

The Use of a Practical Titration Exercise to Assess Student Learning in the General Chemistry Laboratory

Katherine A. Bichler

Associate Professor of Chemistry
University of Wisconsin Colleges

First, Who are the UW Colleges?

- 13 campuses throughout the state of Wisconsin
- One Department of Chemistry
- Large department
 - Many colleagues working together
 - Geographically spread out
- Small departments
 - Autonomy in campus program

Next, Why did we do this?

- Assessment in general
- Assessment in the UW Colleges Chemistry Department prior to 2003
 - What we were doing
 - participation
- Assessment in the UW Colleges Chemistry Department post 2003
 - North Central accreditation visit

UW Colleges Assessment

- Rotating Years
 - Analytical Skills/Aesthetic Skills
 - Quantitative Skills/Communication Skills
- Chemistry Department's Chosen Performance Indicators:
 - Analytical Skills
 - Interpret and synthesize information and ideas
 - Quantitative Skills
 - Interpret graphs, tables, and diagrams

Now, what are we doing?

- Lecture assessment
 - Chosen courses
 - UW Colleges dictated
 - Instructor's highest enrollment
 - Low level/high level courses
 - ACS exams
 - Where appropriate exams exist
 - Chosen questions
 - Various methods
 - Our own exams
 - When no appropriate ACS exam is available

Moving into the Lab

- After 2 years of classroom assessment, we turned to the laboratories
 - Continued with classroom, though not specifically required by UW Colleges
 - Focused on CHE 145/155
- Quantitative Skills (Interpret graphs, tables, and diagrams)
 - Spec 20 simulation

Titration Assessment

- Analytical Skills (Interpret and synthesize information and ideas)
- Hands-on practical desired
- Wanted a standardization technique like the ACS exams offered in the lecture assessment
- Working with ACS Exams Institute to develop a standardized practical

Titration Assessment (Students)

Titration Assessment:

You will be provided with the following clean glassware and solutions (more solutions will not be available if you run out, so plan accordingly):

250 mL 0.100M NaOH

25mL graduated cylinder or 25mL pipet

50 mL buret

2 125mL Erlenmeyer flasks

DI water

Phenolphthalein solution

100mL unknown H_2SO_4 sol'n which is around 0.1M

Your task: Figure out the concentration of the H_2SO_4 solution. A large portion of your grade will be based upon the accuracy of your result.

Outline the Procedure you will follow during your time in the lab. Clearly show any calculations you do in order to design this procedure.

Record and clearly label any Data you collect in the lab.

Calculate the concentration of the H_2SO_4 solution.

Titration Assessment (FAQ for Instructors' Information)

CHE 155 Lab Assessment: Instructor's Information

Give each student the attached handout and have them go to a station with the materials already present. They should be given 60 minutes to design and record their procedure, carry out the titration, and perform the calculations. Non-graphing calculators are allowed.

FAQ's and Answers:

- 1) Can I tell them ahead of time that the assessment will be a titration lab?
Yes, but not specifically that it's an acid-base titration
- 2) Can the students leave early?
Yes, they can leave when they're done.
- 3) Can the students be given a periodic table?
Yes
- 4) Can the students be given more reagents if they run out?
No, they should plan accordingly
If they accidentally spill reagents, you can replace them, but that fact should not be advertised

Titration Assessment (Evaluation)

Assessing the Results:

You can choose to assess your results in whatever manner you'd like for incorporation into the students' grades. **Please follow the point allocations below for reporting on whether students meet, do not meet, or exceed expectations:**

There are 15 total points on the exercise, broken down as follows:

Procedure:	Where H_2SO_4 is	1 point
	Where NaOH is	1 point
	Addition of phenolphthalein to H_2SO_4	1 point
	Titrate to light pink	1 point
Data:	Correct sig figs throughout (data and calc) (2 nd mistake costs entire point)	1 point
	Recording initial and final NaOH volume	1 point
	Recording volume of H_2SO_4 used	1 point
	Two or more trials	1 point

Titration Assessment (Evaluation, cont.)

Calculation:	Incorporates 2:1 mole:mole ratio	1 point
	Rest of calculation correct (any mistake costs the point)	1 point

Accuracy (Not based on their calculation, but on your own calculation using their data):

Within 0.003M of correct	5 points
Within 0.006M but not 0.003M of correct	4 points
Within 0.009M but not 0.006M of correct	3 points
Within 0.012M but not 0.009M of correct	2 points
Within 0.015M but not 0.012M of correct	1 point
Greater than 0.015M off correct answer	0 points

Assessment Criteria:

Exceeds Expectations:	13-15 points
Meets Expectations:	8-12 points
Does Not Meet Expectations:	0-7 points

Titration Assessment (Results)

- Where H_2SO_4 is
 - 14/159 missed (8.8%)
- Where NaOH is
 - 17/159 missed (10.7%)
- Addition of phenolphthalein to H_2SO_4
 - 7/159 missed (4.4%)
- Titrate to light pink
 - 56/159 missed (35.2%)

Titration Assessment (Results)

- Correct significant figures throughout
 - 97/159 missed (61.0%)
- Recording initial and final NaOH volume
 - 31/159 missed (19.5%)
- Recording volume of H_2SO_4 used
 - 5/159 missed (3.1%)
- Two or more trials
 - 34/159 missed (21.4%)

Titration Assessment (Results)

- Incorporating 2:1 mole:mole ratio
 - 105/159 missed (66.0%)
- Rest of calculation
 - 55/159 missed (34.6%)

Titration Assessment (Results)

- Accuracy
 - 109 (68.6%) within 0.003M of correct
 - 23 (14.5%) within 0.006M but not 0.003M of correct
 - 10 (6.3%) within 0.009M but not 0.006M of correct
 - 5 (3.1%) within 0.012M but not 0.009M of correct
 - 2 (1.3%) within 0.015M but not 0.012M of correct
 - 10 (6.3%) greater than 0.015M off correct answer

Results

- Areas missed by a large percentage
 - 2:1 mole:mole ratio (66.0%)
 - Significant Figures (61.0%)
 - “Pink” (35.2%)
 - Other calculation problems (34.6%)
 - More than one trial (21.4%)
 - Recording initial and final NaOH volume (19.5%)

Results

- Overall performance:
 - 64/159 students exceed expectations (40.3%)
 - 83/159 students meet expectations (52.2%)
 - 12/159 students do not meet expectations (7.5%)

Reported Problems/Concerns

- 1st vs. 2nd semester students
 - 2004/5 assessed 1st semester, 2005/06 2nd
- Consistency
 - What students know ahead of time
 - Analysis of results (i.e. sig fig acceptability)
- Actual concentrations
 - Some went over 50 mL NaOH with 25 mL H₂SO₄
 - Significant difference from 0.100M acid

Reported Problems/Concerns

- Time involved
 - Set-up of materials
 - Analysis of results
 - Not bad for individual section
 - Much time for one person to do enough for a statistically significant sample
- Ease in ability to meet/exceed expectations
 - No calculation at all can exceed
 - What do we really want to assess?

Future Plans

- Individual instructors analyze data
 - Comparison of their class to the whole group
 - Some sites have specific areas that differ
 - 2:1 ratio
 - 2 or more trials
 - Recording initial/final volumes on burette
- More consistency
 - Analysis of results
 - Telling students it's a titration exercise

Future Plans

- Changes to Rubric
 - How close must answer be to be accurate?
 - Total scores for assigning exceed, meet, not meet
- More detail in grading (more points)
 - More procedural detail required
 - Various sig fig possibilities (reading burette, calculation, etc)
 - Include precision?
 - 2:1 ratio—completely forgotten or done wrong?
 - “color change” vs. “pink”

Acknowledgements

- UW Colleges Chemists
- ACS Exams Institute