

Incorporating Gas Chromatography and CHN Elemental Analysis into the Undergraduate Science Laboratory Curricula

The author gratefully acknowledges the financial support of the National Science Foundation Course, Curriculum, and Laboratory Improvement program (CCLI. <http://www.nsf.gov/div/index.jsp?div=DUE>) to purchase a high-end capillary gas chromatograph (GC) and Carbon Hydrogen Nitrogen (CHN) elemental analyzer (award ID: DUE-0310264). Photos of the instruments are found on page 3.

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Project Summary

The final charge of this grant was to improve Arizona Western College's (AWC) Chemistry (General and Organic) and 2+2 Environmental Science AWC/NAU (Northern Arizona University-Yuma) programs by developing and then incorporating new capillary gas chromatography (GC) and elemental analysis activities into the aforementioned laboratory curricula. Elemental analysis is carried out using a Carbon Hydrogen Nitrogen (CHN) elemental analyzer. Students in General Chemistry 1 & 2, Organic Chemistry 1 & 2, and the Environmental Science program gained valuable exposure to and constant use of these modern analytical instruments.

Prior to carrying out the gas chromatography labs students first completed a series of GC pre- and mini-lab activities. For three to four consecutive weeks students carried out GC mini-labs to determine experimentally how molecular weight, boiling temperature, and oven and injector temperatures influence (or not) retention time, R_t , and hence peak resolution in a gas-liquid phase chromatographic separation. Each GC mini-lab is prefaced with a GC pre-lab activity, comprised of two or more questions (conceptual in nature), that asks students, among other possibilities, to predict the relationship between the factor being examined on the GC that week and retention time. After the pre-lab students then head into the lab and conduct the GC mini-lab. Students then compare their answers given in the pre-lab to the results of the mini-lab experiment. The mini-labs have served as a foundation for a more detailed analysis of street-grade gasoline and commercially available fuel and fuel injector system products. GC conceptual questions embedded in quizzes and exams (*i.e.* post-lab) and related to the lab activities have been used to assess student understanding of GC principles, a kind of "before vs. after" assessment tool.

Organic Chemistry students used the GC continuously to monitor the extent of consumption of starting material and product formation and to determine the number of products made in a reaction. General Chemistry 2 and Environmental Science students qualitatively interpreted chromatograms of gasoline and STP[®] fuel and fuel injector treatment products and gauged (though not too successfully) the emission profile of vehicle exhaust as a function of time after start (and hence engine and catalytic converter temperatures) of different vehicle types.

Beta-testing has been completed for Microbiology students to use gas chromatography to monitor the extent of gaseous carbon dioxide (CO₂) production by microbes found in the mud of two local surface water sources, Mittry Lake and the Gila River. GC monitoring of microbial soil respiration proved unsuccessful.

Brief Description of Courses That Used the Instruments

General Chemistry 1 (CHM 151, fall/spring semesters) is the first semester chemistry class for students with interest in earning a bachelor's degree in the physical or biological sciences, engineering, or environmental science. At least two class sessions are offered every fall and spring semesters. Historically, enrollment is between 50-60 students per semester. CHM 151 students used CHN data.

General Chemistry 2 (CHM 154, spring semester) is the second semester class offering in the two semester General Chemistry course sequence. CHM 154 is offered every spring semester. Historically, spring enrollment is between 20-30 students. CHM 154 students used both the GC and CHN elemental analyzer.

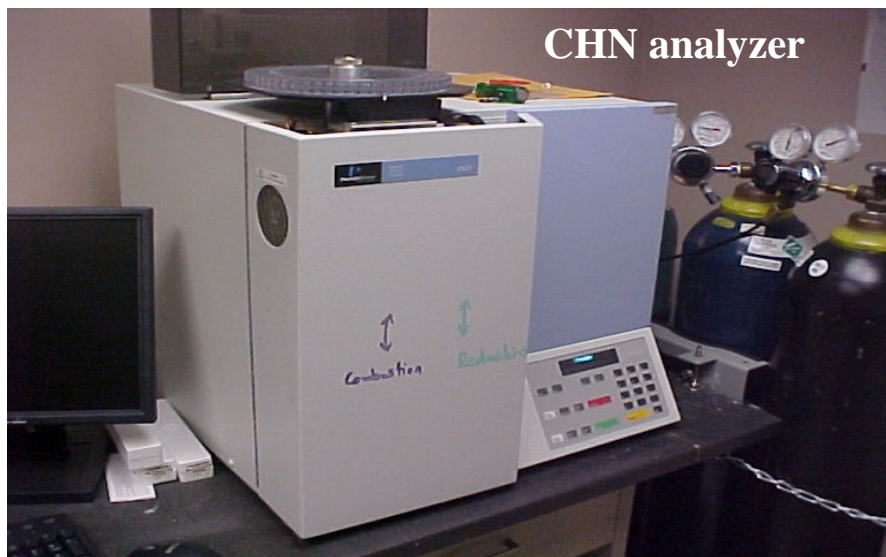
Organic Chemistry 1 (CHM 235, fall semester) and *Organic Chemistry 2* (CHM 236, spring semester) are sophomore level courses. The majority of students are enrolled to meet degree requirements for medical or pharmacy school matriculation. The pre-requisite for CHM 235 is successful completion of *General Chemistry 1* and 2 or permission of instructor. CHM 235/236 students used both the GC and CHN elemental analyzer.

Analytical Methods in Environmental Science (ENV 280, spring semester) is a sophomore level, core course for students seeking a bachelor's degree in environmental science through the 2+2 AWC-Northern Arizona University in Yuma Environmental Science program. The course is divided into three modules, each centered on its own topical problem: 1) water quality, 2) air quality, and 3) waste management. For the past four years the course has been offered every spring semester. Historically, enrollment is between 9-14 students per offering. The PI teaches the air quality module, of which the module is based entirely on gas chromatography. ENV 280 students used both the GC and CHN elemental analyzer.

Environmental Ecology (ENV 330, spring semester) is an upper division core course for students seeking a bachelor's degree in environmental science through the 2+2 AWC-Northern Arizona University in Yuma Environmental Science program. ENV 330 students used the CHN elemental analyzer.

Microbiology (BIO 205, fall/spring semesters), a sophomore level course, is offered every fall and spring semester. The majority of students are enrolled to meet degree requirements for entrance into the AWC Nursing program. Consequently, it's emphasis is clinical microbiology but steps are being taken, albeit small ones due to chronic health issues associated with the Co-PI, to emphasize environmental microbiology, namely the gas chromatographic monitoring of gaseous CO₂ production from microbial activity in lake and river mud.

CHN analyzer



Capillary Gas Chromatograph

