University of California STEM FACULTY LEARNING COMMUNITY

UC STEM Faculty Learning Community Webinar

A Practice-Based Approach to Designing Equitable Undergraduate Science Courses

Presented by: Erin S. Palmer & Sabriya Rosemond
College of Chemistry, UC Berkeley

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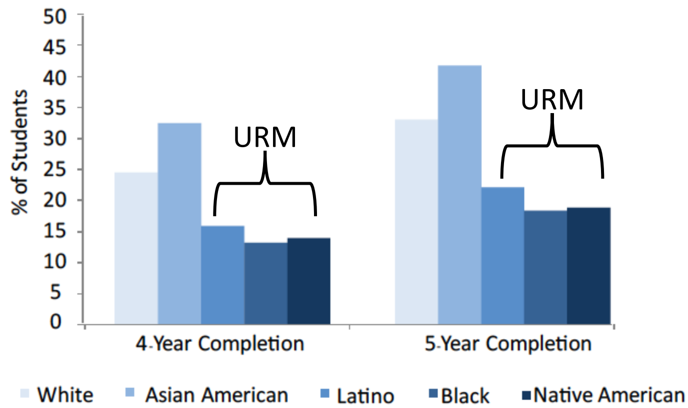
A Practice-Based Approach to Designing Equitable Undergraduate Science Courses

Erin S. Palmer, Sabriya N. Rosemond, Angelica M. Stacy



2004 STEM aspirants who completed STEM degrees in four and five years
Eagan, K. (2010). Degrees of Success, 1–4.

Highest rate of attrition occurs when students are taking gatekeeper courses

Chang et al. 2008; Seymour & Hewitt, 1997

Chem 1A as site of departure for Black students

Partnership with Multicultural Student Development Center

- Concerned about **Black students leaving** the sciences after Chem 1A
- Course led students to **question ability** to succeed in the sciences, particularly Black women.

Next Step: **Focus groups and interviews with students**

"I'ma **drop the class**, I think. Yeah please, I think **science isn't for me**. Like, I just **don't feel smart enough** to continue."

-Kristina
3 weeks into Chem 1A

Narratives about scientific brilliance exclude many students

(Leslie et al., 2015; Leonardo & Broderick, 2011; Nasir, Snyder, Shah & Ross, 2012; McGee & Martin, 2011).

(Carlone, 2004; Carlone et al., 2011).

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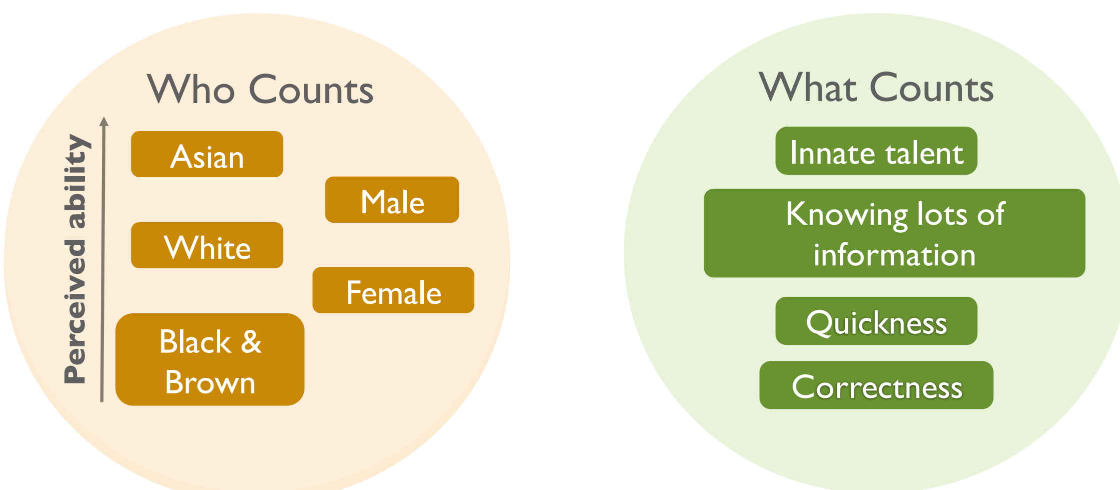


(Leslie et al., 2015; Leonardo & Broderick, 2011; Nasir, Snyder, Shah & Ross, 2012; McGee & Martin, 2011).

(Carlone, 2004; Carlone et al., 2011).

Students see Chem 1A as a "**weeder**" course

High enrollment
High competition

Fast pace with wide breadth of content

Expert knowledge holder

White, middle-class, academic language

Gasiewski, J. A., Eagan, M. K., Garcia, G. A., Hurtado, S., & Chang, M. J. (2011).

Photo from the Daily Cal, Feb 14, 2013, Katherine Chen

Science taught in classrooms incongruent with science as it's practiced

School Science

- Discrete body of facts
- Content available to be memorized
- Static
- Individualized learning

Science

- A way of thinking
- Set of practices
- Iterative, creative process
- Collective sense-making

Carlone, 2004; Redish & Hammer, 2009 ; Sevian & Talanquer, 2014; Talanquer, 2015

How can we reorganize our classrooms toward equity and learning that reflects science as practiced?

Goal

Socialize students into new ways of seeing and participating in science such that they:

- develop a rich, connected, and relevant understanding of chemistry
- recognize the various ways in which they are scientifically brilliant

Organizing principles that informed the curriculum design and participation structures

Organize curriculum around **central ideas and practices** of chemistry

Engage and support students in **collective** chemical practice

Recognize and leverage student **strengths and experiences**

Value and call out **expansive and inclusive** ways to be scientifically brilliant

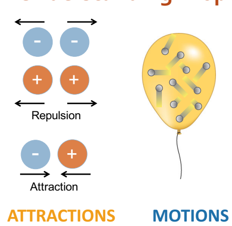
Building Around Big Ideas

CHEM 1A
MATTER AND CHANGE

Potential and kinetic energy considerations provide a powerful basis for explaining the macroscopic properties of matter and the ways in which matter interacts, combines, and changes on an atomic scale.

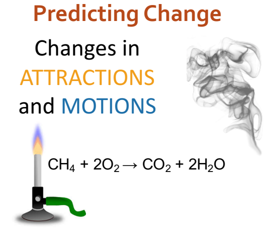
Central Ideas and Practices

UNIT 1: MATTER
Understanding Properties



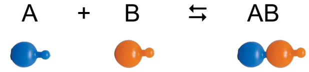
UNIT 2: ENERGY
Predicting Change

Changes in ATTRACTIONS and MOTIONS



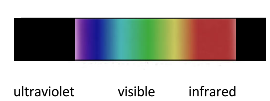
UNIT 3: EQUILIBRIUM
Managing Changes

A + B ⇆ AB

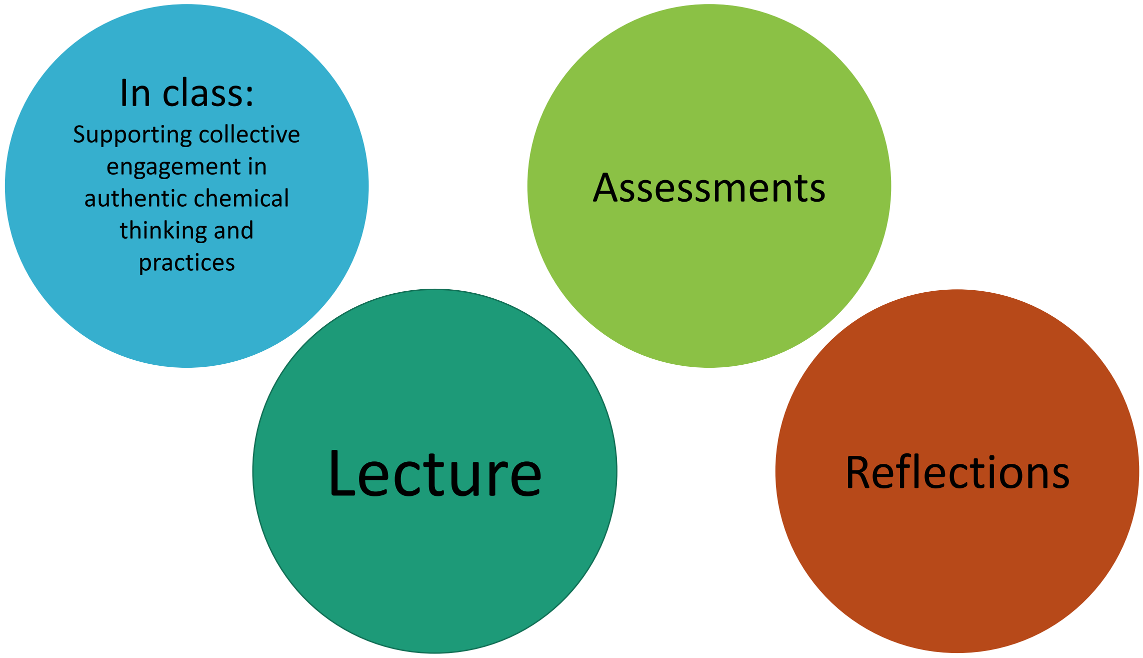


Competition between ATTRACTIONS and MOTIONS

UNIT 4: SPECTROSCOPY
Measuring Matter



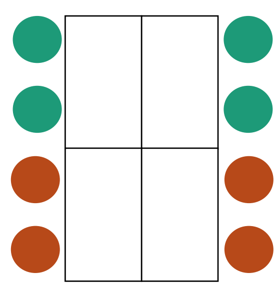
Modifying ATTRACTIONS and MOTIONS with light



In-class Organization

Collective Chemical practice

- Class met 50 minutes 3x per week
- Multi-tiered instructional staff
- Course for non-chemistry majors
- Students with 1≤ year of HS chemistry or repeating
- 100+ students working in teams of 4-5



Designing in-class activity that engages students in chemical practice

- Incorporate and build upon big ideas
- Data-centered
- Invite multiple ways of engagement
- Multiple valid approaches
- Not reliant on formal scientific language

Central Ideas and Practices

Collective Chemical Practice

Student Strengths and Experiences

Designing in-class activity that engages students in chemical practice

- Incorporate and build upon big ideas
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L10: Attractive Molecules

Today's Question: What aspects of molecular structure affect the strength of attractions between similar molecules?

Your Task: Your team will use the data on the **Intermolecular Force Cards** to examine the relationship between structure and boiling point.

Examine the Relationship Between Structure and Boiling Points

Randomly divide up the cards, and then work together as a team of 4.

1. **Examine** the information on each of the **Intermolecular Force Cards**.
   Note: You will **NOT** be using the solubility information today.
2. **Create** as many groups of cards as possible based on similarities of the substances on the cards.
   Note: Some cards may belong to **more than one group**. Don't be afraid to rearrange cards once data have been recorded.
3. **Observe** and **Record** how the boiling point changes within each group and what else differs between the cards within a group.
   Note: In some cases, it might not be possible to strictly control for only one variable. As a team, reason together about what variable is the **main** factor causing the trend in boiling point.

Bringing it Together: Make Claims About Attractions and Boiling Point

Work together as a team of 4. Make sure that each member contributes one claim.

4. **Construct** at least 4 claims about **how** each variable relates to the changing boiling point. Be sure to provide evidence from your card sort. Record each claim on your Note Sheet.
   For example: As the molar mass (increases/decreases), the boiling point (increases/decreases) as evidenced by…

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Central Question of the day

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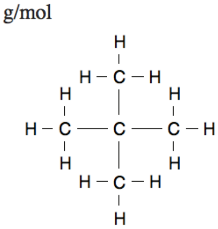
General Description of the day's task

Intermolecular Force Cards

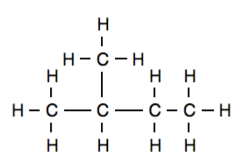
molar mass; 72 g/mol | boiling pt: 10°C



C_5H_{12}
neopentane

solubility in water: 0 | solubility in hexane: ∞

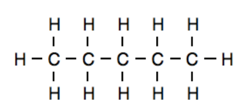
molar mass: 72 g/mol | boiling pt: 28°C



C_5H_{12}
isopentane

solubility in water: 0 | solubility in hexane: ∞

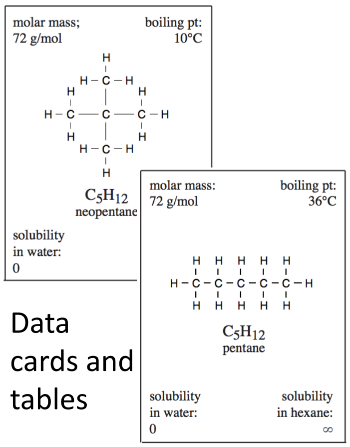
molar mass: 72 g/mol | boiling pt: 36°C



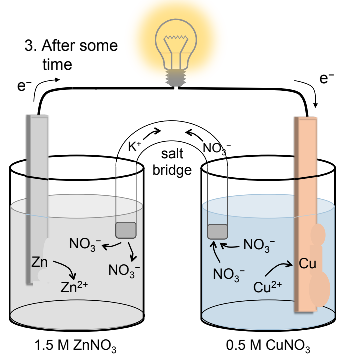
C_5H_{12}
pentane

solubility in water: 0 | solubility in hexane: ∞

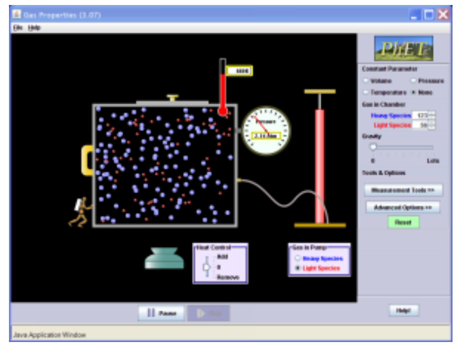
Students worked with various types of data



Data cards and tables



Images



Animations and simulations

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Guiding directions, questions, and hints to support the team to work with data

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Team Product

Bringing it Together

4. **Construct** at least 4 claims about **how** and **why** each variable relates to the changing boiling point. Record each claim on your Note Sheet.
   For example: As the molar mass (increases/decreases), the boiling point (increases/decreases) because…

Note Sheets provide organizational support

L10: ATTRACTIVE MOLECULES – *Liquids* **Note Sheet**

LEARNING GOALS – Students should be able to:

- Explain how Coulomb's law relates to intermolecular forces of attraction/repulsion
- Identify specific types of intermolecular forces between molecules
- Explain how various structural factors affect the strength of intermolecular attractions
- Explain properties, mainly boiling point and vapor pressure, in terms of molecular structure and intermolecular forces

Examine the Relationship Between Structure and Boiling Point

What stays roughly the same?	What changes?	Pattern of boiling point
Molar mass across a row: CH_4, NH_3, HF		
Formula		
Chain length		
Shape		

Challenges of Task Design

- Choosing which concept(s) to include in 40 minutes
- Choosing and designing data
- Keeping the tasks open while still providing necessary support

Supporting the Task:

Support equitable engagement in the tasks and support students recognition of their brilliance

Task launch: re-framing competent scientific learning

Central Ideas and Practices

Expansive and Inclusive Scientific Brilliance

- Situate student work within the context of the course
- Orient students to any new tools needed to complete the day's activities
- Reframe scientific thinking and learning

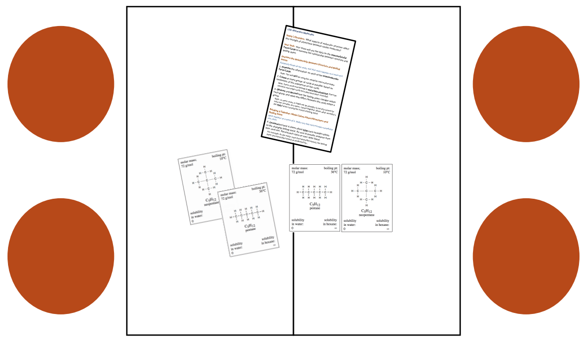
The Smart Things List: providing explicit language to call out collective scientific practice

Expansive and Inclusive Scientific Brilliance

Collective Chemical Practice

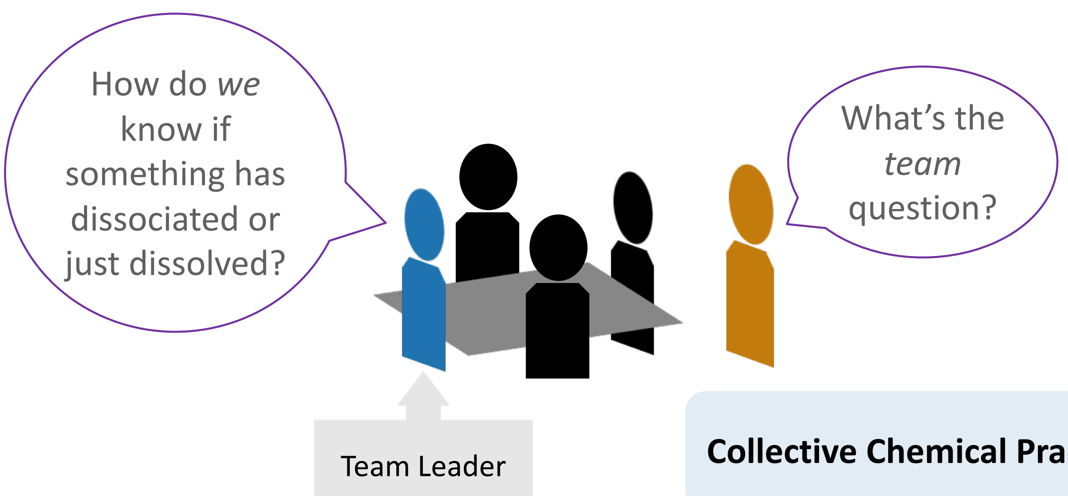
1. Recognize patterns in data
2. Make connections to Coulomb's Law
3. Control variables
4. Try multiple possibilities when grouping cards
5. Justify your ideas in ways other people can follow
6. Offer ideas even if they may not end up being right
7. Ask for people's reasoning when they offer ideas

Support equitable sharing of resources



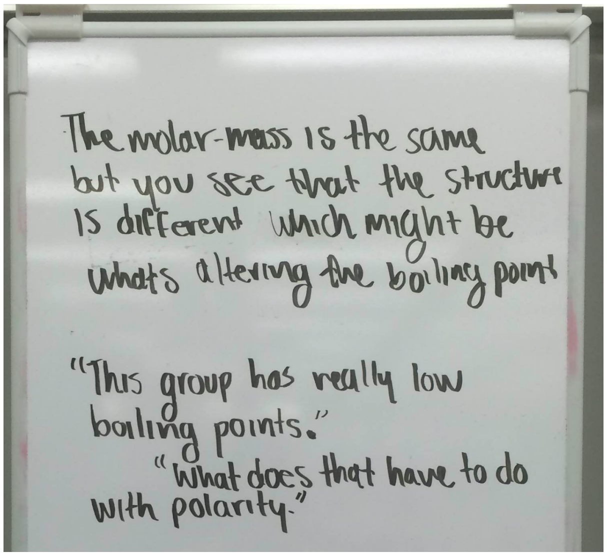
Collective Chemical Practice

Team leader held accountable for communicating group thinking



Collective Chemical Practice

Making student thinking public



Expansive and Inclusive Scientific Brilliance

Closing: calling out and connecting student thinking to chemistry

- Highlight brilliant scientific thinking
- Connect task and students thinking to authentic science practice

Student Strengths and Experiences

Expansive and Inclusive Scientific Brilliance

You guys are asking great questions that are getting me to think in different ways.

Challenges of supporting equitable engagement

- Re-learning how to interact with students
- Hard to intervene appropriately when we can't hear student thinking

In class

Assessments

Lecture

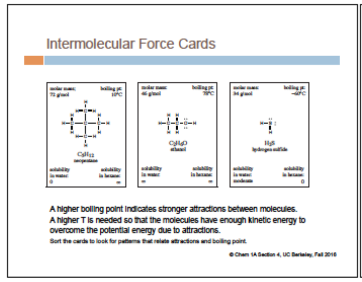
Building on, and expanding what students learned from the Tasks

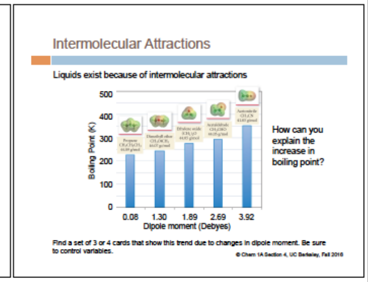
Reflections

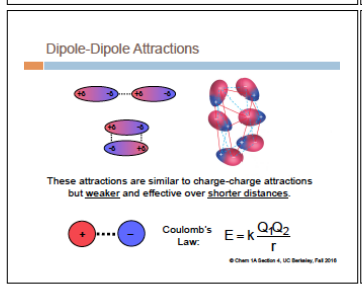
After class: Video lecture is designed for concept review and introduction to formal language

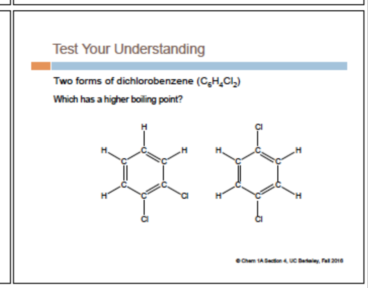
- Review Task
- Introduce formal chemical language
- Connect to previous concepts
- Contextualize chemistry

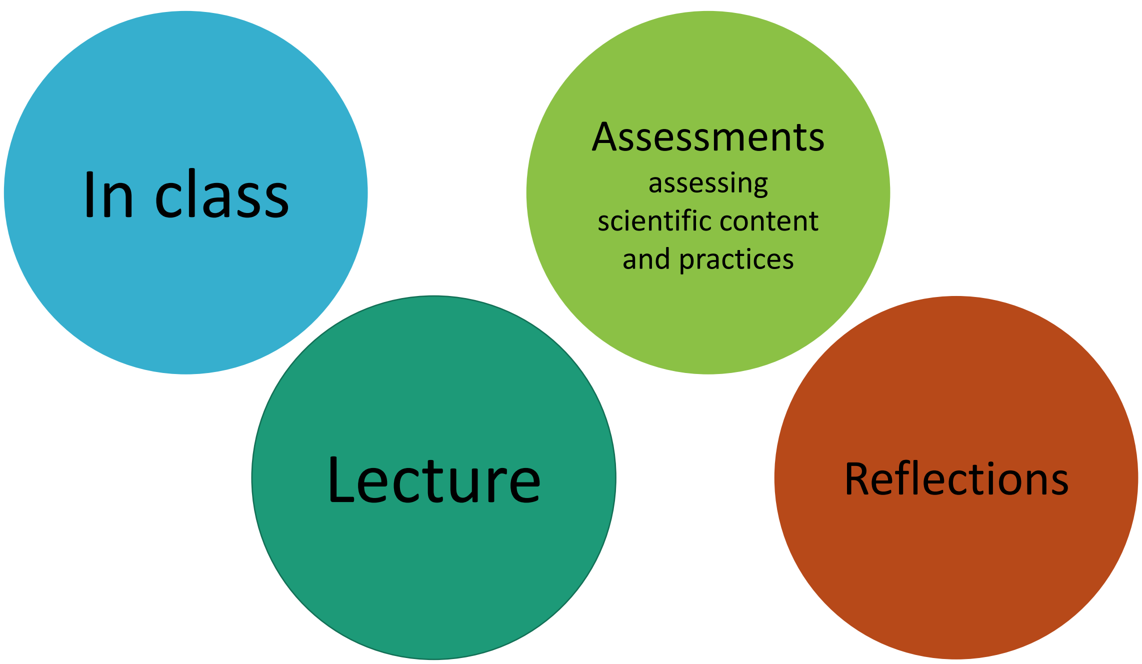
Central Ideas and Practices





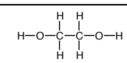
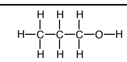
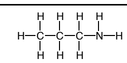
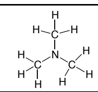






Question Design: engaging students in chemical practice to assess content and practice learning

Central Ideas and Practices

INTERMOLECULAR ATTRACTIONS				
Substance	Molecular formula	Structural formula	Molar mass (g/mol)	Boiling point
ethylene glycol	$HOCH_2CH_2OH$		62	197ºC
propanol	$CH_3(CH_2)_2OH$		60	98ºC
propylamine	$CH_3(CH_2)_2NH_2$		59	48ºC
trimethylamine	$(CH_3)_3N$		59	3ºC

Which statement provides the most compelling explanation of the data?

a) O−H···O is stronger than H−N ··· H
b) O−H ··· O is weaker than H−N ··· H
c) Boiling point increases with molar mass.
d) Increasing the number of CH_3 groups decreases the boiling point.

The boiling point of ethylene glycol is much higher than the boiling point of propanol. **Draw a structure showing the interaction between ethyleneglycol molecules to explain its high boiling point.**

Communicating Science Project: an opportunity for science language learning and practice

Expansive and Inclusive Scientific Brilliance

Central Ideas and Practices

Student Strengths and Experiences

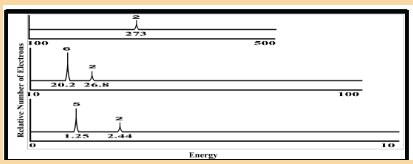
Description

- Students chose either a hormone or toxic metal salt
- Explain the chemistry of their compound to two audiences
  - Classroom Community (formal scientific language)
  - Friends and Family (informal language)
- Peer review

Unit 4: Spectroscopy

Design a post that will teach your audiences about how you can use **spectroscopy** on your **entire compound or an element in your compound** to gain information about your compound.
Compound: Mercurous Chloride

Classroom Community



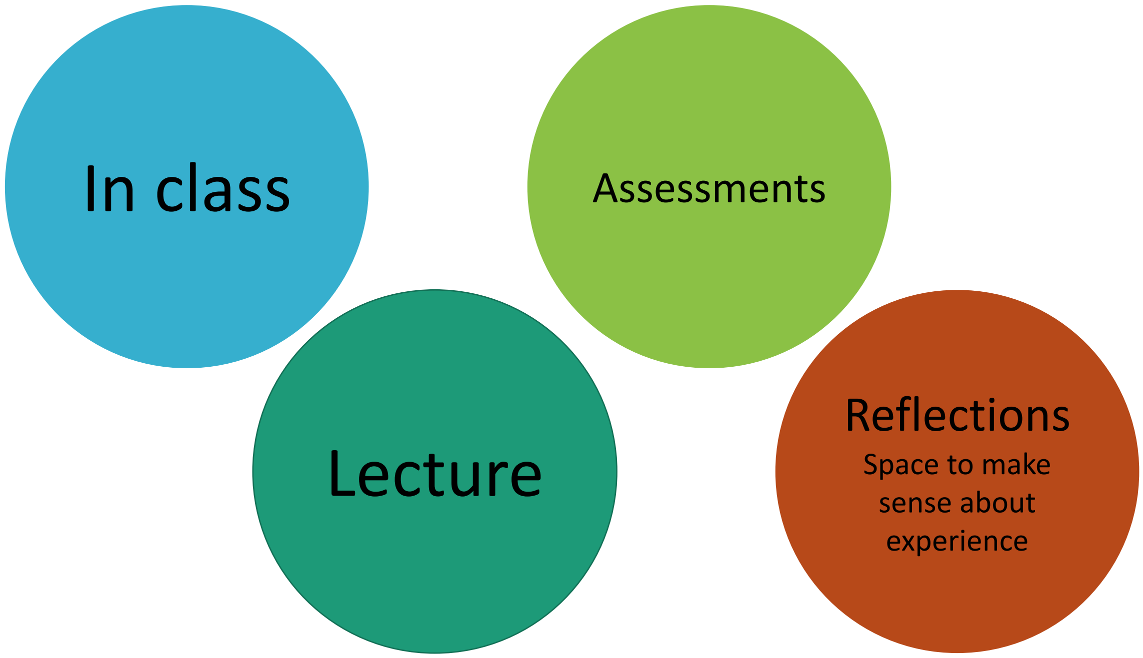
This energy must be large enough to break Coulomb's attractions between the negatively charged electrons and the positively charged nucleus. This suggests that those electrons furthest from the nucleus would require less energy to break because it has a lower attraction, whereas those in the innermost shell would be the most difficult to eject.

Friends and Family

Think of the picture above (Figure 1), where the man has a bunch of layers on. Which layers would be easiest to take off? Well, they would be the ones that are outermost or on top. To take off one of the base layers, you would need more energy because you'd have to dig through all the ones on top

Challenges with assessment design

- Quiz and Exams
  - Finding relevant and accessible data
- Communicating Chemistry
  - Substances with complicated chemistry
  - Not all substances work well with all units



Science Skill Reflection: opportunity to define what counts as central to doing science

Expansive and Inclusive Scientific Brilliance

Which set of skills are you most interested in reflecting on for Unit 1?

- (●) Bouncing back from setbacks
- ( ) Diligent Skepticism
- ( ) Intellectual Courage
- ( ) Collaboration
- ( ) Making Connections

When I struggle, I remind myself that encountering setbacks is a normal part of the work of a scientist. Disagree ( ) ( ) ( ) ( ) Agree

Reflection Feedback: frame responses as shared experience and challenges

- Publicize and normalize concerns
- Explicit connection to science
- Remind students that they are taking on challenging work
- Point them to resources

"Many of you said you're feeling nervous about holding others back by asking questions. . ."

"Wrestling with ideas, struggling, not yet knowing how to form a chemical explanation from data is a normal and important part of the work of doing science."

Student Strengths and Experiences

Final Course Reflections

- How have your ideas about chemistry learning been changed, challenged or confirmed this semester?
- How have your ideas about what it takes to think like a chemist been changed, challenged or confirmed this semester?

Findings

Using video, survey, interview and student work to understand impact of participation

Goal

Socialize students into new ways of seeing and participating in science such that they:

- develop a rich, connected, and relevant understanding of chemistry
- recognize the various ways in which they are scientifically brilliant

Preliminary findings suggest that we are moving towards our goal

- Video data:
  - Students are engaging in scientific practice e.g. Asking chemical questions, and Identifying patterns
- Survey Data:
  - Positive shifts in how students view their relationship to science, e.g. "I am good at science", "I feel a connection with the science community"
- Interview Data:
  - Students see learning as iteratively constructing understanding from data
  - Students have expansive, practice-centered definitions of what it means to be 'good at chemistry'

"Before I had the preconceived notion that being a chemist took some form of innate ability and intelligence but now I know that being a chemist is more than just that. Thinking like a chemist is simply being inquisitive, hardworking, and open to new ideas. Chemistry is more than just getting the right answers, learning the concepts actually means something to me now."

Vin, Course Reflection

Acknowledgements

- Students in all iterations of redesigned Chem1A
- Office of Multicultural Student Development
  - Nzingha Dugas
  - Lupe Gallegos-Diaz
- Education Opportunity Program
  - Yuki Burton
- Office of the Registrar
  - Walter Wong
  - Pam Armstrong
- College of Chemistry
  - Chemistry Library
  - Lucia Briggs
- College Advisors
  - College of Engineering
  - College of Natural Resources
  - Letters and Sciences
- Funding: University of California, Berkeley

THANK YOU!!