Chemistry Department
Student Assessment Plan

Department Learning Goals

Upon successful completion of the requirements for the Chemistry major, students will have learned to:

1. acquire fact-based knowledge necessary to understand chemistry as citizens and practice it as scientists,
2. design and execute laboratory experiments,
3. develop critical thinking skills necessary to assess and assemble facts and data,
4. work effectively individually and in groups,
5. communicate chemistry effectively in written and oral forms, and
6. assess the ethical implications of their work and its impact on our society and environment.

Curriculum Mapping:
The above learning goals are thoroughly integrated into the chemistry department's curriculum as demonstrated by the attached curriculum map (Appendix A). Additionally, the chemistry department's learning goals support achievement of many components of the college's Vision for Student Learning, as demonstrated by the attached map of our departmental learning goals to the learning goals identified in the Vision for Student Learning (Appendix B).

Table I Data Assessing the Quality of Senior Majors

	Quality of Majors
Direct	DUCK[1]
	Senior Capstone Papers
	Grades from Senior Capstone Presentations
	Independent Research Papers (ATEC IRI reports and CHEM 450 reports)
	List of National Presentations
	Professional Plans of Recent Graduates
Indirect	Senior Survey

1. Diagnostic of Undergraduate Chemistry Knowledge (ACS Standardized Cumulative Exam)

Significance of Departmental Assessment:
In keeping with our educational mission, the Chemistry Department carefully assesses the effectiveness of our program. We have to meet both internal and external standards as we provide an undergraduate degree certified by our professional accreditation body, the American Chemical Society (ACS). The ACS accreditation of the Chemistry Department is on a five year cycle. The guidelines for program approval and student certification can be found on the ACS web site at https://www.acs.org/content/acs/en/about/governance/committees/training/acsapproved.html**.** The department's next periodic review to maintain ACS accreditation by the ACS Committee on Professional Training is due in **June 2021**. Additionally, the department's next cyclical external review is scheduled to occur during the **2021/2022 academic year**.

Assessment Data Collection:
The quality of our majors is the primary focus of the department's formal assessment efforts. The quality of our seniors is tracked by collection of the data found in Table I. This data is collected and maintained by the department chair. Both direct and indirect assessment data are collected and used to assess program success in achieving our departmental learning goals. These measures include direct student assessment data:

- an externally designed exam (the Diagnostic of Undergraduate Chemical Knowledge, DUCK) tests our students' knowledge in comparison to what is expected of chemistry majors across the USA.
- copies of senior capstone papers and the grades for the associated senior capstone presentation. These internal measures are discussed yearly by the faculty as we set the threshold for Honors and the departmental senior awards.
- copies of independent research papers submitted at the conclusion of the integrated upper-level laboratory, *Advanced Techniques in Experimental Chemistry* (ATEC),
- copies of student research reports from all students enrolled in CHEM 450: *Directed Research*,
- lists of student presentations at local, regional, and national conferences, and
- a list of the professional plans of recent graduates.

Indirect assessment measures include:

- a senior survey given to all graduating seniors in the spring semester.

Informal Assessment Data:
A number of assessments are used informally throughout the curriculum to insure consistency between faculty in multiple-section courses as well as testing our courses against national norms. These efforts, listed against the courses, include:

- General Chemistry (CHEM 110&120): The laboratory assessment includes a common laboratory experience which includes a laboratory practical, laboratory final and a student survey. The lecture sections use a common final in both semesters. The final used for the second semester is a national standard exam provided by the ACS.
- Organic Chemistry (CHEM 240&250): a common laboratory experience and a common course final in both semesters Organic Chemistry. The final used for the second semester is a national standard exam provided by the ACS.

Most of the upper level courses use the appropriate national standardized exam provided by the ACS as part of the course final. At present, these include Physical Chemistry: Quantum Mechanics and Spectroscopy (CHEM 310), Physical Chemistry: Thermodynamics and Chemical Kinetics (CHEM 320), Advanced Inorganic (CHEM 340), Advanced Analytical Chemistry (CHEM350), and Biological Chemistry (CHEM 330). Although these data are important parts of our assessment work, they are reviewed and maintained informally.

Departmental Learning Goal Assessment Cycle:
Outlined below are the direct and indirect measures used to assess each of the six departmental learning goals:

Learning Goal #1: acquire fact-based knowledge necessary to understand chemistry as citizens and practice it as scientists

Direct Assessment Measures: the DUCK exam, standardized exams for individual courses, senior capstone paper rubric (see Appendix C, rubric assessment "C", "D", "H", and "I"), and professional plans of graduates

Indirect Assessment Measures: Senior Survey (see Appendix D; 1. Likert Scale Question: I feel the Hendrix College Chemistry Curriculum has given me an opportunity to develop a strong background in: Organic, Physical, Analytical, Biological, Inorganic, Lab procedures, and Lab safety; 2. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to acquire knowledge necessary to practice chemistry as a scientist)

1.

Learning Goal #2: design and execute laboratory experiments

Direct Assessment Measures: independent research papers (ATEC IRI and CHEM 450 reports), student conference presentations

Indirect Assessment Measures: Senior Survey (Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to design and execute an experiment)

Learning Goal #3: develop critical thinking skills necessary to assess and assemble facts and data

Direct Assessment Measures: senior capstone paper rubric (see Appendix C, rubric assessment "C" and "D"), student conference presentations

Indirect Assessment Measures: Senior Survey (1. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to critically evaluate the conclusions in popular and scientific articles; 2. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to search and read the primary literature; 3. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to evaluate scientific information assembled form desperate sources)

Learning Goal #4: work effectively individually and in groups

Direct Assessment Measures: independent research papers

Indirect Assessment Measures: Senior Survey (Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to work in a group to accomplish science)

Learning Goal #5: communicate chemistry effectively in written and oral forms

Direct Assessment Measures: senior capstone paper rubric (see Appendix C, rubric assessment "B", "C", "E", "F", and "G"), student conference presentations, grades from senior capstone presentations, and independent research papers

Indirect Assessment Measures: Senior Survey (1. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to write about science effectively as a laboratory report or a paper; 2. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to communicate scientific information effectively as a poster or oral presentation)

Learning Goal #6: assess the ethical implications of their work and its impact on our society and environment

Direct Assessment Measures: senior capstone paper rubric (see Appendix C, rubric assessment "C" and "E") and independent research papers

Indirect Assessment Measures: Senior Survey (1. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to understand what green chemistry is; 2. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to explain what green chemistry is to a non-scientist; 3. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to explain how green chemistry is applied in a chemical laboratory; 4. Likert Scale Question: I feel the Hendrix College Chemistry curriculum has taught me to consider chemical hazards as part of experimental design)

The proposed cycle for assessment of departmental learning goals is reported in Appendix E.

Appendix A. Assessment Audit: Departmental Learning Goals versus Individual Course Goal

This chart uses a 3 point scale to indicate the correlation between the departmental learning goals and individual courses:

N/A Not Applicable | 1 Introduced | 2 Developed | 3 Mastered

Department Goals: / Courses:	Acquire fact-based knowledge	Execute Exp'ts / Design Exp'ts	Develop critical thinking skills to assess and assemble facts and data	Work effectively in groups	Communicate chemistry effectively	Assess the ethics of work
Chem 100 Concepts	3	N/A	2	1	3	3
Chem 101 Chem of Envir.	3	1 / 1	2	2	3	3
Chem 101 lab	2	3 / 1	3	3	1	1
Chem 110 &120 Gen Chem	3	N/A	2	1	1	1
Gen Chem lab	2	2 / 1	3	2	2	1
Chem 150 Adv. Gen Chem						
Chem 150 lab						
Chem 240 & 250 Organic	3	N/A	3	N/A	1	2
Organic Lab	3	3 / 1	3	2	2	3
Chem 280 Env. Analysis	3	NA / 3	3	2	2	3
Env. Anal. Lab	2	3 / 3	3	3	2	1
Chem 310 & 320 P-Chem	3	N/A	3	1	3	1
ATC Lab	2	3 / 3	3	3	3	2
Chem 320 lab	3	3 / 1	3	3	2	1
Chem 330 Biochem.	3	3 / 3	3	2	2	2
Biochem lab	3	3 / 1	3	3	2	1
Chem 335 Adv BioChem	3	N/A	2	1	1	1
Chem 340 Adv. Inorg.	3	N/A	3	1	2	2
Chem 350 Adv. Anal.	3	N/A / 2	3	2	3	2
Chem 410 Adv. P-Chem	3	2 / 2	3	1	2	1
Chem 450 Fac. Spon. Res.	2	3 / 3	3	2	3	3

Appendix B: Map of Chem. LGs to VSLG

Put departmental learning goals starting in Column B. Make a mark in the appropriate cell if your departmental learning goal helps achieve each VSLG

Our students engage in rigorous inquiry and informed deliberation by:		acquire the fact-based knowledge necessary to understand chemistry as citizens and practice it as scientists,	design and execute laboratory experiments,	develop the critical thinking skills necessary to assess and assemble facts and data,	work effectively individually and in groups,	communicate chemistry effectively in written and oral forms, and	assess the ethical implications of their work and its impact on our society and environment.
I1	· investigating and researching underlying causes and connections	x	x	x			x
I2	· synthesizing evidence from multiple sources	x	x	x			x
I3	· designing ways to answer their questions		x	x		x	
I4	· acquiring the skills to evaluate arguments and evidence critically		x	x		x	x
I5	· developing independent, nuanced, and thoughtful analyses		x	x		x	x
I6	· making connections among different bodies of knowledge	x		x		x	x
I7	· communicating their findings effectively and persuasively through written, oral, experiential, visual, or other appropriate methods	x			x	x	
I8	· reflecting on their studies and being prepared to engage with the world based on their inquiry and deliberation				x	x	x
Hendrix College students actively and reflectively engage with multiple communities by:			x				
MC1	· understanding the past, present, and future needs of the earth and of humanity, and of the challenges					x	x
MC2	· considering ethical conundrums from conflicting perspectives		x				x
MC3	· bringing their experiences in the wider community back to the classroom to enhance their course of study		x				x
Hendrix College community supports these goals by:							
C1	· fostering an awareness of different cultures through a commitment to diversity and inclusion						
C2	· providing opportunities for students to confront the diverse challenges and needs of our shared communities in order to inspire them to lead lives of service						
The college community provides opportunities for							
WP1	· guiding students in examining their abilities and strengths			x	x		
WP2	· helping them recognize how their skills can work for them and for the good of others, both now and in the future			x			x
WP3	· providing tools and opportunities to prepare our students for their prospective professional lives	x	x	x	x	x	x
WP4	· striving to inspire students to lead lives of accomplishment as both leaders and team members	x			x	x	x
WP5	· encouraging their development into individuals who are independent, responsible, and attentive to their own mental and physical well-being						
WP6	· nurturing their life-long love of learning, both about themselves and about the world as curious, creative, and active participants in life and in their communities.	x		x	x		x

Hendrix College Department of Chemistry Senior Capstone Paper Grading Rubric (2019/20)

Student Name: _____

Faculty Evaluator Name: _____ Reader (circle one): 1st 2nd

Grade: _____

	DLG	Grade	Poor (Grade D, 1.0)	Satisfactory (Grade C, 2.0)	Good (Grade B, 3.0)	Excellent (Grade A, 4.0)
A. Topic & Title (5 %)	N/A		☐ Topic is not relevant to the field of chemistry and is not based on recent research ☐ Title is not engaging and does not reflect the paper content	☐ Topic is somewhat relevant to the field of chemistry and is based on some recent research ☐ Title somewhat reflects the paper content	☐ Topic is relevant to the field of chemistry and is based on recent research ☐ Title is interesting and largely reflects the paper content	☐ Topic is highly relevant to the field of chemistry and is based on recent research ☐ Title is engaging and accurately reflects the paper content
B. Abstract (5 %)	5		☐ Abstract is not engaging and does not answer the "what," "why," "how," and "to what end" questions	☐ Abstract is somewhat engaging and answers some of the "what," "why," "how," and "to what end" questions	☐ Abstract is engaging and mostly answers the "what," "why," "how," and "to what end" questions	☐ Abstract is highly engaging, and answers all of the "what," "why," "how," and "to what end" questions
C. Introduction & Background Information (15 %)	1, 3, 5		☐ Introduction does not provide adequate description of the relevant background information and no context for the topic	☐ Introduction provides a description of some of the relevant background information and provides some context for the topic	☐ Introduction provides a detailed description of the relevant background information and provides context for the topic	☐ Introduction provides a highly detailed description of the relevant background information and provides context for the topic
D. Analysis of Information & Scientific Understanding (25 %)	1, 3		☐ Paper contains little relevant material ☐ No connections are made between information from different sources ☐ Chemical information is not accurately explained to the reader	☐ Paper contains a description of some relevant material ☐ Some connections are made between information from different sources ☐ Chemical information is sometimes accurately explained to the reader	☐ Paper contains an accurate description of a good amount of relevant material ☐ Good connections are made between information from different sources ☐ Chemical information is usually accurately explained to the reader	☐ Paper contains an accurate description of a large amount of relevant material ☐ Extensive connections are made between information from different sources ☐ Chemical information is always accurately explained to the reader

	DLG	Grade	Poor (Grade D, 1.0)	Satisfactory (Grade C, 2.0)	Good (Grade B, 3.0)	Excellent (Grade A, 4.0)
E. Conclusion (5 %)	5		☐ Conclusion does not summarize the information presented in the paper ☐ Conclusion does not defend a position, and does not discuss possible future directions for the research	☐ Conclusion summarizes some of the information presented in the paper ☐ Conclusion suggests a position, and/or discusses some possible future directions for the research	☐ Conclusion summarizes most of the information presented in the paper ☐ Conclusion defends a position, and/or discusses some possible future directions for the research	☐ Conclusion accurately summarizes all of the information presented in the paper ☐ Conclusion defends a position, and discusses possible future directions for the research
F. Paper Organization (15 %)	5		☐ Paper is disorganized and does not include informative headings and sub-headings ☐ The guidelines on formatting and paper length are not met	☐ Paper is somewhat organized with some use of informative headings and sub-headings ☐ Some of the guidelines on formatting and paper length are met	☐ Paper is organized with good use of informative headings and sub-headings ☐ Most of the guidelines on formatting and paper length are met	☐ Paper is well-organized with extensive use of informative headings and sub-headings ☐ All of the guidelines on formatting and paper length are met
G. Grammar & Syntax (15 %)	5		☐ Text is riddled with grammatical errors and shows no evidence of editing and proofreading ☐ Sentence and paragraph structure are poor and show little organization ☐ None of the relevant scientific terms and abbreviations are defined	☐ Text is grammatically correct some of the time and shows some evidence of editing and proofreading ☐ Sentence and paragraph structure are sometimes clear and well-organized ☐ Some of the relevant scientific terms and abbreviations are clearly defined	☐ Text is usually grammatically correct and shows evidence of editing and proofreading ☐ Sentence and paragraph structure are clear and usually well-organized ☐ Most of the relevant scientific terms and abbreviations are clearly defined	☐ Text is grammatically correct throughout and shows evidence of careful editing and proofreading ☐ Sentence and paragraph structure are always clear and well-organized ☐ All of the relevant scientific terms and abbreviations are clearly defined
H. Figures (5 %)	1		☐ Figures are not relevant, do not support the major points presented, and are not discussed within the text of the paper ☐ None of the figures include descriptive captions and appropriate references	☐ Some of the figures are relevant, support the major points presented, and are discussed within the text of the paper ☐ Some of the figures include descriptive captions and appropriate references	☐ Most of the figures are relevant, support the major points presented, and are discussed within the text of the paper ☐ Most of the figures include descriptive captions and appropriate references	☐ All figures are relevant, support the major points presented, and are discussed within the text of the paper ☐ All figures include descriptive captions and appropriate references

	DLG	Grade	Poor (Grade D, 1.0)	Satisfactory (Grade C, 2.0)	Good (Grade B, 3.0)	Excellent (Grade A, 4.0)
I. References (5 %)	1		☐ Paper indicates that literature search was not performed and appropriate peer-reviewed and primary literature sources are not used ☐ References are absent and/or not correctly cited within text and bibliography	☐ Paper indicates that a literature search was performed and appropriate peer-reviewed, primary literature sources sometimes are used ☐ References are sometimes correctly cited within text and bibliography	☐ Paper indicates that a broad literature search was performed and appropriate peer-reviewed, primary literature sources are mostly used ☐ References are usually correctly cited within text and bibliography	☐ Paper indicates that an extensive literature search was performed and appropriate peer-reviewed, primary literature sources are used ☐ References are always correctly cited within text and bibliography
J. Deadlines & Participation (5 %)	N/A		☐ Student met none of the deadlines and was not engaged with the reading and writing process ☐ Feedback provided to the student was not incorporated in to the next version of the paper	☐ Student met some of the deadlines and was somewhat engaged with the reading and writing process ☐ Feedback provided to the student was sometimes incorporated in to the next version of the paper	☐ Student met most of the deadlines and was engaged with the reading and writing process ☐ Feedback provided to the student was usually incorporated in to the next version of the paper	☐ Student met all the deadlines and was fully engaged with the reading and writing process ☐ Feedback provided to the student was always incorporated in to the next version of the paper

Paper Strengths:

Paper Weaknesses:

Hendrix College
Chemistry Graduate Survey

Question 1

Thank you for taking the time to complete this survey. We hope your education here has been everything you wished for, and more. However, it is possible there are things we haven't thought of that you think you need. Please let us know what we did well and what we can improve.

Drs. Caro, Goodwin, Gron, Hales, Hatch, Kopper, Kett, and Yanney with Mrs. Bradley, Mrs. Desrochers, and Mr. Fuller.

Question 2

Who were you when you arrived and where are you going now?

Question 3

Did you enter Hendrix as a fresher?
[Answer no if you were considered a transfer student when you started here.]

- ○ (1) Yes
- ○ (2) No

• Do Not Calculate Mean/Std.

Question 4

Did you come to Hendrix planning to major in science?

- ○ (1) Yes
- ○ (2) No

• Do Not Calculate Mean/Std.

Question 5

Did you come to Hendrix planning to major in chemistry?

- ○ (1) Yes
- ○ (2) No

• Do Not Calculate Mean/Std.

Question 6

What are your plans after graduation?

- ○ (1) Unsure
- ○ (2) Get a job now using my chemistry education
- ○ (3) Get a job outside of science
- ○ (4) Go on to graduate school in one of the physical sciences or mathematics
- ○ (5) Go on to a health related professional school (medical, dental, nursing, etc.)
- ○ (6) Go on to an unrelated professional program (business, history, law, accounting, etc.)

• Do Not Calculate Mean/Std.

Question 7

I feel that the Hendrix College Chemistry curriculum has given me an opportunity to develop a strong background in:

	(1) strongly disagree	(2) disagree	(3) neutral	(4) agree	(5) strongly agree	(6) not applicable
Organic Chemistry	○	○	○	○	○	○
Physical Chemistry	○	○	○	○	○	○
Analytical Chemistry	○	○	○	○	○	○
Biological Chemistry	○	○	○	○	○	○
Inorganic Chemistry	○	○	○	○	○	○
Laboratory Procedures	○	○	○	○	○	○
Laboratory Safety	○	○	○	○	○	○

Question 8

I feel that the Hendrix College Chemistry curriculum has taught me to:

	(1) strongly disagree	(2) disagree	(3) neutral	(4) agree	(5) strongly agree	(6) not applicable
Acquire knowledge necessary to practice chemistry as a scientist.	○	○	○	○	○	○
Critically evaluate the conclusions in popular and scientific articles.	○	○	○	○	○	○
Search and read the primary literature.	○	○	○	○	○	○
Evaluate scientific information assembled from disparate sources.	○	○	○	○	○	○
Design and execute an experiment.	○	○	○	○	○	○
Write about science effectively (laboratory report or a paper).	○	○	○	○	○	○
Communicate scientific information effectively as a poster or oral presentation.	○	○	○	○	○	○
Work in a group to accomplish science.	○	○	○	○	○	○
Understand what green chemistry is.	○	○	○	○	○	○
Explain what green chemistry is to a non-scientist.	○	○	○	○	○	○
Explain how green chemistry is applied in a chemical laboratory.	○	○	○	○	○	○
Consider chemical hazards as part of experimental design.	○	○	○	○	○	○

Question 9

Consider the Hendrix College Chemistry Program Overall

Question 10

I perceived the strength of the overall program to be:

Question 11

I would suggest the following improvements to the overall program:

Question 12

I gained the following insights from the overall program:

Appendix E

Year	acquire fact-based knowledge necessary to understand chemistry as citizens and practice it as scientists	design and execute laboratory experiments	develop critical thinking skills necessary to assess and assemble facts and data	work effectively individually and in groups	communicate chemistry effectively in written and oral forms	assess the ethical implications of their work and its impact on our society and environment
18-19					18-19	
19-20			19-20		19-20	
20-21	20-21					20-21
21-22		21-22				
22-23				22-23		
23-24			23-24		23-24	
24-25	24-25					24-25
25-26		25-26				
26-27				26-27		
27-28			27-28		27-28	
Direct	DUCK exam, standardized course exams	independent research papers (ATEC/CHEM 450)	capstone paper rubric	independent research papers	capstone paper rubric, student conference presentations, capstone presentation grades	capstone paper rubric
Indirect	Sr. Survey	Sr. Survey	Sr. Survey	Sr. Survey	Sr. Survey	Sr. Survey