy on Intellectual Honesty*** and ***Faculty Discipline Procedures*** is available here:

http://www.dal.ca/dept/university_secretariat/academic-integrity/academic-policies.html

STUDENT CODE OF CONDUCT

Dalhousie University has a student code of conduct, and it is expected that students will adhere to the code during their participation in lectures and other activities associated with this course. In general:

"The University treats students as adults free to organize their own personal lives, behaviour and associations subject only to the law, and to University regulations that are necessary to protect

- the integrity and proper functioning of the academic and non – academic programs and activities of the University or its faculties, schools or departments;
- the peaceful and safe enjoyment of University facilities by other members of the University and the public;
- the freedom of members of the University to participate reasonably in the programs of the University and in activities on the University's premises;
- the property of the University or its members."

The full text of the code can be found here:
http://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

SERVICES AVAILABLE TO STUDENTS

The following campus services are available to help students develop skills in library research, scientific writing, and effective study habits. The services are available to all Dalhousie students and, unless noted otherwise, are free.

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Service	Support Provided	Location	Contact
General Academic Advising	Help with - understanding degree requirements and academic regulations - choosing your major - achieving your educational or career goals - dealing with academic or other difficulties	**Killam Library Ground floor** Rm G28 ***Bissett Centre for Academic Success***	In person: Killam Library Rm G28 By appointment: - e-mail: advising@dal.ca - Phone: (902) 494-3077 - Book online through MyDal
Dalhousie Libraries	Help to find books and articles for assignments Help with citing sources in the text of your paper and preparation of bibliography	**Killam Library Ground floor** Librarian offices	In person: Service Point (Ground floor) By appointment: Identify your subject librarian (URL below) and contact by email or phone to arrange a time: http://dal.beta.libguides.com/sb.php?subject_id=34328
Studying for Success (SFS)	Help to develop essential study skills through small group workshops or one-on-one coaching sessions Match to a tutor for help in course-specific content (for a reasonable fee)	**Killam Library 3rd floor** Coordinator Rm 3104 Study Coaches Rm 3103	To make an appointment: - Visit main office (Killam Library main floor, Rm G28) - Call (902) 494-3077 - email Coordinator at: sfs@dal.ca or - Simply drop in to see us during posted office hours **All information can be found on our website: www.dal.ca/sfs**
Writing Centre	Meet with coach/tutor to discuss writing assignments (e.g., lab report, research paper, thesis, poster) - Learn to integrate source material into your own work appropriately - Learn about disciplinary writing from a peer or staff member in your field	**Killam Library Ground floor** Learning Commons & Rm G25	To make an appointment: - Visit the Centre (Rm G25) and book an appointment - Call (902) 494-1963 - email writingcentre@dal.ca - Book online through MyDal We are open six days a week **See our website: writingcentre.dal.ca**