Atmospheric Chemistry and Climate

AOSC / CHEM 433 & AOSC / CHEM 633

Ross Salawitch: rsalawit@umd.edu

Class Web Sites:
http://www2.atmos.umd.edu/~rjs/class/fall2020
https://myelms.umd.edu/courses/1291919

Photograph by NASA Astronaut Don Pettit: https://www.pinterest.com/pin/212161832415650804

Lecture 0: Introduction & Logistics

1 September 2020

Atmospheric Chemistry and Climate

AOSC / CHEM 433 & AOSC / CHEM 633

Ross Salawitch: **rsalawit@umd.edu**

1) Fine to address me as “Ross” in emails

2) Please, please, pretty please: try to remember to use “433” or “633” (i.e., “AOSC 433” or “CHEM 633” in *the subject* of any class related email

3) I prefer email rather than messages sent via ELMS. I will do my best to reply to messages sent either way

4) The signature line of my standard email contains my personal cell phone number; please use this “judiciously” and note I prefer text messages to voice mail

5) Office hours do not make sense in Fall 2020: please email me to setup meetings, which will occur on my personal Zoom channel (different than the class channel), that is also included in the signature line of my standard emails

6) Please note class will be conducted entirely on-line this semester and I will be glad to arrange socially distanced in-person meetings with anyone who needs to document such meetings.

Class Website, External

https://www2.atmos.umd.edu/~rjs/class/fall2020/

Most Visited | Getting Started | Most Visited | Getting Started | Business Roundtable

AOSC / CHEM 433 & AOSC / CHEM 633 Atmospheric Chemistry & Climate

Instructor: Ross Salawitch

Grader: Laura McBride

Tues-Thurs, 2:00 to 3:15 pm

Fall 2020: 3 units

Required Text:

Chemistry in Context: Applying Chemistry to Society

7th edition, American Chemical Society

Text can be purchased if you'd like. Or, can download PDF file here.

Syllabus

Syllabus is at:

https://www2.atmos.umd.edu/~rjs/class/fall2020/syllabus/Atmospheric_Chemistry_Climate_syllabus_fall_2020.pdf

http://www2.atmos.umd.edu/~rjs/class/fall2020

Syllabus

https://www.facebook.com/academicssay/videos/780281866110010/?v=780281866110010

Syllabus

Atmospheric Chemistry and Climate: AOSC & CHEM 433 / AOSC & CHEM 633

Instructor: Ross Salawitch (rsalawit@umd.edu)

Fall 2020: Tues – Thurs 2:00 to 3:15 pm

On line at https://umd.zoom.us/j/95258479309

Although I had aspired to teach in a hybrid fashion, developments since the time this decision had to made have led to the decision to teach the class entirely on-line for Fall 2020, unless a particular student has a need for face-to-face interactions, in which case these will be arranged on a personal basis.

Website: http://www.atmos.umd.edu/~rjs/class/fall2020

Required Text:

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(purchase if you'd like; I'll provide via PDF file to all registered students)

Supplemental Text (selected readings will be provided):

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Twenty Questions & Answers About the Ozone Layer by Ross J. Salawitch et al. (also freely available)

Global Warming: The Complete Briefing **5th Edition** by John Houghton (readings will be provided)

Green Chemistry: An Inclusive Approach, edited by Béla Török and Timothy Dransfield (ditto)

Beyond Oil and Gas: The Methanol Economy by George A. Olah et al. (readings will also be provided)

Course Description. The effects of human activity on atmospheric composition, focused on global warming, the carbon cycle, air pollution, and the ozone layer. Fundamentals of atmospheric chemistry (spectroscopy, kinetics, isotopic analysis, and biogeochemical cycles) are related to the modern understanding of climate change, air quality, and ozone depletion, based on resources such as satellite missions, field campaigns, and scientific assessments published by international agencies. We also examine how society's future energy needs could be met in a more environmentally friendly manner than the present heavy reliance on combustion of fossil fuels. The course is taught at a level appropriate for upper class undergraduate chemistry or physical science majors, as well as all graduate students in a physical science program.

Prerequisites: (CHEM 131 or CHEM135 or CHEM146) and (MATH241); or permission of instructor.

Any STEM major who has advanced to the Junior year or beyond with a modicum of chemistry (i.e., know the difference between an element and a compound) should be able to handle the class material.

https://www2.atmos.umd.edu/~rjs/class/fall2020/syllabus/Atmospheric_Chemistry_Climate_syllabus_fall_2020.pdf

Syllabus

Atmospheric Chemistry and Climate: AOSC & CHEM 433 / AOSC & CHEM 633

Instructor: Ross Salawitch (rsalawit@umd.edu)

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Prerequisites: (CHEM 131 or CHEM135 or CHEM146) and (MATH241); or permission of instructor.

Humanities majors may struggle: if you do not satisfy these pre-requisites, please send me an email (with appropriate subject) to arrange a Zoom meeting this week.

https://www2.atmos.umd.edu/~rjs/class/fall2020/syllabus/Atmospheric_Chemistry_Climate_syllabus_fall_2020.pdf

Syllabus

Atmospheric Chemistry and Climate: AOSC & CHEM 433 / AOSC & CHEM 633

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Prerequisites: (CHEM 131 or CHEM135 or CHEM146) and (MATH241); or permission of instructor.

Grades: Grades will be determined based on daily short questions (termed *admission tickets*) due prior to the start of lecture that are based on the readings (30%), problem sets (30%), two in class exams (13.33% each), a final exam (13.34%). In addition, students enrolled in 633 will be required to write a research paper on a topic of their choosing, give a presentation on this paper, and may be assigned an extra question on problem sets. For computation of final course grade, the graduate student paper/presentation will have equal weight as each exam.

https://www2.atmos.umd.edu/~rjs/class/fall2020/syllabus/Atmospheric_Chemistry_Climate_syllabus_fall_2020.pdf

Syllabus

Course Topics

- How to Build a Habitable Planet: Geological Evolution of Earth's Atmosphere
- Overview of Global Warming, Air Quality, and Ozone Depletion
- The Greenhouse Effect: Radiative Transfer; Cloud and Water Vapor Feedbacks
- Climates of the Past
- Modeling of Earth's Climate
- The Global Carbon Cycle
- Biogeochemical Cycles of Methane and Nitrous Oxide
- Pollution of Earth's Troposphere: Air Quality, Acid Rain, and Aerosols
- Pollution of Earth's Stratosphere: Ozone Depletion and Ozone Recovery
- World Energy Needs and Future Fossil Fuel Reserves
- The Kyoto Protocol and the Science of CO_2 Stabilization
- Hydraulic Fracturing aka Fracking
- Geo-engineering of Climate
- Renewable Energy I: Solar, Geothermal, Hydro, and Wind
- Renewable Energy II: Ethanol, Methanol, and Biofuels
- Nuclear Energy and The Hydrogen Economy

https://www2.atmos.umd.edu/~rjs/class/fall2020/syllabus/Atmospheric_Chemistry_Climate_syllabus_fall_2020.pdf

Syllabus

Updates based on 28 August 2020 email from our Provost:

On **28 August 2020**, Provost Rankin wrote all Faculty:

> The expectation that every undergraduate course will have a final exam is waived for Fall 2020 as it was for Spring 2020. Faculty are encouraged to use graded "lower stakes" assessments throughout the course, in order that students can build their course grade cumulatively over the course of the semester.

Response:

a) We will decide based on conversation, as the semester proceeds, whether to have a final exam. Class consensus will prevail, including an actual majority vote if necessary. If we do not have a final exam, the weights of other class components (i.e. *admission tickets* and *problem sets*) could be adjusted upwards. **Best to complete the ATs and P Sets.**

b) the design of the ATs has always been to have numerous, "lower stakes" assessments throughout the class. Please note lowest three ATs will be dropped.

https://www2.atmos.umd.edu/~rjs/class/fall2020/syllabus/Atmospheric_Chemistry_Climate_syllabus_fall_2020.pdf

Policy on Excused Absences:

- Anticipating the potential for unanticipated absences during the pandemic, Self-certified notes will serve as documentation for COVID-19-related absences or missed course expectations.
- In providing academic accommodations for students, faculty should consider alternative assignments and make-up work. These course policies should be noted clearly in the syllabus.
- Please work creatively and compassionately with students who have experienced extended excused absences to find ways to allow course completion. If that is not feasible, please direct the student to consult with an academic advisor to explore administrative options, including withdrawing from the course.

Response:

a) self-certified notes it is!

b) an undergraduate student enrolled in 433 can either take a make-up exam, complete a paper instead of a make-up exam, or in an exceptional circumstance simply have the exams they take increase in relative weight, such that the overall weight of exams versus all else is preserved.

c) any student enrolled in 633 can either take a make-up exam, complete a considerably longer paper instead of a make-up exam, or in an exceptional circumstance simply have the exams they take increase in relative weight, such that the overall weight of exams versus all else is preserved.

d) we're all in this together: I've always considered myself to be compassionate with regards to expectations for this class. Students are more than welcome to consult with students who have taken this class in prior semesters to either confirm or refute this "self-assessment".

Last updated 31 August 2020

Class Introductions

Emma B AOSC433-0101	–
Nancy C CHEM433-0101	–
Ciara D AOSC433-0101	–
Endre F CHEM633-0101	–
Heather F AOSC433-0101	–
Nicholas F CHEM633-0101	–
HyunGee H CHEM433-0101	–
Michael H AOSC433-0101	–
Rachel K AOSC433-0101	–
Madeline L... CHEM633-0101	–

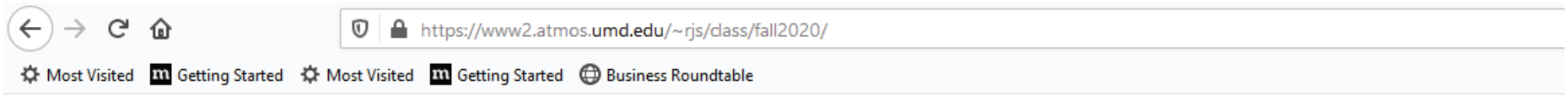
Kotiba M AOSC633-0101	–
Malgorzata P CHEM433-0101	–
Michael R CHEM633-0101	–
Akanksha S AOSC633-0101	–
Stuart S CHEM633-0101	–
Nathaniel S AOSC433-0101	–
Pierce V CHEM633-0101	–
Alice W CHEM433-0101	–
Cindy X CHEM433-0101	–

Please introduce yourself, let us know from where you'll be taking the class this semester (i.e., geographic location), and consider stating something "interesting" about yourself

Let's be sure to not forget any student whose name does not appear above, which reflects the ELMS gradebook as of 1 Aug 2020 at about 12:30 pm

http://www2.atmos.umd.edu/~rjs/class/fall2020

Class Website, External



Date	Lecture Topic	Required Reading	Admis. Tickets	Lecture Notes	Problem Sets*	Additional Readings	Learning Outcome
09/01	Class Overview	No reading for first meeting	No AT	Lecture 0 2020 Zoom Video			No Quiz
09/03	Geological Evolution of Earth's Atmosphere	Paris Beacon of Hope Sec 1.1, 1.2 (intro), and 1.2.1 (11.5 pages)	AT 1	Lecture 1 2020 Zoom Video			Quiz 1
09/08	Overview of Global Warming, Air Quality, & Ozone Depletion	IPCC 2007 FAQ (1.1, 1.2, 1.3, 2.1, & 3.1) (11 pages) EPA AQI Brochure (11 pages) 20 QAs Ozone (Q1, 2, 7, & 14) (11 pages) Paris Beacon of Hope Sec 1.2.2 (3 pages)	AT 2	Lecture 2 2020 Zoom Video		Kerr, *Science*, 2007 * Bell *et al.*, *EHP*, 2006 * Montzka *et al.*, *Nature*, 2018 Naming Convention for CFCs & Halons Entire IPCC 2007 FAQ Entire 20 QAs Ozone Movie Clip	Quiz 2

URL: http://www2.atmos.umd.edu/~rjs/class/fall2020/lectures/ACC_2020fall_lecture00_class.pdf

http://www2.atmos.umd.edu/~rjs/class/fall2020

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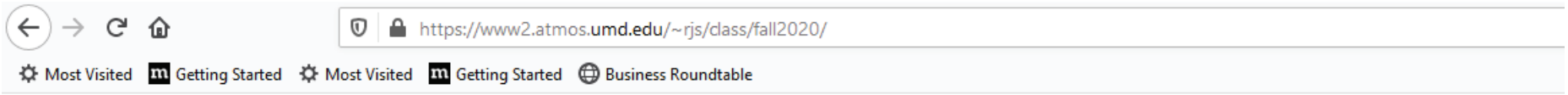

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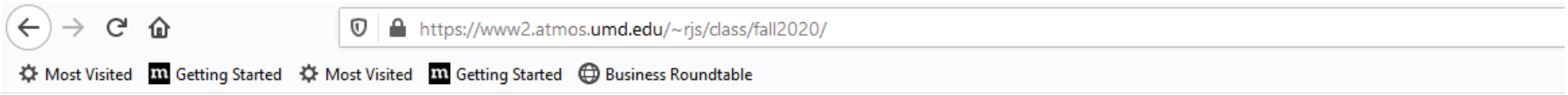

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Will contain link to recording, if we are able to successfully record

http://www2.atmos.umd.edu/~rjs/class/fall2020

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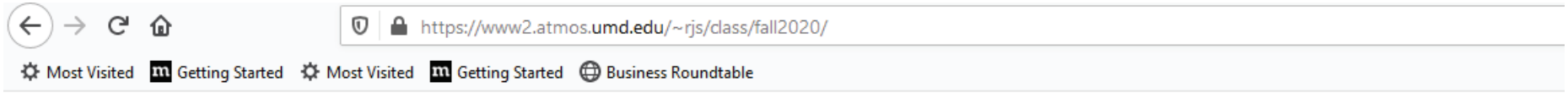

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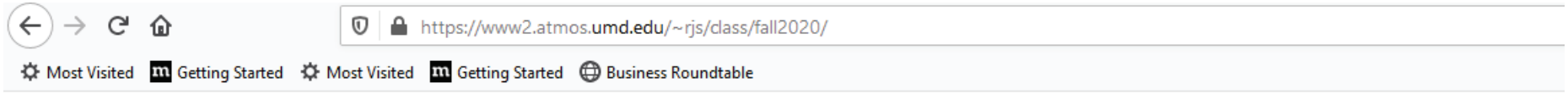
Link to same Admission Ticket, due Thursday (more about this at the end of today)

http://www2.atmos.umd.edu/~rjs/class/fall2020

Class Website, External



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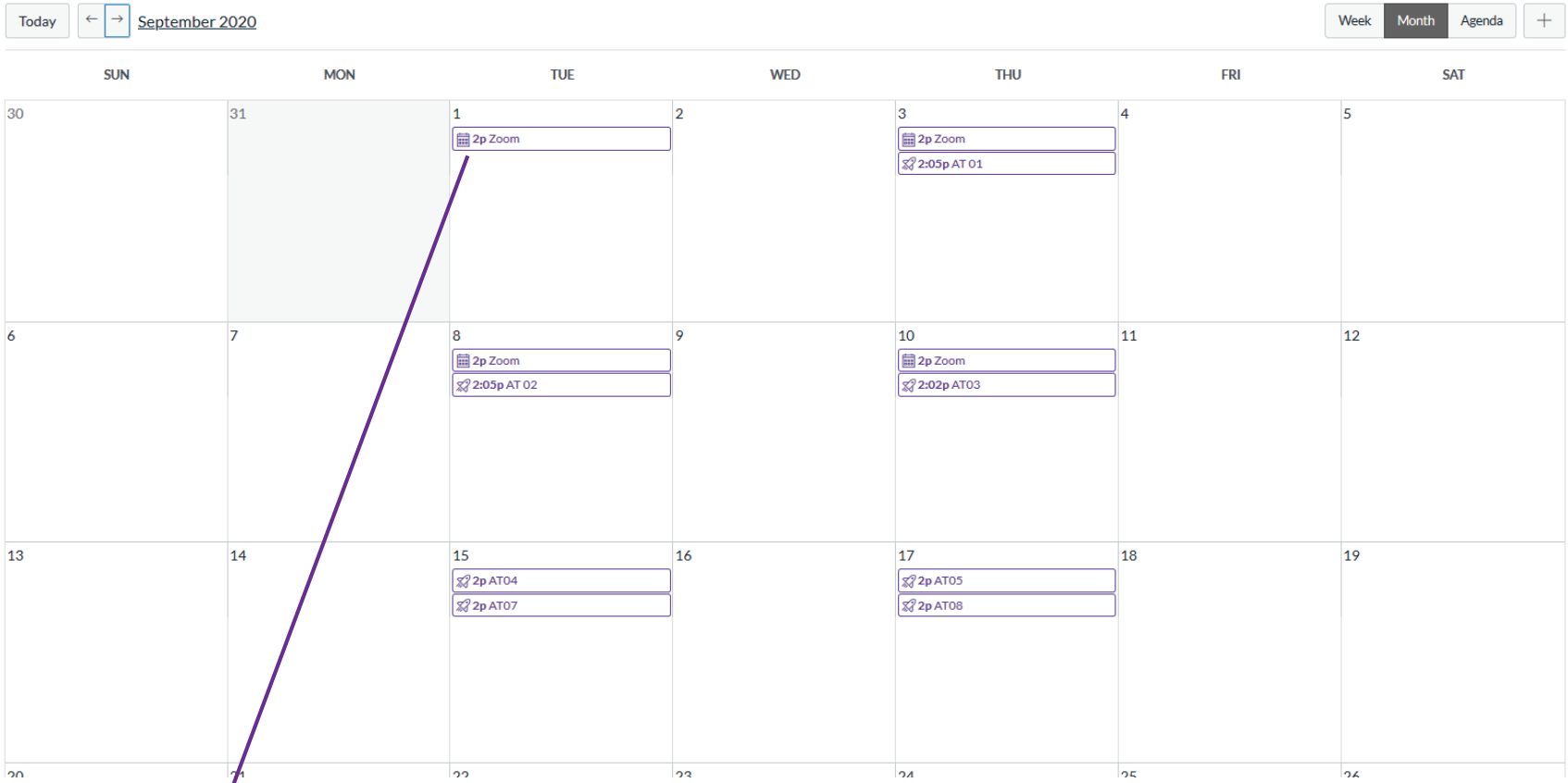
Learning outcome Quiz: https://testmoz.com/q/5440440
Note: must use passcode of ATL2428 to access

http://www2.atmos.umd.edu/~rjs/class/fall2020

Class Website, ELMS (Calendar View)



Zoom link (hopefully the same)

https://umd.instructure.com/courses/1291919

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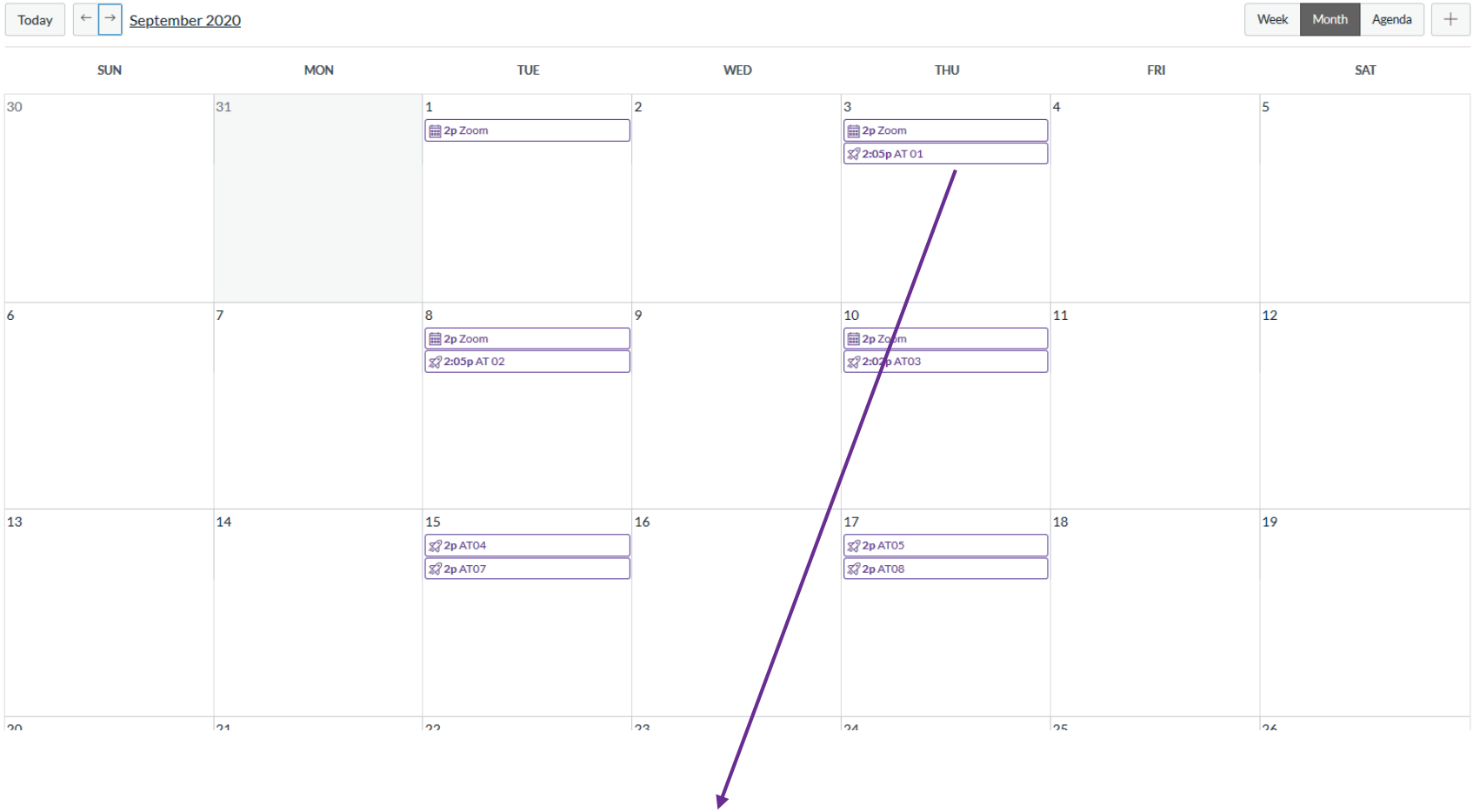

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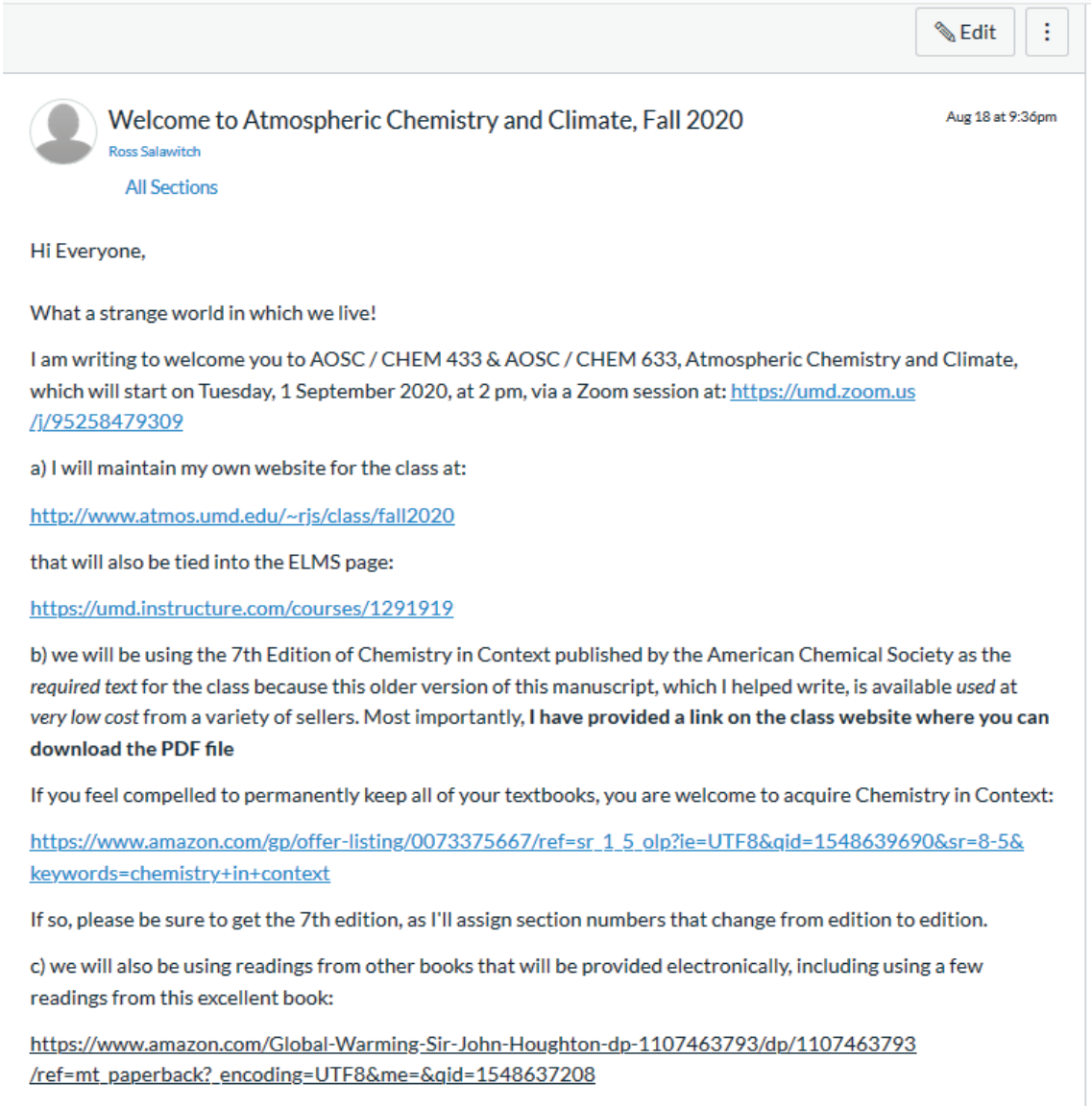
Class Organization

Who did not get this message?



Edit

Welcome to Atmospheric Chemistry and Climate, Fall 2020

Aug 18 at 9:36pm

Ross Salawitch

All Sections

Hi Everyone,

What a strange world in which we live!

I am writing to welcome you to AOSC / CHEM 433 & AOSC / CHEM 633, Atmospheric Chemistry and Climate, which will start on Tuesday, 1 September 2020, at 2 pm, via a Zoom session at: https://umd.zoom.us/j/95258479309

a) I will maintain my own website for the class at:

http://www.atmos.umd.edu/~rjs/class/fall2020

that will also be tied into the ELMS page:

https://umd.instructure.com/courses/1291919

b) we will be using the 7th Edition of Chemistry in Context published by the American Chemical Society as the *required text* for the class because this older version of this manuscript, which I helped write, is available *used* at *very low cost* from a variety of sellers. Most importantly, **I have provided a link on the class website where you can download the PDF file**

If you feel compelled to permanently keep all of your textbooks, you are welcome to acquire Chemistry in Context:

https://www.amazon.com/gp/offer-listing/0073375667/ref=sr_1_5_olp?ie=UTF8&qid=1548639690&sr=8-5&keywords=chemistry+in+context

If so, please be sure to get the 7th edition, as I'll assign section numbers that change from edition to edition.

c) we will also be using readings from other books that will be provided electronically, including using a few readings from this excellent book:

https://www.amazon.com/Global-Warming-Sir-John-Houghton-dp-1107463793/dp/1107463793/ref=mt_paperback?_encoding=UTF8&me=&qid=1548637208

Text Books

Required Textbook: *Chemistry in Context: Applying Chemistry to Society*, American Chemical Society $\Rightarrow$ **7th Edition !**

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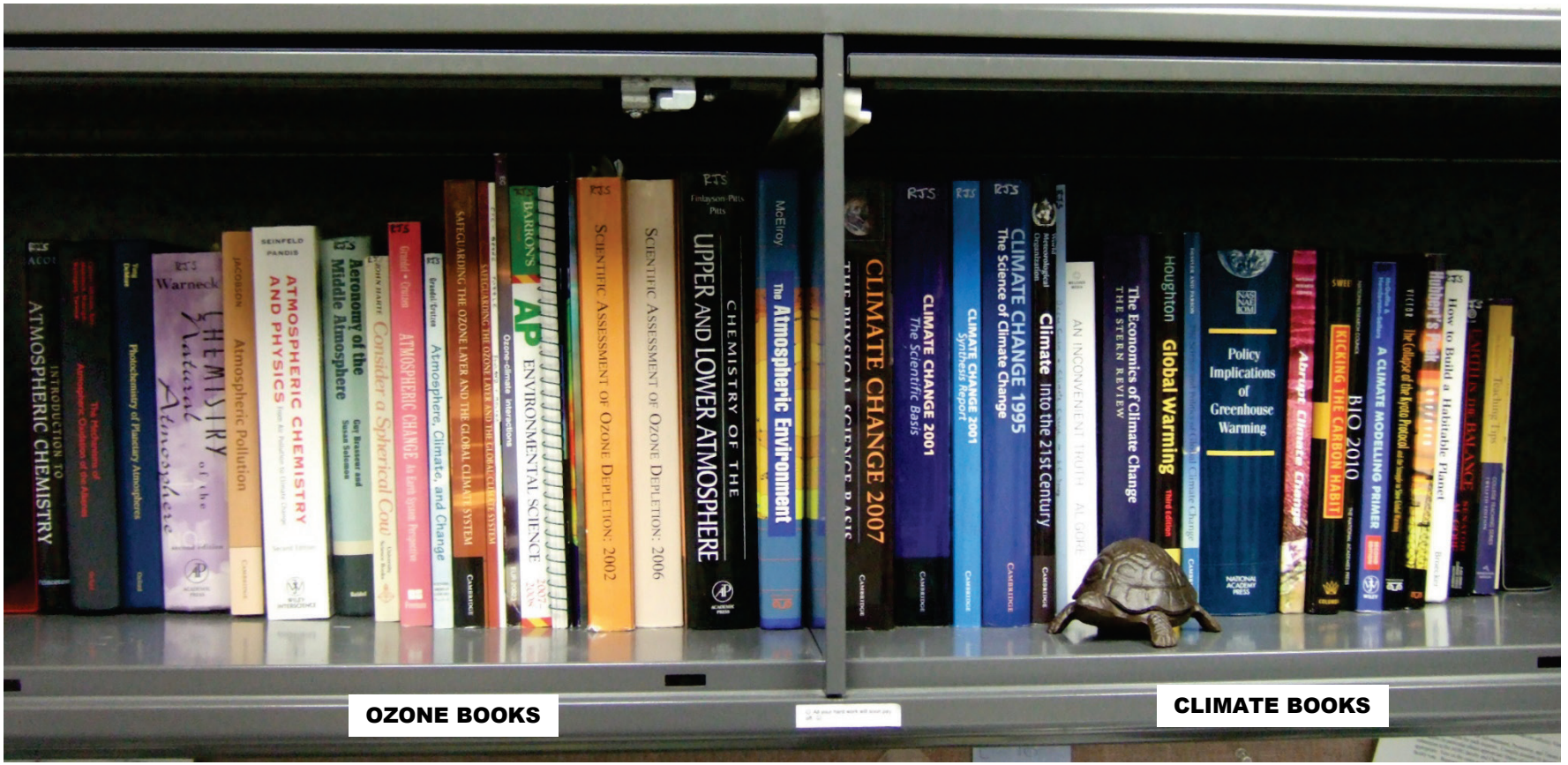
Beyond Oil and Gas: The Methanol Economy by George A. Olah, Alain Goeppert, and G. K. Surya Prakash

Green Chemistry: An Inclusive Approach, edited by Béla Török and Timothy Dransfield

(graduate students will be assigned parts of three chapters)

Why Six Books And So Many Readings?



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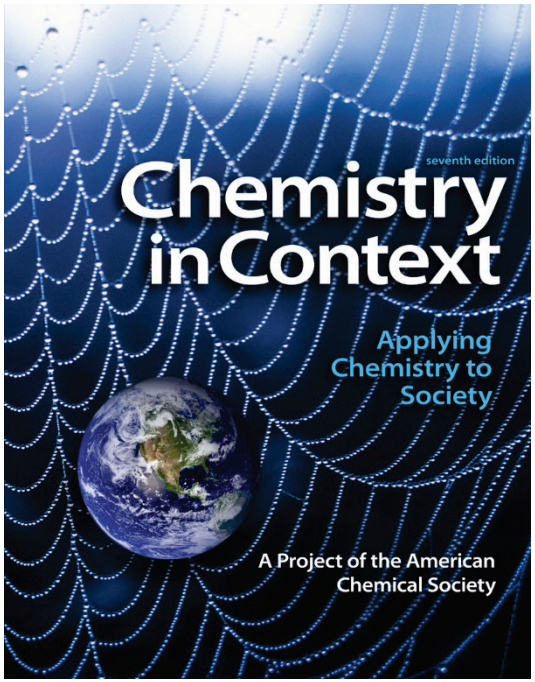


Chemistry in Context : Applying Chemistry to Society, 7/e

American Chemical Society (ACS)
Catherine H. Middlecamp, University of Wisconsin--Madison
Steven W. Keller, University of Missouri--Columbia
Karen L. Anderson, Madison Area Technical College
Anne K. Bentley, Lewis & Clark College
Michael C. Cann, University of Scranton
Jamie P. Ellis, The Scripps Research Institute

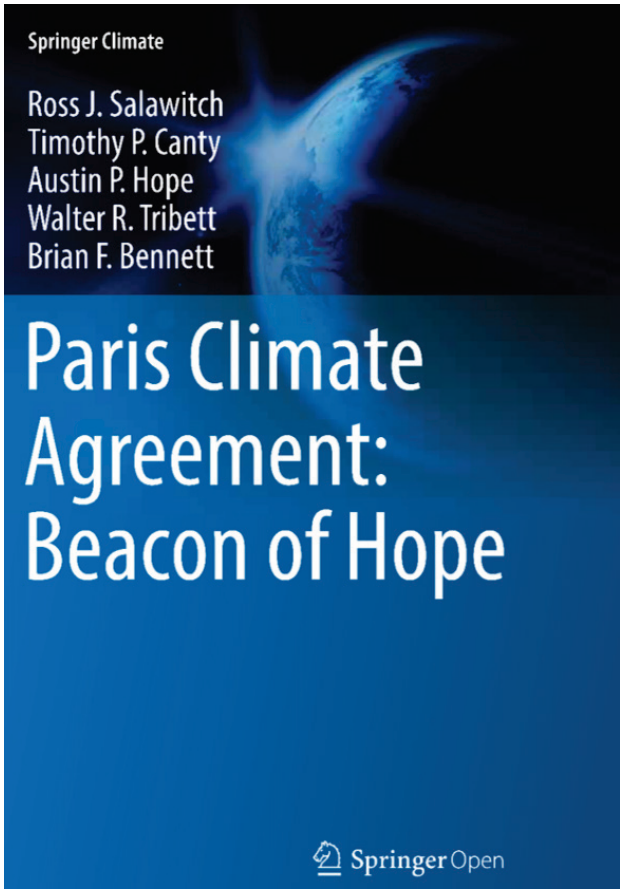
The author team truly benefitted from the expertise of a wider community. We extend our thanks to the following individuals for the technical expertise they provided to us in preparing the manuscript:

Mark E. Anderson, University of Wisconsin–Madison
David Argentar, Sun Edge, LLC
Marion O'Leary, Carnegie Institution for Science
Ross Salawitch, University of Maryland
Kenneth A. Walz, Madison Area Technical College

- Active used book market for 7th edition, since release of 8th, 9th & now 10th editions
- Changes from edition to edition are minor: we will use 7th edition to save you $$$
- Can download from this here link or purchase from this other link (best to buy "used")
- If you collect text books for future reference, please note this book is more of a "tutorial" than an indispensable reference book for your personal library, so probably best to check out free PDF to see if the book is worth buying
- If anyone has trouble accessing PDF file, please let me know

Numerous readings from: *Paris Climate Agreement: Beacon of Hope*

by Ross Salawitch, Tim Canty, Austin Hope, Walt Tribett, and Brian Bennett



On 11 November 2014, a remarkable event occurred. President Barack Obama of the United States and President Xi Jinping of China announced a bilateral agreement to reduce the emission of greenhouse gases (GHGs) that cause global warming by their respective nations. On 12 December 2015, a year and a month later, representatives of 195 countries attending the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change meeting in Paris, France, announced the Paris Climate Agreement.

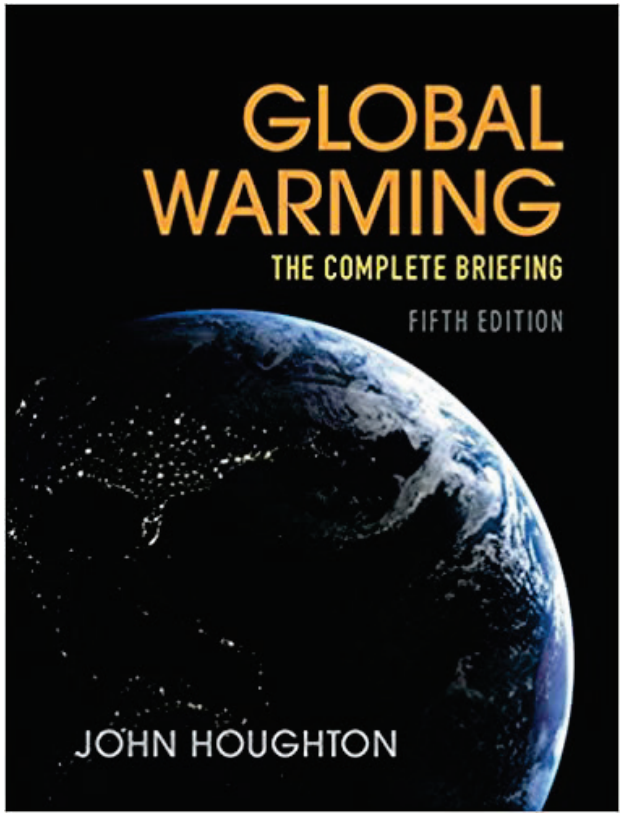
The goal of the Paris Climate Agreement is to limit the future emission of GHGs such that the rise in global mean surface temperature will be no more than 1.5 °C (target) or 2.0 °C (upper limit) above the pre-industrial level. The Paris Climate Agreement utilizes an approach for reducing the emissions of GHGs that is distinctly different than earlier efforts. The approach for Paris consists of a series of Intended Nationally Determined Contributions (INDCs), submitted by the world's nations, reflecting either a firm commitment (unconditional INDCs) or a plan contingent on financial and/or technological support (conditional INDCs).

Here we provide an analysis of the Paris Climate Agreement written for two audiences. The first audience is the bewildered public. Hardly a day goes by without some newsworthy item being reported on climate change. Often the stories are contradictory, tainted by parochialism, skepticism, and extremism by not only the conservative and liberal media but also the camps of so-called believers and deniers. Our book goes back to basics, outlining what is known and not known about climate change. If we have been successful, this book will enable readers to advance their own understanding of this topic, in a manner that will assist in the proverbial "separation of the wheat from the chaff" with regard to climate change.

Our second audience is the women and men who are charting the response of the world to the threat of global warming. As is clear from the title of this book, we believe the Paris Climate Agreement is truly a Beacon of Hope. The Agreement has been severely criticized by some scientists, even a few prominent in the field of climate change. In this book, we closely examine the behavior of the computer models commonly used to inform climate change policy. This examination will be eye opening to many. We urge policy makers to seek their own independent assessment of the veracity of the global warming projections that are being used to inform policy.

- Book published via open access, so text is freely available
- Culmination of many years worth of research initially motivated by this class & AOSC 652
- Can obtain from https://link.springer.com/book/10.1007/978-3-319-46939-3

Numerous readings as well as: *Global Warming: The Complete Briefing* (Fifth Edition) by Sir John Houghton

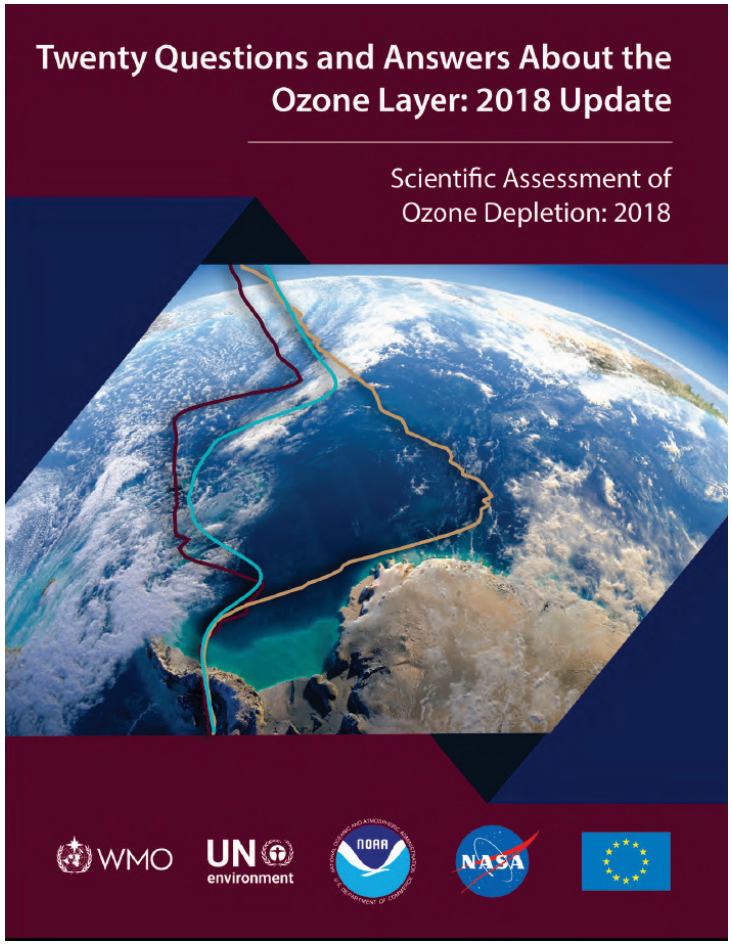


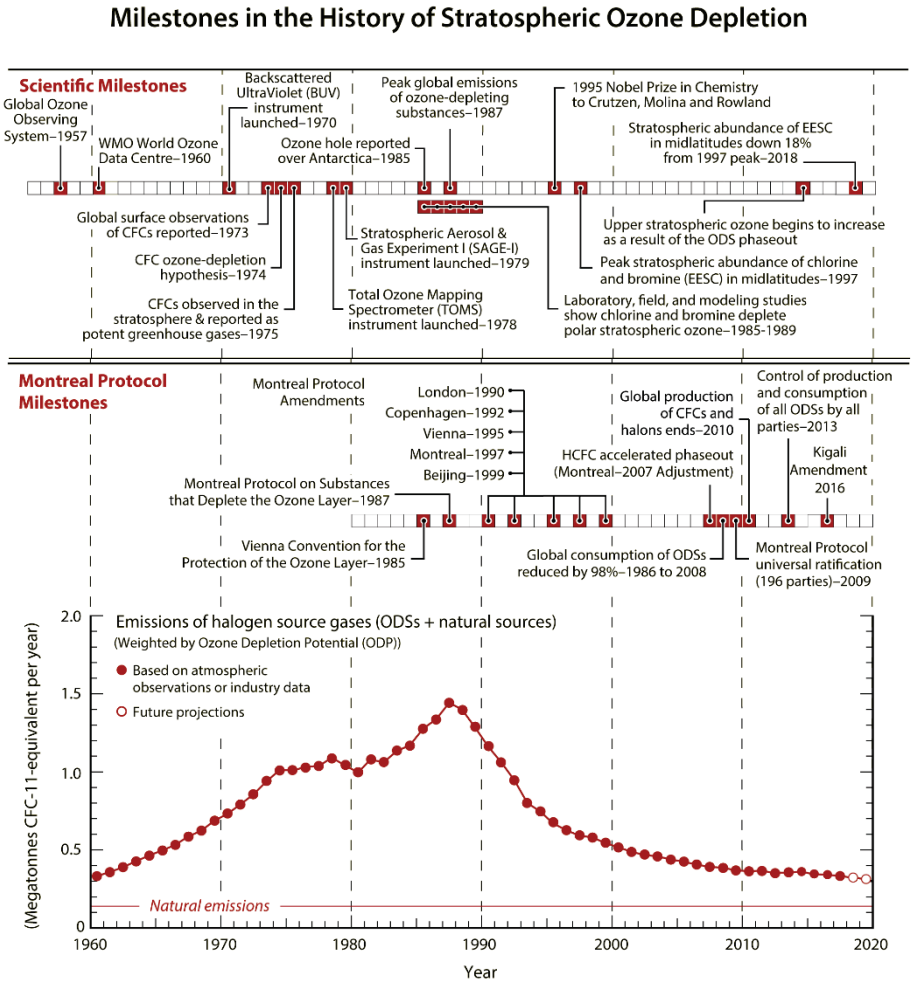
https://twitter.com/hannahmmalcolm/status/1250778555505655808

- Selected readings will be provided in password protected files (ATL2428)
- If you like the style of this book, please consider purchasing for your library
- Can purchase from this link.

Numerous readings also from: *Twenty Questions and Answers About the Ozone Layer*

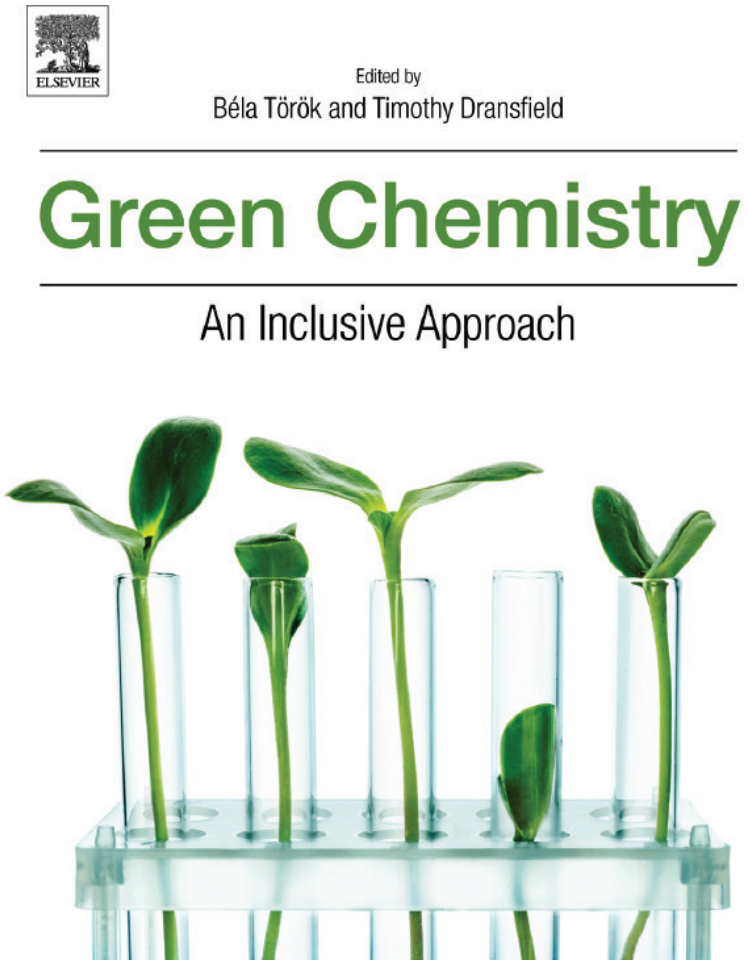
by Ross J. Salawitch, David W. Fahey, Michaela I. Hegglin, Laura A. McBride, Walter R. Tribett, and Sarah J. Doherty





- Book also published via open access, so text is freely available
- This document is updated every 4 years; I led the 2018 update and will lead the 2022 update
- Can obtain from https://www.esrl.noaa.gov/csl/assessments/ozone/2018/twentyquestions/

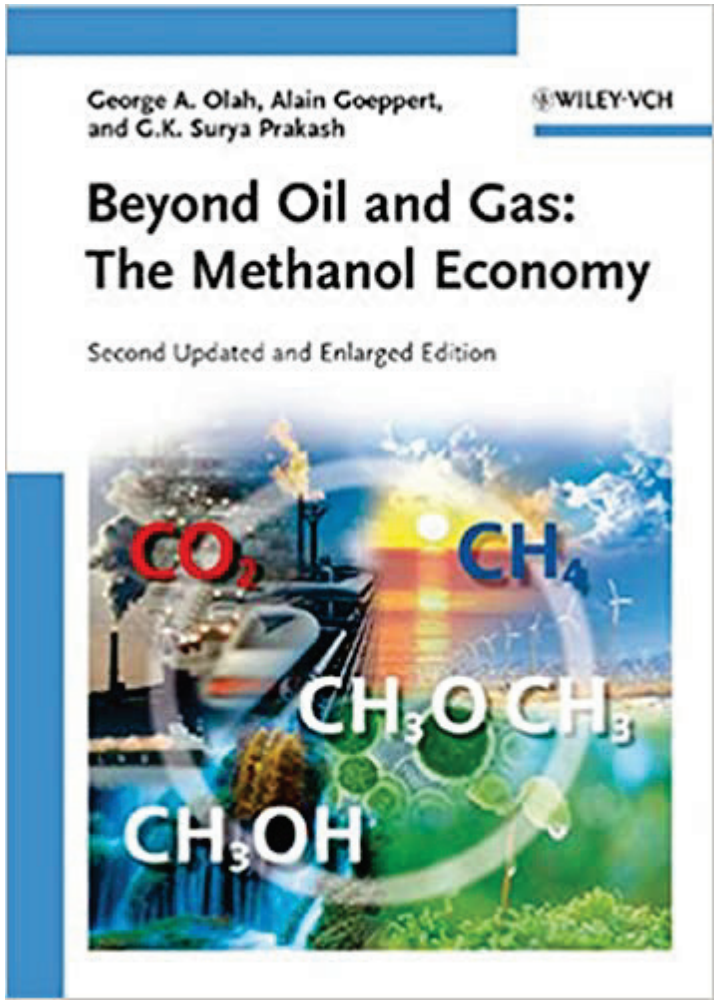
Numerous readings also from: *Green Chemistry: An Inclusive Approach*
edited by Béla Török and Timothy Dransfield



- Selected readings ***for those enrolled in 633*** will be provided in password protected files
- Can purchase from https://www.elsevier.com/books/green-chemistry/torok/978-0-12-809270-5 but this book is pricey

Numerous readings and finally from: *Beyond Oil and Gas:The Methanol Economy*

by George Olah, Alain Goeppert, and G. K. Surya Prakash



Dr. Olah was awarded the Nobel Prize in 1994 for his research on carbocations, positively charged hydrocarbons that form during the intermediate steps of some chemical reactions but are so fleeting (lasting only nanoseconds, in some cases) that it was thought to be virtually impossible to study them.

Dr. Olah in 2014. (Gue Ruelas/University of Southern California via AP)

The chemist realized he could use extremely harsh acids, called superacids, to stabilize the carbocations long enough to use spectroscopic methods to study their properties. The discovery led to a boom in the exploration of these elusive molecules. His work also led to new methods to convert "straight-chain" hydrocarbons into molecules with branched structures, which resulted in higher octane ratings and cleaner-burning fuel.

Later, Dr. Olah developed the idea of a methanol economy as an alternative to one based on fossil fuels. He proposed drawing down carbon dioxide (a single-carbon gas) and turning it into methanol (a single-carbon alcohol), thus creating a renewable fuel and reducing greenhouse gas in the atmosphere.

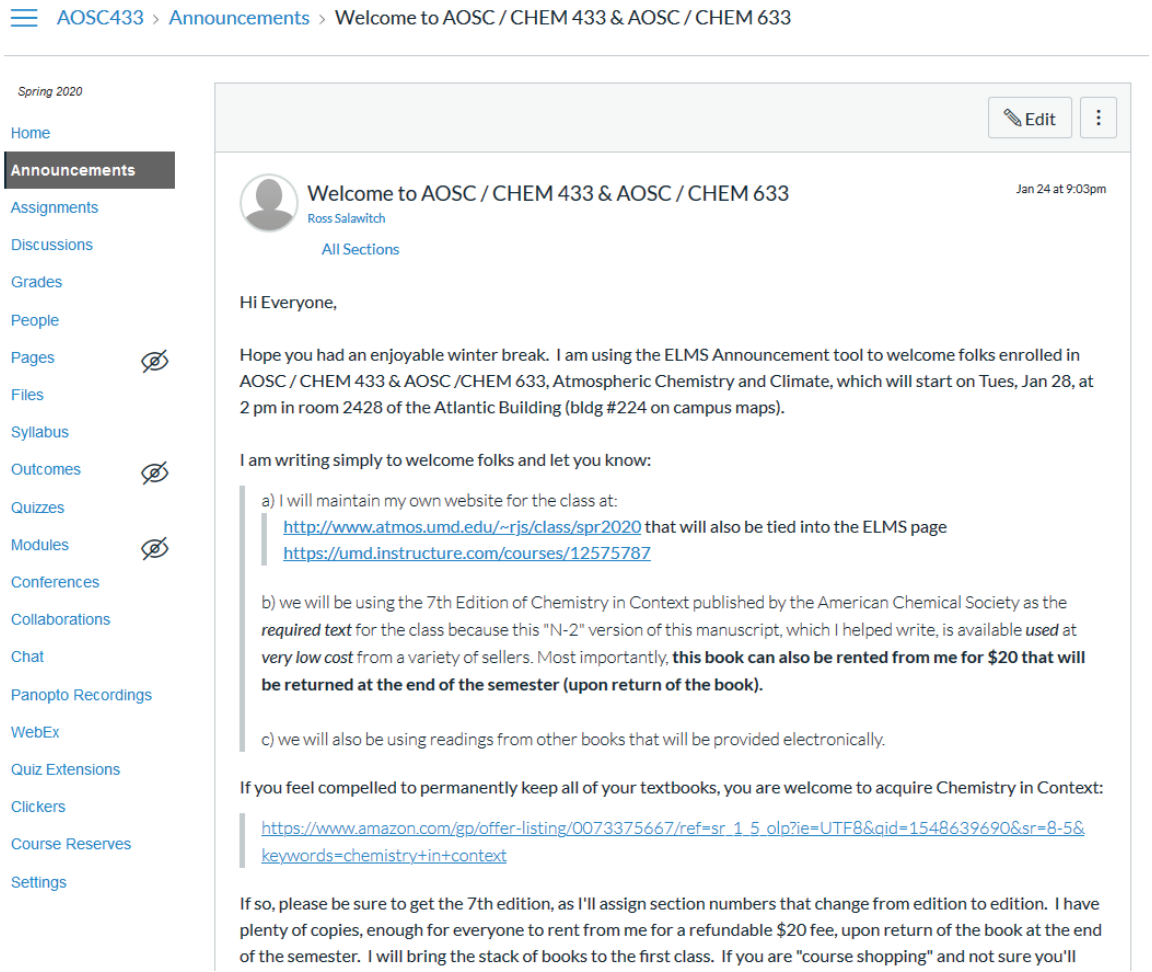
His research paved the way for a new kind of methanol-based fuel cell that produced electricity with high efficiency. More recently, he became interested in methanol found in space, exploring in papers with Prakash whether the molecule could have been one of the key molecules involved in the origin of life.

George Olah Obituary, 13 March 2017, Washington Post

- Selected readings will be provided in password protected files towards end of semester
- Can purchase from this link but the book is a bit dated (albeit, excellent, which is why we use)

Class Organization

How many students got this message?



AOSC433 › Announcements › Welcome to AOSC / CHEM 433 & AOSC / CHEM 633

Spring 2020

Home
Announcements
Assignments
Discussions
Grades
People
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Outcomes
Quizzes
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Conferences
Collaborations
Chat
Panopto Recordings
WebEx
Quiz Extensions
Clickers
Course Reserves
Settings

Edit

Welcome to AOSC / CHEM 433 & AOSC / CHEM 633
Ross Salawitch
Jan 24 at 9:03pm
All Sections

Hi Everyone,

Hope you had an enjoyable winter break. I am using the ELMS Announcement tool to welcome folks enrolled in AOSC / CHEM 433 & AOSC /CHEM 633, Atmospheric Chemistry and Climate, which will start on Tues, Jan 28, at 2 pm in room 2428 of the Atlantic Building (bldg #224 on campus maps).

I am writing simply to welcome folks and let you know:

a) I will maintain my own website for the class at:
http://www.atmos.umd.edu/~rjs/class/spr2020 that will also be tied into the ELMS page
https://umd.instructure.com/courses/12575787

b) we will be using the 7th Edition of Chemistry in Context published by the American Chemical Society as the *required text* for the class because this "N-2" version of this manuscript, which I helped write, is available *used* at *very low cost* from a variety of sellers. Most importantly, **this book can also be rented from me for $20 that will be returned at the end of the semester (upon return of the book).**

c) we will also be using readings from other books that will be provided electronically.

If you feel compelled to permanently keep all of your textbooks, you are welcome to acquire Chemistry in Context:

https://www.amazon.com/gp/offer-listing/0073375667/ref=sr_1_5_olp?ie=UTF8&qid=1548639690&sr=8-5&keywords=chemistry+in+context

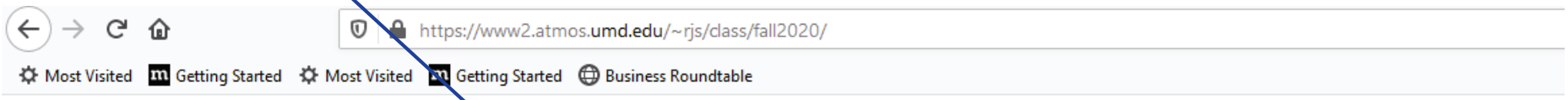
If so, please be sure to get the 7th edition, as I'll assign section numbers that change from edition to edition. I have plenty of copies, enough for everyone to rent from me for a refundable $20 fee, upon return of the book at the end of the semester. I will bring the stack of books to the first class. If you are "course shopping" and not sure you'll

All class related messages will be sent using the ELMS announcement tool, because this tool nicely logs all of the messages.

I nonetheless prefer conducting all other correspondence via email rather than ELMS, because email is easier for me to manage.

Organization Details

- Admission Tickets (AT) (30%)
  - short set of questions, related to lecture; *completed prior to the start of each class*
  - posted on web page; straightforward if reading has been done
  - graded on a 10 point basis; *lowest three scores will be dropped*
  - please complete on ELMS and email me & Laura if you are having a problem with ELMS



Date	Lecture Topic	Required Reading	Admis. Tickets	Lecture Notes	Problem Sets*	Additional Readings	Learning Outcome
09/01	Class Overview	No reading for first meeting	No AT	Lecture 0 2020 Zoom Video			No Quiz
09/03	Geological Evolution of Earth's Atmosphere	Paris Beacon of Hope Sec 1.1, 1.2 (intro), and 1.2.1 (11.5 pages)	AT 1	Lecture 1 2020 Zoom Video			Quiz 1
09/08	Overview of Global Warming, Air Quality, & Ozone Depletion	IPCC 2007 FAQ (1.1, 1.2, 1.3, 2.1, & 3.1) (11 pages) EPA AQI Brochure (11 pages) 20 QAs Ozone (Q1, 2, 7, & 14) (11 pages) Paris Beacon of Hope Sec 1.2.2 (3 pages)	AT 2	Lecture 2 2020 Zoom Video		Kerr, *Science*, 2007 * Bell *et al.*, *EHP*, 2006 * Montzka *et al.*, *Nature*, 2018 Naming Convention for CFCs & Halons Entire IPCC 2007 FAQ Entire 20 QAs Ozone Movie Clip	Quiz 2

Organization Details

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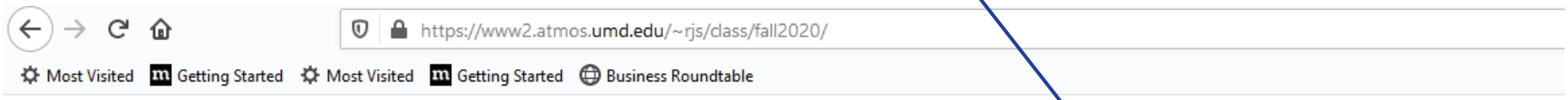
Asterisk denotes assigned reading for students enrolled in 633



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Organization Details

- Admission Tickets (AT) (30%)
  - short set of questions, related to lecture; *completed prior to the start of each class*
  - posted on web page; straightforward if reading has been done
  - graded on a 10 point basis; *lowest three scores will be dropped*
  - please complete on ELMS and email me & Laura if you are having a problem with ELMS
- Problem Sets (30%)
  - posted on web page and announced in class at least 1 week before due date
  - assignment about every two to three weeks; 6 total
  - prescribed "late penalty" and final receipt date: will not be accepted after solutions have been handed out (typically within ~7 days of due date)
  - problem sets are new each year; access to old solutions will be of little or no benefit
- Exams (40%)
  - two in-class exams (early semester; late semester) plus final exam, same weights
  - exams will tend strongly towards understanding of concepts via essay-like answers whereas problem sets will tend strongly towards quantitative understanding
- Prerequisite
  - CHEM131, CHEM135, or CHEM146 plus MATH241 or permission of instructor
  - Class will be taught at a level accessible to any upper level (JR or SR) physical science major (i.e., we expect students are adept at use of equations; have seen a differential, and understand the basic concept of integration)

Organization Details

- Grading:
  - admission tickets: 30%
  - problem sets: 30%
  - in-class exam I and II: 13.33% each (likely open note, limited time)
  - final exam: 13.34% (likely open note, limited time)
  - collaboration policy posted on class website: problems sets & admission tickets should reflect your own work & understanding of the material
- Students enrolled in 633:
  - 5 to 8 page, single-spaced (not including references and figures) **research paper** plus a **verbal presentation** on same topic
  - paper/presentation will contribute to final grade in an amount equal to each exam (i.e., 10 % each)
  - extra question on some problem sets
  - a few different questions on exams (some overlap)
  - extra readings that could very well appear on an exam
- Office hours:
  - Ross: via Zoom, by email appointment
  - Laura: if you have questions on the Problem Set you would rather not ask Ross: also via Zoom, by email appointment
  - We strive to be accessible throughout the semester. However, *just before class is generally not a great time to Zoom* & the AOSC Dept Seminar occurs 3:30 pm each Thurs (I will be hosting three speakers this semester; will announce in class)

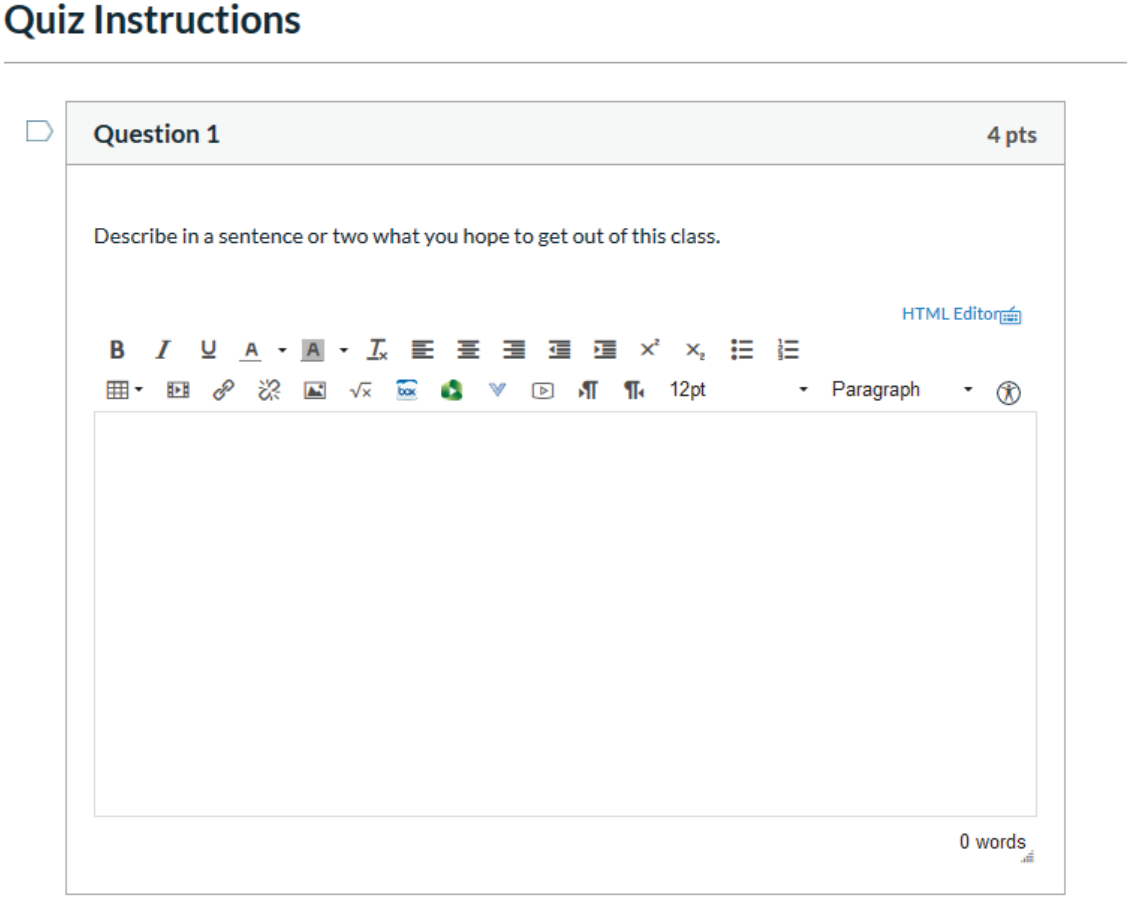
Organization Details, Continued

- Readings
  - All readings, except those from required text, will be posted on class webpage
  - Handouts of selected readings will be provided
  - Publicly available PDF files will be "unprotected"
  - Copyright protected PDF files will be protected, using **password ATL2428**
- Additional Readings
  - Provided for many lectures for students who would like more in depth info, to enhance learning experience for motivated students
  - If noted with an asterisk additional reading is "strongly suggested" for students enrolled in 633; could be used for a question on 633 problem set or exam
- Email
  - ***Please use AOSC 433, CHEM 433, AOSC 633, or CHEM 633 at start of subject line of all class-related email***

Next Lecture: Geological Evolution of Earth's Atmosphere

Reading: Sec 1.1, 1.2 (intro), and 1.2.1 (11.5 pages) of
Paris Climate Agreement: Beacon of Hope

Admission Ticket for Lecture 1 is posted on ELMS



Next Lecture: Geological Evolution of Earth's Atmosphere

Question 2 3 pts

According to Section 1.1 of Paris Climate Agreement: Beacon of Hope:

a) what time marks the first appearance of life on Earth?

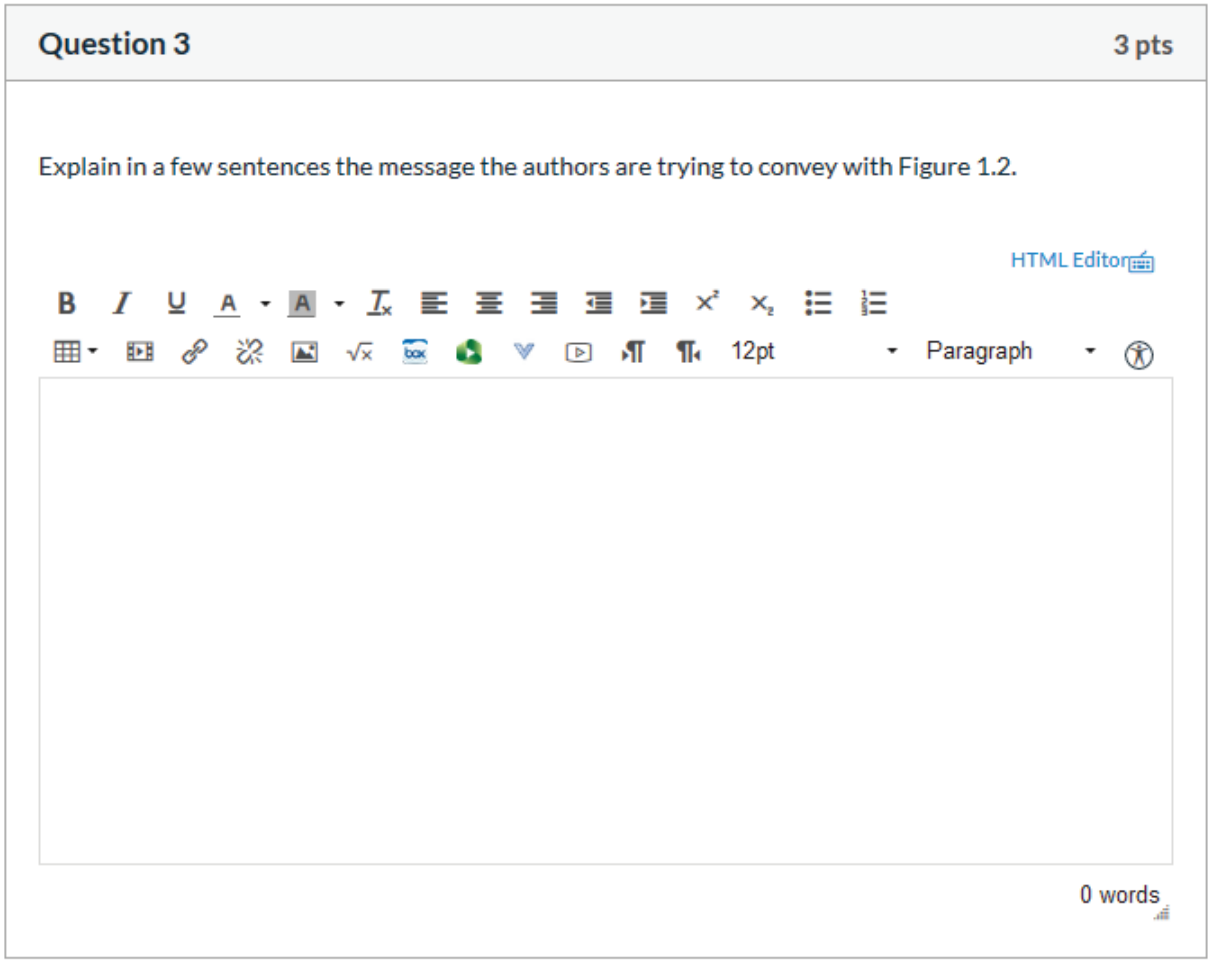
b) when did atmospheric O_2 begin to rise to a level that could sustain eukaryotic cellular forms of life, such as you and I ?

c) what other happenstance associated with the rise in atmospheric O_2 occurred that allowed life to emerge from sea to land?

d) when do scientists believe plant life first appeared on land?

- ○ a) 3.5 billion years before present (Bybp)
  b) 2.5 Bybp
  c) formation of the O_3 layer, which protects terrestrial life from harmful solar UV radiation
  d) 0.5 Bybp
- ○ a) 3.5 billion years before present (Bybp)
  b) 2.5 Bybp
  c) formation of the O_3 layer, which protects terrestrial life from harmful solar UV radiation
  d) 500 Bybp
- ○ a) 3.5 billion years before present (Bybp)
  b) 2.5 Bybp
  c) rise in atmospheric CO_2, which plants need to grow
  d) 500 Bybp
- ○ a) 3.5 billion years before present (Bybp)
  b) 2.5 Bybp
  c) rise in atmospheric CO_2, which plants need to grow
  d) 0.5 Bybp

Next Lecture: Geological Evolution of Earth's Atmosphere



Next Lecture: Geological Evolution of Earth's Atmosphere

Question 3 3 pts

Explain in a few sentences the message the authors are trying to convey with Figure 1.2.

HTML Editor

12pt Paragraph

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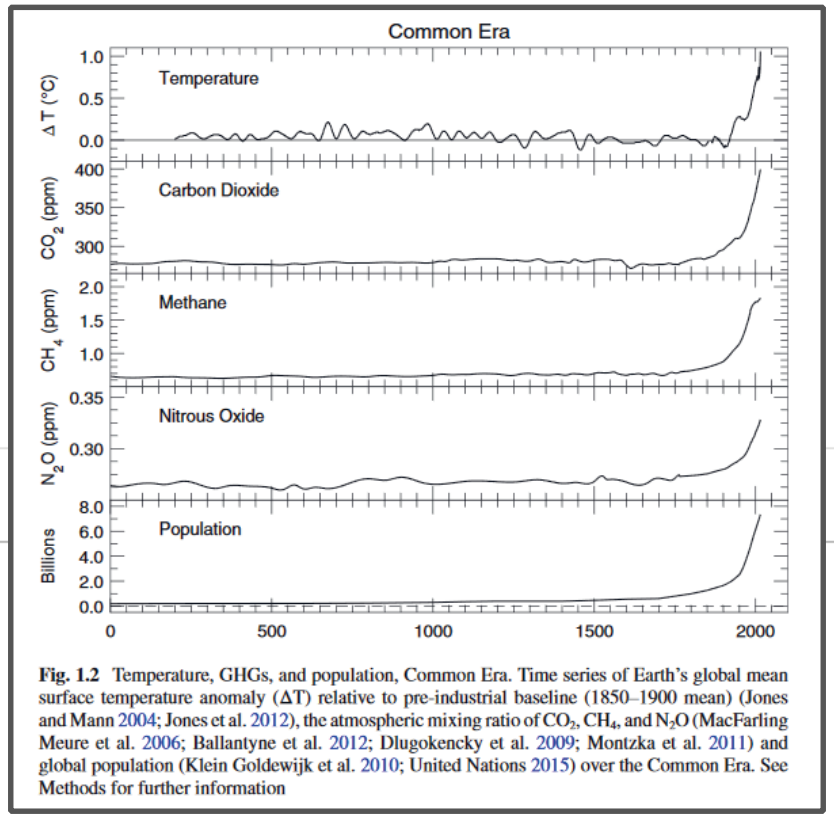

Fig. 1.2 Temperature, GHGs, and population, Common Era. Time series of Earth's global mean surface temperature anomaly (ΔT) relative to pre-industrial baseline (1850–1900 mean) (Jones and Mann 2004; Jones et al. 2012), the atmospheric mixing ratio of CO_2, CH_4, and N_2O (MacFarling Meure et al. 2006; Ballantyne et al. 2012; Dlugokencky et al. 2009; Montzka et al. 2011) and global population (Klein Goldewijk et al. 2010; United Nations 2015) over the Common Era. See Methods for further information

Next Lecture: Geologic Evolution of Earth's Atmosphere