The Relationship and Relevance of Chemistry
in
Viticulture and Enology Processes
Implemented Through
Contextual Learning Activities and Visual Display

Terri Beam

Sabbatical Report

September 2008

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Sabbatical Proposal

Proposal Overview

The State of California has long been a leader in the cultivation (viticulture) and production of wines (enology), and western states Oregon and Washington are increasing their interest and involvement in the business. This is an industry on a significant growth trajectory, one that offers a range of jobs and career opportunities for our students. At the heart of the wine industry is an understanding of chemistry concepts, the conducting of appropriate and specific chemical tests to make important production decisions, and an ability to analyze and correctly interpret chemical analyses. To the best of my knowledge, chemistry concepts related to the wine industry have not been examined for possible inclusion in the chemistry curricula at Mt. SAC. In the Mt. SAC chemistry courses that I primarily teach (CHEM 10, CHEM 40, CHEM 50, CHEM 50H, and CHEM 51), I strive to have students achieve several essential chemistry skills: understanding the concepts, hands-on experimentation and data collection, and critical thinking and analyses of chemical data. With this project, I seek to incorporate real-world chemistry examples from the growing viticulture and enology industries into these particular chemistry courses. Many other industries offer the possibility for such an emphasis in my teaching, of course, but the wine industry is one central to the California economy and one core to the identity of the state. For these reasons, I expect that chemistry assignments, examples, and experiments related to this industry would have particular pedagogical value for our students. I also hope to show these industries as viable career options for Mt. SAC students.

With this in mind, for my sabbatical leave project I propose to travel to several institutions of higher education in California and Oregon that offer courses and programs in viticulture or enology, and study the chemistry-related curricula that they offer. To be specific, I propose to interview viticulture and enology professors, visit their classes and lab sessions, examine their syllabi and assignments, and speak with students to see how chemistry-related processes are integrated into teaching and learning. Also, I propose to visit and work in a vineyard and winery to gather firsthand information on the everyday chemical processes and analyses utilized there. I assure you that my interests in this topic are entirely focused on research and teaching application, not wine tasting! The purpose of these visits would be for me to observe and participate in certain pertinent chemistry-related vineyard and winery operations, field-testing chemical levels in grapes before harvest, performing chemical testing and analyses that lead to making the decision to pick and crush grapes, the chemical reactions involved in the initial fermentation steps, and certain chemical testing and analysis processes used in secondary fermentation and bottling decisions.

In turn, with this gathered information, I propose to create a minimum of 20 contextual learning units regarding chemistry concepts relating to viticulture and enology for incorporation into five different Mt. SAC chemistry courses. These new learning activities will provide an opportunity for students to explore and practice applied chemistry concepts in a more interesting, relevant and contextual manner. Also from the information gathered on my visits, I will create a visual display which highlights the chemistry concepts currently applied in the viticulture and enology industries. This display will be placed in the new Science Building, for all students to view. As a part of the display, an educational flier for students will be created which summarizes all of the chemistry topics mentioned in the display, while introducing them to viticulture and enology as viable career options, and citing resources and current contact information.

Elaboration of Research Plan

In a preliminary study on this project idea, I discovered that viticulture and enology courses are regularly offered at Chemeketa Community College in Salem, Oregon. Since Chemeketa is a community college, I thought that it might be informative for me to further investigate their course offerings. During my Spring Break last year (March 2006), I went to Oregon and visited the Chemeketa Community College campus. I spoke with an enology instructor there in order to learn more about the curricula of these courses. The instructor was very helpful and informative, told me about the course outlines and textbook information on some of the courses, and also provided a tour of the grounds and facilities. He recommended that I visit some other institutions in California at UC, CSU, and CC levels that offered viticulture or enology courses. Among the institutions I plan to visit include University of California, Davis, California State University, Fresno, and Napa Valley College. In addition, through a standard "snowball" method approach to research I expect individuals at these institutions to identify others with such emphases. In these instances, I will talk with relevant faculty, students, and if possible administrators, with a focus on the chemistry-related curricula taught in their viticulture and enology courses.

While I was in Oregon in March 2006, I also visited many wineries and spoke with many winemakers and vineyard workers, with the express purposes of learning about chemical procedures used in their operations, and to inquire about the possibility of setting up laboratory visits at a later time. One of the reasons that I chose to visit Oregon for this initial exploration, was that I felt that Oregon wineries and winemakers might be more open to discussing their winemaking processes than California winemakers, as the industry in Oregon is more in the developing stages than in California. I found Oregon winemakers to be very welcoming to me. They openly showed me their vineyards, laboratories, procedures, lab books, and instruments. They told me about some of the chemical processes and tests that they regularly use to help them make the kind of chemistry decisions that need to be made to produce quality wines. They invited me back to spend more time with them. So, with these points of focus, I plan to visit and speak with winemakers, vineyard managers and winery lab technicians in Oregon and California to study and gather information on their chemical testing procedures used in cultivating grapes and winemaking. The purpose of these visits would be for me to observe and participate in certain pertinent chemistry-related vineyard and winery operations, field-testing chemical levels in grapes before harvest, performing chemical testing and analyses that lead to making the decision to pick and crush grapes, the chemical reactions involved in the initial fermentation steps, and certain chemical testing and analysis processes used in secondary fermentation and bottling decisions. With this study in mind, I have already contacted and received permission from Cadenza Vineyards in Lebanon (winemaker Ralph Weiss), La Bête Winery in McMinnville (winemaker Tom Reinert), and Eola Hills Winery (winemaker Steve Anderson) in McMinnville. I also plan to contact a small number of California wineries to study and observe their winery processes, to see if their approaches are parallel to those of the Oregon outlets.

From the information gathered on my visits, I will create at least 20 new chemistry learning activities (may be wet or dry) that use real-world examples from the viticulture and enology industries, and incorporate these learning activities into five of Mt. SAC's existing chemistry courses. All of these new learning activities will include no actual wine samples (unless permitted); the dry exercises will simulate actual industrial models and data, and the wet experiments will use chemical solutions that simulate industrial grapes or wine samples. These learning activities will help our students to learn these identified chemistry concepts as well as see the relevance of chemistry in the world. Each proposed learning activity will be structured similar to this:

- Introduction to the important chemistry concept(s) covered in the activity
- Information on how each concept is used in the viticulture or enology industry
- Specific instructions for hands-on wet or dry activities to be conducted to apply the concept(s), using real or simulated industrial data
- Instructor resource guide for each activity
- Feedback survey for each student/professor to complete after initial use of the activity

These new learning activities will provide an opportunity for students to explore and practice applied chemistry concepts in a more interesting, relevant and contextual manner.

Also from the information gathered on my visits, I will create a visual display, including photos, which highlights the chemistry concepts currently applied in the viticulture and enology industries. This display will be placed in the new Science Building, for everyone to view. As a part of the display, an educational flier for students will be created which summarizes all of the chemistry topics mentioned in the display, introducing them to these industries as viable career options, and citing resources and contact information for students.

Proposed Project Activities and Timeline

Timeline for proposed project activities:

Activity	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
#1	▨	▨	▨	▨							
#2		▨	▨	▨	▨						
#3								▨	▨		
#4								▨	▨		
#5									▨	▨	
#6										▨	▨

Activity #1: Identify and contact Oregon and California vineyards and wineries that are willing to let me to work with them. These visits to Oregon and northern California would be most effective if occurring in September, October, and November, which are the times when most of the critical viticulture chemical testing and decision-making for picking grapes and initial processing occurs. Arrange times to interview and work with winemakers in the field and lab technicians in their laboratories to observe and experience the cultivation of grapes and chemical processes with wine that relate to the chemistry concepts that are taught in our Mt. SAC chemistry courses. Travel to the identified vineyards and wineries in Oregon and/or California to speak and work with vineyard managers, winemakers, and lab technicians there to study the chemical procedures used in cultivating grapes and winemaking. Work alongside them in the vineyards and laboratories to learn these processes and watch how the everyday decisions that are made are related to these chemical processes. Gather information to help me to create contextual chemistry learning activities related to this industry. An optional additional visit in a later month (in March or April) would be for the purpose of observing and participating in continuing chemical analyses during fermentation, racking into barrels, and possible bottling procedures with wines that ferment only a short while. While at the vineyards and wineries, take extensive notes and photos on all interviews and chemical processes, to be used in the writing of the learning activities, and visual display.

Activity #2: Using the extensive notes from my interviews and work experience in the vineyards and wine laboratories, begin writing the portion of the 20 learning activities that focuses on the use of chemistry in the viticulture and enology industrial processes, while on-site or in the area. If questions develop during this writing phase, ask questions of vineyard workers and winery lab technicians to clarify concepts and their use(s).

Activity #3: Identify institutions of higher education in California or Oregon that offer courses in viticulture or enology. Contact an appropriate person(s) at each identified institution to arrange a visit, interview, and/or classroom observation. Travel to at least 4 identified institutions of higher education (University of California, Davis, California State University, Fresno, and Napa Valley College in California and Chemeketa Community College in Oregon are preliminarily identified) to gather pertinent chemistry information used in viticulture and enology courses. Investigate classes and lab sessions to observe the learning activities used with students in these courses. Gather information to assist me in creating useful, interesting learning activities for use in Mt. SAC's chemistry courses. If I discover more resources to gather from previously unidentified professors or institutions, this trip would provide the time to conduct additional visits to colleges and interviews with professors. While at the institutions or in the area on this trip, take extensive notes and photos on all interviews and chemical laboratory processes, to be used in the writing of the learning activities and visual display.

Activity #4: Begin writing the portion of the 20 learning activities that focuses on the application and use of chemistry in the teaching of viticulture and enology classes, while on-site or in the area. Begin developing the new actual exercises (wet or dry) that Mt. SAC students will perform in the specific learning activity. If questions develop during this writing phase, ask questions of professors and/or students to clarify concepts and their classroom or lab use(s).

Activity #5: Complete (writing and testing) at least 20 chemistry learning activities (wet or dry) to be utilized in CHEM 10, CHEM 40, CHEM 50, CHEM 50H, and CHEM 51 courses that incorporate real-world examples from the viticulture and enology industries and classes. Complete the creation of a visual display which highlights the chemistry concepts learned in this study, and currently applied in the Viticulture and Enology industries. The display will include photos, a summary of this study, and an educational flier for students which summarizes all of the chemistry topics mentioned in the display, and introduces them to these industries as viable career options, and citing resources and contact information for students.

Activity #6: Write and submit a comprehensive sabbatical report, detailing all of the travel and research notes gathered from interviews, observations and work experiences, including the final, modified learning units of the project for the CHEM 10, CHEM 40, CHEM 50, CHEM 50H, and CHEM 51 courses. The report will include the photos and content of the visual display and a copy of the educational flier, showing the relationships and relevance of chemistry to the viticulture and enology industries for all Mt. SAC students and professors. Two complete copies will be submitted to the Salary and Leaves Committee by September 2, 2008.

Importance, Significance and Benefits of this Project

It has long been an interest of mine to study the cultivation (viticulture) and production of wine (enology) from the chemistry perspective. These industries have been growing by leaps and bounds in recent years. I think that this project is important because it will allow me the time to really study and experience these certain industrial processes related to my chemistry discipline, better my teaching of chemistry concepts by creating contextual learning activities for five different chemistry courses, introduce students to possible, interesting and growing career opportunities, and allow me to pursue one of my own personal and professional interests. Since I regularly seek to introduce students to viable career options in the chemistry field in order to help them make career decisions in their educational journey, I hope to show through the use of the visual display and flier in the new Science building that both the viticulture and enology industries are truly career options for our Mt. SAC students.

This project is also significant because the one of the products of this project will incorporate real-world examples from the wine industry, personally experienced and developed, into Mt. SAC's current chemistry curricula to enhance student learning through the application of chemistry concepts. The major outcome of this project is the creation of a minimum of 20 specific, contextual learning activities for at least five different chemistry courses at Mt. SAC for the benefit of many chemistry students. These learning activities will help students to learn difficult chemistry concepts. I have found that students understand difficult chemistry concepts a lot more readily when relevancy and context is shown. After experiencing the chemical processes used in the wine industry, I will be able to transfer my knowledge and enthusiasm for these chemistry concepts into lecture and lab discussions, thereby creating interest for students in learning difficult chemistry concepts and for the field of chemistry in general. It will benefit the students in learning those chemistry concepts within an interesting, industrial context. The visual display in the Science Building will be of interest to all science students, as winemaking is one of California's most identifiable industries. The display and informational flier will attract students to job opportunities in both viticulture and enology, and show their relationship to chemistry. It will help students to see the relevancy in chemistry to the real world, and open the possibility of directing their education toward a viable chemistry-related career in these fields.

Statement of Purpose

This project seeks to incorporate real-world chemistry examples from the growing viticulture and enology industries into Mt. SAC chemistry courses that introduce and apply these chemistry concepts - CHEM 10, CHEM 40, CHEM 50, CHEM 50H, and CHEM 51. Contextual learning activities from a core California industry would help chemistry students in understanding the application and relevance of chemistry concepts through hands-on experimentation, data collection or analysis, and application of critical thinking skills. This project also involves the creation of a visual display, to be placed in the new Science Building, which highlights the chemistry concepts currently applied in the viticulture and enology industries. As a part of the display, an educational brochure for students will be created which summarizes all of the chemistry topics mentioned in the display, introducing students to viticulture and enology as viable career options, and citing resources and current contact information. Project activities include travel to several institutions of higher education in California and Oregon that offer courses and programs in viticulture or enology to interview viticulture and enology professors, visit their classes and lab sessions, examine their syllabi and assignments, and speak with students to see how chemistry-related processes are integrated into teaching and learning. This project also involves working in a vineyard and winery to gather firsthand information on the everyday chemical processes and analyses utilized there. This project allows observation and participation at wineries of field-testing chemical levels in grapes before harvest, chemical reactions involved in the fermentation steps, and processing steps, performing chemical testing and analyses to make critical decisions in gathering the information to be incorporated into the contextual learning activities, visual display, and student brochure.

Rearrangements to Original Timeline and Activities

The timeline of sabbatical activities was originally designed for an entire year, and was modified to accommodate one semester as follows:

Activity	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
#1	▨	▨	▨	▨							
#2		▨	▨	▨	▨						
#3								▨	▨		
#4								▨	▨		
#5									▨	▨	
#6										▨	▨

Here are brief descriptions of each activity in the sabbatical proposal:

#1 – identify, contact, and visit wineries and vineyards

#2 – begin writing learning activities from gathered winery information

#3 – identify, contact and visit colleges and universities

#4 - begin writing learning activities from gathered winery information

#5 – complete writing learning activities, create visual display and student brochure

#6 – write sabbatical report

The original timeline listed above was modified to fit one semester, rather than one year. Below is the modified timeline with same activities, rearranged to fit one semester ("r" represents rearranged):

Activity	Aug	Sept	Oct	Nov	Dec
#1r	▨	▨	▨		
#2r		▨	▨	▨	
#3r			▨	▨	▨
#4r			▨	▨	▨
#5r					▨

The details of the newly revised timeline and activities are as follows:

#1r – identify and contact wineries, vineyards, colleges and universities for permission to visit, interview, work and/or observe classes (combination of original activities #1, #3)

#2r – travel to wineries and colleges to gather information (in original activities #1, #3)*

#3r - write learning activities from gathered information (combination of #2, #4)

#4r – create visual display and student brochure (in original #5)

#5r – write sabbatical report (same as original #6)

*travel to wineries was scheduled to coincide with harvest and processing activities, and was largely determined by grape maturity and vineyard/winery decisions.

Travel Destinations, Materials and Contacts

Initial web research on colleges and universities that have viticulture and/or enology programs resulted in discovering the names of viticulture and enology professors, and the number and types of viticulture or enology courses at UC-Davis, Fresno State University, Napa Valley College and Chemeketa Community College. I contacted the following professors for permission to visit, interview them, and observe their classes and students (**denotes people actually interviewed):

UC-Davis
Mark Mathews
Andrew Waterhouse**
Susan Ebeler**
R. Boulton

Fresno State University
Sayed Badr
Roy Thornton
Ken Fugelsang
Robert Wample**
Sanliang Gu**
John Giannini**

Napa Valley College
Stephen Krebs**
G. Vierra
M. Weis
Greg Siewert

Chemeketa Community College
Barney Watson**
Al MacDonald**
Craig Anderson

During my travels, I discovered that two other universities had programs in Enology or related Food Sciences:

- **Oregon State University (Corvallis, OR)**
- **California Polytechnic State University (San Luis Obispo, CA)**

Web research on vineyards and wineries that I had visited on a previous trip to Oregon resulted in finding contact information for the winery or vineyard managers. Cool and wet weather conditions in Oregon during the summer and early fall resulted in later than usual grape harvest times, thus making my travel plans shift to later in the semester. I contacted the following people for permission to visit, interview them, and participate in their vineyard or winery processes:

- **Eola Hills Wine Cellars (Rickreall, OR)**
  Steve Anderson, Winemaker**
- **Bethel Heights Winery (Salem, OR)**
  Terry Casteel, Winemaker
- **La Bete Winery (McMinnville, OR)**
  John Eliasen** and Tom Reinert**, Winemakers
- **Cadenza Vineyards (Lebanon, OR)**
  Ralph Weiss**, Vineyard and Winery Manager/Owner

During my travels, I also visited and observed winery or chemical analyses processes at:

- **V. Sattui Winery (Napa, CA)**
- **Spangler Vineyards (Roseburg, OR)**
- **Van Duzer Winery (Dallas, OR)**
- **Panther Creek Cellars (McMinnville, OR)**
- **ETS Laboratories (McMinnville, OR)**

In initial contact with professors and winery personnel, I was encouraged by them to purchase some books to familiarize myself with basic vineyard and wineries practices before visiting them. I bought and read the following books prior to my travels:

- **Beginner's Guide to Understanding Wine**, by Michael Schuster
- **The University Wine Course**, by Marian W. Baldy
- **Wine Analysis and Production**, by Bruce W. Zoecklein, et al
- **The Complete Handbook of Winemaking**, by The American Wine Society
- **From Vines to Wines**, by Jeff Cox

During my travels, I also obtained and read these additional publications:

- **Concepts in Wine Chemistry**, by Yair Margalit
- **Chemical Analysis of Grapes and Wine: Techniques and Concepts**, by Patrick Iland et al.
- **Wines of California**, by Stephen J. Krebs [course material for VWT 137, NVC]
- **Napa Valley Vintners Association Teaching Winery Procedures Manual**, [NVC]
- **Fundamentals of Enology**, by Gerrie Ritchie [course material for VWT 180, NVC]
- **Sensory Evaluation of Wine**, by Stephen J. Krebs [course material for VWT 173, NVC]
- **Wine Chemistry and Microbiology**, by Stephen J. Krebs [course material for AG 272, NVC]

Detailed Travel Itinerary Including Summary Notes and Photos

Travel for this project revolved around vineyard harvest and winery processing activities, which depended on local weather and grape maturity. Grape harvest occurred, for the most part, in October in northern California and Oregon. At every destination, I introduced myself as a Mt.

San Antonio College chemistry professor. I explained the purpose of my sabbatical project, and then asked the interviewee the following two questions:

1) Which introductory, general, or organic chemistry or biochemistry concepts do you utilize in your vineyard or winery practices/classes?
2) For any chemistry concepts that you apply, can you describe specific viticulture or enology examples of how that concept is applied?

During these interviews, I took extensive notes. My detailed travel itinerary and abbreviated journal for this project are as follows:

Date(s) **Destination/Location** **Summary Notes**
October 2 **Fresno State University/Fresno, CA** Visited the Enology Department offices, interviewed department chair and other Enology faculty, toured and photographed classrooms, laboratories, and winery, discussed the Enology Program – courses, curricula, number of students, internships, career placement, textbooks, vineyard and winery processes, visited the bookstore to purchase enology books
October 3 **Napa Valley/St. Helena, CA** Visited commercial wineries, interview workers, observe winery processes, took photographs
October 4 **Napa Valley College/St. Helena, CA** Visited the Enology Department offices, interviewed department chair and Enology students, toured and photographed classrooms, laboratories, and winery, discussed the Enology Program – courses, curricula, number of students, internships, career placement, textbooks, vineyard and winery processes, observed students preparing for chardonnay de-stemming and crush process at the College winery. **University of California - Davis/Davis, CA** Visited the Enology Department offices, interviewed department chair, other Enology faculty and students, toured and photographed classrooms, laboratories, research laboratories, and winery, discussed the Enology Program – courses, curricula, number of students, internships, career placement, textbooks, vineyard and winery processes, visited the bookstore to purchase enology books
October 5 **Spangler Vineyards/Roseburg, OR** Visited winery, interviewed winemaker and observed chemical analyses processes

October 10
La Bete Winery/McMinnville, OR
Visited and worked alongside winemaker/chemist in wineries, interviewed winemaker/chemist, observed and participated in winery processes, took photographs

October 11
Panther Creek/McMinnville, OR
Visited and interviewed winemaker, observed winery processes, took photographs

Davison Winery Supply/McMinnville, OR
Visited supply store to learn about typical labware and equipment used in chemical analyses of wine and must, interviewed store owner about local winemaking practices

ETS Laboratories/McMinnville, OR
Visited nationally recognized analytical laboratory servicing the winemaking community, interviewed chemists and observed analytical processes, took photographs

October 12
Van Duzer Winery/Dallas, OR
Visited and interviewed winemaker

Eola Hills Wine Cellars/Rickreall, OR
Visited and interviewed winemaker, observed winery processes, took photographs

October 12-20
Cadenza Vineyards/Lebanon, OR
Visited and worked in vineyard and winery – picked grapes, sorted grapes, trimmed vines, loaded hopper, de-stemmed grapes, prepared musts for initial fermentation, crushed white grapes, added yeast, performed chemical analyses, prepared solutions and sulfite additives, racked must from one fermentation container to another, punched down the caps, cleaned and sanitized containers, composted the lees, labeled bottles, interviewed winemaker, and observed other winery processes, took extensive photographs

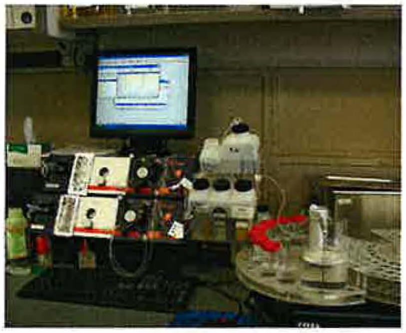
Oct 17
Chemeketa Community College/Salem, OR
Visited the Viticulture and Enology Department offices, interviewed Viticulture faculty and Enology faculty, toured and photographed classrooms, laboratories, research laboratories, and winery, discussed the Enology Program – courses, curricula, number of students, internships, career placement, textbooks, vineyard and winery processes, took photographs

During my travels, I extensively photographed laboratories, vineyards and wineries for inclusion in both the visual display and student brochure. At every destination, vineyard workers, winemakers and university professors were more than obliging when I asked for permission to take photographs of winery processes. Here are some of those photographs:







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Viticulture and Enology Applications

Using my extensive interview notes, I compiled the following list of specific example(s) of the concept's viticulture or enology application, the chemistry concept it utilizes, and the Mt. SAC courses in which the concept is currently taught:

Chemistry Concept Addressed	CHEM Course(s)	Contextual Application
Acid dissociation constants, K_a	51	Acids in wines
Acidity	10,40,50,50H,51	Grape harvest determinations
Acidity	10,40,50,50H	Acids and their tastes in wines
Acidity	10,40,50,50H	Sugar and the sensory thresholds in wines
Anti-oxidants	50,50H,51	Phenolic molecules in wines
Aqueous equilibria	51	Sulfite equilibria in fermentation decisions
Boyle's law	40,50,50H	Pressing grapes at harvest
Buffers in solutions	51	Fermentation decisions
Calculations using equations	10,40,50,50H	Temperature calculations for cold stabilization processes
Chelation	51	Complex formation in wine fermentation
Chemical reactions	10,40,50,50H	Sugar to alcohol reaction
Chemical reactions	50,50H	Alcohol to acetic acid reaction
Chemical reactions	50,50H	Malic acid to lactic acid reaction
Chemical reactions	50,50H	Citric acid to acetic acid reaction
Computer skills	50,50H	Spreadsheet activities using harvest data
Conversion factors/ratios	10,40,50,50H	Yield of juice from grapes
Critical thinking	40,50,50H,51	Harvest decisions
Critical thinking	50,50H,51	Fermentation decisions
Density	40,50,50H	Density of juice at grape harvest
Dilution of solutions	40,50,50H	Preparing cleaning solutions of certain concentrations
Dimensional analysis calculations	10,40,50,50H,51	Calculations for wine additives
Distillation	50,50H	Determination of alcohol amount in wines
Elements	10,40,50,50H	Soil analysis
Energy transfer	10,40,50,50H	Solar to chemical energy transformations
Filtration techniques	10,40,50,50H	Fining and filtration of wines
Precision in lab techniques	10,40,50,50H,51	Quality control in chemical analyses
Free radicals/molecular structure	50,50H	Phenolics in wines
Graphing skills	50,50H	Standard curves and calibrations
Henderson-Hasselbach equation	51	Fermentation decisions
Indicators using in titrations	50,50H,51	Sulfur dioxide analysis
Molecular structure	50,50H	Acids in wines
Molecular structures	50,50H	Grape maturity
Molecular structures	50,50H	Smells in wines
Multiple acid equilibria	51	Multiple acids in wines
Neutralization reactions	50,50H	Acid reductions in fermentation
Oxidation reactions	51	Sulfur reactions in wines

Percent composition	40, 50, 50H	Amount of sugar in grapes at harvest
pH measurements	40, 51	Grape harvest decisions
pH measurements	40, 51	Fermentation decisions
Ratio calculations	10,40,50,50H	Acidity ratios in juice at grape harvest
Sampling solutions	10,40,50,50H,51	Chemical analysis processes
Solubility	40,50,50H,51	Additives to wines
Solution concentrations	50,50H	Preparing sulfite additives to the juice
Solution concentrations	50,50H	Preparing yeast additives to the juice
Solution concentrations	50,50H	Final alcohol percentages
Solution concentrations	50,50H	Cork spoilage smells in wines
Solution preparation calculations	40,50,50H	Solution preparation of cleaning solutions
Specific gravity	50,50H	Grape harvest decisions
Spectrophotometry	40,50,50H	Chemical analysis
Spectrophotometry	51	Anthocyanin determination in red wines
Thin layer chromatography (TLC)	51	Fermentation decisions
Titration	51	Sulfur dioxide analysis
Titration	40,50,50H	Total acidity determinations
Titration curves	51	Acids in wines

From the above list, one can easily see that more than 20 contextual examples were gathered from interviews for inclusion into chemistry learning activities. Many of the contextual examples can be utilized in more than one chemistry course, as some of these applications have numerous examples that apply at different levels, and can used when discussing chemistry concepts with students. Different types of learning activities can be created to suit the depth of coverage of the chemistry concept in a particular course, utilizing the same basic contextual application. Subsequent reading of the books gathered during this study gave me nearly limitless ideas for more examples to be included in future learning activities!

For the purposes of this sabbatical study, contextual examples to be included in the learning activities were carefully selected for each course, based on several criteria that relate to the existing curricula for these particular five chemistry courses. Examples were selected if they addressed major chemistry concepts in the courses. Selection was also based on if the contextual application addressed certain chemistry concepts that were utilized many times during the course, or if that particular course is the only chemistry course at Mt. SAC that covers that particular concept. The possibilities for development of future learning activities is very great, as many of the examples can used for more than one course or applied concept.

Selected Topics for Contextual Learning Activities

Here are the contextual examples that were selected to be included in the learning activities, the particular courses that they would supplement, and the specific chemistry concept addressed:

Learning Activity #	CHEM Course	Chemistry Concept Addressed	Contextual Application
1	10	Density	Density of grape juice at harvest
2	10	Acidity	Acidity of grape juice at harvest
3	10	Conversion factors/ratios	Grape yields and sulfur additives
4	10	Filtration techniques	Filtration of wines for clarity
5	40	Calculations using equations	Temperature-dependent winery processes
6	40	Chemical reactions	Fermentation reactions
7	40	Unit conversions	Adding sugar to wines
8	40	Dilution of solutions	Preparing sterilization solutions
9	50	Laboratory precision	Quality control in chemical analyses
10	50	Percent composition	Percent sugar in grapes at harvest
11	50	Dimensional analysis calculations	Sulfur additives to wines
12	50	Solution concentrations	Concentrations of wine components
13	50H	Chemical reactions	Fermentation reactions/analyses
14	50H	Molecular structure	Acids in wines
15	50H	Neutralization reactions	Acid reduction in wines
16	50H	Critical thinking	Grape criteria at harvest time
17	51	Acid dissociation constants, K_a	Acids in wines
18	51	pH measurements	Fermentation decisions related to pH
19	51	Aqueous equilibria	Complex equilibria of sulfur additives
20	51	Titration curves	Relative strength of acids in wines

The contextual learning activities for this project are not intended to be a replacement for the regular introduction and practice of chemistry concepts in chemistry courses. The course instructor and textbook are the best resources for those purposes. These learning activities are designed to be used as a contextual supplement, in the lecture classroom or the laboratory after the initial introduction of the chemistry concept, and subsequent discussion or homework practice with problems. These learning activities are to extend the student learning process on certain chemistry topics, bringing real life examples to the students for them to see the relevance in learning chemistry.

The next section of this report includes the 20 contextual learning activities for 5 different chemistry courses.

Learning Activity 1 **DENSITY** **Name**__________________

CHEM 10 / wet

This activity is designed to supplement student learning after the concept of **density** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

The best time of the year to harvest wine grapes is largely determined by their ripeness, which is related to the density of the grape juice. As grapes mature, their juice becomes more dense (more sugar in the juice). As harvest time approaches, vineyard workers take a sample of grapes from various sections of the vineyard to test them for ripeness, by measuring their density. Vineyard managers say that an optimum harvest density of grape juice (for producing wines) is between 1.08 g/mL and 1.10 g/mL at room temperature.

The density of grape juice can be easily determined in the laboratory. The procedure is as follows:

1. Determine the mass of a clean, dry 10 mL graduated cylinder on the laboratory balance. Record this mass value to the appropriate amount of decimal places, as it relates to the precision of the balance.

2. Place a funnel in the top of the 10 mL graduated cylinder, in order to filter the grape juice into the graduated cylinder.

3. Obtain a piece of filter paper from your instructor and fold it according to instruction. Place the filter paper in the filter funnel. Do not wet it with water, as that will dilute the juice sample.

4. Obtain approximately 10 grapes in a beaker. Do not wash the grapes, as that will draw water into the grapes and affect the density of the juice.

5. Using a clean test tube, crush all of the grapes in your beaker, producing grape juice.

6. Gently pour the grape juice from the beaker into the filter paper in the funnel. Wait as the juice filters into the graduated cylinder.

7. Measure the volume of grape juice in the 10 mL graduated cylinder, by reading the measurement at the bottom of the meniscus. Record this volume to the hundredths place, estimating the last digit.

8. Calculate the mass and density of your grape juice sample in the graduated cylinder, in the space below.

Measurements and Calculations:

Mass of empty graduated cylinder ____________
Mass of graduated cylinder with juice ____________

Calculations of grape juice mass:

Show all work.

Mass of grape juice ____________

Volume of juice ____________

Calculations of grape juice density:

Show all work.

Density of grape juice = ________________________

Follow-up Questions/Comments:

1. Are your grapes ready for harvest? Why or why not?
2. If you had washed the grapes before crushing, how would that have affected the density of your juice sample? Would the density be higher or lower than it should be? Why?
3. If you had wetted the filter paper with water before filtration, how would that have affected the density of your juice? Would the density be higher or lower than it should be? Why?
4. Did you encounter any problems in this activity? If so, please describe.

Learning Activity 2 **ACIDITY** **Name**________________

CHEM 10 / wet

This activity is designed to supplement student learning after the concept of **acidity** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

The best time of the year to harvest wine grapes is largely determined by their ripeness, which is related to the acidity of the grape juice. As grapes mature, their juice becomes less acidic (fewer acids remain in the juice). As harvest time approaches, vineyard workers take a sample of grapes from various sections of the vineyard to test them for ripeness, by measuring their total acidity (TA). Vineyard managers say that an optimum harvest TA of grape juice is between 0.65 and 0.85% (grams tartaric acid/100 mL juice) at room temperature for producing quality white wines.

The total acidity (TA) of grape juice can be easily determined by the following procedure:

1. Obtain approximately 25 grapes in a 250 mL beaker. Using the bottom of a clean 150 mL beaker, crush all of the grapes, producing grape juice.

2. Place a funnel in the top of a test tube, in order to filter the grape juice into the test tube.

3. Obtain a piece of filter paper from your instructor and fold it according to instruction. Place the filter paper in the filter funnel. Wet it with water to "set" it within the funnel.

4. Gently pour the grape juice from the beaker into the filter paper in the funnel. Wait as the juice filters into the test tube. Discard crushed grapes.

5. Using a clean, dry 50 mL graduated cylinder, measure exactly 15.00 mL of the filtered grape juice by reading the measurement at the bottom of the meniscus. Pour the juice from the graduated cylinder into a 50 mL clean beaker.

6. Add 3 drops of phenolphthalein indicator solution to the beaker with the juice. Phenolphthalein will be used to indicate that all acid has been removed from solution, when it turns the solution a bright pink color.

7. In a second clean, dry 50 mL graduated cylinder, obtain 25 mL of 0.100 M NaOH solution. Measure and record the actual volume in the 50 mL graduated cylinder.

8. Obtain a disposable plastic eyedropper. Drop by drop, add NaOH to the juice in the beaker, swirling the solution regularly. Watch the solution carefully for a bright pink color to appear and remain. As long as the pink color disappears with swirling, keep adding drops of the NaOH solution. When the pink color takes a long time to disappear, it means that you are nearing the endpoint of this process, and subsequent drops should be added very slowly. If the pink color remains in the juice sample, stop adding NaOH. Place any leftover NaOH in the eyedropper back into the graduated cylinder.

9. Measure and record the final volume of NaOH in the 50 mL graduated cylinder.
10. Calculate the volume of NaOH used in this process. From that value, calculate the TA of the juice.

Measurements and Calculations:

Volume of juice used ____________

Initial volume of NaOH in 50 mL graduated cylinder ____________

Final volume of NaOH in 50 mL graduated cylinder ____________

Calculations of volume of NaOH used in this process:

Show all work.

Volume of NaOH used ____________

Calculations of grape juice TA (divide the mL of NaOH by 2):

Show all work.

TA of grape juice = ______________________ % (grams tartaric acid/100 mL juice)

Follow-up Questions/Comments:

1. What is the TA of your grape sample?
2. Are your grapes ready for harvest? Why or why not?
3. How is phenolphthalein used in this activity?

Learning Activity 3 **CONVERSION FACTORS** **Name__________________**
CHEM 10 / dry

This activity is designed to supplement student learning after the concept of **conversion factors** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Vineyard managers use conversion factors to calculate juice yields from harvest grape volumes while winemakers use conversion factors to calculate how much sulfur dioxide to add to wine to keep it from spoiling. When grapes are picked during harvest, their total mass is easily determined by simply weighing the bins that are used to collect the grapes (subtracting out the mass of the empty bin). Vineyard managers expect to obtain 150 gallons of juice from 2000 pounds of grapes. Directly after collecting the juice from the grapes, winemakers add potassium metabisulfite to the juice to prevent it from spoiling, in the amount of 0.60 grams of "sulfite" for every gallon of juice. Each conversion factor mentioned above may be expressed in two different ways, as a fraction or ratio.

Exercises (show all work):

1. Write the two different expressions of the grape volume yield conversion factor:

   a) b)

2. Write the two different expressions of the sulfite additive conversion factor:

   a) b)

3. If a vineyard manager harvests 57,850 lbs of grapes, what volume of juice will he have to make wine?

4. If the vineyard manager ends up with 1500 gallons of juice, what mass of grapes must have been harvested?

5. If the winemaker is given 2500 gallons of juice from the vineyard manager, how many grams of "sulfite" should he/she add to the juice to prevent spoiling?

6. If the winemaker only has 25.0 grams of "sulfite", how many gallons of juice can he prevent from spoilage?

Learning Activity 4 **FILTRATION** **Name**__________________
CHEM 10 / wet

This activity is designed to supplement student learning after the concept of **filtration** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

When wines are to be bottled before sale, they are inspected for clarity. Winemakers, as well as consumers, like their wines to be clear or transparent solutions. If there are solids suspended in the wine, then the wine may look murky or cloudy. This murkiness may or may not affect the taste of the wine, but definitely affects a person's initial impression of the wine's quality. Winemakers can add chemicals to the wine to try to precipitate the suspended solids to the bottom of the container, and then the solids can be separated from the wine. Or, winemakers can filter the wine to remove the suspended solids. Either process can have a small or marked affect on the final taste of the wine.

Filtration of recently pressed juice from grapes can be accomplished easily in the laboratory. The procedure is as follows:

1. Obtain approximately 25 grapes in a 400 mL beaker.
2. Using a clean 250 mL beaker, crush all of the grapes in your beaker, producing grape juice.
3. Place a funnel in the top of the 125 mL Erlenmeyer flask in order to filter the grape juice into the flask.
4. Obtain a piece of filter paper from your instructor and fold it according to instruction. Place the filter paper in the filter funnel. Wet the filter paper with water to "set" it into the funnel.
5. Gently pour about one half of the grape juice from the beaker into the filter paper in the funnel. Wait as the juice filters into the Erlenmeyer flask.
6. When filtration is complete, compare the unfiltered juice with the filtered juice. Discard juices in the sink, followed by water. Discard of crushed grapes in the trash.

Questions/Comments:

1. Which juice appears more transparent?

2. Which juice would you rather drink?

3. Name at least 3 other purposes for using filtration.

Learning Activity 5 **CALCULATIONS** **Name**__________________

CHEM 40 / dry **USING EQUATIONS**

This activity is designed to supplement student learning after the concept of **calculations using math equations** and **significant figure rounding rules** have been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

In order to produce quality wines, standard winemaking processes require certain procedures to be conducted at or near particular temperatures. For example, many winemakers believe that fermentation of the juice of white grapes should be done at temperatures below 60 degrees Fahrenheit so that unwanted chemical reactions that can spoil the wine do not happen. Temperatures should not fall below 45 degrees or necessary fermentation reactions may not happen, and the resultant wine may be too bitter. Undesirable solids in wines can be made to precipitate out of the wine solution if the temperature is kept at or below 32 degrees Fahrenheit (it does not freeze) for about 2 weeks during the end of fermentation (cold stabilization). Then the solids can be removed by filtration or "racking" (decanting).

Temperature is very important to winemakers and chemists alike. Chemists regularly use thermometers in lab experiments, and may often need to convert from one temperature scale to another. Chemists must be able to appropriately use the mathematical equations and significant figures rules for rounding calculation answers when converting temperature measurements. Complete the following exercises for practice in converting temperature measurements among the Celsius, Fahrenheit and Kelvin temperature scales.

Exercises (show original equations, all calculations, and circle the correctly rounded answer):

1. The winemaker wants to maintain the temperature of the juice of his white grapes at 57 degrees Fahrenheit to ferment into wine. What temperature is this in degrees Celsius?

2. If the winemaker keeps his wine at -3.0 degrees Celsius for 2 weeks to cold stabilize his wines, what temperature would this correspond to on his Fahrenheit thermometer?

3. What temperature would correspond to -3.0 degrees Celsius if the winemaker used a Kelvin thermometer?

4. Fermentation temperatures are usually higher for red wines than white wines. How many kelvins would the winemaker need to raise the temperature of his white wine cellar (see question #1) in order to ferment his red wines at 72 degrees Fahrenheit?

Learning Activity 6 **CHEMICAL REACTIONS** **Name**__________________
CHEM 40 / dry

This activity is designed to supplement student learning after the concept of **chemical reactions** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Many chemical reactions occur when grape juice is fermented to make a wine. The first important reaction occurs when the sugar in the juice is catalyzed by yeast to form alcohol and carbon dioxide. This chemical reaction can be written in the following chemical equation:

$$\underset{\text{sugar}}{C_6H_{12}O_6} \rightarrow \underset{\text{alcohol}}{C_2H_5OH} + \underset{\text{carbon dioxide}}{CO_2} \qquad (1)$$

Another chemical reaction that may have occurred in wines that have spoiled is the reaction of alcohol to acetic acid. This chemical reaction can be written in the following chemical equation:

$$\underset{\text{alcohol}}{C_2H_5OH} + \underset{\text{oxygen}}{O_2} \rightarrow \underset{\text{acetic acid}}{C_2H_3OOH} + H_2O \qquad (2)$$

Winemakers control the first chemical reaction in order to produce wines that have varying amounts of alcohol (see label on bottle for alcohol percentage). Wines that have the first reaction halted before all of the sugar is converted to alcohol have some residual sugar in them, and are sweet to the taste. Wines that have all of their sugar converted to alcohol are called "dry" wines.

Exercises (show all work):

1. Balance chemical equation #1.

2. Balance chemical equation #2.

3. How many alcohol molecules are formed from every 10 sugar molecules?

4. How many acetic acid molecules are formed from every 10 alcohol molecules?

5. How many oxygen molecules are needed to react with each alcohol molecule?

6. How many acetic acid molecules are formed from every 10 sugar molecules?

Learning Activity 7 **UNIT CONVERSIONS** **Name___________________**
CHEM 40 / dry

This activity is designed to supplement student learning after the concept of **unit conversion** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

When winemakers make wine from grape juice, they are very concerned about the amount of alcohol that will be present in the wine at the end of the process. Most wines are made to contain 11-14% alcohol. If every 2% of sugar in the juice roughly produces 1% of alcohol in wines, then most winemakers want to start the fermentation process with about 22 – 26 % sugar in the grape juice in order to produce wines with the desired amount of alcohol. Sometimes when harvest time arrives, grapes do not always contain the optimum amount of sugar, yet all other factors require harvest at that time. If that happens, then winemakers add some sugar to the pressed grape juice before fermentation (a process called chaptalization) to bring the sugar percentage to where it needs to be in order to produce a wine with the final alcohol percentage in the desired range. Winemakers add 17 grams of sugar to each liter of juice before fermentation in order to raise the final alcohol amount in the wine by one percent.

Exercises (show all work):

1. Two conversion factors associated with the chaptalization process described above can be written. One conversion factor relates the amount of sugar and the volume of grape juice. The other conversion factor relates the percent alcohol in the wine and the percent sugar in the juice. Write the 2 conversion factors below.

   (a) (b)

2. If a grape juice has 23% sugar, will this juice produce a wine that has the desired amount of alcohol? Why or why not?

3. If a wine has 13.6% alcohol in it, roughly what percent sugar did its juice have before fermentation?

4. If a grape juice has 20.5 % sugar at harvest, how many grams of sugar must the winemaker add to 50.0 L of the juice to bring its sugar percentage up to 24.0 % before fermentation?

5. If a grape juice has 18.0 % sugar in it, how much sugar should be added to 100 liters of juice before fermentation, so that the resultant wine will have a final alcohol percentage of 12.0%?

Learning Activity 8 **DILUTION OF SOLUTIONS** **Name**__________________
CHEM 40 / wet

This activity is designed to supplement student learning after the concept of **dilution of solutions** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Many chemicals are purchased from chemical supply companies in a concentrated solution. The purchased solution may not be usable in the concentrated form, and must be mixed with water to form a diluted solution that can be used. Winemakers need dilute solutions containing ammonia or sulfite (from sodium sulfite, Na_2SO_3 or potassium metabisulfite, $K_2S_2O_5$) for sterilized cleaning of winemaking equipment. Concentrated sulfite solutions are made from purchased powders and subsequently diluted to the appropriate molarity just before using them for sterilization purposes.

Making dilute solutions is easy to do by adding water to a concentrated solution. The procedure is as follows:

1. Obtain approximately 25.0 mL of 2.00 M. sodium nitrate ($NaNO_3$) solution into a 50 mL graduated cylinder. Measure the actual volume of this solution at the bottom of the meniscus, and record the value.

2. Add distilled water to the graduated cylinder until the final volume of solution in the graduated cylinder is exactly 50.0 mL. An eyedropper may be used to obtain the correct final volume.

3. Gently stir the diluted solution with a glass stirring rod. Discard solution in container.

4. Calculate the concentration (molarity, M.) of the dilute solution.

Questions/Comments:

1. What is the final concentration of the dilute solution made in this activity? Show all calculations.

2. How many mL of the above concentrated solution would be needed to make 100 mL of a 0.125 M. $NaNO_3$ solution? Show all calculations.

3. How many mL of water should be added to the mL of concentrated $NaNO_3$ solution (answer in #2) to make the dilute solution in #2? Show all calculations.

4. Winemakers need 5.0 L of a sterilizing solution of 0.10 M. potassium metabisulfite, $K_2S_2O_5$, for rinsing winemaking equipment. If the wine cellar contains a bottle of a concentrated solution of 2.25 M. $K_2S_2O_5$, how many mL of this concentrated solution will be used to make the sterilizing solution? Show all calculations.

Learning Activity 9 **LABORATORY PRECISION** **Name__________________**
CHEM 50 / wet

This activity is designed to supplement student learning after the concept of **precision** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

At harvest times and during winemaking processes, juice or wine samples are periodically sent to an analytical laboratory for determination of sugar percentage in the juice, total acidity, pH, sulfur dioxide parts per million, etc. ETS Labs in St. Helena, California is such an analytical laboratory, serving the wine industry. At their labs, samples are processed by strict protocols, in order to provide consistent and reliable test results over time for their clients. In fact, periodically ETS Labs is sent "unknown" samples for analyses, to check/test their analytical results against known industry standards. Results from their tests must lie within a certain precision (all results are reproducible with that range) for all of the test samples in order for the lab to remain an accredited analytical laboratory. This is commonly called Quality Control. It is extremely important for a functioning commercial laboratory remain accredited, in order to maintain their reputation for quality work and client satisfaction.

To test the precision of certain lab ware, follow this procedure:

1. The instructor will set up five labeled activity stations around the lab room. One station will contain a volume of water in a 10 mL graduated cylinder, a 50 mL graduated cylinder, a 25 mL buret, a 100 mL beaker, and a 125 mL Erlenmeyer flask.

2. Students will take a piece of paper and pencil around to each activity station and take a measurement from the device with the volume of water in it. Record the measurement of volume of water within each lab ware at each station onto the piece of paper.

3. After all students have recorded their measurements, the instructor will ask all students to write their recorded values on the board, under the heading for each station's lab ware.

4. Class discussion will take place after all values are written on the board, regarding the consistency and reliability of the values written under each station heading.

Questions:

1. Are all the values written under each heading the exact same value? Why or why not?

2. Should all of the values under each heading be the exact same value? Why or why not?

3. Are all of the values under each heading reported to the same decimal place? Why or why not?

4. Should all of the values under each heading be reported to the same decimal place? Why or why not?

Learning Activity 10 **PERCENT COMPOSITION** **Name**__________________
CHEM 50 / dry

This activity is designed to supplement student learning after the concept of **percent composition** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Near harvest time, vineyard managers test their grapes on the vines to see if the sugar percentage in the grapes falls within the winemaker's desired range. Sugar percentages in grapes can change dramatically from day to day at the end of the growing season, and are routinely checked every day in the vineyard near harvest time. Sugar will be converted to alcohol during fermentation in an approximate 2 to 1 ratio. Since most wines contain between 11-14 % alcohol, a pre-fermentation desired sugar percentage in grapes is about 20-28%. Vineyard workers collect a sample of grapes from various locations on the vines throughout the vineyard to get a representative sample. They smash the grapes to release the juice, and winemakers or lab enologists test to see what percentage of sugar is currently in the grape juice. Testing may be conducted using a refractometer, hydrometer, or other density or specific gravity determinations of the juice. If the sugar percentage is lower than desired, then the grapes are allowed to mature ("hang") longer on the vines before harvest. If the grapes contain the desired percentage of sugar (and other harvest criteria are met), then the grapes are immediately harvested and processed into wines.

Exercises (show all work):

1. If lab enologists determine that 68.0 kilograms of sugar are found in 325.0 kilograms of grapes, what percent of sugar is in the grapes?

2. From the results in #1, should the lab enologists tell the vineyard manager that these grapes are ready for harvest? Why or why not?

3. If lab enologists determine that 92.7 kilograms of sugar are found in 579.0 kilograms of grapes, what percent of sugar is in the grapes?

4. From the results in #3, should the lab enologists tell the vineyard manager that these grapes are ready for harvest? Why or why not?

5. How much sugar should be found in 2.57 tons of grapes at harvest if the winemaker wants the sugar percentage in the grapes at maturity to be 24.0 %?

Learning Activity 11 **DIMENSIONAL ANALYSIS CALCULATIONS** **Name**__________________
CHEM 50 / dry

This activity is designed to supplement student learning after the concept of **dimensional analysis calculations** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Immediately after crushing wine grapes, winemakers add certain chemicals to prevent unwanted chemical reactions from occurring in the wine must (mixture of juice, pulp, seeds, and stems before it becomes wine) before the appropriate yeast is added to start the fermentation process. The most commonly added chemical after grape crush is potassium metabisulfite, $K_2S_2O_5$. Potassium metabisulfite breaks down and releases sulfur dioxide, SO_2, which stuns natural yeast action, kills many microorganisms, and prevents other oxidation reactions from occurring. After a day of "rest" with the potassium metabisulfite addition, the yeast, chosen specifically for the particular varietal grape undergoing fermentation and which is resistant to the added potassium metabisulfite, is added to the must. Then fermentation is carried out in a controlled fashion by the winemaker.

Potassium metabisulfite is added to grape musts immediately after crush at levels to produce 15-100 ppm (parts per million) SO_2, dependent on the pH of the must, the varietal of grape, and other factors. Winemakers add about 2 grams potassium metabisulfite to every 5 gallons of must to achieve an optimum preservative state (50-70 ppm SO_2) in the must.

Exercises (show all work):

1. How many grams of potassium metabisulfite should be added to 355 gallons of must in order to protect it from unwanted chemical reactions before fermentation?

2. If the winemaker has 1.75 kg of potassium metabisulfite, how many gallons of wine can be treated with it?

3. If the level of potassium metabisulfite is 75 ppm in a 2.00 ton must sample, how many grams of potassium metabisulfite have actually been added to the sample?

4. How many grams of alcohol are there in a wine that has 12.5 % (mass/volume %) alcohol, contained in a standard 750. mL wine bottle?

Learning Activity 12 SOLUTION CONCENTRATIONS Name__________________
CHEM 50 / dry

This activity is designed to supplement student learning after the concept of **solution concentrations** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Immediately after crushing wine grapes, winemakers add certain chemicals to prevent unwanted chemical reactions from occurring in the wine must (mixture of juice, pulp, seeds, and stems before it becomes wine) before the appropriate yeast is added to start the fermentation process. The most commonly added chemical after grape crush is potassium metabisulfite, $K_2S_2O_5$. Potassium metabisulfite breaks down and releases sulfur dioxide, SO_2, which stuns natural yeast action, kills many microorganisms, and prevents other oxidation reactions from occurring. After a day of "rest" with the potassium metabisulfite addition, the yeast, chosen specifically for the particular varietal grape undergoing fermentation and which is resistant to the added potassium metabisulfite, is added to the must. Then fermentation is carried out in a controlled fashion by the winemaker.

Potassium metabisulfite is added to grape musts immediately after crush at levels to produce 15-100 ppm (parts per million) SO_2, dependent on the pH of the must, the varietal of grape, and other factors. Winemakers add about 2 grams potassium metabisulfite to every 5 gallons of must to achieve an optimum preservative state (~60 ppm SO_2) in the must.

Exercises (show all work):

1. If the level of potassium metabisulfite is 50.0 ppm in a 100.0 gallon must sample, what is that concentration of potassium metabisulfite, expressed in molarity?

2. How many moles of alcohol, C_2H_6O, are contained in a wine that has 12.5 % (m/v %) alcohol, contained in a standard 750. mL wine bottle?

3. If the level of potassium metabisulfite is 65 ppm in a 100.0 gallon must sample, and the winemaker wants to raise the level to 75 ppm, how many grams of potassium metabisulfite need to be added to the sample?

Learning Activity 13 **CHEMICAL REACTIONS** **Name**__________________
CHEM 50H / wet

This activity is designed to supplement student learning after the concept of **chemical reactions** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Many chemical reactions occur when wine grape juice is fermented to make a wine. The first important reaction occurs when the sugar in the juice is catalyzed by yeast to form alcohol and carbon dioxide. This chemical reaction can be written in the following unbalanced chemical equation:

$$\mathbf{C_6H_{12}O_6 \rightarrow C_2H_5OH + CO_2} \qquad (1)$$

sugar alcohol carbon dioxide

Winemakers control this chemical reaction in order to produce wines that have varying amounts of alcohol and residual sugar (see label on wine bottle for alcohol and sugar percentages). Wines that have the first reaction halted before all of the sugar is converted to alcohol have some residual sugar in them, and are sweet to the taste. Wines that have all of their sugar converted to alcohol are called "dry" wines.

A secondary fermentation reaction, which is regularly utilized by winemakers to reduce excess acidity in red wines, is the conversion of malic acid to lactic acid. (Malic acid makes up about 30-35 % of the total acid in wines). This bacteria-catalyzed reaction is called malolactic fermentation. Wines undergoing malolactic fermentation usually result in softer, more complex, less fruity, and less bitter wines. This chemical reaction is written in the following unbalanced chemical equation:

$$\mathbf{C_4H_6O_5 \rightarrow C_3H_6O_3 + CO_2} \qquad (2)$$

malic acid lactic acid carbon dioxide

Winemakers need to periodically analyze wines undergoing malolactic fermentation in order to determine if all of the malic acid has been converted to lactic acid. If all of the malic acid has been converted, the winemaker can transfer the wine to barrels for aging. Winemakers analyze the malic acid and lactic acid levels in wine by a process of thin layer chromatography or paper chromatography.

Procedure for paper chromatography of wine acids is as follows:

1. Obtain a piece of pre-cut chromatography paper. Make a line with a pencil across the bottom of the paper, about 2 cm from the bottom edge.

2. Label the standard acids and wine samples to be tested with a pencil below the line – MA (malic acid), LA (lactic acid), W1 (wine 1), W2 (wine 2). Also label with your name.
3. Using a capillary tube, dot each liquid sample on the line directly above each label. For best results, keep the dots small and re-apply the dot twice more, allowing the dot to dry in between applications.
4. When the spots are dry, curl the paper into a cylinder, and staple edges together.
5. Place about 1 cm of chromatography solvent in the bottom of a 1000 mL beaker. Place the paper cylinder into the beaker without touching the paper to the sides of the beaker. Cover the beaker with a watch glass, watch and wait. The solvent will "travel" up the paper, carrying and depositing standard acid spots and any components from the wines with it.
6. After the solvent has traveled up the sides of the cylinder to within 1-2 cm of the top of the cylinder, carefully remove the paper from the beaker and allow it to dry completely in the hood area. The drying process may be facilitated through the use of a heat dryer or oven. The paper should develop yellow spots on a green background.
7. Identify the spots of the standard acids. Circle them with a pencil. Identify the spots arising from the two wine samples. Circle them also.

Questions/Comments:

1. Do any of the "traveled" spots from the wines align with the acid standard spots? If so, which spots are observed?
2. If sample wine spots align with a standard acid spot, that is a positive test for that acid in the wine sample. Which acids are present in Wine #1?
3. Which acids are present in Wine #2?
4. Has either Wine #1 or Wine #2 completed malolactic fermentation? Why or why not?
5. Balance chemical equation (1) :
6. Balance chemical equation (2):

Learning Activity 14 **ACIDS** **Name**__________________
CHEM 50H / dry

This activity is designed to supplement student learning after the concept of **molecular bonding** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Acids play an important part in a quality wine. Acids impart a slightly sour taste in wines, which is extremely important in the sensation of "quenching thirst". Natural fruit acids present in most wine grapes are tartaric acid, malic acid, citric acid, and lactic acid. Some acidity is removed during fermentation, but some acidity left in the wine is desired for a well-balanced, drinkable wine. To explore the various acids in wines, complete the following activities.

Questions/Activities:

1. Determine the chemical formula for each wine acid mentioned above.

   a) tartaric acid

   b) malic acid

   c) citric acid

   d) lactic acid

2. Draw a Lewis structure for each acid.

   a) tartaric acid

   b) malic acid

   c) citric acid

   d) lactic acid

3. What are some similarities among these acids?

4. What are some differences between these acids?

5. List these acids in decreasing acidic "strength". Give your criteria for how these acids were ranked.

Weakest acid ______________________________

____

____

Strongest acid ______________________________

Learning Activity 15 NEUTRALIZATION REACTIONS **Name__________________**
CHEM 50H / dry

This activity is designed to supplement student learning after the concepts of **neutralization reactions** and **stoichiometry** have been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

When wine grapes are harvested, they contain significant levels of acids in them. Acids play an important part in the overall taste of the wine, in providing a clean, light, and fruity taste as compared to the heavier, more complex molecules found in wines. Too high an acid content can sometimes lead to sour or bitter wines. Wine acid amount is reduced naturally through some of the fermentation process, but sometimes an "acid reduction" is necessary to bring the acid levels down to desirable levels. An acid reduction is carried out in a variety of ways, but most commonly by adding base to the wine/juice sample to neutralize the acids (mostly tartaric acid) present.

The most common acid reduction reaction (acid-base reaction) is done by adding calcium carbonate to the juice, producing calcium tartrate, carbon dioxide, and water. This reaction reduces the amount of the tart tasting tartaric acid, and replaces a portion of it with relatively taste-free calcium tartrate. This reaction can be written as the following chemical equation:

$$\mathbf{C_3H_5O_4COOH + CaCO_3 \rightarrow CaC_3H_5O_4COO + CO_2 + H_2O} \qquad \mathbf{(1)}$$

tartaric acid calcium carbonate calcium tartrate carbon dioxide water

Other very similar acid reductions are done using potassium carbonate (2), sodium carbonate (3), or potassium bicarbonate (4) instead of calcium carbonate. Potassium acid reduction reactions can sometimes lead to undesirable precipitation of other potassium salts that are naturally found in all plants, so care must be taken then performing these reactions.

Questions:

1. Write the balanced chemical equations associated with reactions (1), (2), (3), and (4) mentioned above:

   (1)

   (2)

   (3)

   (4)

2. How many grams of calcium carbonate must be added to a wine sample containing 15.0 grams of tartaric acid to reduce the tartaric acid content to half of the original amount?

3. How many mL of a 0.175 M calcium carbonate solution is needed to reduce the tartaric acid amount in a wine sample by 10.00 grams?

4. Does the process described in question #3 seem like a reasonable process for acid reduction in wines? Why or why not?

Learning Activity 16 **CRITICAL THINKING** **Name**___________________
CHEM 50H / dry

This activity is designed to supplement student learning after the concept of **critical thinking** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Vineyard managers consult with winemakers on what criteria is needed in the wine grapes at harvest as it gets closer to harvest time. The three most important aspects in the grapes to be considered are sugar percentage (degrees Brix), pH, and total acidity (TA). The optimal values for these 3 aspects can vary with type of grape (varietal) harvested. In general, as grapes mature, the sugar percentage and pH rises, and the acidity lessens. The sugar level is important as the sugar will be converted to alcohol during fermentation at roughly half the original percentage of sugar. Wines usually contain between 11-15 % alcohol, so there needs to be plenty of sugar in the grapes at harvest to produce the appropriate amount of alcohol in the resultant wine. If the sugar percentage is low at harvest, additional sugar can be added to the juice to increase the total percentage of sugar. The pH is important as wine will begin to spoil if the pH rises too high. pH is more difficult to adjust, as the system is buffered and does not change in pH very easily. The total acidity is important as low acid levels can lead to flat or poor taste in wines. Total acidity can be reduced by adding base, in the form of calcium carbonate.

There are optimal values for these 3 aspects in both red and white wines, which are tested daily by winemakers on the grapes near harvest time. These optimum values are shown in the table below:

Wine types	Sugar percentage (degrees Brix)	pH	Total acidity (TA) g acid/100 mL
Red wines	24	3.2 – 3.5	0.7-0.9
White wines	22	3.2 – 3.5	0.8-0.9

Other factors that come into secondary consideration (but are nonetheless important too) are the weather at harvest time, availability of vineyard and winery workers, and availability of clean winery equipment. Thinking critically at harvest time in consideration of the above factors is always a complex decision-making process.

Questions:

1. In harvesting Pinot Noir (red wine) grapes, the analyses of sugar %, pH and TA give values of 20.5, 3.0, and 0.8. What should be the harvest decision of the winemaker at this time? Should harvest occur or should more time pass before harvest? If this is not the time for harvest, cite what needs to occur before harvest can occur. If it is time for harvest, cite the reasons why it should occur immediately.

2. In harvesting Riesling (white wine) grapes, analyses of sugar %, pH, and TA give values of 23, 3.5, and 1.0. What should be the harvest decision of the winemaker at this time? Should harvest occur or should more time pass before harvest? If this is not the time for harvest, cite what needs to occur before harvest can take place. If it is time for harvest, cite the reasons why it should occur immediately.

3. In harvesting Chardonnay (white wine) grapes, analyses of sugar %, pH, and TA give values of 21.5, 3.2, and 0.7. What should be the harvest decision of the winemaker at this time? Should harvest occur or should more time pass before harvest? If this is not the time for harvest, cite what needs to occur before harvest can take place. If it is time for harvest, cite the reasons why it should occur immediately.

4. In harvesting Merlot (red wine) grapes, analyses of sugar %, pH, and TA give values of 22, 3.4, and 0.6. What should be the harvest decision of the winemaker at this time? Should harvest occur or should more time pass before harvest? If this is not the time for harvest, cite what needs to occur before harvest can take place. If it is time for harvest, cite the reasons why it should occur immediately.

5. Some winemakers use a Brix:TA ratio as a criteria for determining harvest dates. They consider that a 30:1 to 35:1 ratio is a better indicator for grape harvest readiness. Would this ratio have changed your answers in questions #1 - #4? Which ones, and why?

6. Do any questions come to mind as you consider these harvest examples? List 2 of those questions here and consult resources to try to answer those questions.

   (A)

   (B)

Learning Activity 17 **ACID DISSOCIATION CONSTANTS, K_a** **Name**__________________
CHEM 51 / dry

This activity is designed to supplement student learning after the concept of **acid dissociation constants (K_a)** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

Acids play an important part in a quality wine. Acids impart a slightly sour taste in wines, which is extremely important in the sensation of "quenching thirst". Natural fruit acids present in most wines are tartaric acid, malic acid, citric acid, lactic acid, and sometimes acetic acid. Some acidity is removed during fermentation, but the acidity left in the wine is desired for a well-balanced, drinkable wine.

The acids in wines are of varying "strengths". The relative strength of an acid is determined by examining its dissociation constant, K_a. The larger the K_a value, the stronger the acid, or the more the molecule breaks apart into a hydrogen ion and the corresponding anion (dissociation). The undissociated acid contributes much more to the taste of the wine than the corresponding anion.

Questions:

1. Determine chemical formulas and K_a values for:

   (a) acetic acid, formula________________ K_a ________________

   (b) citric acid, formula________________ K_a ________________

   (c) lactic acid, formula________________ K_a ________________

   (d) malic acid, formula________________ K_a ________________

   (e) tartaric acid, formula________________ K_a ________________

2. Rank the 5 acids in terms of decreasing acid strength:

   ____________ > ____________ > ____________ > ____________ > ____________

3. Write dissociation reaction equations for each acid:

   (a) tartaric acid ____

   (b) malic acid ____

   (c) citric acid ____

(d) lactic acid ____

(e) acetic acid ____

4. Which acid imparts the most acidity in wines? the least acidity? Give reasons for your choices.

Learning Activity 18 **pH SCALE** **Name**__________________
CHEM 51 / dry

This activity is designed to supplement student learning after the concept of **pH scale** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

The pH is very important in the processing of wines. High pH (>3.5) in wine grapes can mean that the grapes are overripe or the soil has too much potassium in it. The pH usually rises during fermentation due to acid reductions, reactions or precipitation, so the pH in wines is always a little higher than the grapes. High pH values in wines can lead to spoilage and off-odors. pH is affected by many things – the acids present in wines, the amount of SO_2 inhibitor/preservative, and whether CO_2 is used at bottling time. The higher the pH in wines, the higher the level of SO_2 that is required at bottling time to keep the wine from spoiling. This can be a delicate winemaker decision, as many people are sensitive or allergic to SO_2. The best way to keep the pH of wines from rising too high is to harvest wine grapes when their total acidity is high, keeping the pH low (3.2 – 3.5).

Testing for the pH in grapes is relatively easy to do with a pH meter. Divide the class into 4 groups, and follow this procedure:

1. Each group is to obtain 2 different samples of the same type of grape – a) approximately 10 berries of firm, fresh grapes and b) 10 berries that appear to be overripe (wrinkled, split open, soft or a little browned). Place the 2 different grape samples into different, labeled beakers. Do not wash the grapes, as that will draw water into the grapes and affect the makeup and pH of the juice.

2. Using a clean test tube or beaker, crush all of the grapes in each beaker, producing grape juice. Be sure to keep the juice samples uncontaminated from each other. Filtration of the juice may be done if grape pulp interferes with pH readings.

3. Turn on one pH meter and allow it to warm up for at least 10 minutes. Calibrate the pH meter with buffer solutions of 4.0 and 7.0, so that pH measurements in the 0-7 range will be accurate.

4. Gently place the pH electrode into each juice sample and stir slowly. Wait until the pH value on the display becomes relatively constant before taking a reading. Rinse the electrode extremely well with distilled water before placing into another juice sample.

5. All 4 groups will use the same pH meter to measure the pH of their juice samples, so comparison will be noteworthy.

6. Discard juice samples down the drain, and discard grape pulp in the trash.

Questions:

1. What is the pH of each of the grape samples from the 4 different groups?

   1a) 1b) 2a) 2b)

   3a) 3b) 4a) 4b)

2. Based on the pH values measured, which grapes are "ready" for harvest?

3. Do you notice any difference in pH values between the "fresh" and "overripe" grapes? If so, what is the difference?

4. How might an adult over the age of 20 be able to estimate the pH of wines?

Learning Activity 19 **AQUEOUS EQUILIBRIA** **Name**__________________
CHEM 51 / dry

This activity is designed to supplement student learning after the concept of **aqueous equilibrium** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

A very important chemical additive used in winemaking processes is potassium metabisulfite, $K_2S_2O_5$. Potassium metabisulfite is added to just pressed grapes to stun undesired natural yeast action, kill many microorganisms, prevent oxidation reactions, and to protect both the color and delicate flavors of the wine grapes. Potassium metabisulfite breaks down in the grape must (mixture of juice, stems, seeds and pulp) and produces sulfur dioxide, SO_2, which is the desired active chemical species with wines. The potassium metabisulfite maintains a complex aqueous equilibrium with other species – potassium ions (K^+), sulfite ions (SO_3^{2-}), bisulfite ions (HSO_3^-), hydrogen sulfide (H_2S), as well as molecular SO_2. The SO_2 concentration in the must consists of 2 different SO_2 species, what winemakers call "bound" SO_2 and "free" SO_2 (gaseous). This complex sulfite equilibrium is greatly affected by the pH of the must, and can shift to produce more or less free SO_2 ("sulfite" to winemakers) at any time as the pH of the must changes with acid concentrations during processing.

The complex aqueous equilibria of this "sulfite" system could be described by these 2 simplified equilibrium reactions:

(1) $$K_2S_2O_{5(s)} + H_2O_{(l)} \leftrightarrow K^+_{(aq)} + HSO_3^-{}_{(aq)} + SO_3^{2-}{}_{(aq)}$$

(2) $$SO_3^{2-}{}_{(aq)} \leftrightarrow SO_{2(aq)} + [\text{bound-}SO_2]_{(aq)}$$

The amount of free SO_2 in the must and resultant wine is monitored at all times, and is maximized by winemakers to control spoilage reactions and minimized to not cause sensitivity or allergic reactions for consumers. SO_2 concentrations reduce over time as the molecule is oxidized or reacts with other species in solution.

Questions:

1. The SO_2 concentration in musts is monitored during winemaking by chemical analyses methods, most commonly the Aeration Oxidation (AO) method and the Ripper method. What is the Ripper method and what does it detect?

2. What are some problems associated with the Ripper method?

3. What is the Aeration Oxidation method of SO_2 analyses and what does it detect?

4. Are there problems associated with the Aeration Oxidation method?

5. Are there any problems associated with red wine samples for analyses?

6. At lower pH, the sulfite equilibrium shifts to produce more free SO_2. What do you think causes more SO_2 to be produced? Write an equilibrium reaction that supports your hypothesis.

Learning Activity 20 **TITRATION CURVES** **Name**__________________
CHEM 51 / dry

This activity is designed to supplement student learning after the concept of weak acid-strong base **titration curves** has been introduced and practiced during the course. This activity illustrates examples of this chemistry concept used in the viticulture (growing of grapes) and enology (winemaking) industries.

The three different weak acid species that are dominant in wines are tartaric acid, $C_4H_6O_6$, malic acid, $C_4H_6O_5$, and lactic acid, $C_3H_6O_3$. Each acid has a Ka value and a pKa value associated with it. When titrating a weak acid with a strong base, the resultant titration curve will exhibit an inflection point in the curve that is indicative of the equivalence point of the titration. Another region of the curve will indicate the buffering of the acid, when the undissociated acid species (HA) and its conjugate base species (A^-) are present in equal concentrations. The pH in the middle of the buffering region is equal to the pKa value of the acid, and will occur at the halfway point of the titration. Identifying the inflection points in a weak acid-strong base titration curve can lead to identification of an unknown acid species in the titration.

Questions:

1. What are the Ka values for the acids in wines?

   (a) tartaric acid ___________(b) malic acid ___________(c) lactic acid___________

2. What are the pKa values for these same acids?

   (a) tartaric acid ___________(b) malic acid ___________(c) lactic acid___________

3. Draw a predicted titration curve (mL base vs. pH) that would correspond to the titration of 12.00 mL of a 0.200 M tartaric acid with a 0.100 M. sodium hydroxide solution. Show the buffering region (equal to the pKa) at the half-equivalence point, and the inflection of the curve at the equivalence point.

4. Draw a predicted titration curve (mL vs. pH) that would correspond to the titration of 12.00 mL of a solution that is 0.200 M in tartaric acid and 0.200 M in malic acid, titrated with a 0.100 M NaOH solution. Indicate on the curve where the buffering regions of each acid are and where the equivalence point of titration is located. Label accordingly.

5. At what pH in the titration (see #4) could the titration be halted and the only acid in solution would be malic acid?

There are many more ideas for learning activities that can be created and implemented in these 5 courses as well as in CHEM 20 – Introduction to Biochemistry, and CHEM 80/81 – Organic Chemistry I and II. If the incorporation of these learning activities is well-received into the initial courses by instructors and students, then I would be encouraged to create more learning activities for these additional courses.

A feedback survey for instructors and students who use these new Learning Activities has also been created to assist me in improving these initial efforts. The feedback survey is on the following page.

Contextual Learning Activities Feedback Survey

Date: ______________________________ Course: ______________________________

Professor: ______________________________

Learning Activity Number and Name: ______________________________

What did you like about this activity?

What did you dislike about this activity?

Did you have any difficulties with conducting this activity?

What would you change about this activity to improve it?

General Comments or Additional Suggestions:

Return Feedback Survey to Professor Terri Beam, Office 7-2108 G.

Any useful learning activity also includes a set of notes for instructors. To encourage chemistry instructors to use these learning activities in their courses, I have written a set of notes for instructors so they will know what to expect as they incorporate these learning activities into their courses.

Instructor's Notes for Contextual Learning Activities

General Information

The contextual learning activities for this project are not intended to be a replacement for the regular introduction and practice of chemistry concepts in chemistry courses. The course instructor and textbook are the best resources for those purposes. These learning activities are designed to be used as a contextual supplement, in the lecture classroom or the laboratory after the initial introduction of the chemistry concept, and subsequent discussion or homework practice with problems. These learning activities are to extend the student learning process on certain chemistry topics, bringing real life examples to the students for them to see the relevance in learning chemistry.

Specific Information for Each Learning Activity

Learning Activity #1 – Density

Materials needed: 10 mL graduated cylinder, 10 grapes per working group, 250 mL beaker, test tube, balance, glass funnel, filter paper
Answers: density values should be ~1.08 - 1.15 g/mL, 1. if between 1.08 – 1.10, then grapes are ripe, 2. density would be lower because water diluted juice in grape, 3. water addition from wetting filter paper is negligible, density would be not affected

Learning Activity #2 – Acidity

Materials needed: 25 grapes per working group, 250 mL beaker, 2 - 50 mL graduated cylinders, glass funnel, filter paper, 50 mL beaker, eyedropper, 0.100 M NaOH solution, phenolphthalein
Answers: TA of grape juice should be between 0.65 – 0.85 %, 2. if TA is in range, then they are ready for harvest, 3. phenolphthalein is used to turn the color of solution to bright pink when acid is all removed from the juice

Learning Activity #3 – Conversion Factors

Answers: 1. for a) and b) 150 gallons juice/2000 lb grapes, 2000 lb grapes/150 gallons juice, 2. for a) and b) 0.60 grams sulfite/1 gal juice, 1 gal juice/0.60 grams sulfite, 3. 4339 gallons of juice, 4. 2.0×10^5 lb grapes, 5. 1500 grams sulfite, 6. 41.7 gallons juice

Learning Activity #4 – Filtration

Materials needed: 25 grapes per working group, 400 mL and 250 mL beakers, glass funnel, filter paper, 125 Erlenmeyer flask

Answers: 1. filtered juice is more transparent, 2. filtered juice, many examples can be here

Learning Activity #5 – Calculations Using Equations

Answers: 1. 14 °C, 2. 26.6 °F, 3. 270. K, 4. 8.3 Kelvins

Learning Activity #6 – Chemical Reactions

Answers: 1. $C_6H_{12}O_6 \rightarrow 2\,C_2H_5OH + 2\,CO_2$, 2. $C_2H_5OH + O_2 \rightarrow C_2H_3OOH + H_2O$, 3. 20 alcohol molecules, 4. one acetic acid molecule, 5. one oxygen molecule, 6. 20 acetic acid molecules

Learning Activity #7 – Unit Conversions

Answers: 1. a) 2% sugar/1% alcohol or flipped over, b) 17 grams sugar/1 liter juice, 2. yes, 12 % alcohol is in desired range for wines, 27.2 % sugar in the juice, 4. 2980 grams sugar, 5. 10,200 grams sugar

Learning Activity #8 – Dilution of Solutions

Answers: 1. should be close to 1.00 M., 2. 6.25 mL of the 2.00 M $NaNO_3$ solution is needed, 3. 93.75 mL water should be added, 4. 0.22 mL of the 2.25 M. $K_2S_2O_5$ solution is needed

Learning Activity #9 – Laboratory Precision

Answers: 1. no, probably not, because technique and users may be difference gives slightly different values, 2. yes, measurement device is the same, and technique for reading device should be the same, 3. may or may not, depending on what is written down by students, 4. yes, they are all using the same device and the estimated digit in the reading should be the last digit recorded by all users

Learning Activity #10 – Percent Composition

Answers: 1. 20.9 % sugar in grapes, 2. yes, since 20.9 % is within harvest range, 3. 16.8% sugar in grapes, not ready for harvest (not in range), 5. 0.617 tons

Learning Activity #11 – Dimensional Analysis Calculations

Answers: 1. 142 grams potassium metabisulfite, 2. 4380 gals of wine, 3. 136 g, 4. 93.8 g

Learning Activity #12 – Solution Concentrations

Answers: 1. 4.75×10^{-4}M., 2. 2.03 moles alcohol, 3. 6.66 grams potassium metabisulfite

Learning Activity #13 – Chemical Reactions

Answers: 1. yes, there should be 2 wine spots that align with tartaric acid and malic acid, and perhaps citric acid., 2. positive spot tests should be mentioned here, 3. same as #2, 4. if the lactic acid spot is present from the wine sample, and NO malic acid spot is visible, then malolactic fermentation has been completed in the wine. If both spots are visible, or if only malic acid spots are visible, then the wine has not completed malolactic fermentation.
5. $\underline{1}\,C_6H_{12}O_6 \rightarrow \underline{2}\,C_2H_5OH + \underline{2}\,CO_2$ 6. $\underline{1}\,C_4H_6O_5 \rightarrow \underline{1}\,C_3H_6O_3 + \underline{1}\,CO_2$

Learning Activity #14 – Molecular Structure

Answers: 1. a) tartaric acid formula is $C_4H_6O_6$, b) malic acid formula is $C_4H_6O_5$, c) citric acid formula is $C_6H_8O_7$, d) lactic acid formula is $C_3H_6O_3$, 2. Lewis structures, 3. similarities are carboxylic acid groups (–COOH), 4. differences are carbon chain length 5. Weakest to strongest acid are as follows: lactic acid > malic acid > citric acid > tartaric acid

Learning Activity #15 – Neutralization Reactions

Answers: 1. balanced chemical equations associated with reactions:
(1) $\underline{2}\,C_3H_5O_4COOH + CaCO_3 \rightarrow Ca(C_3H_5O_4COO)_2 + CO_2 + H_2O$
(2) $2\,C_3H_5O_4COOH + K_2CO_3 \rightarrow 2\,KC_3H_5O_4COO + 2\,CO_2 + H_2O$
(3) $2\,C_3H_5O_4COOH + Na_2CO_3 \rightarrow 2\,NaC_3H_5O_4COO + 2\,CO_2 + H_2O$
(4) $C_3H_5O_4COOH + KHCO_3 \rightarrow KC_3H_5O_4COO + CO_2 + H_2O$

2. 2.5 grams calcium carbonate, 3. 190.3 mL of a 0.175 M calcium carbonate solution, 4. no, it adds too much extra volume of liquid to the wine, diluting the taste and quality of the wine

Learning Activity #16 – Critical Thinking

Answers: 1. It is not quite harvest time. The sugar % should increase a little more before harvest happens. Since the pH can rise a little more (high end of 3.2-3.5) and acid can drop a little more (0.7-0.9) before the grapes must be picked. 2. Harvest time is here! The % sugar and pH are all at their critical levels, which indicates that harvest should occur as soon as possible to avoid spoilage. Even though the total acidity is a little high, that is fine for white wines, to give balance to the fruity taste. Acid levels can be brought down with the addition of calcium carbonate. 3. Harvest time is here! Because the total acidity is at the low end of its acceptable range, harvest must occur immediately. Sugar can be added to bring the 5 sugar up. The pH is good for harvest. 4. The pH and TA are approaching the critical points and signal that harvest time is now. Even though the pH could go up just a little more, the TA should not go down any more, to produce a balanced wine. The % sugar is a little low, but sugar can be added before fermentation to correct for this. 5. No. The only answer that might be affected is #1, and the Brix/TA ratio is 25.6, still not ready for harvest! 6. Other questions that might come to mind: What other factors might be taken into consideration for harvest time? Are people available to harvest the grapes? Is the weather conducible for harvesting the grapes? Is the equipment available for harvest and transportation to the winery?

Learning Activity #17 – Acid Dissociation Constants

Answers: 1. Chemical formulas and K_a values for (a) acetic acid ($C_2H_4O_2$), $K_a = 1.75 \times 10^{-5}$, (b) citric acid ($C_6H_8O_7$), $K_{a1} = 7.45 \times 10^{-4}$, (c) lactic acid, ($C_3H_6O_3$), $K_a = 1.38 \times 10^{-4}$, (d) malic acid ($C_4H_6O_5$), $K_{a1} = 3.48 \times 10^{-4}$, (e) tartaric acid ($C_4H_6O_6$), $K_a = 9.2 \times 10^{-4}$, 2. tartaric acid >

citric acid > malic acid > lactic acid > acetic acid, 3. a) tartaric acid: $C_4H_6O_6 \leftrightarrow H^+ + C_4H_5O_6^-$, b) malic acid: $C_4H_6O_5 \leftrightarrow H^+ + C_4H_5O_5^-$, c) citric acid: $C_6H_8O_7 \leftrightarrow H^+ + C_6H_7O_7^-$ d) lactic acid: $C_3H_6O_3 \leftrightarrow H^+ + C_3H_5O_3^-$, e) acetic acid: $C_2H_4O_2 \leftrightarrow H^+ + C_2H_3O_2^-$, 4. tartaric acid imparts most acidity in wines, acetic acid imparts the least acidity, K_a values are the reason as it indicates how much hydrogen is placed into solution (which largely determines the extent of acidity of solution)

Learning Activity #18 – pH Scale
Answers: 1. student data 2. grapes with pH 3.2 – 3.5, 3. overripe grapes should exhibit higher pH values and some brown edges 4. by tasting it

Learning Activity #19 – Aqueous Equilibria
Answers: 1. Ripper method is an analytical method to determine the SO_2 concentration in wines, 2. the color of red wines interferes with the method results (which are red-colored), 3. The Aeration Oxidation method determines the SO_2 concentration in wines, 4. expensive, 5. the color of the red wines interferes with the test results (which are red-colored), 6. at lower pH's, there are more hydrogen ions in solution because they have dissociated from their corresponding sulfite or bisulfite ions, in the process forming more SO_2 adding to the SO_2 already in solution. Reaction equation: $H_2SO_3^- \leftrightarrow H^+ + SO_2 + OH^-$

Learning Activity #20 – Titration Curves
Answers: 1. Ka values for (a) tartaric acid $K_a = 9.2 \times 10^{-4}$, (b) malic acid $K_{a1} = 3.48 \times 10^{-4}$, (c) lactic acid $K_a = 1.38 \times 10^{-4}$, 2. pKa values for (a) tartaric acid is 3.03, (b) malic acid is 3.46 , (c) lactic acid is 3.86, 3. weak acid/strong base titration curve (see textbook), buffering region at pH = 3.03, inflection point at equivalence point (24.00 mL), 4. titration curve with 2 weak acids and strong base, buffering regions at pH = 3.03 and pH = 3.46, equivalence points at inflection points, 5. after the first inflection point (equivalence point of tartaric acid).

Visual Display and Brochure

As a part of this sabbatical project I developed a poster and brochure that I placed on display for students in both the Science Laboratory (Bldg 60) and in Bldg 7, where most of the chemistry lecture classes are held. The poster and brochure are tools that I hope will encourage students to continue their studies in a science discipline. The poster and brochure are designed to give students some ideas on how chemistry concepts are used in the viticulture and winemaking industries. Each tool provides information on college and university programs and career opportunities related to viticulture and enology. The brochure is shown here:

For more information on Viticulture or Enology programs, visit:

California Polytechnic State University, San Luis Obispo - Wine and Viticulture Program
http://www.lsn.calpoly.edu/undergraduate/wine.asp

Chemeketa Community College - Northwest Viticulture Center
http://www.chemeketa.edu/aboutus/locations/eola

Fresno State University - Viticulture and Enology Department
http://cast.csufresno.edu/ve

Fresno State University - Viticulture and Enology Research Center
http://cati.csufresno.edu/verc/

Fresno State Winery
http://www.fresnostatewinery.com

Napa Valley College - Winery and Viticulture Technology
http://napavalley.edu/apps/comin.asp?Q=943

Oregon State University - Food Science and Technology, Enology
http://oregonstate.edu/dept/foodsci/

University of California, Davis - Viticulture and Enology Department
http://wineserver.ucdavis.edu/

Robert Mondavi Institute for Wine and Food Science
http://robertmondaviinstitute.ucdavis.edu/

Viticulture and Enology Resources

American Journal of Enology and Viticulture (AJEV)
http://www.ajevonline.org/

American Society of Enology and Viticulture (ASEV)
http://asev.org/

National Viticulture Research Conference
http://groups.ucanr.org/nvrc/

Wine Jobs and Employment
http://www.agriseek.com/jobs/e/Employment/Wine/

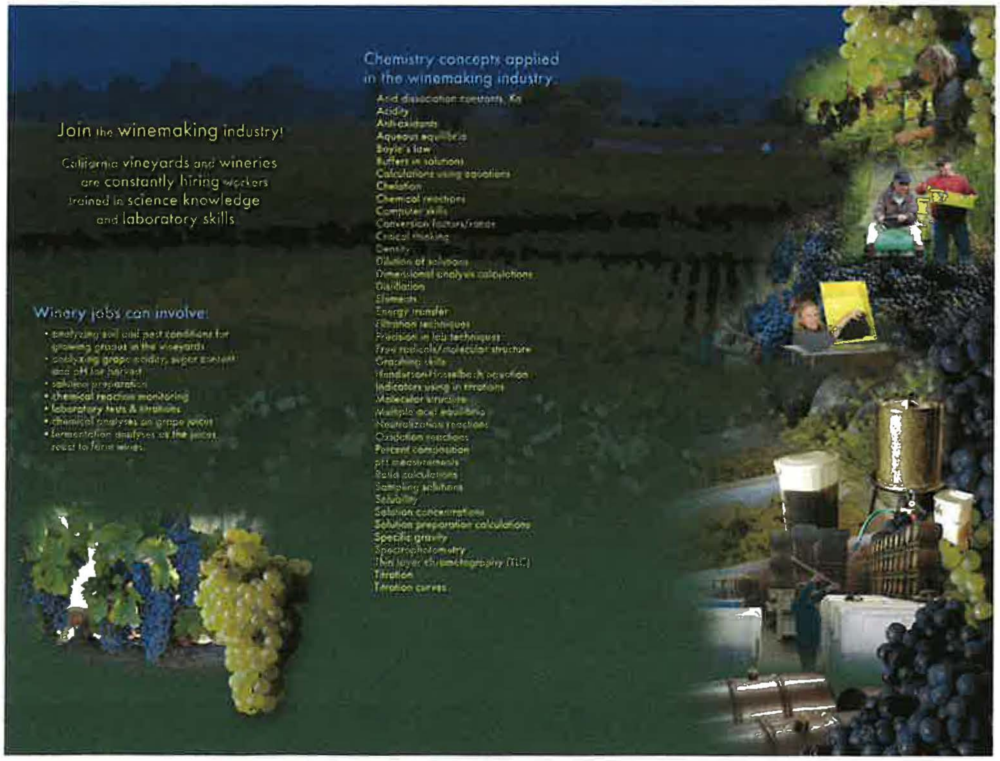
Terri Beam
Chemistry Department
Mt. San Antonio College
Sabbatical Project 2008
Brochure Design by Jeffrey George

Chemistry Winemaking

Taking Chemistry classes?

Not sure what to do with your newly developed science knowledge and laboratory skills?

Transfer to a college or university offering programs or degrees in Viticulture (growing grapes) Enology (winemaking)!



Join the winemaking industry!

California vineyards and wineries are constantly hiring workers trained in science knowledge and laboratory skills.

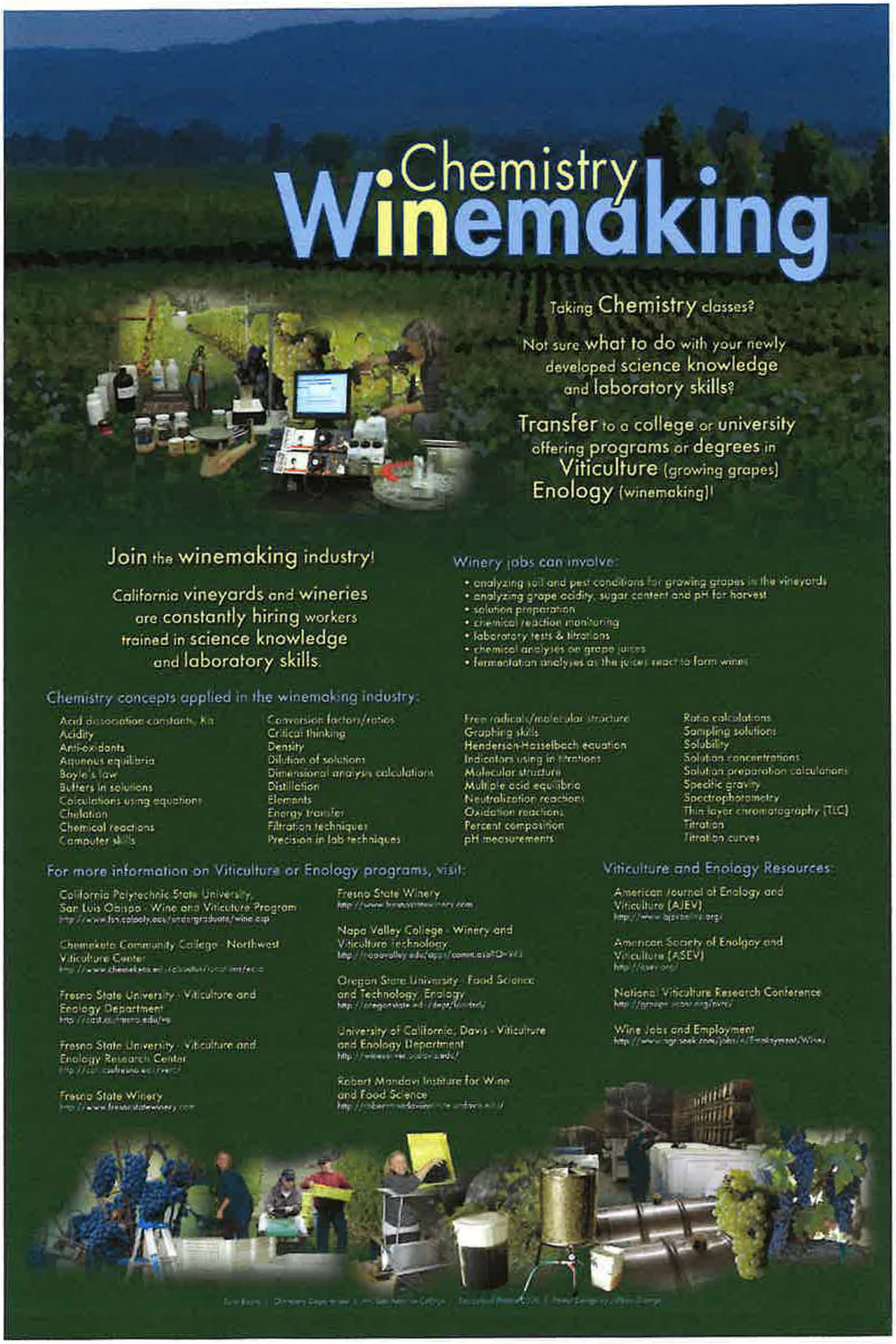
Winery jobs can involve:

- analyzing soil and pest conditions for growing grapes in the vineyards
- analyzing grape acidity, sugar content and pH for harvest
- solution preparation
- chemical reaction monitoring
- laboratory tests & titrations
- chemical analyses on grape juices
- fermentation analyses as the juices react to form wines.

Chemistry concepts applied in the winemaking industry:

Acid dissociation constants, Ka
Acidity
Anti-oxidants
Aqueous equilibria
Boyle's law
Buffers in solutions
Calculations using equations
Chelation
Chemical reactions
Computer skills
Conversion factors/ratios
Critical thinking
Density
Dilution of solutions
Dimensional analysis calculations
Distillation
Elements
Energy transfer
Filtration techniques
Precision in lab techniques
Free radicals/molecular structure
Graphing skills
Henderson-Hasselbach equation
Indicators using in titrations
Molecular structure
Multiple acid equilibria
Neutralization reactions
Oxidation reactions
Percent composition
pH measurements
Ratio calculations
Sampling solutions
Solubility
Solution concentrations
Solution preparation calculations
Specific gravity
Spectrophotometry
Thin layer chromatography (TLC)
Titration
Titration curves

An image of the poster is shown here.



Chemistry
Winemaking

Taking **Chemistry** classes?

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Titration
Titration curves

For more information on Viticulture or Enology programs, visit:

California Polytechnic State University, San Luis Obispo - Wine and Viticulture Program

Chemeketa Community College - Northwest Viticulture Center

Fresno State University - Viticulture and Enology Department

Fresno State University - Viticulture and Enology Research Center

Fresno State Winery
http://www.fresnostatewinery.com

Fresno State Winery

Napa Valley College - Winery and Viticulture Technology

Oregon State University - Food Science and Technology, Enology

University of California, Davis - Viticulture and Enology Department

Robert Mondavi Institute for Wine and Food Science

Viticulture and Enology Resources:

American Journal of Enology and Viticulture (AJEV)

American Society of Enolgoy and Viticulture (ASEV)

National Viticulture Research Conference

Wine Jobs and Employment

Conclusions of this Sabbatical Project

Benefits to this Faculty Member

This sabbatical project permitted me to experience firsthand the chemical processes and critical decisions made in the winemaking industry, which has long been an interest of mine. This sabbatical project has added so many contextual applications and ideas for examples that I will use in my teaching of chemistry classes to bring alive the chemistry concepts. In my experience, students always benefit from seeing the relevancy of chemistry as they learn the concepts in class. Bringing these winemaking examples to class will also open students' eyes to the possibility of continuing studies in science, especially when job opportunities that might interest them are described. This is extremely important in encouraging chemistry students to continue taking chemistry and other rigorous science classes.

Benefits to the Chemistry Department

As I share these learning activities with my colleagues in the chemistry department, I expect many dialogues to ensue that will lead to development of additional contextual examples for lecture and laboratory activities for more chemistry courses. I will be happy to share the knowledge and resources that I have gathered during this sabbatical project, in order to further the development of more contextual learning activities for chemistry students.

Benefits to the College

The benefits to the College are fourfold:

- this faculty member has been refreshed by a semester sabbatical opportunity to follow her interests in winemaking, and will return to teaching and campus responsibilities with renewed vigor
- the College has received recognition through all communications conducted in this sabbatical project - with vineyards, wineries and higher education institutions visited by this faculty member during her travels
- the courses that incorporate these new contextual learning activities will be improved as they help and encourage student to learn the chemistry concepts
- the improved education that students receive in their chemistry courses will serve to better the reputation of our institution.