

GES/MSE 465 (CRN 72310, 72595, 72596) – Fall 2024

Sustainable Strategies for E-Waste Management

Section 001 – TuTh 11:00 am –12:15 pm, Clark C144

Section 801 – Online

Instructors: Dr. Terry M. Gray

Office: Chemistry B303B

Office Hours: Tuesday 1:00–3:00pm; Wednesday 2:00-4:00pm; by appointment/drop-in

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Description Trans-disciplinary overview of the electronics industry, with an emphasis on sources and impacts of e-waste on human and natural systems. Students will learn systems approaches to mitigating environmental and social impacts of electronics—from product design, materials and manufacture to use, re-use, recycle and disposal. Apply these learnings in trans-disciplinary project teams to evaluate opportunities for improving the sustainability of the industry and its products. Junior standing required. Credit not allowed for both GES 465 and MSE 465.

Objectives Upon completion of the course, students should be able to 1) Relate the challenge of managing e-waste to the broader goal of developing sustainable electronics; 2) Describe the sources of e-waste in the life cycle of major electronics products, as well as the trends for future e-waste generation; 3) List the components of electronic devices and explain their chemical and material composition and properties; 4) Compare and contrast the e-waste stream with other waste streams (e.g. municipal solid waste, mining and drilling waste) at a national and global level; 5) Describe the chemical processes involved in mining/extraction, processing, recycling, and disposal of materials used in electronic devices; 6) Assess the human toxicity and eco-toxicity and environmental fate of chemicals found in e-waste and the biological mechanisms of these toxic effects; 7) Describe the current state of laws and regulations affecting e-waste; 8) Analyze the social, economic, and political issues surrounding natural resources, e-waste disposal, and pollution caused by e-waste in light of global and environmental justice concerns; 9) Describe consumer attitudes about e-waste and manufacturer marketing approaches to e-waste and to formulate future novel approaches; 10) Perform cradle to grave lifecycle analyses of the materials used in electronic devices including natural resource use, manufacture, shipping, sales, use, re-use, component re-use, recycling, and disposal; 11) Evaluate current efforts to design new approaches that facilitate the re-use, recycling, reduction in toxicity, and safe disposal of electronic materials; 12) Apply the aforementioned learning outcomes in a collaborative team project.

Acknowledgements

The initial development of this course during the summer and fall of 2017 and its teaching at Colorado State University during Spring 2018 and Fall 2018 was funded by Arrow Electronics. A special thanks goes to Carol Baroudi for her role on the development team and for her support and inspiration.

Canvas Grades, homework, and other course materials will be posted on a Canvas site designed for this course (canvas.colostate.edu). You will need a CSU NetID and password. If this course does not show up in your Canvas listing, please let us know right away.

Required Texts

Gray, Terry M. and Rappé, Anthony K., *Modern Chemical Sustainability: The Laws of Conservation*, 2024.

This text will be available soon as an Apple Book or as a Kindle Book. Until it is available chapters will be provided via the course Canvas page.

Minter, Adam, *Junkyard Planet: Travels in the Billion-Dollar Trash Trade*, Bloomsbury Press, 2013.

Other readings available through the Canvas page.

Supplemental/Recommended Texts

Gray, Terry M. & Rappé, Anthony K., *Molecules of Life with a Chemistry Bootcamp*, Second Edition, 2023.

This text is also available *only* as an electronic book. An Apple Books version is available for iPad or Macintosh computers running OS X 10.9 or higher from the Apple Books Store at <https://books.apple.com/us/book/molecules-of-life/id6461348742>. An Amazon Kindle version will also be available from the Amazon Kindle store but is currently under review. A link will be posted as soon as it is available. It may be possible to find an old version of the Amazon Kindle online, but I would recommend that you wait until the new edition is available to purchase the book.

Information about this book can be found at <http://energywhattheworldneedssnow.com> Purchases at the Apple Books Store or at the Kindle Store can be made via credit card or via iTunes gift cards or Amazon Kindle gift cards. iTunes gift cards and Amazon Kindle gift cards can be purchased at RamTech through your student account.

Gray, Terry M. & Rappé, Anthony K., *Energy: What the World Needs Now*, 2013-2019.

This text is available *only* as an electronic book. This ebook is currently under revision and will be made available later in the semester. It may be possible to find an old version of the ebook online, but I would recommend that you wait until later in the semester when the new edition is available to purchase the book. Information about this book can be found at <http://energywhattheworldneedssnow.com> Purchases at the Apple Books Store or at the Amazon Kindle Store can be made via credit card or via iTunes gift cards or Amazon Kindle gift cards. iTunes gift cards can be purchased at RamTech through your student account.

On-line Lectures

Class session will be recorded using the Echo360 system. A link to the recording will be provided on the Canvas page shortly after the live lecture for the on-line students

Important Dates	August 22 (Tue)	First day of class
	September 6 (Wed)	Last day to add or drop with no record
	November 18–26 (Sat–Sun)	Fall Break
	December 8 (Fri)	Last day to drop with “W”
	December 12 (Tue)	Project Presentations (6:20–8:20pm)

Tentative Class Schedule

(The schedule is very tentative in order to be flexible with the availability of guest lecturers. The “schedule” should be seen primarily as a list of topics.)

- Week 1 Introduction and Overview; Course Policies
- Week 2 Sustainability as a Framework for Discussing E-waste
- Week 3 Introduction to Life Cycle Assessment (LCA)
- Week 4 Environmental and Human Health: Toxicity of E-waste
- Week 5 Social Justice Aspects of E-waste (E-waste Dumps, Conflict Minerals, NIMBY, SLO)
Legal and Regulatory Aspects of E-waste
- Week 6 Ethics of E-waste (Consumerism, Social Media, Virtual Reality)
The Business Case (Corporate Responsibility, Economics of Re-Use)
- Week 7 Materials of Electronics: Components and Materials
Materials of Electronics: Metals (Mining, Refining, Recycling Chemistries)
- Week 8 Materials of Electronics: Glass, Plastics, Semi-conductors
Materials of Electronics: Rare Earth Elements
- Week 9 Materials of Electronics: Recycling Strategies
Materials of Electronics (Commodity Value, Storage, Disposal)
- Week 10 *Junkyard Planet* Discussion
- Week 11 Future E-waste
Projects (Initial proposals and progress reports will be scheduled during the weeks
designated Projects; also there may be guest lectures during this time depending
on availability)

Week 12-15 Projects

11/23–12/1 (Sat-Sun) **FALL BREAK**

Exam Week 12/10 (Tue) Projects: Final Presentations (6:20-8:20pm)
(*We may do these during the last week of class.*)

Grading

Response Essays. Each week there will be two or three open-ended questions posted on Canvas. You will respond to these questions with an essay response of 1000 to 1500 words. Your essays should demonstrate that you have read the assignments, listened to lectures and class discussions, and thoughtfully engaged the material. These essays will be posted on Canvas for everyone in the class to read (and respond to). There will be ten such assignments, each worth 60 points for a total of 600 points. 30% of your grade will be based on these essays. Essays will be due every Tuesday morning at 11:00 am after the first week of class for the next 10 weeks of the course.

On-line Discussion. You should respond to your classmates’ posted essays in the discussion forum with some kind of substantial response. Since there are so few students, it would be great if each person could respond to

each person's initial post with some substantial comment or follow-up question; further responses should appear as appropriate—this is a discussion! The response should be in the spirit of discussion, comment, further elaboration. Ideally, the response includes aspects of relevant class material (readings, lectures, and class discussions). Criticism is okay, but be aware of how you are coming across. Basic responses will be worth 20 points. An additional 10 points is possible if you continue a high quality discussion. On-line discussion is worth 300 points. 15% of your grade is based on these responses.

Reading Quizzes. There will be a 10 point quiz over readings and posted videos. These will be some combination of 1 or 2 point questions and will ordinarily be multiple choice or true/false. Mostly these serve to keep you accountable with respect to weekly assignments. They will also be due every Tuesday morning at 11:00 am weeks 2-11 of the course. Quizzes are worth a total of 100 points, 5% of your grade.

Projects. Each student will be in a group of 2-3 students, ideally covering multiple disciplines. Projects will build upon course concepts in novel and creative ways and will be substantial attempts to solve problems presented in the course. More details will be given about the projects about halfway through the semester. The tentative course schedule simply lists “Projects” for the last several weeks of class. It is expected that students attend class during these weeks for group work and for consultation with the instructors. Projects will be evaluated at three stages, first at the proposal stage involving a written proposal with a presentation and engagement with the whole class (125 points), then a progress report involving a presentation and engagement with the whole class (125 points), then at the final result stage involving a poster and a presentation (750 points). It is possible that interested outside parties will be invited to the final presentations. The project is worth 50% of your grade. 125 points for the proposal, 125 points for the progress report, and 750 points for the final poster/presentation.

Final Course Grade. Your final grade will be based on the total number of points that you accumulate out of 2000 possible points. Letter grade minimums will be assigned according to a standard 10-point scale (90% = A; 80% = B; 70% = C, 60% = D; <60% = F). Ordinarily, no pluses or minuses will be given. **No extra credit or additional assignments will be given.**

Miscellaneous Matters

On-line Students. In principle online students could watch the livestream of the course available through the Echo360 link. If this works with your schedule, then please do this and engage the class with the Chat tool. Otherwise, watch the video at your convenience. You will take quizzes, write essays and participate in the online discussion the way everyone else does. Ideally, for group projects you will work remotely with one of the groups in the class. We will negotiate how that works later in the semester when we begin to think about projects.

Accommodations for Students with Disabilities: Students who have known disabilities and those that need to be tested for potential learning disabilities can go to Student Disability Services for help. It is located on campus at 100 General Services Building. The phone number is 491-6385. Its hours are 7:45 am – 4:45 pm. Students who need accommodations, such as alternative testing modes, copies of class notes, interpreters, and appropriate seating for seeing and hearing, should give this information to the professor as soon as possible so the necessary accommodations can be made.

Attendance Policy: We will only informally monitor your attendance/progress, but it is important that you view the lectures and come to class regularly, since the material covered in class is a significant component of what is to be discussed on the essay questions.

Academic Integrity. The integrity of society and therefore of Colorado State University depends critically on the academic integrity of all of its members—students, faculty and staff. This course will adhere to the CSU Academic Integrity Policy as found on the Student' Responsibilities page of the CSU General Catalog and in the Student Conduct Code. At a minimum, violations will result in a grading penalty in this course and a report to the Office of Student Resolution Center. Academic dishonesty will not be tolerated. Examples of academic dishonesty include, but are not limited to: cheating in the classroom, plagiarism, unauthorized possession of academic materials, falsification, and facilitation of cases of academic dishonesty, that is, helping someone else cheat. Suspected cases of academic dishonesty will be investigated and forwarded to the Office of Conflict Resolution and Student Conduct Services and may seek the maximum penalty for students found guilty. *Many cases of academic dishonesty arise when a student falls behind in his or her coursework and attempts cheating as a poorly thought-out replacement for hard work. Our best advice to you is: don't fall behind and you won't be tempted to cheat!*

Discussions on Canvas. There will be an ungraded “Coffee Shop” feature for our Canvas site will be engaged for general discussion about class material and helping each other learn. It is not a place to post your gripes, vent about the class, or to attack another student's post, etc. Civil, intelligent, courteous and helpful on-line behavior is expected of everyone using the board. If you have issues with the class, one of the instructors, or anything else regarding the course, please bring them to our attention. We desire is to resolve any issues that you have in a mutually satisfactory way. If not, we will direct you to the other University resources that you have for resolving conflicts. The “Golden Rule” applies here, treat others as you would like to be treated.

Learning and Teaching Philosophy. The responsibility for learning is yours! I can't learn anything for you. Teaching involves structuring the course and the learning environment, presenting material and providing strategies for mastering difficult concepts, and inspiring students to learn. But in the end it is the learner who learns and it usually only happens when proper diligent effort is given.

Instructor Biography. I received my BS from Purdue University in 1980 and my PhD from the University of Oregon in 1985 both in Molecular Biology. My research was in the area of protein structure using x-ray crystallography as the main methodology. From 1986 to 1997 I taught chemistry and biochemistry courses at Calvin College (now Calvin University) in Grand Rapids, MI. There I continued my research on protein structure, folding, and stability with undergraduate students. In 1997 I moved to CSU originally as a research associate being the Chemistry Department's Computer Support Scientist. I am now an Assistant Professor in the Chemistry Department and have taught Biology 111 at Front Range Community College. I am married, have five children, 32 and up, and eleven grandkids. To learn more about me, just Google “Terry M. Gray” and you'll learn more about me and my opinions. (Most, but not everything, that comes up is about Dr. Gray.) You can also find me on Facebook and WordPress as grayt2 and on Twitter as grayt5. Here are some websites that I help maintain: <http://grayt2.wordpress.com> — <https://chemapps.colostate.edu/grayt> — <http://www.asa3.org/ASA/resources> — <http://www.energywhattheworldneedsnow.com>.