The Chemistry of Wine (Chemistry 0821)
The Fall of 2019
A General Education Class for the College of Science and Technology

Instructor: Robert-André F. Rarig, Ph. D. rarig@temple.edu
Lecture: Mondays, Wednesdays, & Fridays; 12:00 - 12:50 PM in Beury 166

Lab / Recitation instructors: Mondays (11:00-11:50 AM):
Tuesdays (10:00-10:50 AM):
Wednesday (10:00-10:50 AM):
Wednesday (1:00-1:50 PM):
Thursday (2:00-2:50 PM):
Friday (1:00-1:50 PM):

Office hours: Robert Rarig (202 Beury): Tuesdays 1:30-3:00 PM, Fridays 9-10:30 AM, and by appointment

Teaching Assistants (TBA): TBA – will be posted on Canvas

Description: Wine has occupied a central role in human culture. In our exploration of the science of wine we will learn why wine was the beverage of choice through the ages, why a bottle of wine can range from $2 to $2,000, how wine is made, what makes a good/bad wine, how is white different from red, and how we know what is in a bottle of wine. The course involves with a large scale fermentation of red and/or white wine and will continue with team-based hands-on exercises that provide students with the tools and opportunities to analyze the process of turning grape juice into wine. Many aspects of the production and consumption of wine will be addressed in this course. Students will also gain exposure to peer-reviewed literature review in the context of researching wine topics that extend beyond chemistry and into the everyday lives of students and wine enthusiasts. NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and the Science & Technology Second Level (SB) requirement for students under Core. Most lectures are accompanied with demonstrations to illustrate practical applications of the topics being discussed. A lot of concepts will be reinforced in laboratory activities during the recitation sessions.

Learning Goals: Students will learn...
- The basics of the wine-making process while learning about what an experimental variable is and how one would optimize the process to achieve different kinds of wines. This will include how nature's molecules relate to the color, taste, smell, feel, and preservation of wine.
- How to assemble of a research presentation on a topic based on peer-reviewed academic literature searches instead of generic internet searches.
- The application of the scientific method and how it relates to the peer-review process in the context of the publishing on academic articles.
- The basics of chemical structure and classification, including the recognition and differentiation of salts, sugars, acids, carbohydrates, fats, and alcohols.
- Why some chemicals mix (e.g. water and salt) and why some will not (e.g. oil and water) and then how this applies to the buoyancy of a liquid (wine), purification of water, and cell & protein structure & function.
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<tbody>
<tr>
<td>Sep 2nd - 6th</td>
<td>Introduction to the periodic table; Chemical Bonding; Chemical Structure</td>
<td>September 2nd is Labor Day</td>
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<tr>
<td>Sep 9th - 13th</td>
<td>Density, Buoyancy, Specific Gravity, and the Sweetness/Dryness of Wine</td>
<td>September 9th is the last day to drop a course Extra Credit Movie Sep 14th</td>
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<td>Sep 16th - 20th</td>
<td>Understanding Chemical Symbols; Which Molecular Pieces Affect Wine and in what Specific Ways</td>
<td>LAB: Density</td>
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<tr>
<td>Sep 23rd - 27th</td>
<td>The (History of) Chemistry of Fermentation; The Law of Conservation of Mass; What is a Carbohydrate?; Glycolysis: Demonstrating that Science is Much More Complicated Than This Course.</td>
<td>Extra credit movie &amp; Exam Q &amp; A: Sep 28th</td>
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<td>Sep 30th - Oct 4th</td>
<td>The Many Impacts of Acidity (pH) one Wine; Malolactic Fermentation; Equilibrium</td>
<td>LAB: Fermentation Extra credit movie Oct 12th</td>
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<td>Oct 7th - 11th</td>
<td>The Oxidation of Chemicals in Wine</td>
<td>Literature Search I</td>
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<td>Oct 14th - 18th</td>
<td>Energy is Everything: Thermodynamics &amp; Kinetics of Wine; The Many forms of Energy; Qualitative vs. Quantitative; The Relationship Between Stability, Energy, and Reactivity</td>
<td>Oct 22nd is the last day to withdraw from a course! Literature Search II</td>
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<td>Oct 21st - 25th</td>
<td>How Chemists Know Which Molecules are in Wine: Spectroscopy</td>
<td>Extra Credit Movie &amp; Exam Q&amp;A Nov 2nd Literature Search III</td>
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<td>Nov 4th - 8th</td>
<td>Student Presentations</td>
<td>LAB: Chromatography</td>
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<td>Nov 11th - 15th</td>
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<td>Nov 18th - 22nd</td>
<td>No Class</td>
<td>Fall &amp; Thanksgiving Breaks</td>
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<td>Nov 25th - 29th</td>
<td>No Class</td>
<td>Take-Home Lab: Spartan (Due Dec 6th)</td>
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<td>Dec 2nd - 6th</td>
<td>Student Presentations</td>
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<td>Dec 9th</td>
<td>Student Presentations</td>
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<td>Wed. Dec 18th</td>
<td>10:30 AM – 12:30 PM</td>
<td>Final Exam</td>
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Course materials: please buy a stapler if you don’t own one.
1) Assorted readings that will be made available for you on Canvas
2) TOP HAT membership—you will receive an email with instructions to follow.
3) “Wine Science” by Ronald S. Jackson, Ph. D. ISBN: 978-0-12-373646-8
4) “Chemical Principles” (3rd Edition) By Richard E. Dickerson, Harry B. Gray, and Gilbert P. Haight
   Available for free from Caltech: http://authors.library.caltech.edu/25050/

Grading:
Your course grade will be based on your performance on:
in-class questions (TOP HAT)..........................(50 points)
Recitation & Lab participation (including pre-labs)..........................(300 points)
1 team presentation (see the list of possible topics below)..........................(150 points)
2 midterm examinations...........................................................................(250 points)
a final examination.....................................................................................(250 points)
There will also be...

Extra credit opportunities: movie viewings (10 points each; 2 max), designing a Temple wine label (10 points),
Reading Questions (20 pts), and 3 post-labs (10 points each).

Grading cutoffs: The worst grade you can earn with the following course percentages are as follows:
100%-90% (A - ); 89%-80% (B - ); 79%-70% (C - ); 69%-60% (D); <60% (F).

Team Presentation Topics:
1. Effects of alcohol on the brain
2. Effects of alcohol on sleep.
3. Terroir – Soil
4. Determining alcohol content
5. When you are under the influence
6. Fortified wines
7. Terroir – Microclimate
8. Counterfeit wines
9. Malolactic Fermentation
10. Detecting blood alcohol levels
11. Does coffee help with DUI
12. Ice wine
13. Corked wine
14. Plastic vs. cork vs. screw top
15. Champagne
16. Clear vs. Colored bottles; Why so many green bottles?
17. Wine and cardiovascular disease
18. Does eating before/while drinking affect blood alcohol levels?
19. Pregnancy and wine/alcohol
20. Yeast strains vs. wine quality
21. Why the legal drinking age is 21.
22. Why the legal drinking age could be 18.
23. The Chemistry of Oak-Barrel Ageing

Policies on Accepting Work:
- Pre-Labs are due at the beginning of your recitation session during lab weeks. Late Pre-Labs won’t be accepted.
- Post-Lab extra credit (due 1 week after each lab) will not be available to anyone who did not attend the corresponding lab. Late post-labs will not be accepted.
- Any other assignment will lose 10% of its value for every day it is late. This includes weekend days.
- Any work submitted by email or to my mailbox will not be graded. You may email an image before a due date to prove it’s been done, but only hard copies will be graded. Adjustments may not be made after the picture is submitted.
- Work submitted without a name will receive no credit.

Staple Policy: Anyone who brings a stapler to recitation in week two of the semester gets 10 extra credit points. Any unstapled work that is handed in throughout the semester will automatically lose 2% of the assignment’s total value.
**Accounting for Improvement:**

If **a)** your attendance record is solid, **b)** you have handed in all course assignments on time, **and c)** you have taken both midterm exams, then your final exam percentage can replace a lower score on one of your midterm exams.

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**Course Resources**

**Lecture:** TR 3:30-4:50 AM. Please come! Attendance and participation will be monitored via Tophat interactions throughout each class.

**Canvas:** There will be a course Canvas site. Dr. Rarig will use this site to post a few slides from each lecture, reading assignments, homework assignments, answer keys, and grades.

**Recitation/Laboratory Sessions (worth 30% of your grade):** You will meet in smaller groups once a week to work on questions that will help you prepare for the exams, to develop your research skills for the end of semester presentations, and to conduct laboratory exercises. You will need to purchase a pair of safety goggles and fill out a laboratory safety form in order to be allowed into lab. These will be TA-run.

**Problem sets:** These will be covered in recitation, but they will also be made available on Canvas.

**Text(s):** See aforementioned “Course materials” section.

**Library Site:** [http://guides.temple.edu/wine](http://guides.temple.edu/wine)

**TOPHAT**

**Recitation instructor office hours:** *(see first page).* Remember: office hours are **NOT** just for emergency situations!

**Dr. Rarig:** I have weekly office hours *(see first page).* Additionally, you are welcome to arrange a time to meet with me to discuss course content, your current performance, to solicit suggestions on improving your learning experience, or anything else pertaining to the Chemistry of Wine. **Email is the best way to arrange such appointments.**

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**Chemistry Department Calculator Policy (9/1/2008)**

The use of programmable and/or graphing calculators on examinations or quizzes is strictly prohibited. The use of simple calculators *(i.e. those without keyboards)* is allowed only with the permission of the Instructor. The use of PDAs, cell phones, and electronic or paper dictionaries is strictly prohibited.
## Fall 2019 Semester Approximate Schedule of Topics (i)

**Aug 26th - 30th: Module 1:** Introduction to the course and the practical aspects of wine making

**Concepts:** Lab safety; course policies, the differences in the process of red vs. white wine making; how temperature affects kinetics (how fast things happen); the difference between champagne and sparkling wine; introduction to fermentation; that everything in wine is a chemical; how chemists emulate nature

**Demonstrations:** The formation of water from hydrogen gas and oxygen gas; a video on the reliability and reproducibility of wine evaluations based on tastings.

**Recitation:** Reviewing lecture material and practice problems from TOPHAT & Canvas

**Homework:** Practice questions posted on TOPHAT and Canvas

***Lectures slides posted on TOPHAT***

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**Sep 2nd - 6th: Module 2:** Introduction to the periodic table, and chemical bonding & structure.

**Concepts:** The patterns of the periodic table; atomic structure; valence electrons; the octet rule; the different kinds of ions; covalent vs. ionic bonding; electronegativity; molecular shape and its effect on polarity; why salt and water mix but oil and water will not; “like dissolves like”; the scientific method

**Demonstrations:** Solubility and insolubility demo with liquids and solids; applying the scientific method: when one experiment doesn’t convince someone; solution dynamics.

**Recitation:** Reviewing lecture material and practice problems from TOPHAT & Canvas

**Homework:** Practice questions posted on TOPHAT and Canvas

***Lecture slides posted on TOPHAT***

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**Sep 9th - 13th: Module 3:** Density, Buoyancy, Specific Gravity, and the Sweetness of Wine

**Concepts:** The difference between a solute & solvent; all solutions are mixtures, but not all mixtures are solutions; measuring volume; how density, buoyancy, specific gravity, and °Brix are related; the significance of peer-review in science and in research in general; how not all wine research is physical science.

**Demonstrations:** The buoyancy of coke vs. diet coke & wine vs. grape juice; guest lecture by the science librarian, Ms. Sarah Jones

**Recitation:** Reviewing lecture material and practice problems from TOPHAT & Canvas

**Homework:** Pre-Lab 1 and practice questions posted on TOPHAT and Canvas

***Lectures slides posted on TOPHAT***

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**Sep 16th - 20th: Module 4:** Understanding Chemical Symbols (Formulas & Structures)

**Concepts:** Recognizing the different pieces (functional groups) that make up organic molecules; each functional group’s significance to wine; how certain words in normal vocabulary originate from and have broader meaning in chemistry, e.g. “alcohol” and “carbohydrate’

**Demonstrations:** Starting the large scale in-class wine-making process

**Recitation:** Lab 1: Density

**Homework:** Complete Lab 1 and practice questions posted on TOPHAT and Canvas

***Lectures slides posted on TOPHAT***
Fall 2019 Semester Approximate Schedule of Topics (ii)

Sep 23rd – Oct 4th: Module 5: The Chemistry of Fermentation

**Concepts:** The Law of Conservation of Mass; Percent Yield; the relationship between atomic mass and molecular mass; how scientific understanding improves over time; yeast is a fungus; the chemical difference between a simple carbohydrate and a complex carbohydrate; atomic size; what a mole is; how to prepare for a college science exam; how what we learned in module 3 allows scientists to better monitor fermentation; glycolysis and how science is really way more complicated than this course.

**Demonstrations:** Monitoring the class’ wine during its fermentation process

**Recitation:** Exam 1 review; Presentation groups work on literature exercise I

**Homework:** Practice questions posted on TOPHAT and Canvas; Prepare for Exam 1; Complete Pre-Lab 2; Finish literature search exercise I

***Lectures slides posted on TOPHAT***

Oct 7th & 11th: Module 6: The Many Impacts of Acidity (pH) on Wine

**Concepts:** What is an acid?; What is a Base?; What is an equilibrium?; relative acid strength; the quantitative and practical application of pH; the pH range of wine; how pH relates to the taste, color, and preservation of wine; the difference between malolactic fermentation and “normal” fermentation; how to read a graph properly; what a baseline is their importance to science.

**Demonstrations:** red cabbage do-it-yourself pH determination; comparing the cabbage indicator with universal indicator; determining the pH of common household items; monitoring the class’ wine during its fermentation process.

**Recitation:** Lab 2: Fermentation

**Homework:** Complete Lab 2; Practice questions posted on TOPHAT and Canvas

***Lectures slides posted on TOPHAT***

Oct 14th & 18th: Module 7: The Oxidation of Chemicals in Wine

**Concepts:** Several ways of identifying oxidation and/or reduction based on chemical structures; how combustion is oxidation; how we metabolize alcohol in our bodies; how oxidation leads to hangovers, blindness (when drinking moonshine instead of wine), and brown wine; how oxidation affects the smell of wine; how to prevent oxidation that is harmful to wine; what an anti-oxidant is and how oxidation can be used to preserve wine thanks to kinetics

**Demonstrations:** Thermite balls; candle burning in different sized beakers; oxidation & breathalyzer tests; a demo group research presentation (topic: botrytized wine)

**Recitation:** Presentation groups work on literature exercise II

**Homework:** Practice questions posted on TOPHAT and Canvas

***Lectures slides posted on TOPHAT***
Fall 2019 Semester Approximate Schedule of Topics (iii)

Oct 21st – Nov 1st: **Module 8**: Energy is Everything: Thermodynamic and Kinetics of Wine

**Concepts**: Energy comes in many forms; how thermodynamics and kinetics relate to energy; qualitative vs. quantitative; the relationship between stability, reactivity, and energy; exothermic vs. endothermic; how energy relates to many topics previously discussed in the course; the significance of low energy vs. high energy in chemistry

**Demonstrations**: water electrolysis; water formation from hydrogen and oxygen gases; glow stick kinetics; thermite balls

**Recitation**: Presentation groups work on literature exercise III & Review for Exam 2

**Homework**: Practice questions posted on TOPHAT and Canvas; Prepare for Exam 2

***Lectures slides posted on TOPHAT***

Nov 4th - 8th: **Module 9**: How Chemists Know Which Molecules are in Which Wines: Spectroscopy

**Concepts**: Light is Radiation; Invisible vs. visible radiation; the difference between absorbed, transmitted, reflected, and emitted light; the relationship between energy, wavelength, & frequency; conjugation: why some molecules (and therefore wines) have color and others don’t; How calculations (theoretical chemistry) can predict chemical behavior.

**Demonstrations**: Lights-out demo; flame test (burning different chemicals); diffraction glasses with different elemental emissions; light filter demo

**Recitation**: Presentation groups work on literature exercise IV

**Homework**: Practice questions posted on TOPHAT and Canvas; Prepare for Exam 3

***Lectures slides posted on TOPHAT***

Nov 11th - 15th: **Module 10**: CSI: Napa Valley: How enologists know which molecules in wine taste or smell the way they do.

**Concepts**: The scientific method as it applies to discover new tastes, smells, and/or medicines; how scientists emulate nature; the significance of purifying chemicals; intermolecular forces; chromatography; “like dissolves like,” reapplied; how we smell and taste; the significance of proteins

**Demonstrations**: Making Nylon; shoe lace protein structure; slinky protein structure

**Recitation**: Review Exam material

**Homework**: Pre-Lab 4; Practice questions posted on TOPHAT and Canvas

***Lectures slides posted on TOPHAT***

Nov 18th- Dec 9th: **Module 11**: Research Presentations

**Concepts**: significance of peer-review; how to be clear both visually and orally during a presentation; the significance of peer-reviewed literature; proper citation technique and formatting; application of what the students have learned throughout the semester

**Demonstrations**: The presentations themselves

**Homework**: Final Literature exercise, Take-home lab 3; Practice questions posted on TOPHAT and Canvas; Prepare for Final exam

***Lectures slides posted on TOPHAT***
Laboratory Safety

Students are expected to conduct themselves as adults who are cognizant of their safety and the safety of those around them. Unauthorized experiments utilizing equipment and/or chemicals are not permitted. Participants in this course who are behaving inappropriately or unsafely will not be permitted to continue in the laboratory. Make-up of missed laboratory work will not be permitted. Although most of the chemicals used in this course are no more dangerous than those used in your home, students are required to come to class dressed properly.

- Eating and/or drinking in the laboratory are not permitted.

- Long pants or full-length skirts should be worn. Short pants, short skirts, and kilts are not permitted in the lab at any time. Arms should be covered to the elbow and midriffs should not be exposed. Clothing serves to provide an additional barrier which is important in a laboratory environment.

- Shoes/sneakers that cover the entire foot should be worn. Sandals, clogs, or open-toe shoes are not permitted in the lab at any time.

- Laboratory participants must wear safety glasses or safety goggles as soon as they enter the laboratory. We do not keep spare goggles to lend to students. It is the students’ responsibility to bring their goggles with them to the lab meeting. The wearing of contact lenses is not recommended. Contact lenses should, if possible, be replaced with eye-glasses worn behind safety goggles.

- Long hair must be tied back.

Improperly dressed students will not be permitted to work in the lab.

Disability disclosure statement

Any student who has a need for accommodation based on the impact of a disability should contact me privately to discuss the specific situation as soon as possible. Contact Disability Resources and Services at 215-204-1280 in 100 Ritter Annex to coordinate reasonable accommodations for students with documented disabilities.

Temple Policy on Student and Faculty Academic Rights and Responsibilities

Freedom to teach and freedom to learn are inseparable facets of academic freedom. The University has adopted a policy on Student and Faculty Academic Rights and Responsibilities

(Policy # 03.70.02) which can be accessed through the following address:

http://policies.temple.edu/getdoc.asp?policy_no=03.70.02
Important Registration Dates

**Drop/Add:** Without special approval from the instructor as long as the desired section(s) are open. Students should check the Diamond Line (215-204-2525) phone registration system frequently or Temple's On-line Course Schedule. Both systems will allow students to determine which sections are currently open. Note that a section that was closed in the early morning may have opened up by the afternoon, so check frequently.

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**Withdrawal:** Students may withdraw from the course without penalty (Grade of "W") any time up to **Drop/Add deadline.** After that grace period the "W" grade is only given in accordance with institutional procedure. The procedure to obtain a "W" grade after 12 September is governed by the Temple University Policy (#03.12.12) on Withdrawal.

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**Incomplete:** Incomplete ("I") Grades will only be given in accord with Temple procedures. The "I" grade cannot be given until the specific requirements have been met and forms filled out, signed and submitted. This course is governed by the Temple University Policy (#03.12.13) on Incompletes. http://policies.temple.edu/getdoc.asp?policy_no=02.10.13

**Make-up Exams**

There will be no make-up exams except as explicitly designated by official written Temple policy.