**General Education Course Inclusion Proposal**

**SCIENTIFIC INQUIRY**

*This proposal form is intended for departments proposing a course for inclusion in the Northern Michigan University General Education Program. Courses in a component satisfy both the Critical Thinking and the component learning outcomes. Departments should complete this form and submit it electronically through the General Education SHARE site.*

**Course Name and Number: Chemical Principles, CH 105**

**Home Department: Chemistry**

**Department Chair Name and Contact Information** (phone, email): Mark Paulsen (ext 1064, mpaulsen@nmu.edu)

**Expected frequency of Offering of the course** (e.g. every semester, every fall): every semester

**Official Course Status**: Has this course been approved by CUP and Senate? YES

*Courses that have not yet been approved by CUP must be submitted to CUP prior to review by GEC. Note that GEC is able to review courses that are in the process of approval; however, inclusion in the General Education Program is dependent upon Senate and Academic Affairs approval of the course into the overall curriculum.*

**Overview of course** (please attach a current syllabus as well): *Please limit the overview to two pages (not including the syllabus)*

A. Overview of the course content

The Catalog describes CH 105 as an “introduction to chemistry including contemporary applications and problems. Topics include states of matter, atomic and molecular structure, electrochemistry, energy, nuclear chemistry, organic and polymer chemistry.” The laboratory portion of the course re-enforces concepts taught in lecture in addition to providing practice with mathematical concepts such as plotting data and using calibration curves. The course consists of 3 hours of lecture and a 2 hour laboratory period each week.

B. Explain why this course satisfies the Component specified and significantly addresses both learning outcomes

**Critical Thinking Outcome**.

The final exam will be used to assess if students have achieved competency in the critical thinking dimensions. Although students think critically in each component of the course, the final exam is geared primarily toward lecture material and therefore, only examples of critical thinking in the lecture portion of the course are given as examples below.

**Evaluate**

Throughout the lecture portion of the course the students are presented material in manner that requires them to evaluate information. One example involves understanding features of unstable isotopes (such as emission type, half-life, and decay product) and applying those ideas to evaluate the potential of various isotopes used in nuclear medicine. The properties of isotopes used for diagnosis and treatment of disease are quite different. The same features are used to help understand the potential and limitations of radio-isotopic dating or the concerns of the radon problem. A type of problem asked that many students find to be challenging is to predict *and explain* how changes in the decay series of uranium-238 would affect the radon problem (no effect, make it better, make it worse). Success requires that students understand the general features of unstable isotopes and the radon problem and then be able to connect the two.

**Integrate**

Connecting concepts is a regular feature of lecture and evaluated assignments. When the section on energy is reached, for example, students are asked to fuel a spacecraft to explore the solar system. Their practical knowledge (how would you refuel a spacecraft?) and newly gained knowledge of chemical and nuclear energy lead them to the conclusion that chemical energy is not feasible. Various isotopes are then evaluated in order to determine which would make the better power source. In regards to molecules, students are given structures of molecules and asked questions like “which would result in your Olympic medal being taken back if this was found in your system” or “which might result in hallucinations if ingested” or “which would be more soluble in gasoline.” Students learn to recognize molecules, in a rather rote manner and their properties are discussed, but these questions help them to make connections to real world applications.

**Evidence**

Students in CH 105 assess the quality of information through interactive lecture along with the solution of problems on homework and exams. During the problem solving process, students will be faced with choices which could include which concepts to apply and which pieces of information are required. One example involves smoke detectors. Smoke detectors are not discussed in class, but on the exam students were provided with the following: *“Americium-241 is used in smoke detectors. Being unstable, it constantly emits a stream of high energy particles. These particles ionize the air in the detector and an electrical current is generated. When smoke blocks the emissions, the electrical current is disrupted and the alarm goes off.”* Students are then asked to evaluate whether or not the isotope is a gamma or an alpha emitter. Following that, a decay curve is provided and students use it to determine the half-life of Am-241. Finally, given that, they are asked a True/False question: *“If your smoke detector does not work it could be because all of the Am-241 has decayed.”* Hopefully they intuit that the long half-life they obtained from the plot makes it highly unlikely that all of the isotope has decayed and the problem lies elsewhere.

**Scientific Inquiry Outcome**

Scientific inquiry is modeled through the lecture component of the course via interactive lectures, online homework assignments and in-class examinations as well as in the laboratory.

**Discussion/Conclusions**

For most laboratory experiments students collect data and then at the end are asked to draw some conclusions based upon this data. See the **Research Question** section below for examples.

**Analysis, Results, and Presentation:**

In three laboratories students prepare or use a calibration curve. They explore why a calibration curve is needed, how to collect the data, plot it using Excel, and then obtain and use a best-fit line to determine an unknown quantity. Production of good plots (titles, axis labels, and recognizing outliers) is emphasized.

**Methodology/Data Collection:**

Students don’t develop methodology during laboratory and focus more on learning how to use laboratory equipment and make good measurements. Students learn how to use a variety of scientific glassware. On some laboratories, points are awarded for accuracy such as when determining the amount of anthocyanin in cranberry juice or when standardizing a solution of triiodide used in the determination of vitamin C in fruit juice. Students do not develop their own methodology, but rather are using a preselected, known methodology to solve a problem or answer a question.

**Research Question:**

The short laboratory periods allow only rudimentary research questions to be addressed, but different techniques are used to answer “unknown” questions. In one exercise students explore line spectra by looking at the emission and absorption of radiation. Students excite atoms the higher energy states by the use of electricity and by heat, identify the elements in unknown solutions by emission color or line spectra, and look at light from a common light bulb. At the conclusion of the laboratory students are told that fluorescent light bulbs have an element added to them and are asked to identify what the element. Naturally, they look at the fluorescent lamp with a spectroscope—hopefully they conclude that mercury is present in the lamp and provide the appropriate evidence. In another laboratory students explore the removal of triclosan (an antibacterial that is found in some soap products) by activated charcoal. Students are asked in the prelaboratory assignment to predict how changes in temperature, amount of charcoal, and reaction time will affect the amount of triclosan removed. Different groups of students explore each question and then report back at the conclusion to the period.

In lecture, models of atomic structure (along with the experiments that lead to the models) are presented. Details of those experiments are worked through and how those details are consistent with a proposed model. While a working knowledge of the models is essential and tested, students are also asked to propose changes in the model *given different results.* How would the Rutherford Model of an atom need to be changed, for example, if half of the alpha particles were deflected during the Gold Foil Experiment instead of only an occasional one? Again—the lecture portion of the course  research.

C. Describe the target audience (level, student groups, etc.)

Students needing a refresher course in chemistry before taking CH 111 or CH 109 compose about two-thirds of the enrolled students. For the remaining third of the class, the course fulfills NMU’s laboratory science requirement.

D. Give information on other roles this course may serve (e.g. University Requirement, required for a major(s), etc.)

Many non-traditional students take CH 105 (as compared to CH 111) as way to work back into the routine of college—most of that group seem to take it to complete the laboratory requirement. The experience and perspective of these older students often adds a great deal to lecture discussions.

E. Provide any other information that may be relevant to the review of the course by GEC

Not applicable.

**PLAN FOR LEARNING OUTCOMES  
CRITICAL THINKING**

*Attainment of the CRITICAL THINKING Learning Outcome is required for courses in this component. There are several dimensions to this learning outcome. Please complete the following Plan for Assessment with information regarding course assignments (type, frequency, importance) that will be used by the department to assess the attainment of students in each of the dimensions of the learning outcome. Type refers to the types of assignments used for assessment such as written work, presentations, etc. Frequency refers to the number of assignments included such as a single paper or multiple papers. Importance refers to the relative emphasis or weight of the assignment to the entire course. For each dimension, please specify the expected success rate for students completing the course that meet the proficiency level and explain your reasoning. Please refer to the Critical Thinking Rubric for more information on student performance/proficiency in this area. Note that courses are expected to meaningfully address all dimensions of the learning outcome.*

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| **DIMENSION** | **WHAT IS BEING ASSESSED** | **PLAN FOR ASSESSMENT** |
| **Evidence** | Assesses quality of information that may be integrated into an argument | **Type:** Homework and exams.  **Relation to Dimension:** Students must use information correctly to solve problems.  **Success Rate:** We expect ~60% of our students will get these evidence questions correct. |
| **Integrate** | Integrates insight and or reasoning with existing understanding to reach informed conclusions and/or understanding | **Type:** Homework and exams.  **Relation to Dimension:** Students will combine skills and knowledge learned from solving problems in lecture to solve new problems using the same principles.  **Success Rate:** We expect ~60% of our students will get these integration questions correct. |
| **Evaluate** | Evaluates information, ideas, and activities according to established principles and guidelines | **Type:** Homework and exams.  **Relation to Dimension:** Students will have to evaluate the problem and determine which chemical principles and problem solving methods should be applied.  **Success Rate:** We expect ~65% of our students will get these evaluation questions correct. |

**PLAN FOR LEARNING OUTCOMES  
SCIENTIFIC INQUIRY**

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| **DIMENSION** | **WHAT IS BEING ASSESSED** | **PLAN FOR ASSESSMENT** |
| **Research Question** | Develop a manageable and appropriate research question that is tied to testable hypotheses. | **Type:** Several electronic assignments administered at various times throughout the semester.  **Relation to Dimension:** These assignments will consist of a scenario or case study which students must evaluate using concepts developed in class. Students will be provided with a list of research questions, and they must choose questions that are appropriate for the described situation.  **Success Rate:** We expect 50% of our students will be able to reach this goal by the end of the semester. |
| **Methodology/Data Collection** | Select and/or develop appropriate scientific methodologies | **Type:** Several electronic assignments administered at various times throughout the semester.  **Relation to Dimension:** These assignments will consist of a scenario or case study which students must evaluate using concepts developed in class. Students will be provided with a list of methods, and they must choose methods which are appropriate for the described situation.  **Success Rate:** We expect 55% of our students will be able to reach this goal by the end of the semester. |
| **Analysis, Results and Presentation** | Collected data is appropriately analyzed and presented | **Type:** Several electronic assignments administered at various times throughout the semester.  **Relation to Dimension:** These assignments will consist of a scenario or case study which students must evaluate using concepts developed in class. Students will be given data within these case studies and be asked to analyze this data in a manner similar to that which was employed in the performed laboratories.  **Success Rate:** We expect 65% of our students will be able to reach this goal by the end of the semester. |
| **Discussion/Conclusions** | Conclusions are linked to evidence and are in the context of scientific limitations and implications. | **Type:** Several electronic assignments administered at various times throughout the semester.  **Relation to Dimension:** These assignments will consist of a scenario or case study which students must evaluate using concepts developed in class. Students will be provided with a list of conclusions which were drawn from the provided data and they must choose which of these conclusions, based upon the given data, are appropriate.  **Success Rate:** We expect 65% of our students will be able to reach this goal by the end of the semester. |