Assessment Progress in Physical Science

Faculty Development Week

Fall 2018

Step One: What Do Faculty Actually Teach?

A survey was given to six faculty who teach Chem 201, asking what specific topics from each chapter they cover. Below is an example of the results obtained.

- **Chapter 4:**
- Do your students memorize solubility rules?
- Yes__2__ No__4__
- Net ionic equations?
- Yes__6__ No____
- Do your students memorize strong/weak acids and bases?
- Yes__4__ No__2__
- Calculating oxidation numbers?
- Yes__5__ No__1__
- Do your students memorize any part of the activity series?
- Yes__1__ No__5__

Step Two: Assessing Prerequisite Skills

- We used an ACS (American Chemical Society) standardized test – the Toledo Exam.
- In general, students begin Chem 201 with little prior chemistry knowledge.
  - Distinguishing between chemical and physical properties (67% correct)
  - Using a density value in a calculation (60%)
  - Counting atoms in a chemical formula (59%)
  - Isotopes (two questions, 35 and 36%)
  - Periodic trends and predicting reactivity from position on the periodic table Balancing equations (two questions, 21 and 30%)
  - Molarity (two questions, 22 and 31%)
  - Students scored by far the best on the section on math skills – on average, students got questions right 70% of the time in this section.

Step Three: Assessing Student Learning

- On average, scores slightly below national average on an ACS standardized exam (18.7 correct compared to 24, out of 40).
- There was not much difference between various semesters.
- The same test is also used as the pretest for Chem 203, and the scores were 17.4 out of 40.
- A few topics were relatively easy – resonance, diatomic molecules, basic intermolecular forces.
- Other questions were challenging – kinetic molecular theory, bond angles in a Lewis dot structure, and accurately describing what happens when solids dissolve in water.

Plan for 2017: Targeted Interventions

- After several years of using ACS exams for pre- and post-tests, we began to think that we had learned as much as we could from this assessment method. Student scores were relatively constant from semester to semester, and the “bird’s-eye view” of the entire semester made it difficult to recommend solutions for what are usually pretty granular problems.
- One of the biggest learning goals for Chem 201 is stoichiometry.
- According to the assessment results, our students do well on easy questions, but struggle with more challenging ones.
- Can we as a department increase student learning gains in this key topic?

A Homemade Stoichiometry Assessment

- Faculty were consulted to determine the optimal length and depth of this assessment. (An example from Oakton College provided by Prof. Ray Tse was a helpful starting point for these conversations.) It was decided that we wanted a three question assessment, with an easy conceptual question, a "typical" algorithmic calculation question, and a challenging question that students had not seen before.
- Sample questions were solicited from full- and part-time faculty.
- Questions were grouped into the above three categories, and faculty voted on one question per category. There was a clear majority preference for each category.
- The assessment was deployed at the end of the Fall semester 2017 in all participating sections (we did not do a pilot).

Question 1

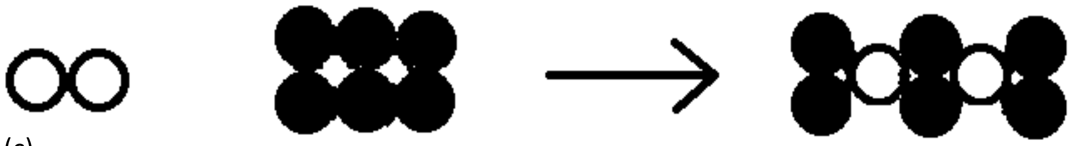
#1. Circle the response that answers the question below.

Which of the following pictorially represents the balanced chemical equation $N_2 + 3H_2 \rightarrow 2NH_3$?

 = nitrogen  = hydrogen

(a)

(b)



(c)

(d)

(e)

Question 2

#2. Calculate the answer to the question below. Show your work.

If 50.0 mL of 2.0 M HCl solution reacts with excess magnesium according to the balanced equation below, calculate the moles of hydrogen gas that is produced.

$$2\ HCl\ (aq) \ + \ Mg\ (s) \ \rightarrow \ MgCl_2\ (aq) \ + \ H_2\ (g)$$

Question 3

#3. Calculate the answers to the two questions below. Show your work.

A bracelet, originally made of pure silver, became tarnished over time with black silver sulfide (Ag_2S) forming on the surface. The bracelet was cleaned by converting the silver sulfide back to metallic silver using aluminum in the following reaction. The mass of the bracelet decreased by 0.0096 g in the cleaning process.

$$3\ Ag_2S + 2\ Al \rightarrow 6\ Ag + Al_2S_3$$

i) How many moles of sulfur (S) were removed from the bracelet when the silver sulfide (Ag_2S) was converted to aluminum sulfide (Al_2S_3)?

ii) What mass of aluminum was used in the reaction?

First type of wrong answer

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i) How many moles of sulfur (S) were removed from the bracelet when the silver sulfide (Ag_2S) was converted to aluminum sulfide (Al_2S_3)?

from equation

$\frac{3\ mol\ Ag_2S}{1\ Al_2S_3}$ $3\ \cancel{mol} \times \frac{32.07\ g\ S}{1\ mol\ \cancel{S}} \times 6.022 \times 10^{23}$

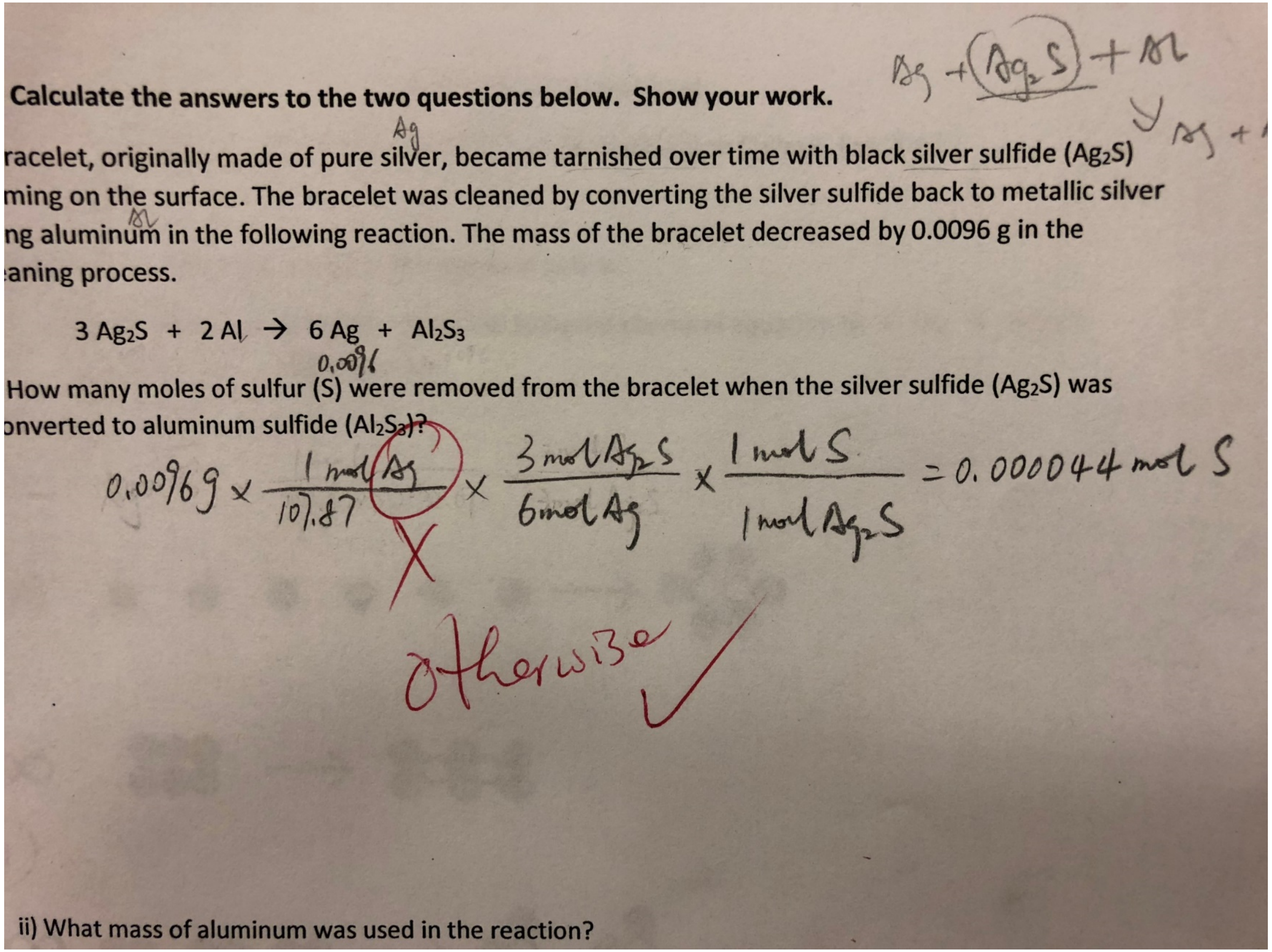
96.21 mol

$= \boxed{1.5976\ mol\ S}$

ii) What mass of aluminum was used in the reaction?

2 mol Al   26.98 g Al = 53.96 Al

Second type of wrong answer



Calculate the answers to the two questions below. Show your work.

$Ag + Ag_2S + Al$

$\rightarrow Ag +$

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How many moles of sulfur (S) were removed from the bracelet when the silver sulfide (Ag_2S) was onverted to aluminum sulfide (Al_2S_3)?

$$0.0096\,g \times \frac{1\,mol\,Ag}{107.87} \times \frac{3\,mol\,Ag_2S}{6\,mol\,Ag} \times \frac{1\,mol\,S}{1\,mol\,Ag_2S} = 0.000044\,mol\,S$$

otherwise

ii) What mass of aluminum was used in the reaction?

Some quantitative results

- The problem was worth 2 points. CHEM 121 students missed on average 1.51 points, while CHEM 201 students missed on average 1.43 points. So the CHEM 201 students did do slightly better, but this difference is not statistically significant.

Points lost due to:	Mistake type 1	Mistake type 2
CHEM 121	0.316 points	0.246 points
CHEM 201	0.333 points	0.360 points

- These types of mistakes are statistically significant.
- THANK YOU FERNANDO FOR YOUR HELP!

A stoichiometry question bank

- Clearly students in both courses could benefit from more questions where the chemical name of the substance is not specified. But these questions are often difficult to write.
- So I requested examples of such questions from our faculty, searched textbooks and online sources, and wrote a few myself, with the goal of creating a question bank that professors can draw from when creating activities.
- This question bank now has 7 questions, but they are of a nice variety and I hope to add more over time.
- This question bank will be emailed to faculty next week, and then the assessment will be given at the end of the semester.

Example questions

On average, an acre of corn will remove 6 kilograms of phosphorus from the ground, and this needs to be replaced each year using fertilizer.

Imagine you inherit a farm. The farm is 340 acres and had corn planted the previous year. You must add fertilizer to the soil before you plant this year's crop. At the store, you find a fertilizer which, according to the bag, has the molecular formula $Ca_3P_2H_{14}S_2O_{21}$. One bag contains 50 pounds of this fertilizer and costs \$54.73. How much will it cost you to add the necessary fertilizer to your fields? (454 g = 1 pound)

The stone "icicles" found hanging from the ceilings of caves are called stalactites. They are formed gradually as dissolved calcium bicarbonate in rainwater precipitates out of solution according to the equation below.

$$Ca(HCO_3)_2\ (aq) \rightarrow CaCO_3\ (s) + H_2O\ (l) + CO_2\ (g)$$

Not all of the calcium bicarbonate precipitates – the "percent yield" of this reaction is typically only 1%. If 50 mL of rainwater flows over a stalactite per hour, with a calcium bicarbonate concentration of 0.004 M, how much mass is added to the stalactite in one century?

Airbags in an automobile inflate during a collision to help protect the passengers from injury. The airbags are inflated by the chemical decomposition of sodium azide according to the reaction shown below. What mass of sodium azide is necessary to inflate a 60.0 L airbag at 25^{o}C and 1.0 atm?

$$2\ NaN_3\ (s) \rightarrow 2\ Na\ (s) + 3\ N_2\ (g)$$