# Science General Education in Chemistry 147 Assessment

# December 2012

## Scientific Reasoning Pilot Group

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On December 12, 2012 the group met to pilot the assessment of scientific reasoning. The group used randomly selected student responses for one question on Exam 2 from chemistry 147. This exam was taken during finals week of the Fall 2012 semester by approximately 200 students.

On February 8, 2013 the chemistry department met to review the results of the report prepared by the pilot group. In that conversation there was some ambiguity regarding the distinction between the criteria from the science division general education committee. In particular a disagreement regarding the competent criteria and if the mathematical results must be correct to meet the criteria for competent.

The department also discussed the source of students doing poorly on this assessment. In particular that students at the competent level may have been limited by how carefully they read the question, that to achieve masterful it is important for these students to improve their reading skills. Students at the beginner level often show problems with mathematical problem solving that made it difficult for them to find a reasonable answer. Likewise for students who were scored not adequate it is clear that these students have significant problems with understanding and need to spend extra time working problems.

The department discussed strategies to improve student success. The plan for having at risk students attend an extra hour problem solving session for lecture should help students who were at the “not adequate” level improve next year.

## Goal and Objective

The University general education goal and objective related to science are:

4) A liberally educated graduate has developed a wide range of intellectual perspectives and methodologies.

a) Evaluates the workings of the natural and physical world using theories and models that can be tested by experiments and observations.

## Criteria

The science division general education committee suggested the following criteria for rating student outcomes for this objective:

Beginner – identify which theory or model is appropriate, not using misconceptions

Competent – clearly demonstrate that they know what model to use and how to solve the problem ; explain a theory or model

Masterful – Extend and apply model to a different situation or apply multiple models to solve a problem, get correct answer, and explain relationship

## Science General Education Criteria

The group started by discussing criteria they would use to evaluate student’s quantitative reasoning and developed the following scale that was used for the assessment. The general criteria are from the science division general education committee. The group developed the specific criteria we used to assess this specific question.

Table 1. Scoring Criteria

|  |  |  |
| --- | --- | --- |
| **Score** | **General Criteria** | **Specific Criteria for this question** |
| **3 Masterful** | Extend and apply model to a different situation or apply multiple models to solve a problem, get correct answer, and explain relationship | Use PV=nRT to find atomic mass and identify metal  Use vapor pressure correction  Clear response to error question |
| **2 Competent** | Clearly demonstrate that they know what model to use and how to solve the problem ; explain a theory or model | Use PV=nRT to find atomic mass and identify metal  Student not required to get correct answer, minor math errors were accepted |
| **1 Beginner** | Identify which theory or model is appropriate, not using misconceptions | Identifies they need to use PV=nRT to solve problem |
| **0 Not Adequate** |  | Did not identify need to use ideal gas law. |

## Assessment of Chemistry 147 Exam 2, Question 2, Fall 2012

The full text of this question is provided in Appendix 1. From a class of 200 students, 24 students were randomly selected. The student response to this question was photocopied. The assessment team reviewed each paper and discussed the scoring. A summary of the results is listed in Table 2. The full results for each student are listed in Table 3.

Table 2. Chemistry 147, Fall 2012, Exam 2, Question 2 Scientific Reasoning Assessment

|  |  |
| --- | --- |
| **Score** | **Students (%)** |
| **3 – Masterful** | 17 |
| **2 – Competent** | 33 |
| **1 – Beginner** | 33 |
| **0 – Not Adequate** | 17 |

## Summary of Notes – Number of students who

* Used Vapor pressure correction 4
* Picked Cu and ignored silvery observation of metal 6
* Used observation that metal was gone in error discussion 6
* Used excess HCl calculation in error discussion 7
* Made a mistake with mL to L conversion 4
* Made a calculator mistake 3
* Made an algebra mistake 1
* Results were a total mess 5

Table 3. Results and notes for Each Student, Fall 2012, Chem 147, Exam 2, Question 2

|  |  |  |
| --- | --- | --- |
| **Student** | **Score** | **Notes** |
| **14** | 3 | Used ideal gas law and partial pressure of water vapor to determine answer. Used color information to support claim. Did make minor math mistake (added vapor pressure). Calculated HCl excess. |
| **15** | 3 | Used ideal gas law and partial pressure. Missed color of metal, but good error discussion, including calculation of HCl excess. |
| **17** | 3 | ideal gas law, vapor pressure, OK error discussion |
| **21** | 3 | ideal gas law and partial pressure, good error discussion, did not use color observation |
| **3** | 2 | Used gas law to determine metal, but did not include vapor pressure correction |
| **10** | 2 | Made a calculator error, but answer was reasonable based on results, explanation for parts b and c were good based on answer. |
| **16** | 2 | Division error, used gas law to identify the metal. |
| **18** | 2 | no vapor pressure correction, but everything else is great |
| **20** | 2 | Calculation error, did not use vapor pressure |
| **22** | 2 | no vapor pressure correction, error discussion was very good |
| **24** | 2 | no vapor pressure correction |
| **25** | 2 | no vapor pressure correction |
| **2** | 1 | Used gas law, but did not use result to determine metal |
| **4** | 1 | Used vapor pressure to find moles. Did not change volume to liters |
| **6** | 1 | Calculation error converting to liters, resulted in nonsense answer, student guessed answer |
| **7** | 1 | Fatal algebra error, resulted in nonsense answer, guessed answer |
| **8** | 1 | Student calculated moles, but did not know how to determine atomic mass, guessed answer given silvery color |
| **11** | 1 | Found moles but did not know how to determine atomic mass. guessed answer |
| **13** | 1 | Found moles but did not know how to determine atomic mass. |
| **23** | 1 | found moles using gas law and vapor pressure. Problem with atomic mass calculation, gave nonsense answer and guessed metal |
| **1** | 0 | Did not use gas law |
| **5** | 0 | Did not solve problem, only converted pressure to ATM |
| **12** | 0 | Divided mass of metal by volume of gas to find density, guessed aluminum. |
| **9** | 0 | Used gas law with wrong R and incorrect conversions, got nonsense answer and guessed aluminum. |
| **AVG** | 1.50 |  |
| **STD** | 0.98 |  |

# Appendix 1, Chemistry 147 Fall 2012 Exam 2, Question 2

1. **Gas Law Experiment** (20 points)

A student carries out an experiment to identify an unknown metal. Use the experimental results to calculate the atomic mass of the metal – assume a +2 charge on the metal ion in solution. See Figure on page 1 of the exam

M (*s*) + 2 HCl (*aq*) -> H2 (*g*) + MCl2 (*aq*)

0.2446 g of metal – the metal is a silvery color

8.0 mL of 16 M HCl

Water temperature 23.0 ºC

After the tube is flipped, bubbles form

After 5 minutes the silvery colored solid is gone and no more bubbles are formed

Volume of H2 gas 94.56 mL

Barometric Pressure 763.51 mm Hg

* 1. (10 pts) Calculate the atomic weight of the unknown metal based on the data.

P = 763.51 – 21.0 = 742.51 mm Hg (-4 pts. if they fail to correct for water vapor)

P = 742.51 mm Hg = **0.9770 atm** (1 point)

V = 94.56mL = **0.09456 L** (1 point)

T = 23.0 + 273.15 = **296.15 K** (1 point)

n = 3.799 x 10-3 moles (3 pts)

Atomic mass = 64.39 (3 pts)

* 1. (5 pts) Identify the unknown metal and clearly explain how you determined your claim.

Zn. (3 pts)

Atomic mass between Cu and Zn, but metal is silver colored (2 pts)

* 1. (5 pts) One possible source of error is that there was not sufficient HCl added for the reaction.
     1. Is this source of error consistent with the direction of the error observed in this experiment? Explain your answer

(2 pts) Not consistent. Insufficent HCl would cause incomplete reaction so volume would be smaller, so number of moles would be smaller than expected, so atomic mass would be larger.

* + 1. Use the information from above to critique the possible claim that there was insufficient HCl for the reaction.

(3 pts must include)

-Observation was made that all the solid was gone