To: Lisa Christenson, Assessment Facilitator
From: Kelly Sheppard (Dept. Assessment Chair), Assistant Professor, Steven Frey, Associate Professor, and Raymond Giguere, Professor and Department Chair
Re: Chemistry Department Assessment Report for F'12/S'13
Date: May 16, 2013

For the F'12/S'13 school year, we chose to follow up on our assessments of Organic Chemistry (CH 221/222) and General Chemistry (CH 105 and 106, Chemical Principles I and II) sequences. Annually, 35-45 students take both semesters of Organic Chemistry. Our General Chemistry sequence serves up 150 students per year and is a foundational course for majors in biology, chemistry, environmental science, exercise science, geoscience, and neuroscience. It's important that we provide these students with a strong framework in chemistry that will permit their understanding of, and success in, upper-level coursework.

Organic Chemistry: Each spring, we administer a standardized exam from the American Chemical Society (ACS) to students who have completed the two-course Organic Chemistry sequence (CH 221/222). During finals of the 2013 Spring Semester, we administered the 2008 ACS Organic Chemistry Exam to the 35 students who were enrolled in CH 222. The exam is 70 multiple choice questions in length, and is administered at colleges and universities across the United States. The ACS encourages colleges and universities to submit their exam scores, and makes comprehensive, nationwide statistics available to exam administrators. These statistics include a correct response rate for every question on the exam. It should be noted the exam covers more topics than typically covered in a two-semester organic chemistry sequence.

The national median raw score on the exam is a 38.2 with a standard deviation of 12.16. The Skidmore median raw score in 2013 was a 47 with a standard deviation of 10.14. A raw score of 47 corresponds to the 71st percentile nationally. This is an improvement over the 2012 results, which had a median raw score of 43 (61st percentile) with a standard deviation of 9.77. The average raw scores also increased this year: 42.6 to 45.2. To identify additional areas of potential weakness in our organic chemistry curriculum, the Skidmore correct response rate for each question was compared to the national average for each question (see accompanying Excel Spreadsheet).

Last year, using this approach we identified the following topic areas to focus on: synthesis with MCPBA, nucleophilic acyl substitution, decarboxylation of beta-keto carboxylic acids, Grignard additions & hydrolysis of nitriles, and the Hammond postulate relationship with reaction energy diagrams.

Improvement:
We found this year, we had significant improvement for 3 out of the 5 questions identified.
35. What is the product of this reaction?
(**net 7 percentage points higher than 2012**)

39. What is the major product of this reaction?
(**net 23 percentage points higher than 2012**)

61. Which reaction sequence best accomplishes this transformation?
(**net 16 percentage points higher than 2012**)

No Significant Difference:
On one question, there was no significant difference from previous years regarding a synthesis question.
49. What is the major organic product obtained from this reaction?

Decrease:
On one question, despite increased emphasis this academic year in Organic Chemistry students did poorer this year as compared to last year's class. It was on relating Hammond's postulate with reaction energy diagrams.
6. Which energy diagram corresponds to this reaction sequence?
(**net 7 percentage points lower than 2012**)

We will reexamine how those latter two topic areas are covered to develop better ways of teaching the students this material.

It should be noted, on 36 out of the total 70 questions (51 %), Skidmore students did at least 10 percentage points better than the national average. Those areas of competency included core Organic Chemistry topics such as applications of organic spectroscopy (NMR, IR, and MS), organic reactions and synthesis, reaction mechanisms (e.g., S_N1, S_N2, E1, E2) and intermediates, as well as carbocation rearrangements.

General Chemistry: Each year, we administer a standardized exam from the American Chemical Society (ACS) to students who have completed the two-course general chemistry sequence (CH 105/106). During finals of the 2012 Spring Semester, we administered the 2009 ACS General Chemistry Exam to the 76 students who were enrolled in CH 106. The exam is 70 multiple choice questions in length, and is administered at colleges and universities across the United States. The ACS encourages colleges and universities to submit their exam scores, and makes comprehensive, nationwide statistics available to exam administrators. These statistics include a correct response rate for every question

on the exam. We examined our students' success on each individual question relative to the national average. The ability to do this allowed us to determine areas in the General Chemistry curriculum that our students may need more assistance in mastering. Overall, the national median raw score on the exam is a 36 with a standard deviation of 11.41. The Skidmore median raw score in 2012 was a 44 with a standard deviation of 9.97. A raw score of 44 corresponds to the 72nd percentile nationally.

Based on the 2011 results, we identified six areas to focus on during the 2011-2012 Academic Year: stoichiometry, using equilibrium constants to determine concentrations, phase diagrams, atomic mass, oxidation number, and ion arrangement. On each of those topic areas, we saw significant improvement last year, and we wanted to see if we were able to maintain those gains despite not explicitly focusing on them during the 2012-2013 Academic Year. The results indicate we were able to maintain the improvements in these areas.

- Balanced equations/ Stoichiometry
  (question 23, **in 2013 net 27 percentage points higher than 2011**)

- Using equilibrium constants to determine concentrations
  (question 63-acids/bases, in 2013 **net 13 percentage points higher than 2011**; question 55-molar solubility, in 2013 **net 5 percentage points higher than 2011**)

- Phase diagrams
  (question 44, **in 2013 net 18 percentage points higher than 2011**)

- Atomic mass
  (question 19, **in 2013 net 10 percentage points higher than 2011**)

- Oxidation number
  (question 24, **in 2013 net 14 percentage points higher than 2011**)

- Ion arrangement
  (question 10, **in 2013 net 16 percentage points higher than 2011**)

In 2012, we identified electrochemistry, in particular distinguishing the cathode from anode reaction, to be area to focus on as Skidmore students last year did poorly on that topic compared to the national average (Question 67, 12 percentage points below the national average). We expanded our coverage of electrochemistry both in lecture and lab. With those interventions, this year Skidmore students were 11 percentage points better than the national average, an improvement from the 2012 results of 23 percentage points.

This year, only on 1 question (question 12) did Skidmore students do worse than the national average by 10 percentage points or more. The question focused on radiochemistry, a topic area not covered in our general chemistry curriculum at Skidmore.

Regarding content covered in CH 105/106 at Skidmore, there were two topic areas where our students did between 5 and 10 percentage points worse than the national average, periodicity related to electron configuration and integrated rate laws. Next year, we will spend more time on these two topics.

6. Which three elements in the 4^{th} period have exactly three unpaired electrons in their ground state?

(**net 5 percentage points below the national average**)

69. To study the kinetics of N_2O_5 decomposition, a student measures the $[N_2O_5]$ as a function of time. The student then plots the $\ln[N_2O_5]$ verus time and $1/[N_2O_5]$ versus time and obtain these plots. The student correctly concludes the reaction is _____ order with a slope equal to _____.

(**net 7 percentage points below the national average**)

Yellow Number	Grey Total	Yellow Total	Skid %	% NA	Diff 2013	Diff 2011	Diff. in Diff	Material
1	29	31	78.95	59	19.95	8.07	11.87	electron/atom
2	25	20	59.21	50	9.21	13.41	-4.20	isoelectronic ion
3	21	26	61.84	61	0.84	13.39	-12.55	energy electronic transition
4	33	32	85.53	73	12.53	12.37	0.16	isotope/atomic mass
5	34	35	90.79	83	7.79	-1.29	9.08	ion
6	20	17	48.68	54	-5.32	5.76	-11.07	periodicity/electron conf.
7	9	14	30.26	29	1.26	-4.61	5.87	electron config.
8	31	27	76.32	75	1.32	7.93	-6.61	Ionic reactivity
9	26	28	71.05	71	0.05	8.27	-8.22	atomic/ionic radius
10	37	34	93.42	84	9.42	-7.17	16.59	ion arrangement salt
11	11	13	31.58	39	-7.42	-2.41	-5.01	acid nomenclature
12	18	10	36.84	49	-12.16	5.88	-18.04	Radiochem
13	34	28	81.58	56	25.58	11.07	14.51	lattice energy
14	25	19	57.89	51	6.89	13.63	-6.74	dipole moment
15	17	15	42.11	47	-4.89	15.20	-20.09	hybrid orbital
16	26	28	71.05	64	7.05	1.85	5.20	bond strength
17	22	17	51.32	43	8.32	15.54	-7.22	VSEPR
18	16	18	44.74	47	-2.26	24.95	-27.21	molecular geometry
19	28	27	72.37	70	2.37	-7.80	10.17	atomic mass
20	30	34	84.21	68	16.21	2.73	13.48	Net ionic equation
21	21	18	51.32	35	16.32	29.63	-13.32	oxiditing agent
22	28	25	69.74	54	15.74	5.76	9.98	balanced equation
23	30	35	85.53	83	2.53	-24.46	26.99	balanced equation
24	31	32	82.89	76	6.89	-7.71	14.60	oxidation number
25	15	14	38.16	36	2.16	6.68	-4.53	106 electrochem, half reactions
26	32	27	77.63	57	20.63	3.98	16.66	percent yield
27	24	23	61.84	51	10.84	14.85	-4.01	limiting reagent

28	21	22	56.58	52	4.58	10.20	-5.62	enthalpy reaction
29	18	20	50.00	39	11.00	18.32	-7.32	limiting reagent
30	28	22	65.79	54	11.79	4.54	7.25	Combustion
31	29	26	72.37	56	16.37	15.95	0.42	106, mass %
32	21	18	51.32	51	0.32	3.88	-3.56	106, phase transition/enthalpy
33	17	22	51.32	37	14.32	14.22	0.10	106, phase transition/enthalpy
34	27	26	69.74	49	20.74	5.88	14.86	Specific heat
35	19	23	55.26	46	9.26	1.56	7.70	Enthalpy formation
36	30	31	80.26	58	22.26	6.63	15.63	enthalpy reaction
37	26	20	60.53	51	9.53	-4.66	14.18	heat capacity
38	33	31	84.21	65	19.21	-5.24	24.45	enthalpy reaction
39	21	17	50.00	47	3.00	1.78	1.22	enthalpy formation, equation
40	29	29	76.32	63	13.32	0.41	12.90	limiting reagent, gas
41	15	12	35.53	36	-0.47	0.59	-1.06	gas law
42	24	19	56.58	49	7.58	-2.66	10.24	gas law
43	21	19	52.63	49	3.63	10.76	-7.12	gas law
44	29	32	80.26	71	9.26	-8.80	18.07	106 phase diagram
45	25	21	60.53	27	33.53	26.66	6.87	106 intermolecular forces
46	18	13	40.79	33	7.79	14.56	-6.77	106 vapor pressure
47	18	16	44.74	26	18.74	-1.61	20.35	106 freezing point/colligative properties
48	29	24	69.74	43	26.74	4.56	22.18	106 rate law
49	20	25	59.21	42	17.21	10.44	6.77	106 rate, mechanism
50	24	29	69.74	57	12.74	-3.34	16.08	106 kinetics
51	28	22	65.79	46	19.79	12.54	7.25	106 kinetics
52	31	29	78.95	49	29.95	4.66	25.29	106 thermodynamics
53	30	25	72.37	65	7.37	0.85	6.51	106 entropy
54	34	35	90.79	76	14.79	8.15	6.64	106 equilibrium constant
55	22	17	51.32	53	-1.68	-6.66	4.97	106 molar solubility
56	11	16	35.53	29	6.53	7.59	-1.06	106 solubility

57	21	20	53.95	32	21.95	13.12	8.83	106 acid/base salts
58	25	20	59.21	41	18.21	-6.85	25.06	106 Kw/pH
59	25	23	63.16	29	34.16	7.59	26.57	106 Lewis Base
60	24	27	67.11	48	19.11	-0.44	19.54	106 titration curve
61	24	21	59.21	36	23.21	-1.85	25.06	106 acid base
62	27	20	61.84	38	23.84	3.46	20.38	106 Buffer
63	14	28	55.26	55	0.26	-12.32	12.58	106 acid/base
64	24	22	60.53	52	8.53	-3.22	11.75	Le Chatelier's
65	8	13	27.63	27	0.63	13.24	-12.61	106 electrochem
66	26	33	77.63	71	6.63	-24.66	31.29	106 electrochem
67	21	24	59.21	48	11.21	-7.76	18.97	106 electrochem
68	33	33	86.84	62	24.84	-24.20	49.04	106 electrochem
69	21	10	40.79	48	-7.21	9.32	-16.53	106 kinetics, rate law
70	26	30	73.68	39	34.68	9.78	24.90	ions in solution
Totals	38	38	62.44	51.57	10.87	4.18	6.69	
		76						
Yellow number: question number on yellow form								
Grey Total: total number of correct responses grey form								
Yellow Total: total number of correct reponses yellow form								
% Skid: Percent Correct at Skidmore								
% NA: Precent Correct Nationally								
Diff 2013: Difference between Skidmore Correct Response and nationally based on the 2013 results (% Skid -% NA)								
Diff 2011: Difference between Skidmore Correct Response and nationally based on the 2011 results								
Diff. in Diff: Diff 2013 - Diff 2011								
Material: Topic area								

Question #	% Skid	% NA	Differ 2013	Differ 2012	Diff in Diff
1	83	69	14	11	3
2	29	33	-4	-15	11
3	40	56	-16	-5	-11
4	74	60	14	-5	19
5	97	89	8	5	3
6	40	60	-20	-13	-7
7	83	61	22	25	-3
8	37	34	3	-12	15
9	80	61	19	25	-6
10	100	86	14	8	6
11	74	63	11	25	-14
12	74	35	39	32	7
13	77	74	3	2	1
14	66	58	8	-9	17
15	29	38	-9	15	-24
16	49	55	-6	-12	6
17	86	82	4	6	-2
18	43	46	-3	9	-12
19	69	72	-3	1	-4
20	17	35	-18	-8	-10
21	91	59	32	21	11
22	83	63	20	2	18
23	74	67	7	-6	13
24	60	30	30	25	5
25	51	41	10	-21	31
26	86	65	21	11	10
27	63	48	15	-1	16
28	83	58	25	5	20
29	80	66	14	16	-2
30	29	40	-11	13	-24
31	60	48	12	1	11
32	77	53	24	23	1
33	77	66	11	3	8
34	66	64	2	16	-14
35	29	52	-23	-30	7
36	77	69	8	2	6
37	63	61	2	-2	4
38	86	53	33	16	17
39	74	61	13	-10	23
40	37	52	-15	9	-24

41	74	56	18	11	7
42	54	70	-16	-7	-9
43	43	46	-3	1	-4
44	71	75	-4	-6	2
45	74	63	11	8	3
46	37	43	-6	-10	4
47	71	58	13	3	10
48	63	50	13	19	-6
49	**9**	**34**	**-25**	**-24**	**-1**
50	71	56	15	-3	18
51	43	42	1	7	-6
52	71	51	20	16	4
53	54	54	0	-3	3
54	89	78	11	10	1
55	63	53	10	-8	18
56	57	61	-4	-6	2
57	77	68	9	12	-3
58	71	43	28	8	20
59	43	41	2	14	-12
60	43	42	1	-7	8
61	**34**	**41**	**-7**	**-23**	**16**
62	46	33	13	8	5
63	91	63	28	27	1
64	91	67	24	31	-7
65	89	70	19	12	7
66	94	71	23	21	2
67	83	45	38	16	22
68	77	62	15	3	12
69	77	68	9	16	-7
70	91	64	27	20	7

% Skid	Percentage of Skidmore students who got the question correct
% NA	Precentage nationally that got the question correct
Differ 2013	Difference between % Skid 2013 and % NA (% Skid - % NA)
Differ 2012	Difference between % Skid 2012 and % NA (% Skid - % NA)
Diff in Diff	Difference between Differ 2013 and Differ 2012