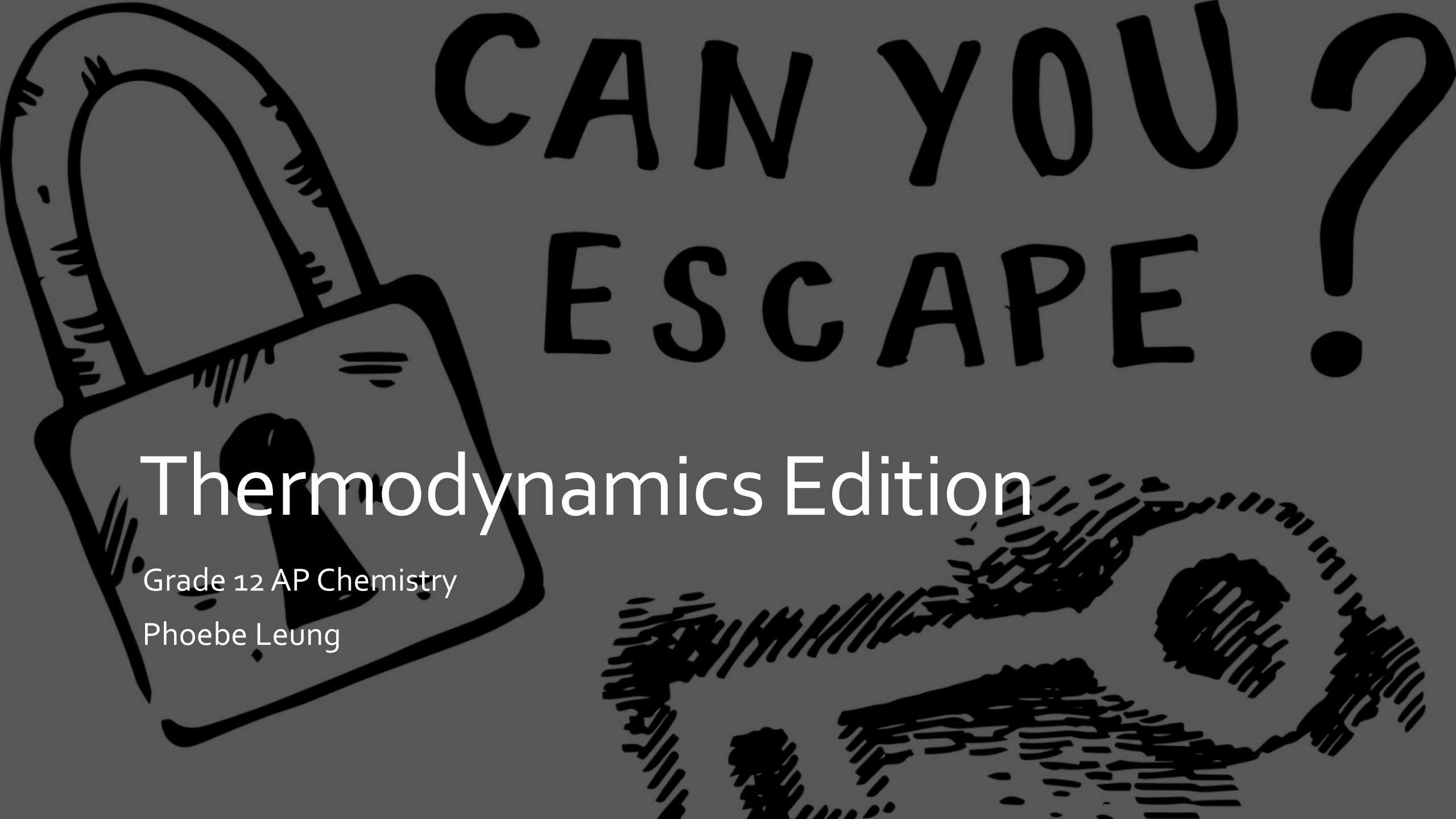


Thermodynamics Edition

Grade 12 AP Chemistry

Phoebe Leung

Purpose

- To implement an alternative form of assessment that combines the theory of a written test, and the practical skills of a lab experiment
- Carried out in the form of the popularized *Escape Room* games

Curriculum Connection SCH4U

Big Ideas

1. A. Scientific Investigation Skills
   - A1.2: Select appropriate instruments and materials, and identify appropriate methods, techniques, and procedures, for each inquiry
   - A1.5: Conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials, and equipment safely, accurately, and effectively, to collect observations and data
2. B. Organic Chemistry
   - B2.1: Use appropriate terminology related to organic chemistry
   - B3.2: Describe the similarities and differences in physical properties within each class of organic compounds
3. D. Energy Changes and Rates of Reaction
   - D2.1: Use appropriate terminology related to energy changes and rates of reaction
   - D2.2: Write thermochemical equations, expressing energy changes as ΔH value or as a heat term in the equation
   - D2.3: Solve problems involving analysis of heat transfer in a chemical reaction, using $q = mC\Delta T$
   - D2.8: Plan and conduct an inquiry to determine how various factors affect the rate of a chemical reaction

Rules

- A maximum of 50 minutes to escape the room
  - 100 points if no help is needed and escaped within the given time
  - Buy a hint for 10 points (maximum of 3 hints given)
    - Must wait 10 minutes between hints
  - 10 extra points earned if your group can escape in the first 30 minutes
- Groups of 3

Materials

- Baking Soda
- Borax
- Calcium chloride
- Distilled Water
- Hydrochloric acid
- Magnesium sulfate
- Sodium chloride
- Sodium hydroxide
- Vinegar
- Thermometer
- Test tubes & Stoppers
- Test tube holder / clamp

Challenge #1: Let there be light!

- On the wall, you will find a light switch. You need to turn on the light (by hitting the cover), but you cannot touch it. The immediate area in front of the light is littered with broken glass. Therefore, you must stand 1 meter away from it (defined by caution tape).You must turn on the light using a chemical reaction.
- **Goal**: Shoot the rubber stopper at the tap light to turn it on

1. Write a balanced chemical equation for the reaction used.
2. What information would you need to calculate the amount of work involved in this process?
3. What is the *sign* of work for this process?
4. What is the sign of $\Delta H, \Delta S, \Delta G$ for the reaction you used? Justify your answer in each case.

Challenge #2: Free the Key

- Uh-oh! You've found the key, however, it is buried in ice. You need to FREE the key by performing a chemical reaction.
  - There are no Bunsen burners, hot plates, or sources of fire available
- **Goal**: Devise a chemical reaction to free the key

1. Write a balanced chemical equation for the reaction used.
2. What is the value of ΔH for the reaction used? (Assume no heat is lost to the container, and that the specific heat capacity is the same as water)
3. What is the sign of ΔH, ΔS, and ΔG for the reaction used? Justify your answer in each case.

Challenge #3: Free the lock

- Now that you've freed the key, it's time to free the lock. The lock is buried in glue. You need to separate the lock from the glue with a chemical reaction.

Goal: Devise a chemical reaction to free the lock

1. What kind of polymer did you make in this reaction?
2. Microscopically, what happened as the substances were mixed together?
3. What is the ΔS for the reaction? Justify your answer.
4. Is this reaction driven by enthalpy only, entropy only, or both? Explain.

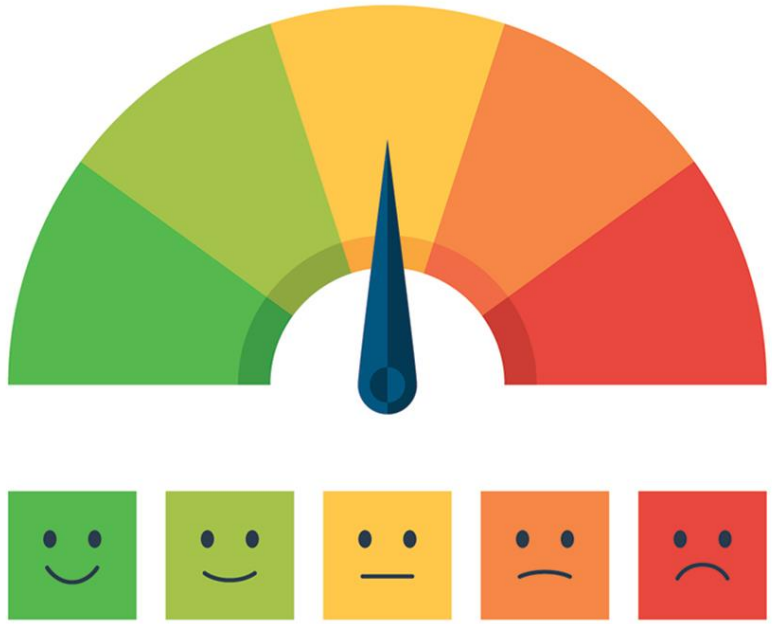
almost

WE ESCAPED!

WE BROKE OUT!

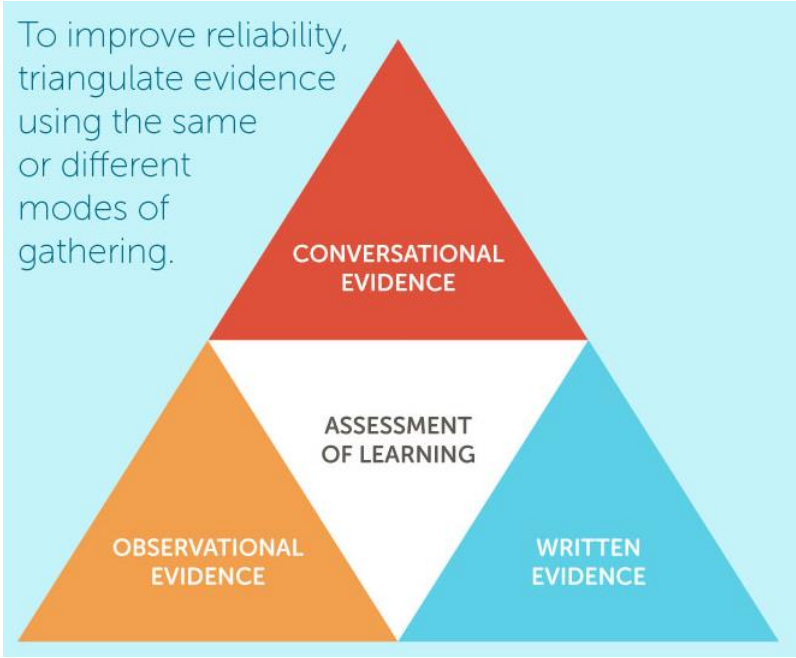
Student Feedback

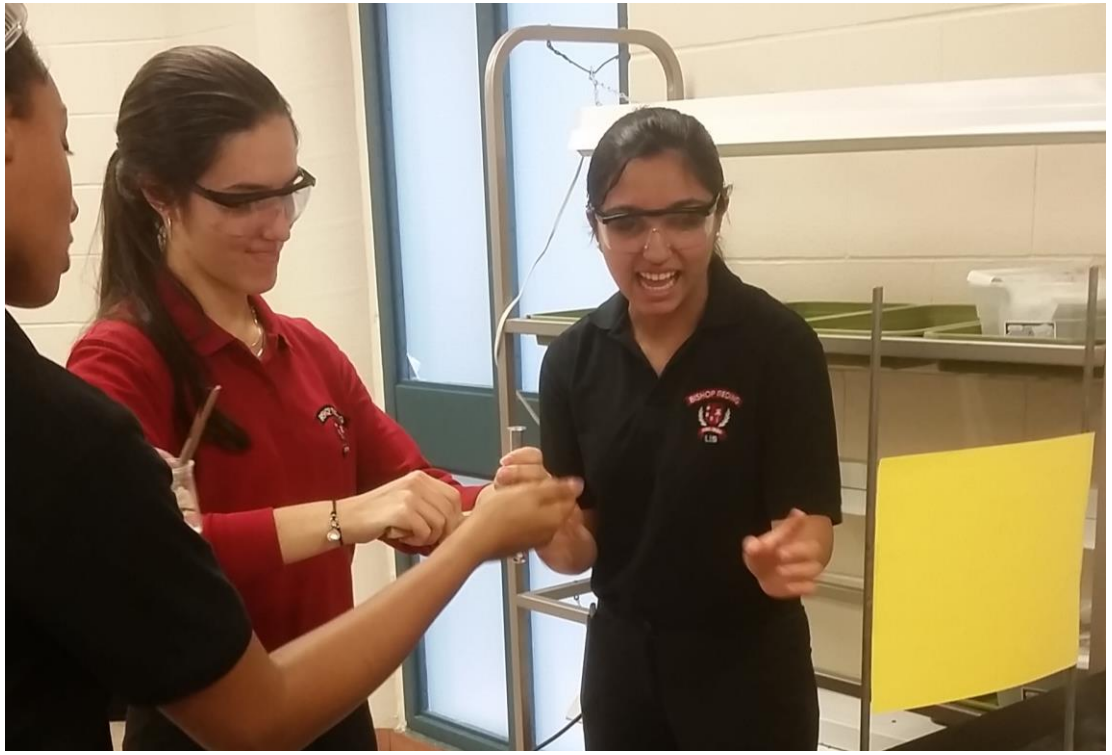
- "Can we do this activity for the next unit?"
- "This is a great STEM activity. May we use it for the STEM conference for elementary feeder schools?"
- "It would be great if we had more equipment (i.e. lock and keys, props) available to us."
- "Can we design our own escape room for each other?"

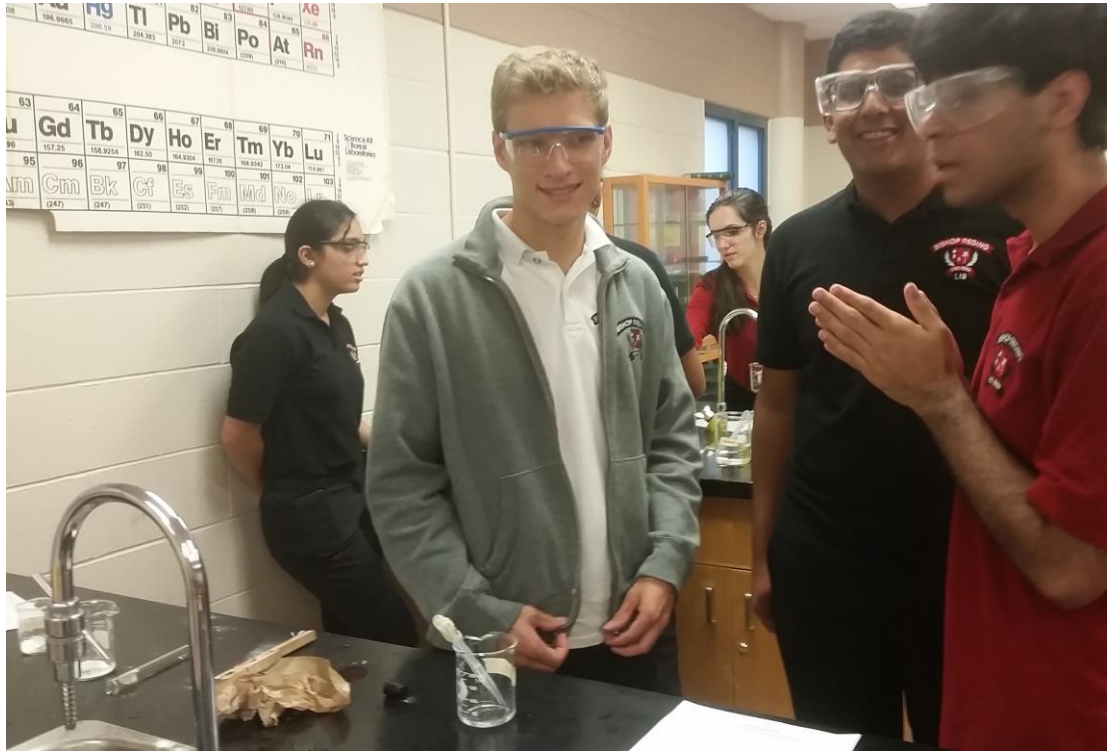


Teacher Reflection

- Inquiry-based activity that promotes collaboration and reviews essential concepts in a non-traditional manner
- Student directed activity that allows students to record observational data, engage in dialogue with peers, and demonstrate their knowledge in written form
- Assessment AS learning during verbal discussions

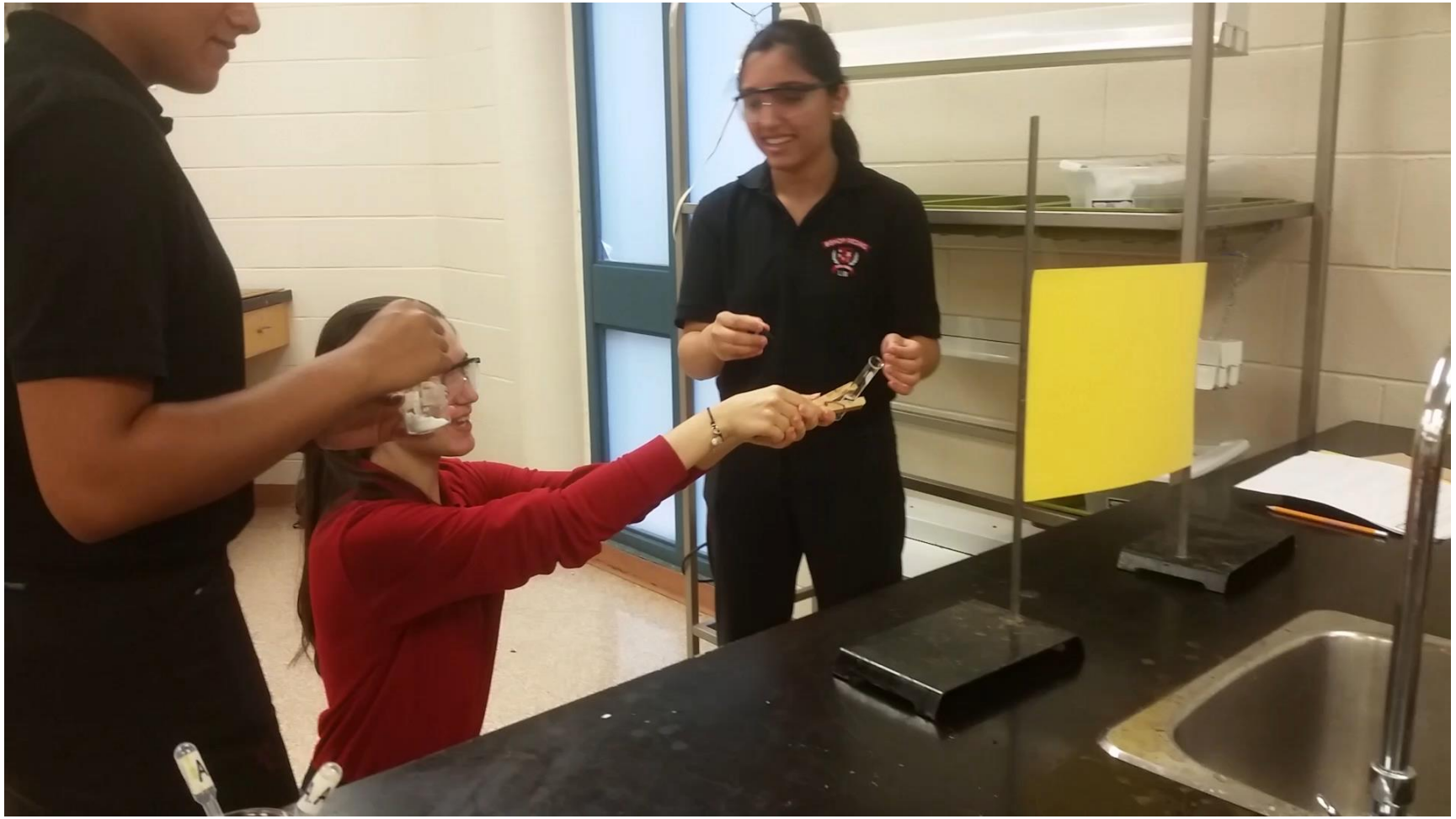






Student Exemplars

In Action!



Student Exemplar

1. Write a balanced chemical equation for the reaction you used.

$NaHCO_3(aq) + CH_3COOH(s) \longrightarrow NaC_2H_3O_2(aq) + H_2O(l) + CO_2(g)$

2. What SPECIFIC information would you need to calculate the numeric value of the work involved in this process?

You would need the pressure in atm and the change in volume to use the $w = -P\Delta V$ formula to calculate work.

3. What is the sign of work for this process? Justify your answer.

Since work is done by the system (turn on the light by applying a force resulting from the reaction), the sign of work is negative.

4. What is the sign of ΔH, ΔS and ΔG for the reaction you used? Justify your answer in each case.

ΔH ⊕ → Endothermic, temperature decreased

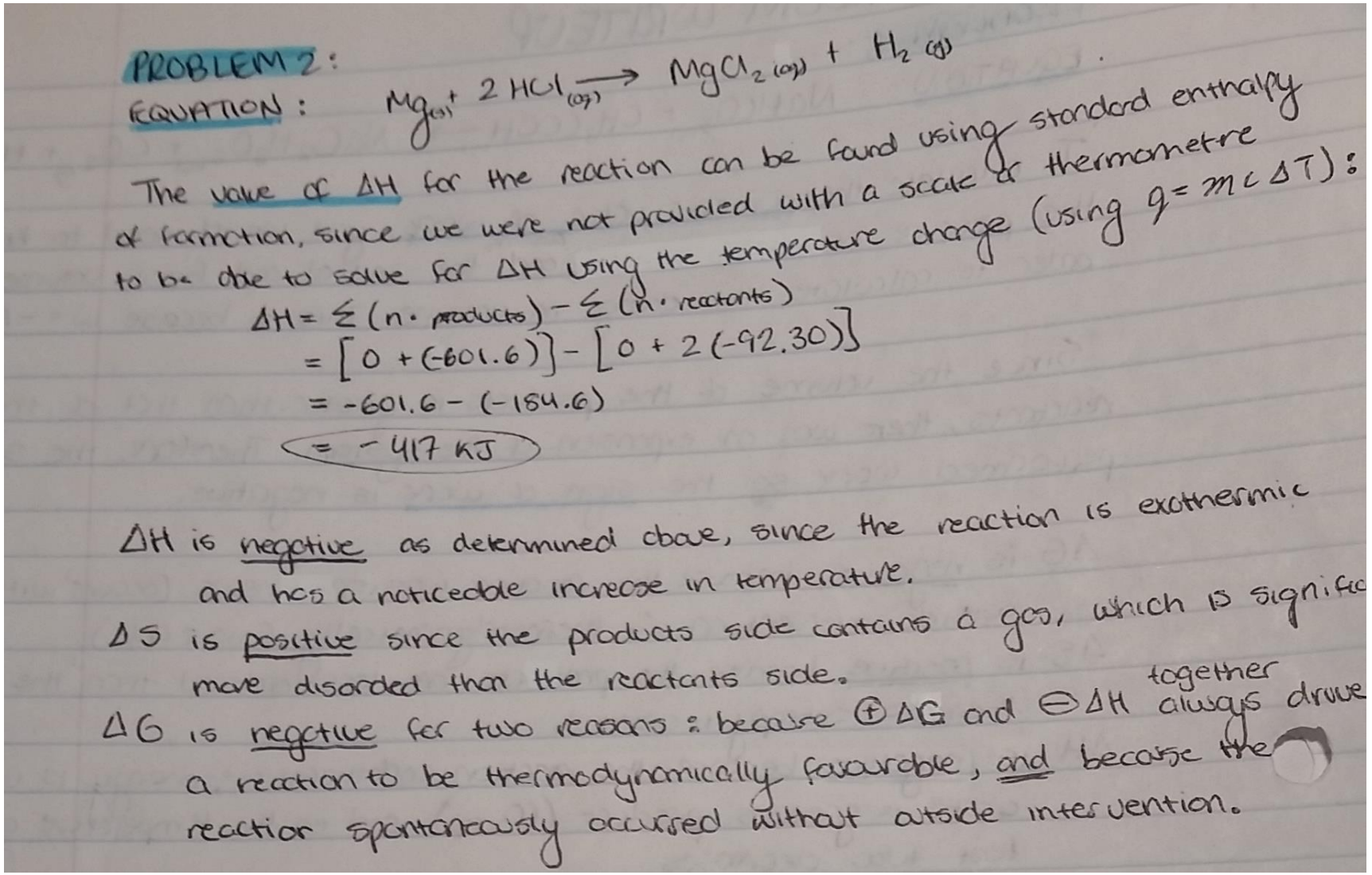
ΔS ⊕ → States transition from solid to liquid and gas which indicates an increase in disorder.

ΔG ⊖ → Experimentally, the reaction occured without intervention, $T\Delta S$ must be larger than ΔH if it is spontaneous (ie higher temperatures).

Write a procedure that could be followed by someone with your level of chemical knowledge to reproduce your results.

1. Fill a test tube half way with vinegar.
2. Quickly add approximately 2 scoops of baking soda into the test tube and cover with a stopper immediately.
3. Aim the test tube at the light switch. May need to try several times until target is reached (repeat entire process).

Student Exemplar



PROBLEM 2:

EQUATION: $Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$

The value of ΔH for the reaction can be found using standard enthalpy of formation, since we were not provided with a scale or thermometre to be able to solve for ΔH using the temperature change (using $q = mc\Delta T$):

$\Delta H = \Sigma(n \cdot \text{products}) - \Sigma(n \cdot \text{reactants})$

$= [0 + (-601.6)] - [0 + 2(-92.30)]$

$= -601.6 - (-184.6)$

$= -417\ kJ$

ΔH is negative as determined above, since the reaction is exothermic and has a noticeable increase in temperature.

ΔS is positive since the products side contains a gas, which is significa more disorded than the reactants side.

ΔG is negative for two reasons: because ⊕ ΔG and ⊖ ΔH together always drive a reaction to be thermodynamically favourable, and because the reactior spontaneously occurred without outside intervention.

Student Exemplar

Problem 3: Free the lock

Now that you've freed the key, it's time to free the lock. The lock is buried in glue and water. You need to make the mixture more viscous in order to easily grab the lock from the beaker. Luckily, Ms. Leung give you a clue and tells you to add Borax to help you. She provides an info sheet as well.

1. What is the sign of DS for the reaction? Justify your answer.

The sign of Δs for the reaction would be negative. This is because the liquid-like glue becomes more viscous or solid-like as the borax solution is added.

2. Is this reaction driven by enthalpy only, entropy only or both enthalpy and entropy? Justify your answer.

This reaction is driven by enthalpy only. This is because entropy is negative and thus must work against the reaction since the universe prefers positive or an increase in entropy. Therefore, since the reaction is spontaneous the enthalpy must drive the reaction since entropy counteracts the reaction.

Credits

- Original creator: *Elizabeth Christophy*

Helpful Resources:

- All About That Base "Escape Room"