Improving the General Chemistry Curriculum through Objective Assessment Measures

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2023 Assessment Faire

Friday, April 28, 2023

Overview

General chemistry is a set of multi-section, lower-division, introductory courses designed to present many foundational chemical concepts.

General Chemistry I (CHEM 1100)

General Chemistry II (CHEM 1110)

General Chemistry for Engineers (CHEM 1040)

These courses typically have high DFW rates. Standardized assessment instruments can be useful to measure student learning across many sections.

Purpose of Assessment

- Assess PLO1 and PLO2
  - "…demonstrate fundamental knowledge, including chemical and biochemical theories, concepts, and laboratory methods."
  - "…understand and use scientific processes to create knowledge of molecular properties and behavior."

- Assessment should complement DFW rates in course.
  - What are students learning?
  - Are there areas where instructors can do better?
  - Should we spend more (or less) time on certain topics?
  - How does course (or quiz) modality impact student learning?
  - "closing the loop"

Assessment Tool

Assessment Quizzes

- 20 multiple choice questions
- 30-minute time limit
- Questions modeled after American Chemical Society exam
- Implemented in Canvas (hardcopy version exist though)
- CHEM 1100 / 1110 / 1040 lecture instructor input
- Low stakes (extra credit, etc.)
- Test administered along with final exam

Lecture Data

CHEM 1100 Fall 2021

- Three sections, three instructors
- 331 students total
- 200 students took quiz (60%)
- Course DFW rate: 42.6%

CHEM 1110 Fall 2021

- Two sections, one instructor
- 168 students total
- 113 students took quiz (67%)
- Course DFW rate: 45.2%

CHEM 1100 Spring 2022

- Two sections, two instructors
- 264 students total
- 185 students took quiz (70%)
- Course DFW rate: 30.0%

CHEM 1110 Spring 2022

- Two sections, two instructors
- 84 students total
- 67 students took quiz (80%)
- Course DFW rate: 25.0%

CHEM 1100 question examples

Question 9 1 pts

Complete dehydration of a 5.0 g sample of which hydrated salt below produces the largest mass of water?

Hydrated Salt	Molar Mass
$CaCl_2 \cdot 6H_2O$	219.07 g/mol
$CaBr_2 \cdot 6H_2O$	307.98 g/mol
$MgCl_2 \cdot 6H_2O$	203.30 g/mol
$Ca(NO_3)_2 \cdot 4H_2O$	236.15 g/mol

The following is an example of a dehydration reaction:

$$CaCl_2 \cdot 6H_2O \longrightarrow CaCl_2 + 6H_2O$$

- ○ $CaBr_2 \cdot 6H_2O$
- ○ $MgCl_2 \cdot 6H_2O$
- ○ $Ca(NO_3)_2 \cdot 4H_2O$
- ○ $CaCl_2 \cdot 6H_2O$

Question 11 1 pts

A mixture of 4.5 moles of aluminum and 3.0 moles of oxygen is allowed to react:

$$4\ Al(s) + 3\ O_2(g) \longrightarrow 2\ Al_2O_3(s)$$

Identify the limiting reactant and determine the amount remaining of the excess reactant.

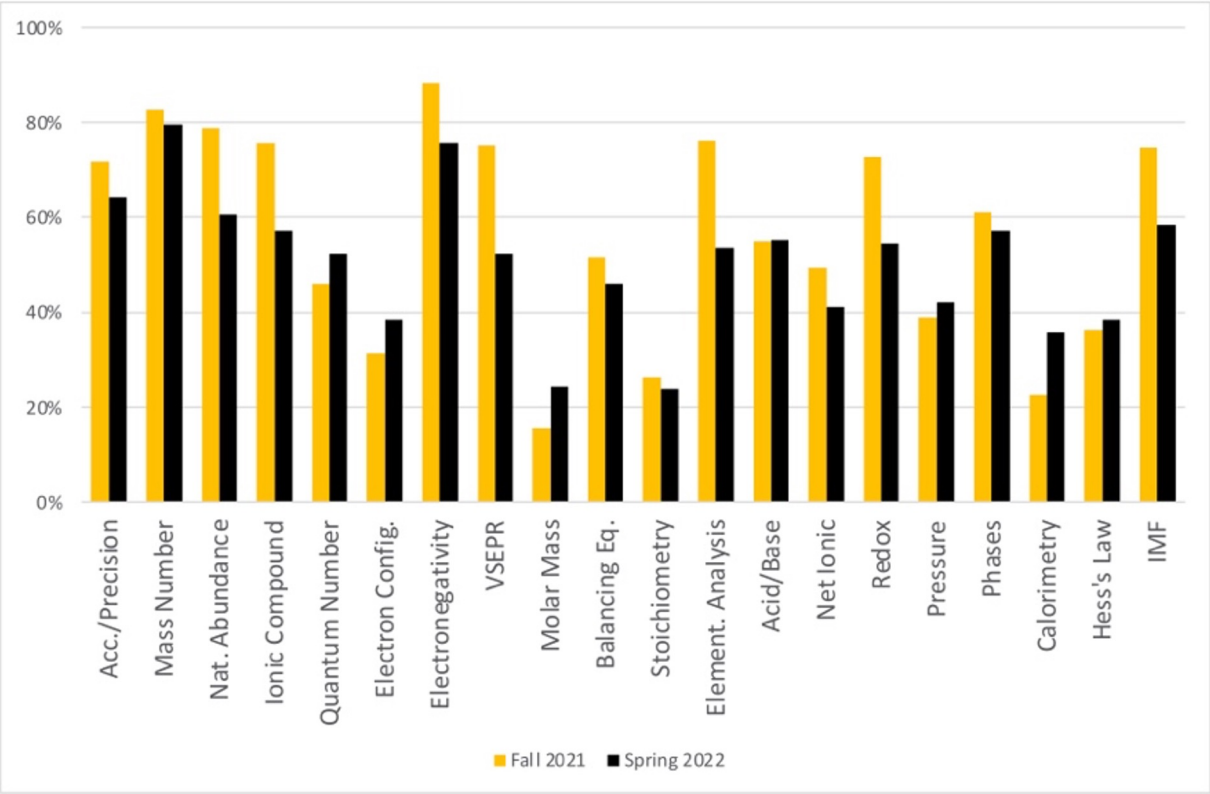
- ○ O_2 is limiting; 0.5 moles of excess aluminium
- ○ O_2 is limiting; 1.5 moles of excess aluminium
- ○ Al is limiting; 2 moles of excess oxygen
- ○ Al is limiting; 1 mole of excess oxygen

Question 12 1 pts

Iron forms a compound with oxygen that is 72.36% iron and 27.64% oxygen by mass. What is the empirical formula?

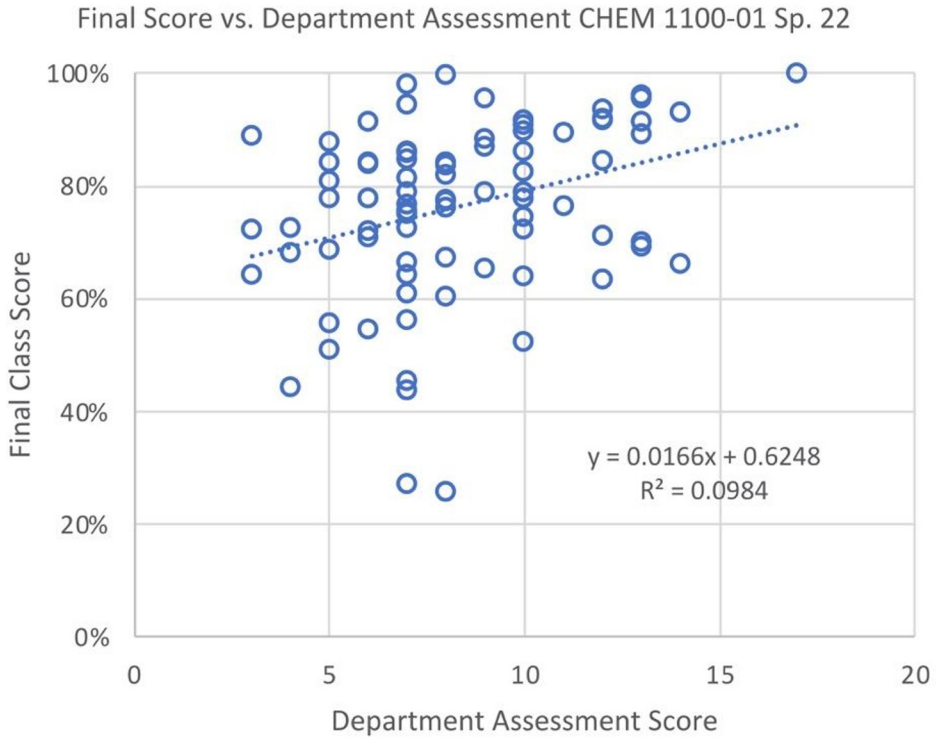
- ○ FeO_2
- ○ Fe_2O_3
- ○ Fe_3O_4
- ○ FeO

CHEM 1100 percent correct per question



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CHEM 1100 final score vs assessment score



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CHEM 1110 question examples

Question 5 1 pts

Addition of products to a chemical reaction in solution or gas phase at equilibrium results in _____

- ○ no change in K and a shift in equilibrium to produce more reactants.
- ○ an increase in K and a shift in equilibrium to produce more reactants.
- ○ a decrease in K and a shift in equilibrium to produce more products.
- ○ a decrease in K and a shift in equilibrium to produce more reactants.
- ○ no change in K and a shift in equilibrium to produce more products.

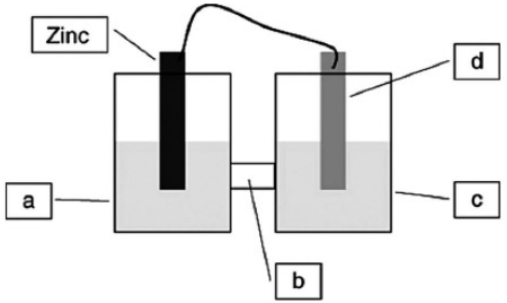
Question 11 1 pts

Which of the following can be mixed together in water to produce a buffer solution?

- ○ H_3PO_4 and NaH_2PO_4
- ○ $HClO_4$ and $NaClO_4$
- ○ HNO_3 and $NaNO_3$
- ○ H_2SO_4 and $NaHSO_4$
- ○ HCl and NaCl

Question 18 1 pts

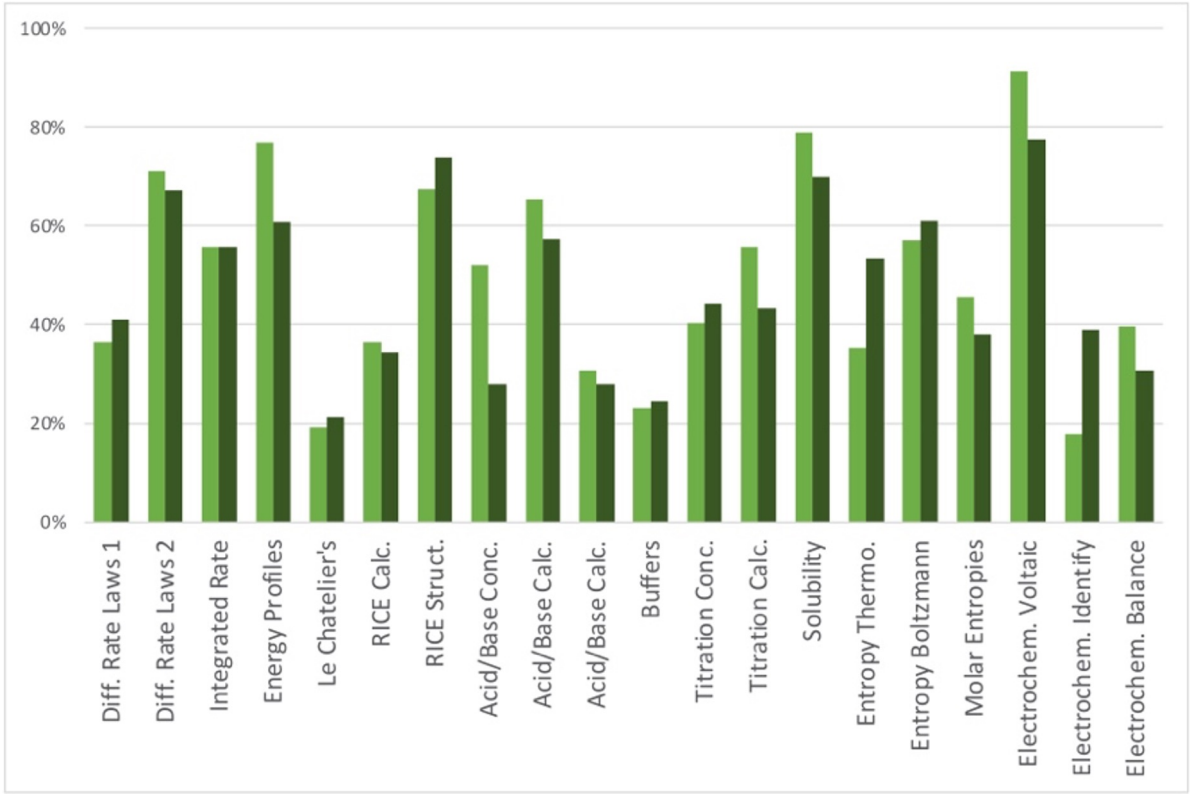
A voltaic cell is constructed based on the oxidation of zinc metal and the reduction of silver cations. Solutions of silver nitrate and zinc nitrate also were used. Locate the zinc nitrate on the diagram.



- ○ a.
- ○ b.
- ○ c.
- ○ d.

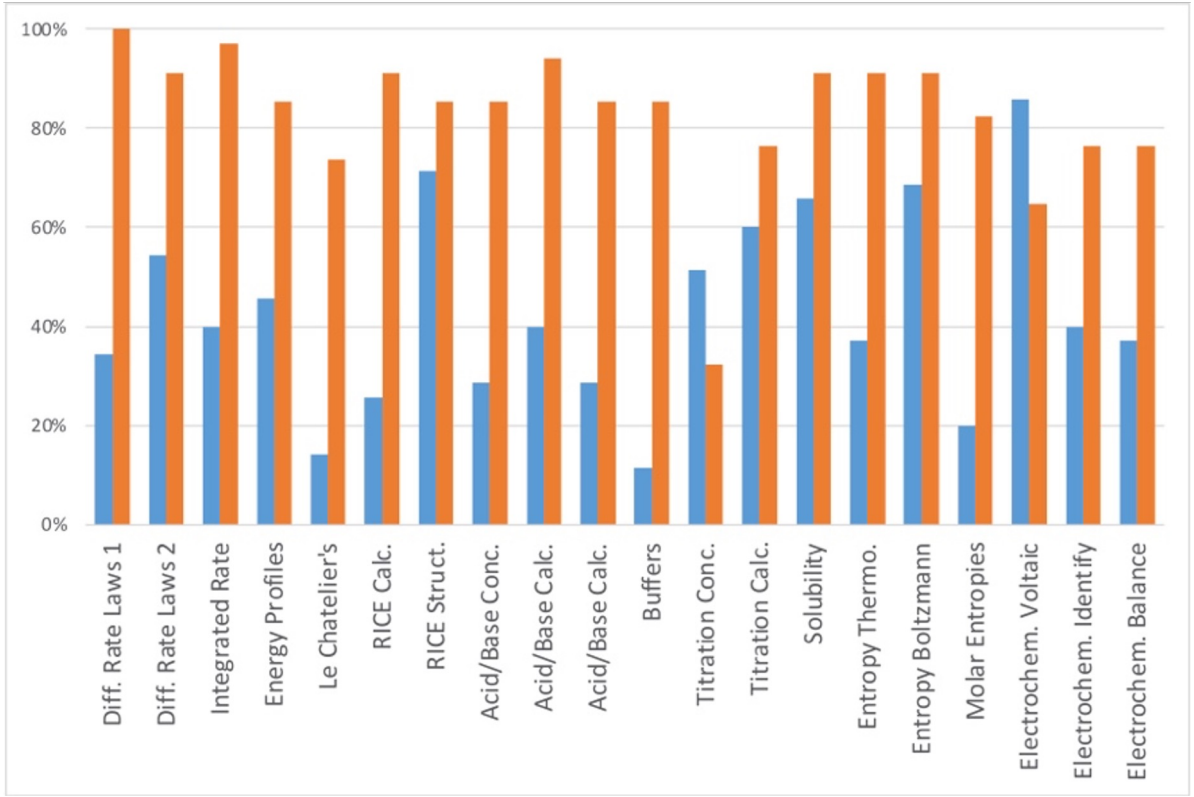
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CHEM 1110 percent correct per question



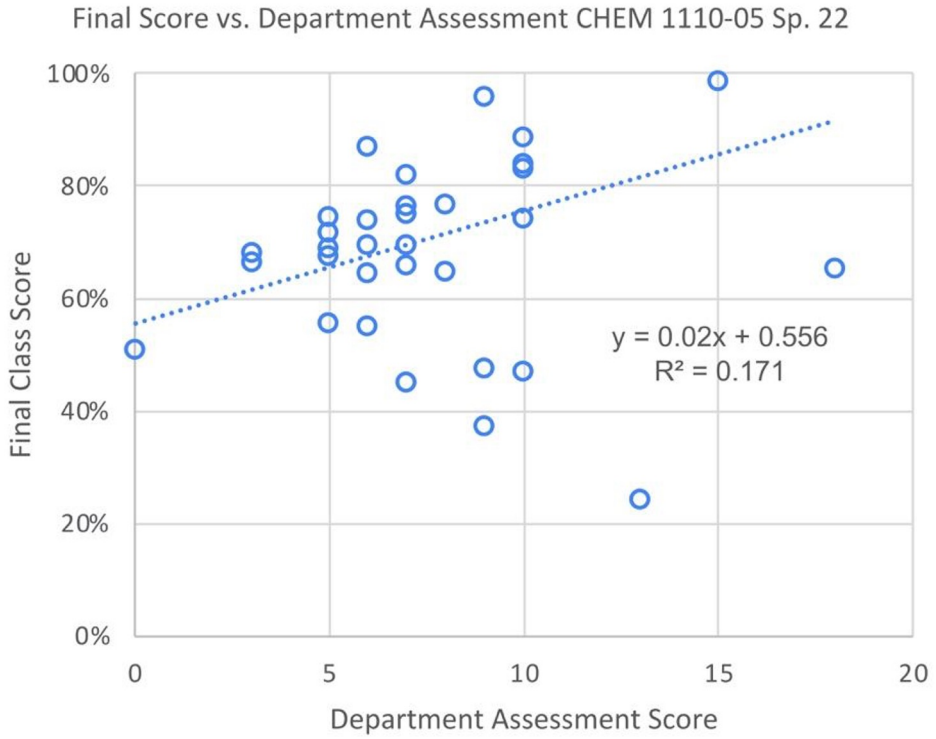
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CHEM 1110 percent correct per question



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CHEM 1110 final score vs assessment score



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Conclusion

- Closing the loop
  - Students performed well in mass number, electronegativity, intermolecular forces, ICE structure, solubility, and electrochemistry.
  - Students performed poorly on molar mass, stoichiometry, Le Chatelier's principle and buffers.
  - Data presented to department and assessment committee for curricular improvements.

- Challenges
  - Assessment quiz implementation must be standardized
  - Students who drop course do not take assessment quiz
  - Less than ideal correlation between assessment scores and final class score