An Alternative to the Misconceptions View of Learning and Assessment

Ryan Stowe

December 3rd, 2021

Acknowledgements

WARF
Wisconsin Alumni Research Foundation

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DUE 1725520

Rarely is the question asked:
Is our children learning?

- George W. Bush

How will we know students are progressing toward the goals we value?

We want chemistry students to explain how and why phenomena occur in terms of atomic/molecular behavior

Our Phenomenon for Today

Our Phenomenon for Today

Yes, this is lithium chloride

Our Phenomenon for Today

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Our Phenomenon for Today

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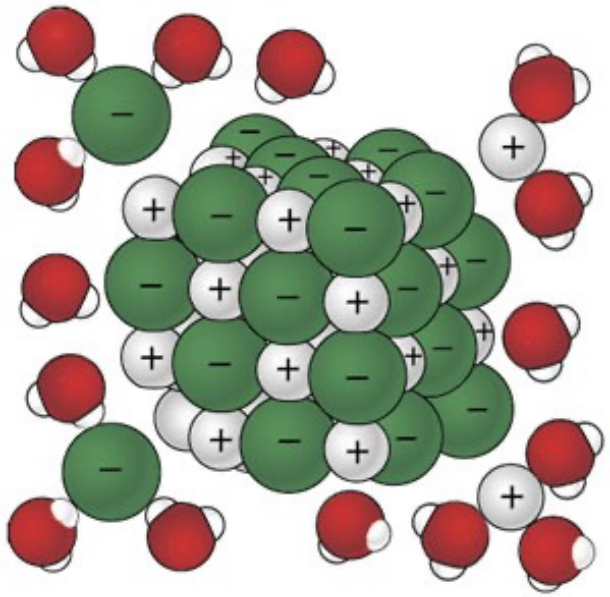
Our Phenomenon for Today



https://www.middleschoolchemistry.com/multimedia/chapter5/lesson3

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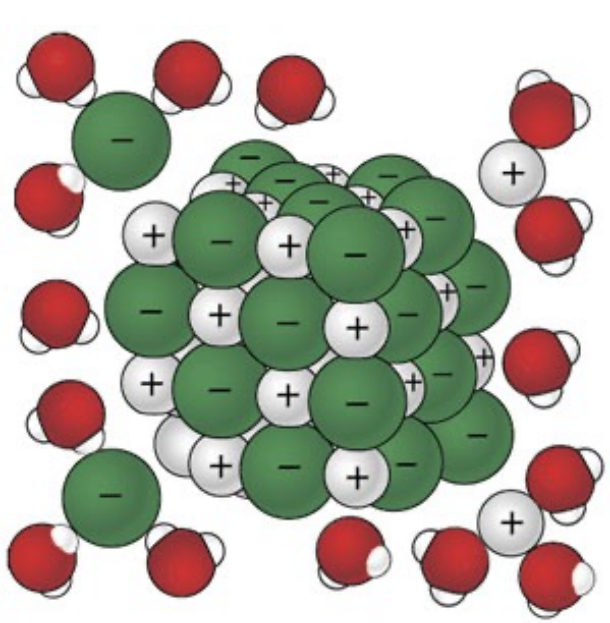

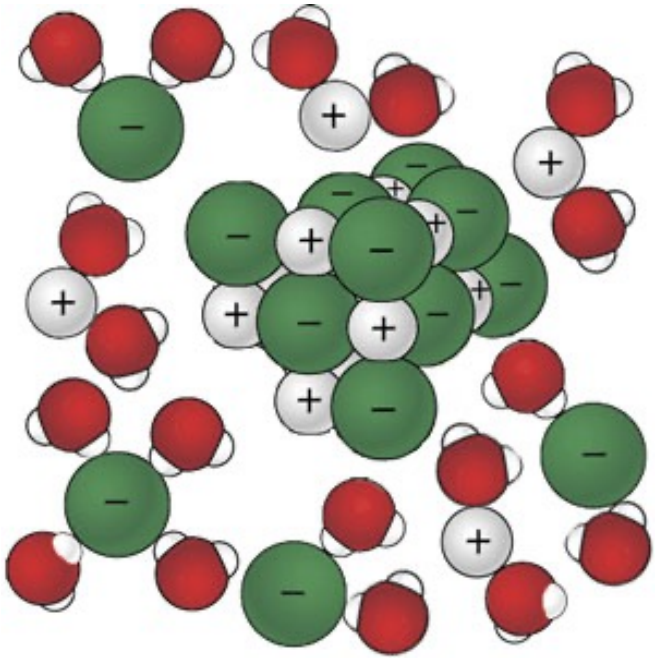

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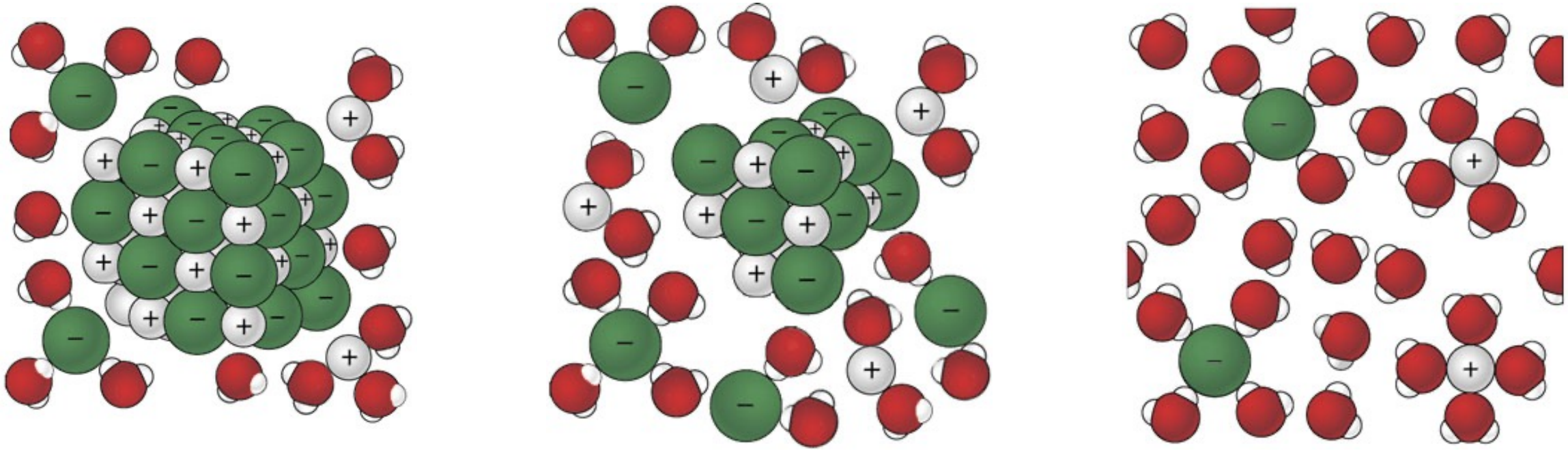

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Assessing Learning

Exactly what knowledge do you want students to have, and ***how*** do you want them to know it?

Mislevy, R.; Haertel, G. **2006**. *Educ. Meas. Issues Pract.*, 33, 379-416.

Defining our expectations

Develop and use a model to explain the energy flow into or out of a system that occurs when a substance is dissolved in terms of the energetics of forming and breaking electrostatic attractions between solute and solvent particles

The National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*; National Academies Press: Washington, D.C., 2012.

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SEP: Developing and Using Models

DCI: Electrostatic and Bonding Interactions, Energy

CCC: Systems and System Models, Energy and Matter

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Assessing Learning

Exactly what knowledge do you want students to have, and ***how*** do you want them to know it?

What will you accept as ***evidence*** that a student has the desired knowledge?

How will you ***analyze and interpret*** the evidence?

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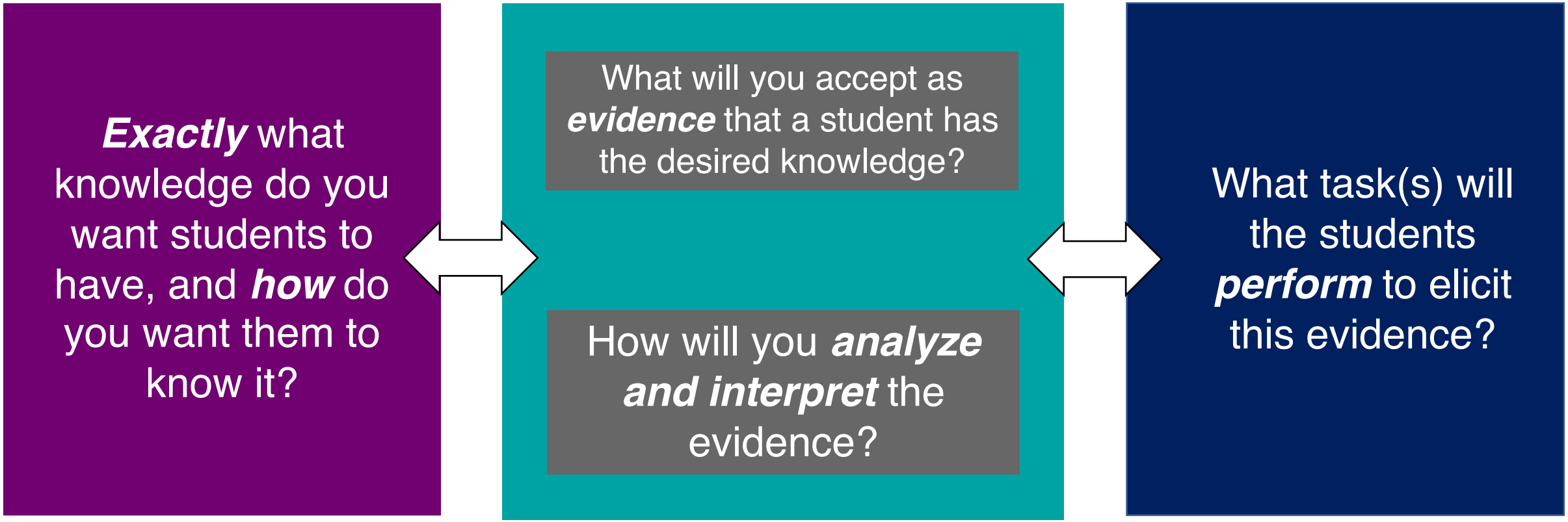
Assessing Learning



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1. In the boxes below, draw a **molecular level representation** of the sequence of events required for LiCl to dissolve in water

Undissolved	**Dissolving**	**Dissolved**

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2. Referring to the diagram you drew for question #1, **describe** the sequence of events that happens when solid LiCl dissolves in water.

3. When LiCl dissolves, the temperature of the solution increases (it gets warmer). Explain **why the temperature goes up.**

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We’re missing something rather important in this discussion

Observation

Observation

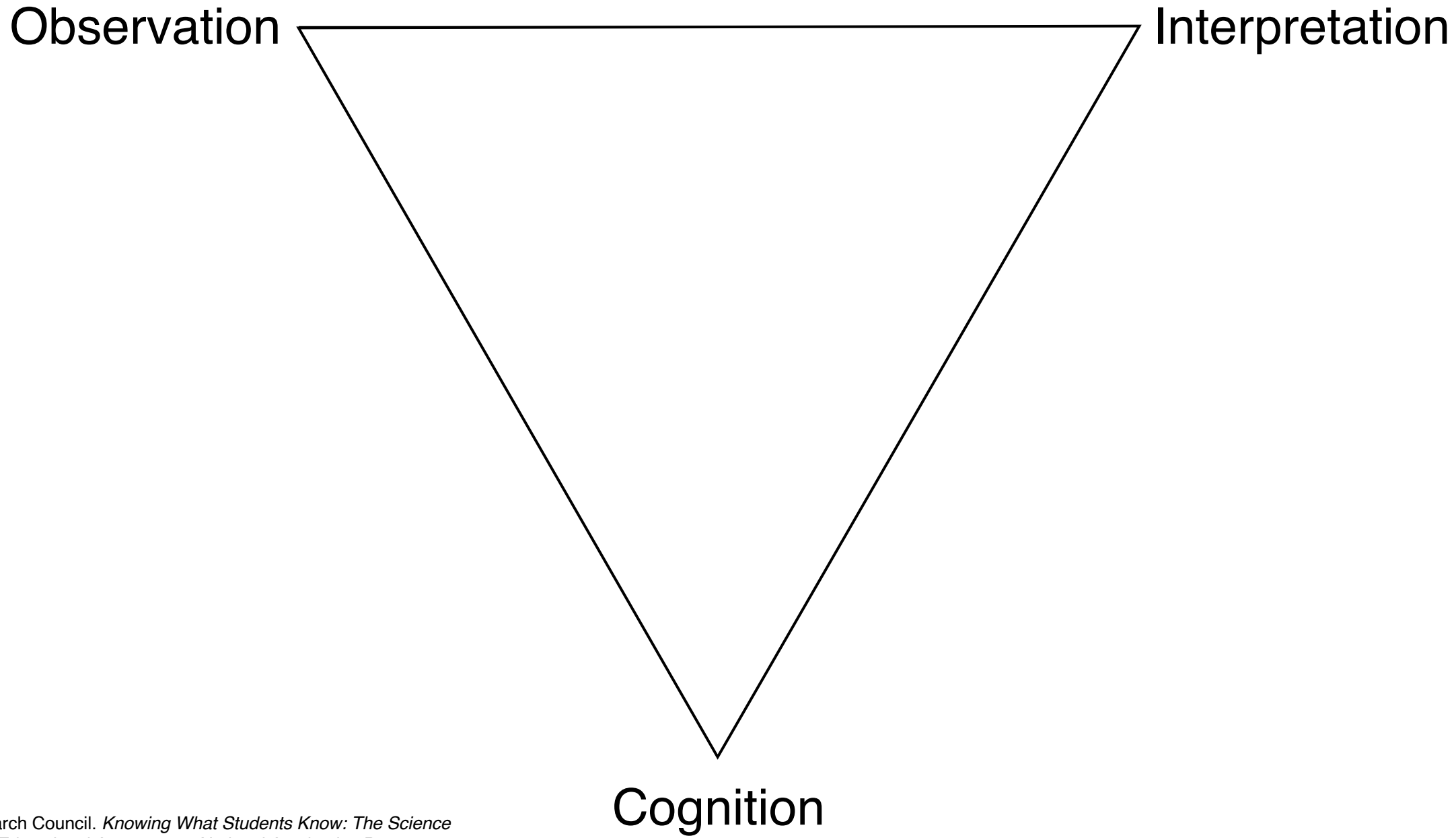
What students write in response to assessment tasks

Observation ——————————————————— Interpretation

Observation ——— Interpretation

How we infer learning from evidence

Observation ——————————————————— Interpretation



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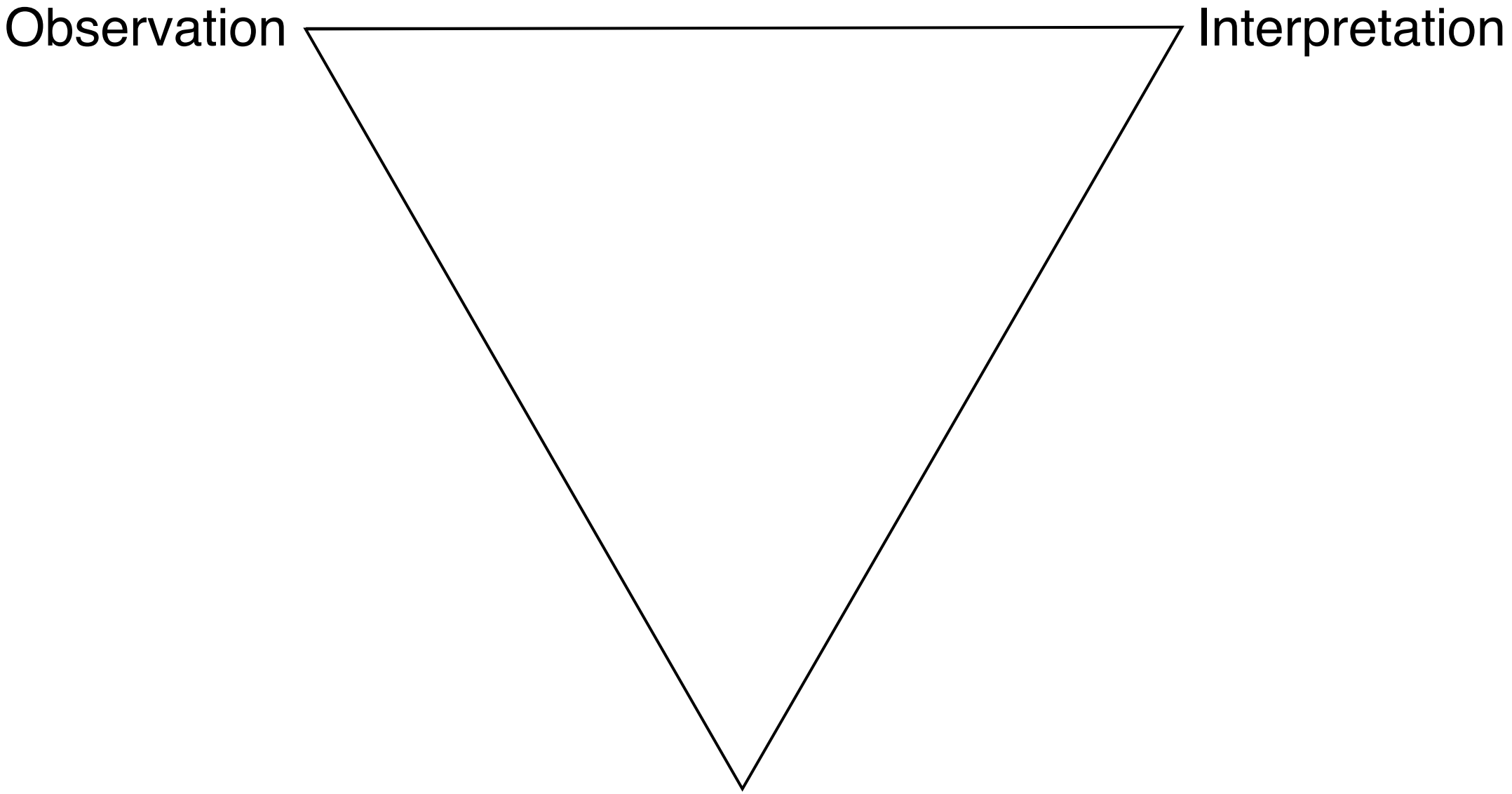

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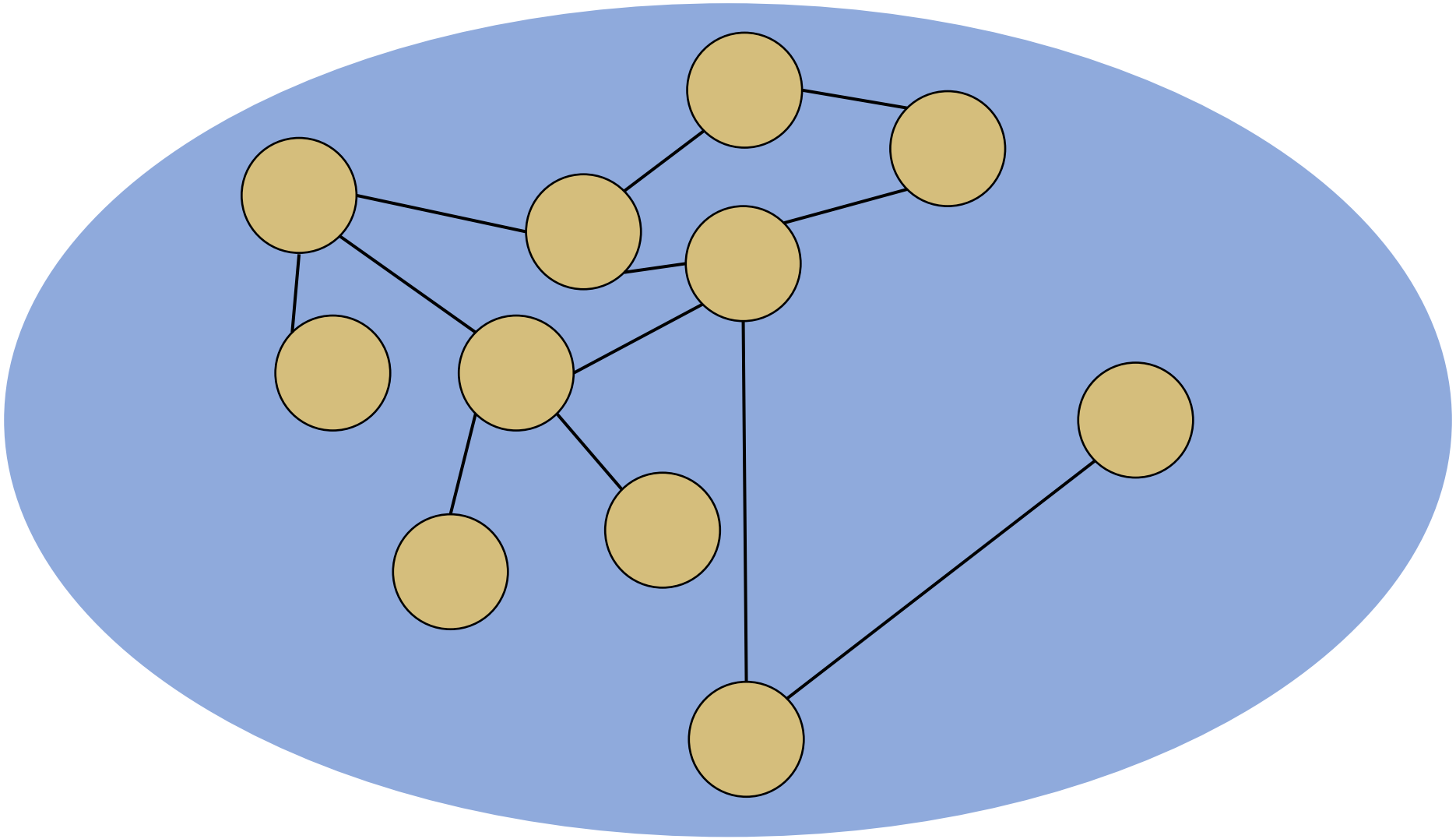
Theory-Theory



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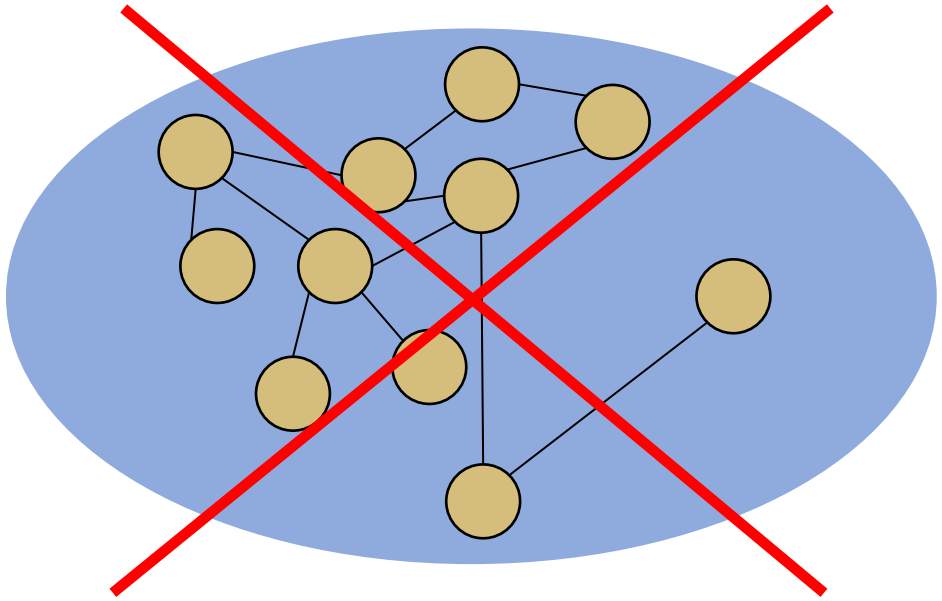

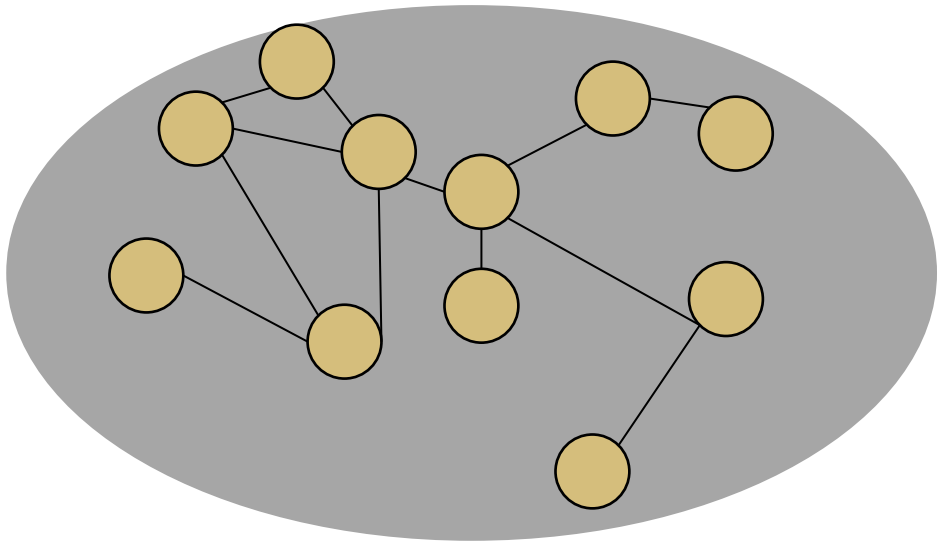

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Interpreting Assessment Evidence Assuming a Theory-Theory Model of Learning

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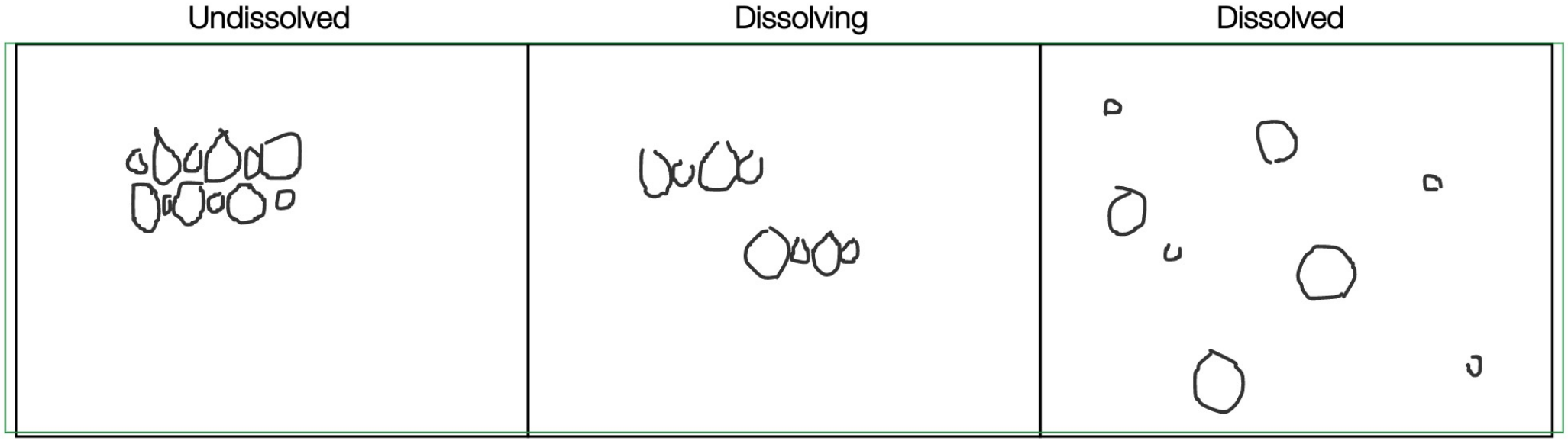

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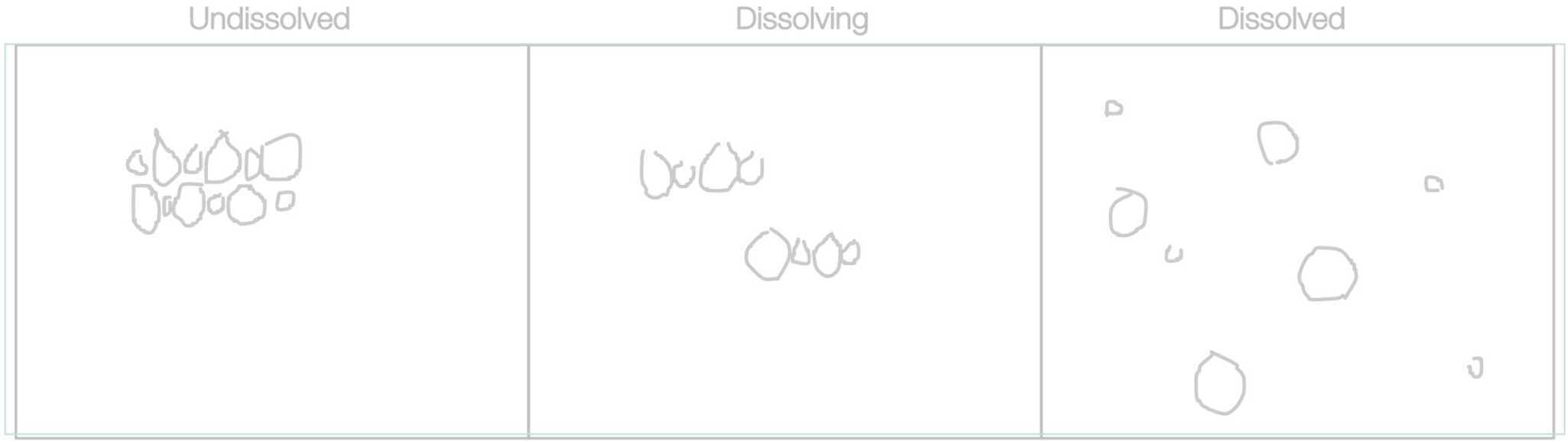

What do you infer about student learning from this response?

A. The student does not think the solvent matters in dissolution
B. The student did not think it necessary to depict solvent in this context
C. The student thinks solute particles simply fall apart

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2. Referring to the diagram you drew for question #1, **describe** the sequence of events that happens when solid LiCl dissolves in water.

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In the undissolved LiCl, ion-ion interactions hold together the substance. As it dissolves, the water molecules form ion-dipole interactions with the individual ions and pull them away from the substance. When fully dissolved, the ions are free floating."

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What do you infer about student learning from this response?

A. The student is connecting ideas related to interactions formed and broken in the moment
B. The student understands the role of solvent in the dissolution process
C. The student understands the ionic lattice is held together by electrostatic attraction

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In the undissolved LiCl, ion-ion interactions hold together the substance. As it dissolves, the water molecules form ion-dipole interactions with the individual ions and pull them away from the surface of the solid.

The responses to 1) and 2) are from the same student

What do you conclude about student understanding in this response?

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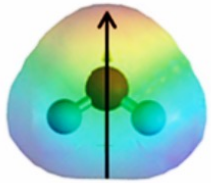
Do students possess coherent “wrong theories”?

Connecting Structure to Properties



Identification of molecular polarity

→ Deduce type and relative strength of intermolecular forces → **Predict Properties**

Pick the compound with the highest boiling point and explain why:

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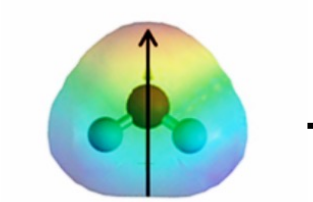

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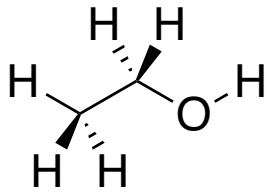

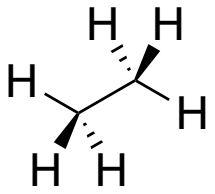

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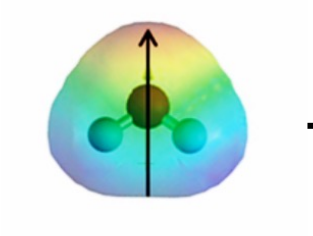

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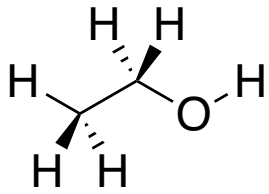

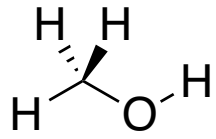

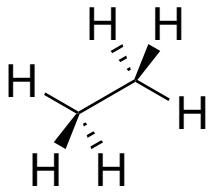

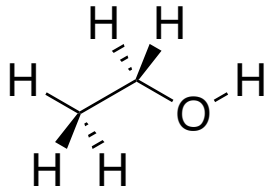

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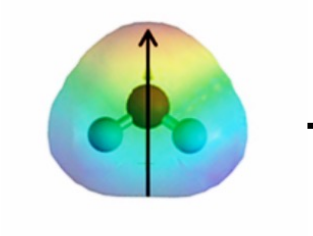

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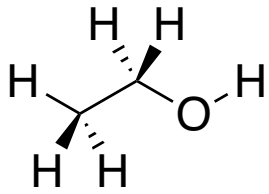

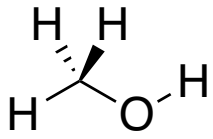

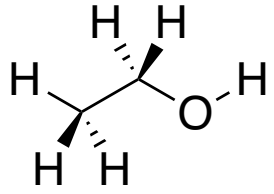

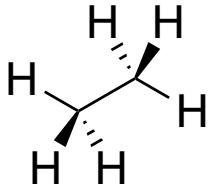

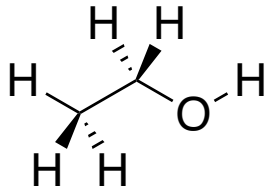

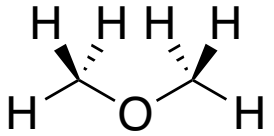

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Connecting Structure to Properties

"Each student individually constructed a different approach to the task posed. These approaches were hindered by other factors that interacted with each other in different ways."

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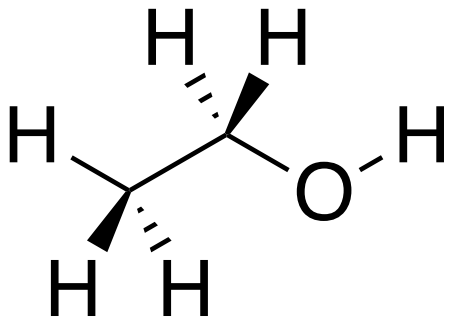

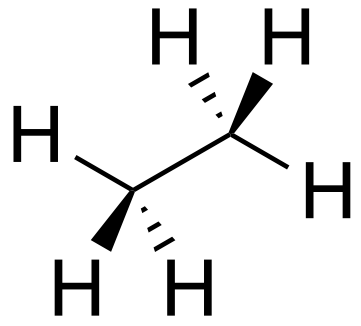

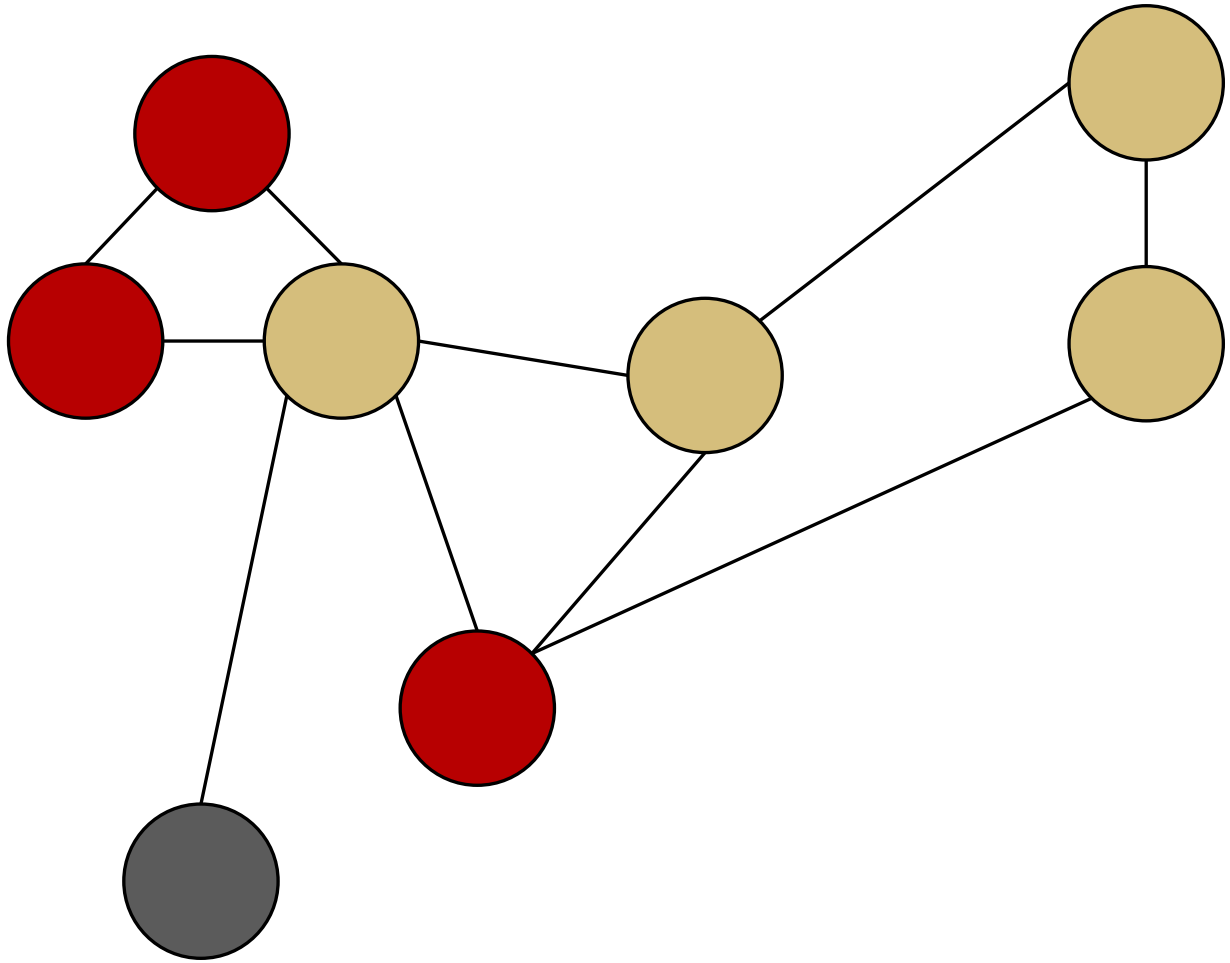

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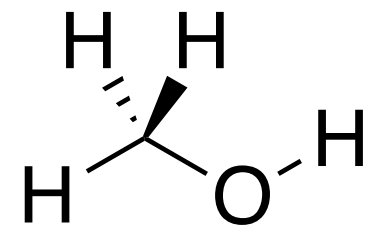

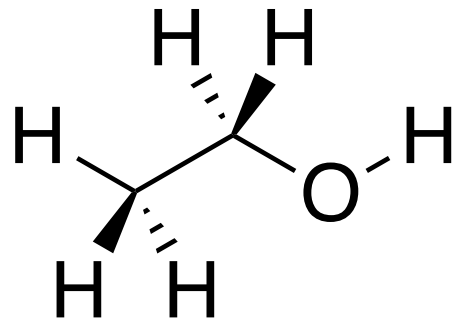

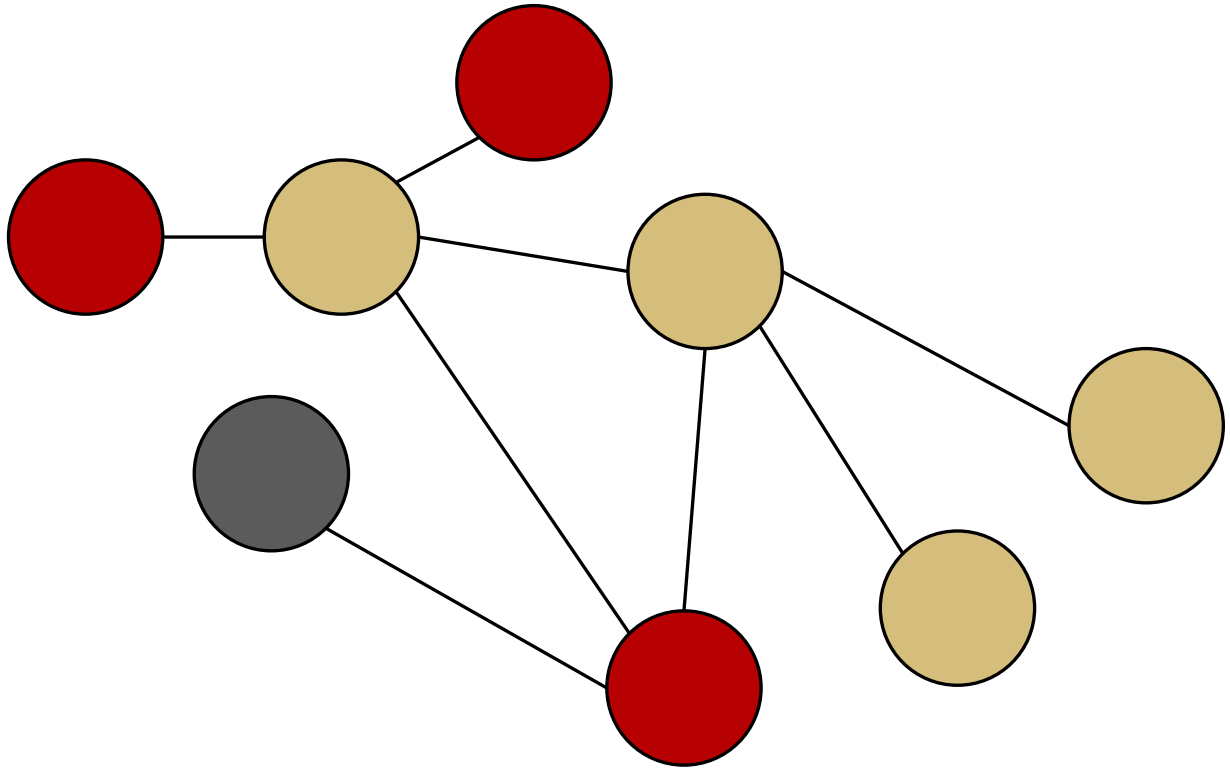

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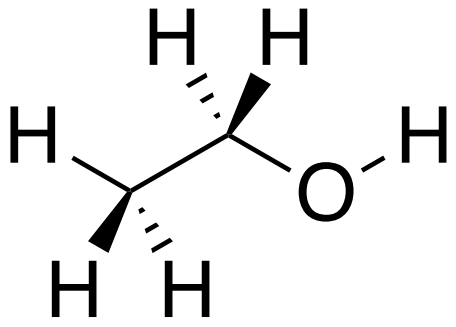

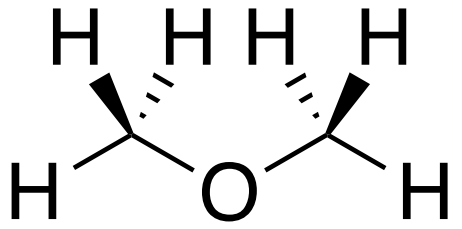

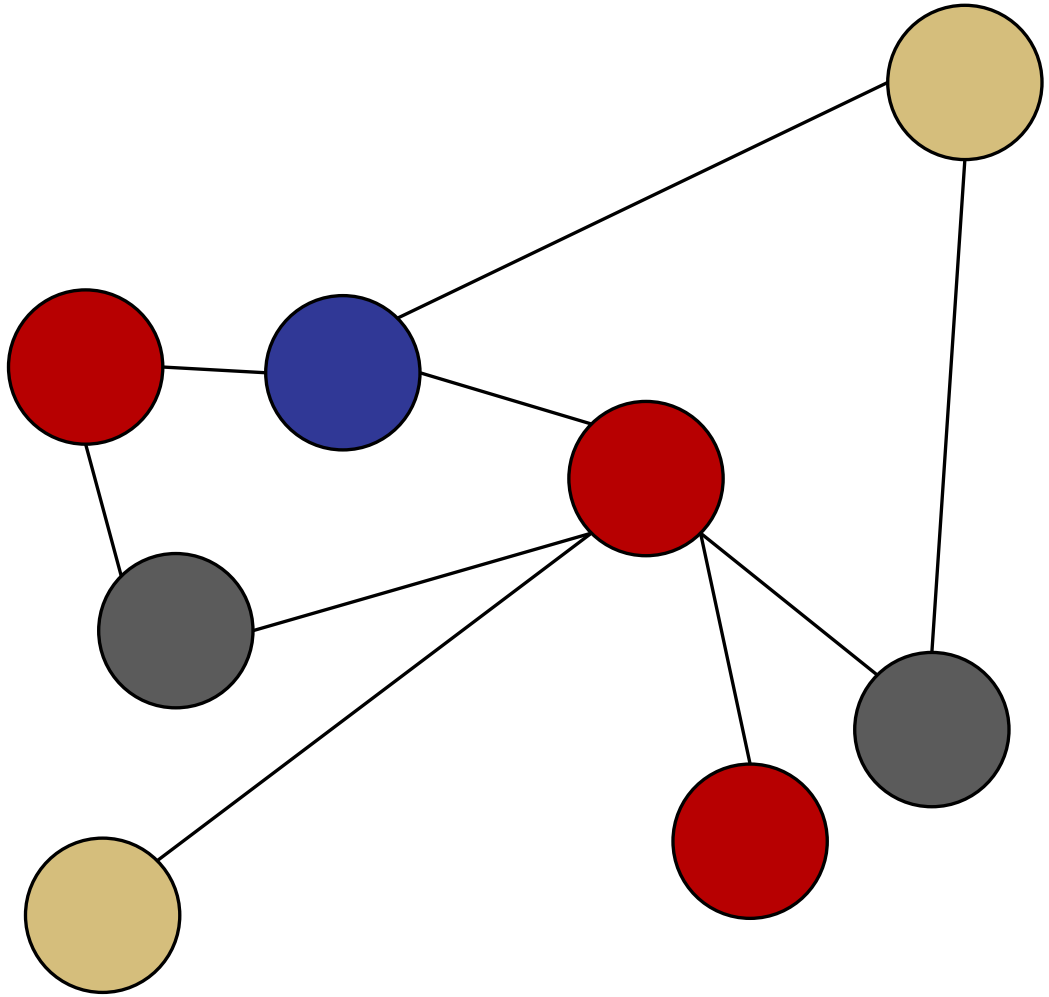

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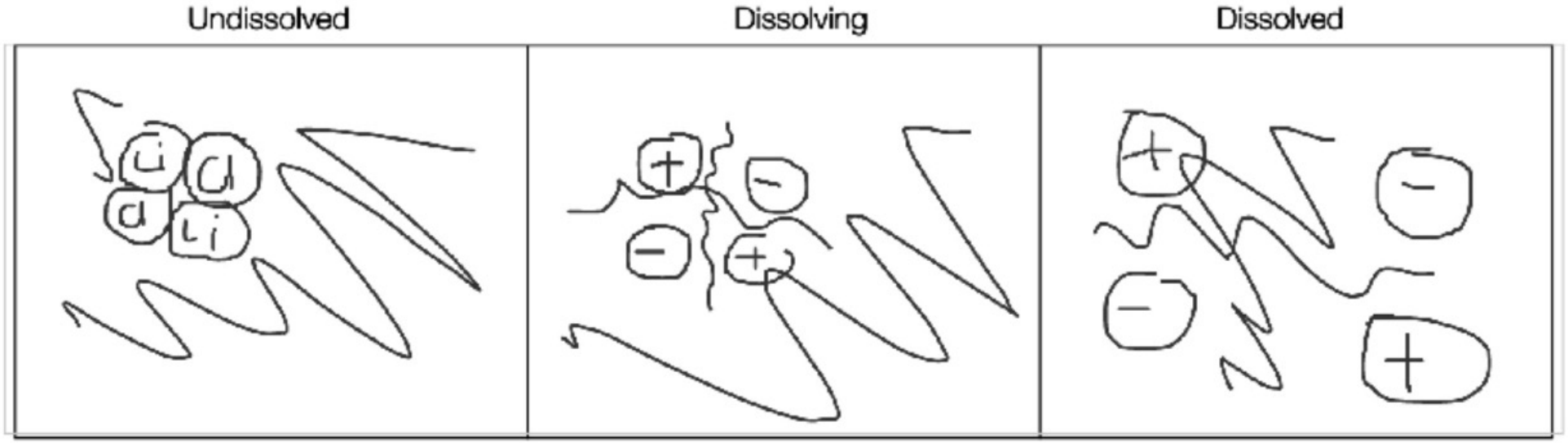

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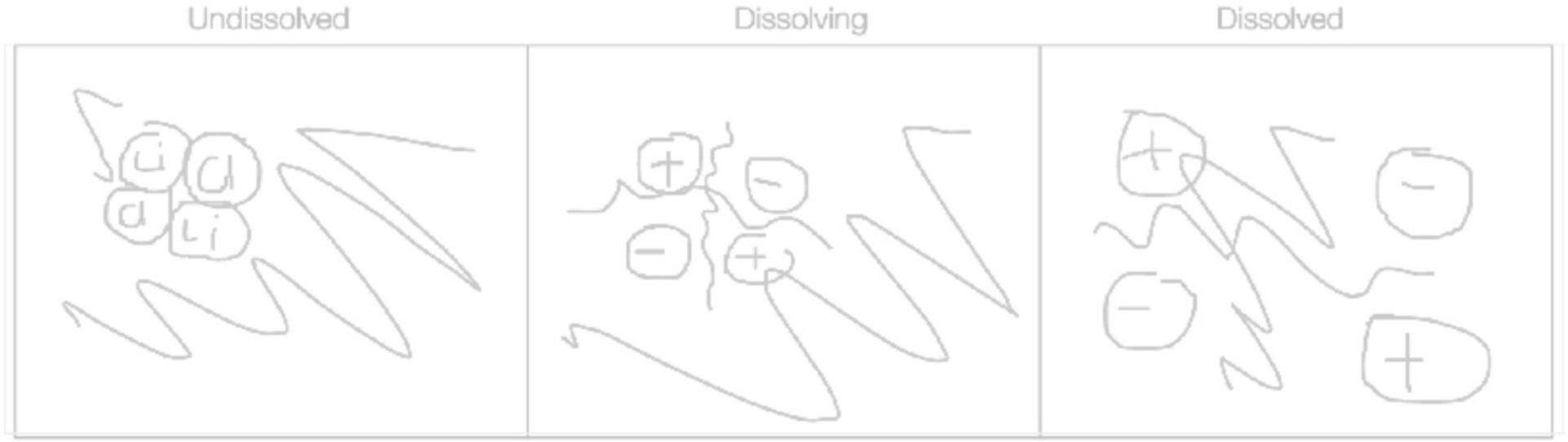

What do you infer about student learning from this response?

A. The student is activating resources related to charges separating
B. The student does not think the solvent matters in dissolution
C. The student thinks solute particles simply fall apart

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2. Referring to the diagram you drew for question #1, **describe** the sequence of events that happens when solid LiCl dissolves in water.

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Assuming LiCl is a solid before it dissolves, the ions/particles would be packed closer together. When LiCl is beginning to dissolve, the water molecules attract/separate the ions. (Oxygen is attracted to Lithium, and Hydrogen attracted to Chlorine) Finally, when LiCl is full dissolved, the ions should be evently distributed throughout solution

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What do you infer about student learning from this response?

A. The student understands the role of solvent in the dissolution process
B. The student understands the electron distribution on a molecule of water
C. The student is connecting ideas related to interactions formed and broken in the moment

Evidence for context-dependent resource activation

1. In the boxes below, draw a **molecular level representation** of the sequence of events required for LiCl to dissolve in water

Undissolved	**Dissolving**	**Dissolved**

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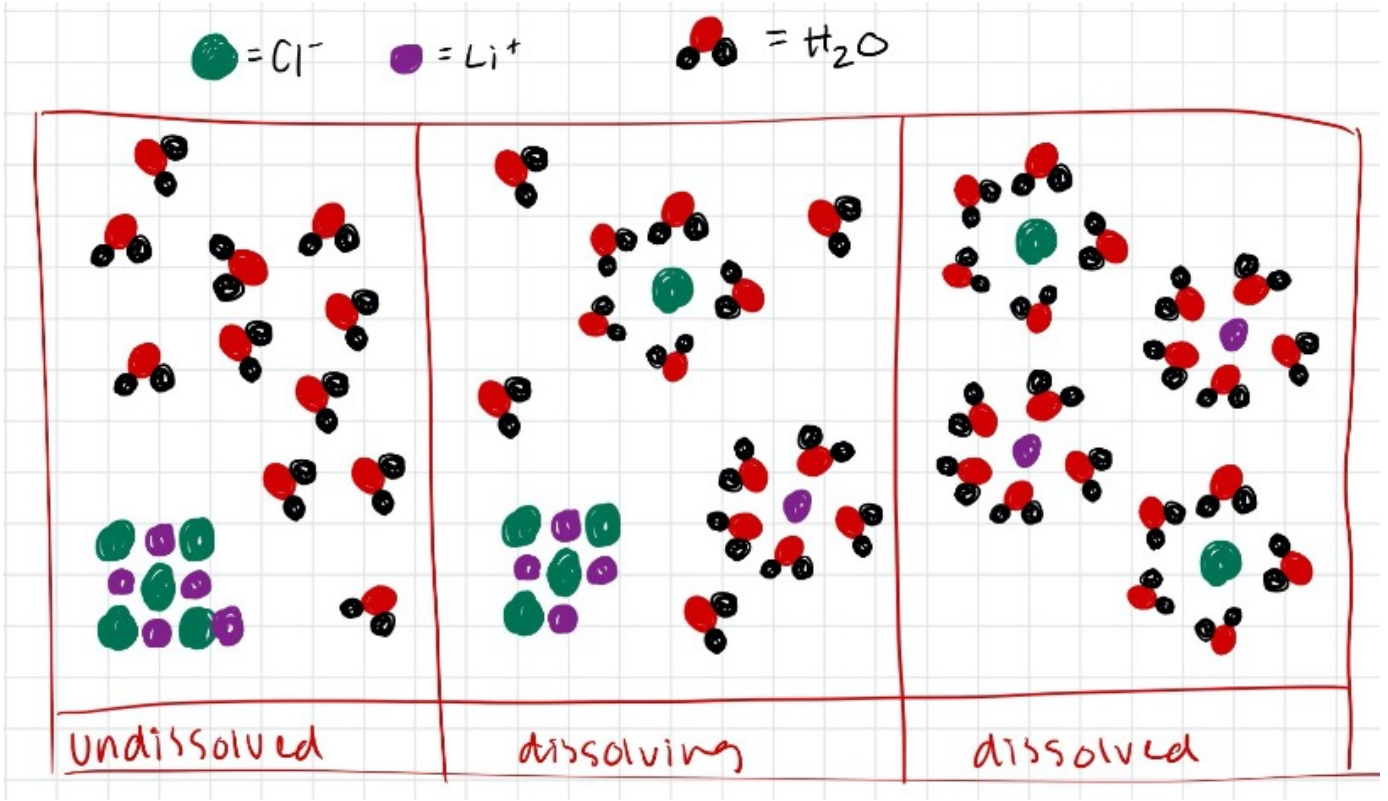
1. Illustrate

Breaking and Forming



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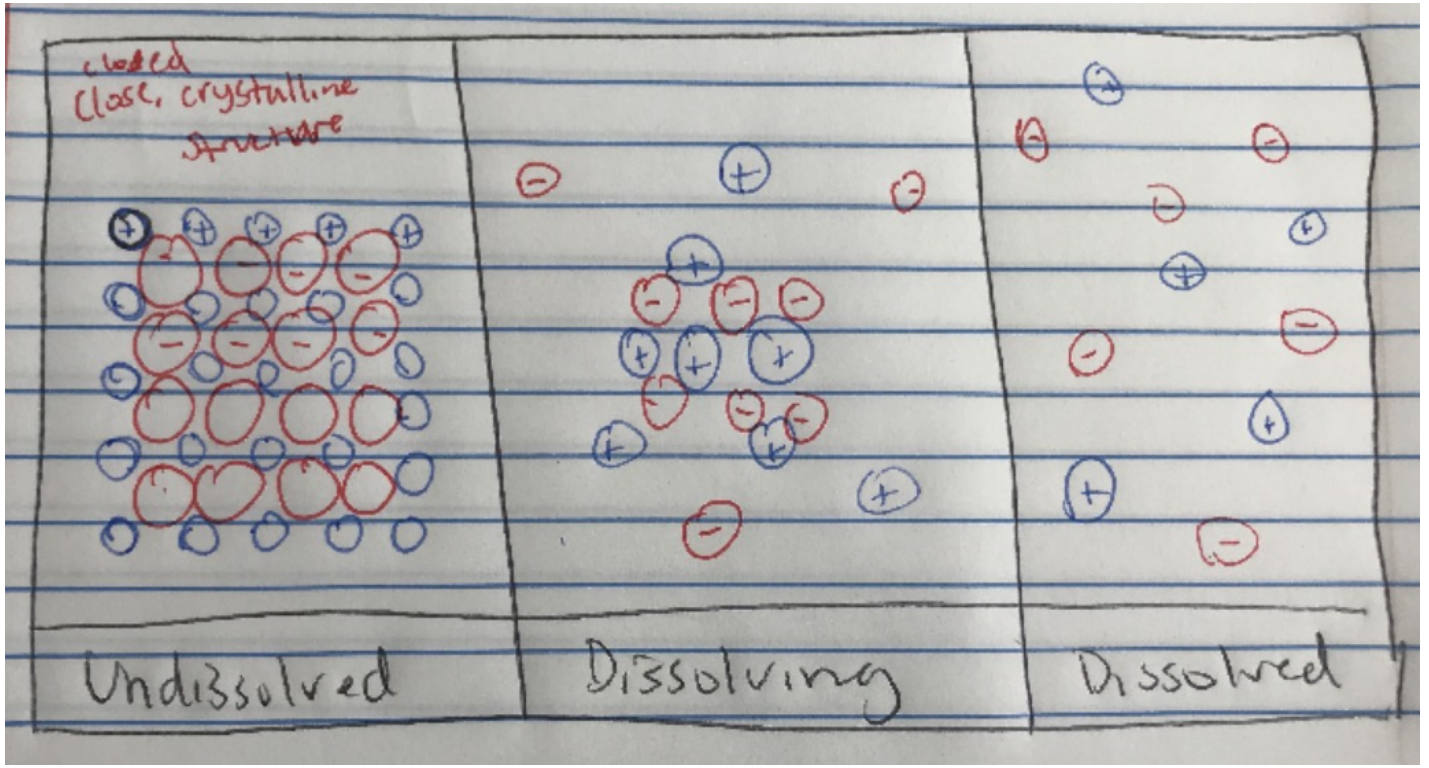

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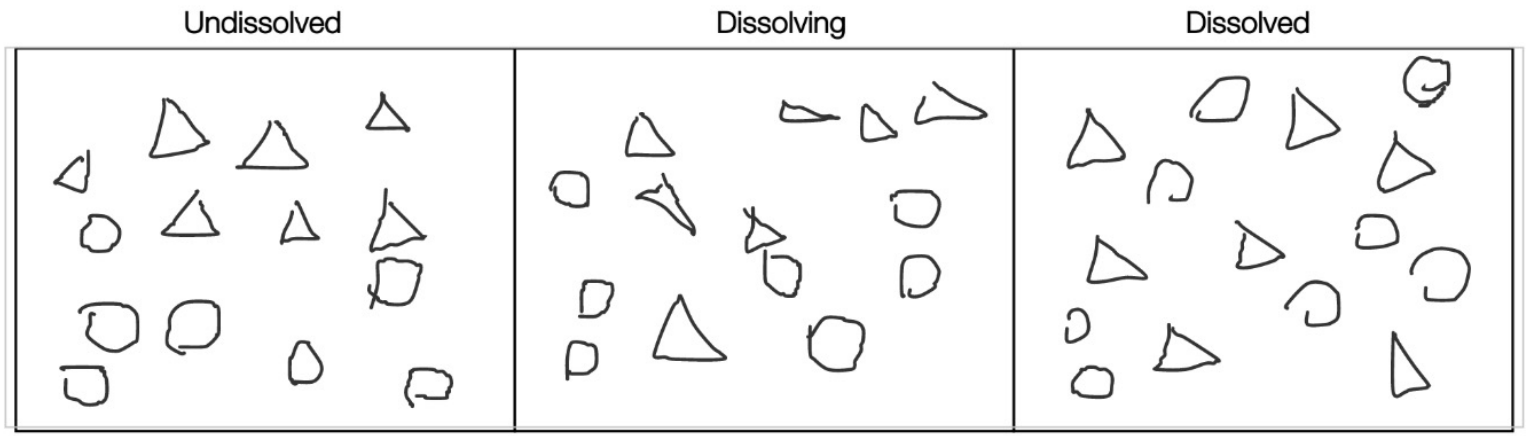

Neither Breaking nor Forming

1. In the boxes below, draw a **molecular level representation** of the sequence of events required for LiCl to dissolve in water

Undissolved	**Dissolving**	**Dissolved**

2. Referring to the diagram you drew for question #1, **describe** the sequence of events that happens when solid LiCl dissolves in water.

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2. Describe

The LiCl ion-ion interactions are first present in the undissolved state. Then in the dissolving state, the ion-ion ***interactions are being broken*** *as* ***ion-dipole interactions are being formed*** *between the ions and water molecules. The dissolved state shows ion-dipole interactions and water molecules completely surrounding Li and Cl ions.*

Breaking and Forming

2. Describe

*The H+ from water **attaches** to Cl- of LiCl and the O- of water **attaches** to the Li+ of LiCl.*

Breaking or Forming

2. Describe

When it dissolves in water, energy from the system is transferred to the surroundings and used to give off energy.

Neither Breaking nor Forming

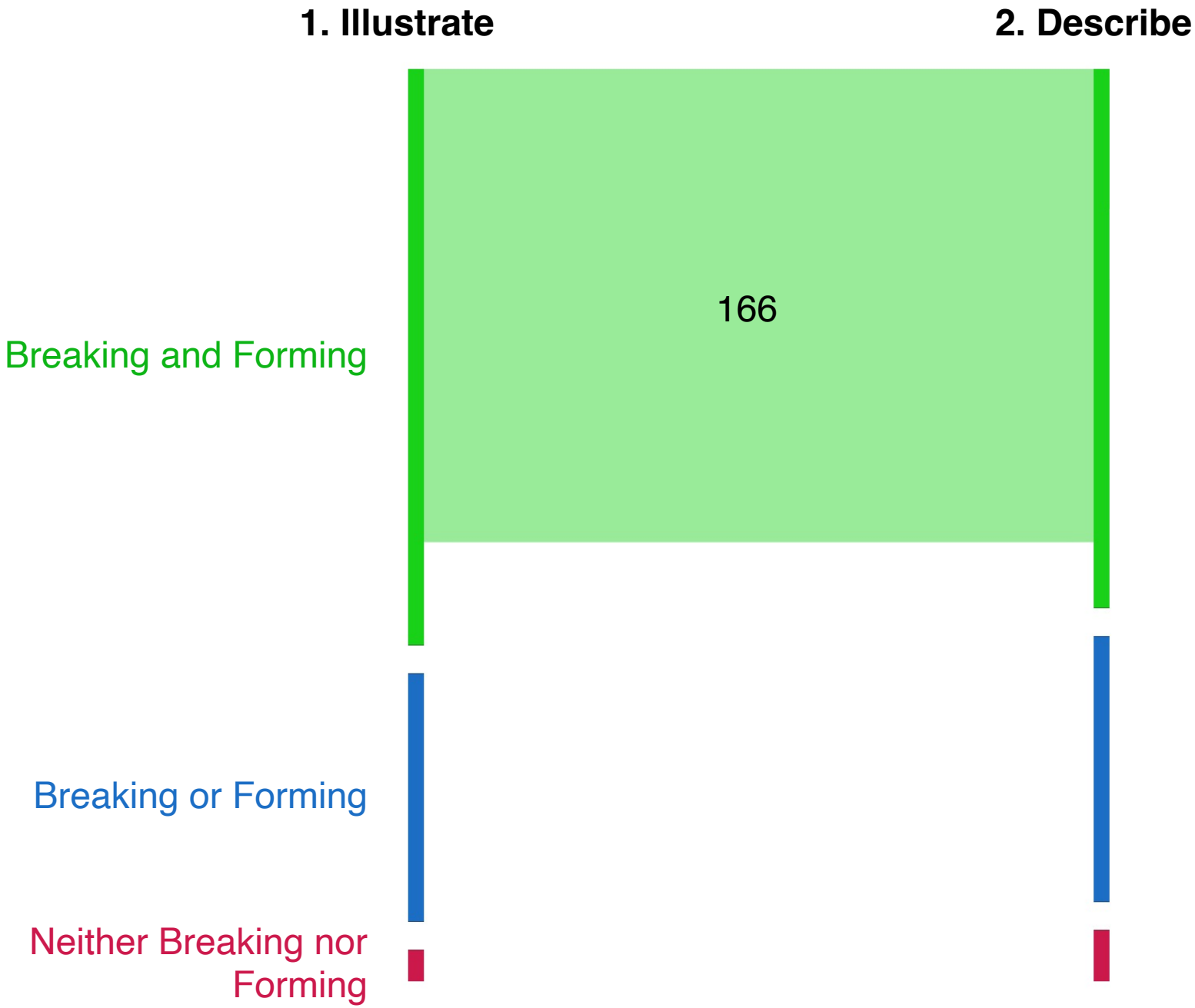
1. Illustrate

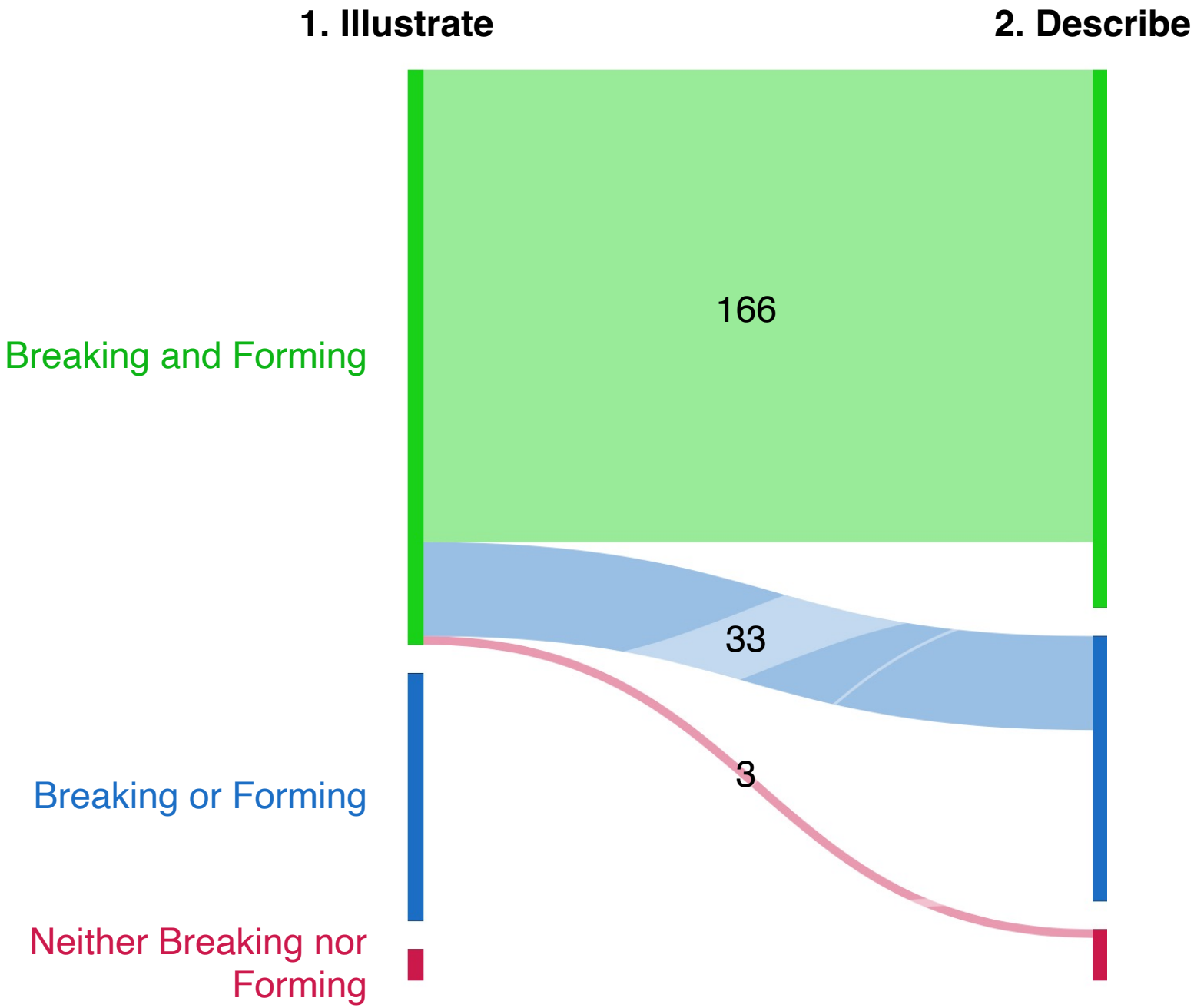
Breaking and Forming

Breaking or Forming

Neither Breaking nor Forming

2. Describe


1. Illustrate
2. Describe
166
Breaking and Forming
Breaking or Forming
Neither Breaking nor Forming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Undissolved	**Dissolving**	**Dissolved**

2. Referring to the diagram you drew for question #1, **describe** the sequence of events that happens when solid LiCl dissolves in water.

3. When LiCl dissolves, the temperature of the solution increases (it gets warmer). Explain **why the temperature goes up.**

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3. Explain

Causal Mechanistic

When LiCl dissolves, the temperature increases because the ***interactions that were formed are stronger than the ones that were broken****, so energy is released to the surroundings.*

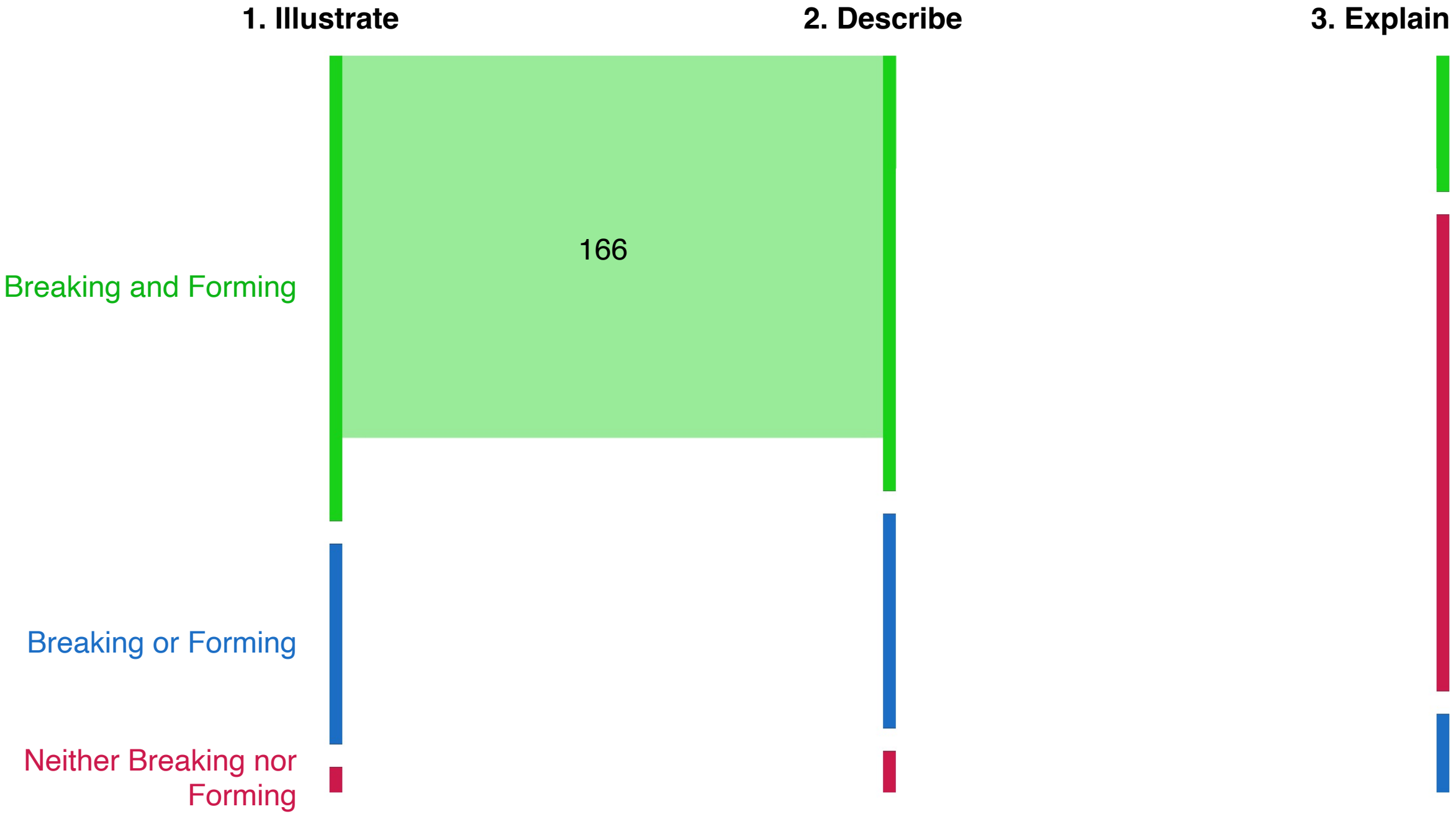
Mechanistic

The reaction is exothermic, and ***heat is released as the Hydrogen bonds are formed.***

3. Explain

Neither

Because this dissolving is a reaction giving off heat in the process. In other words, it is an exothermic reaction where energy going in is less than energy going out.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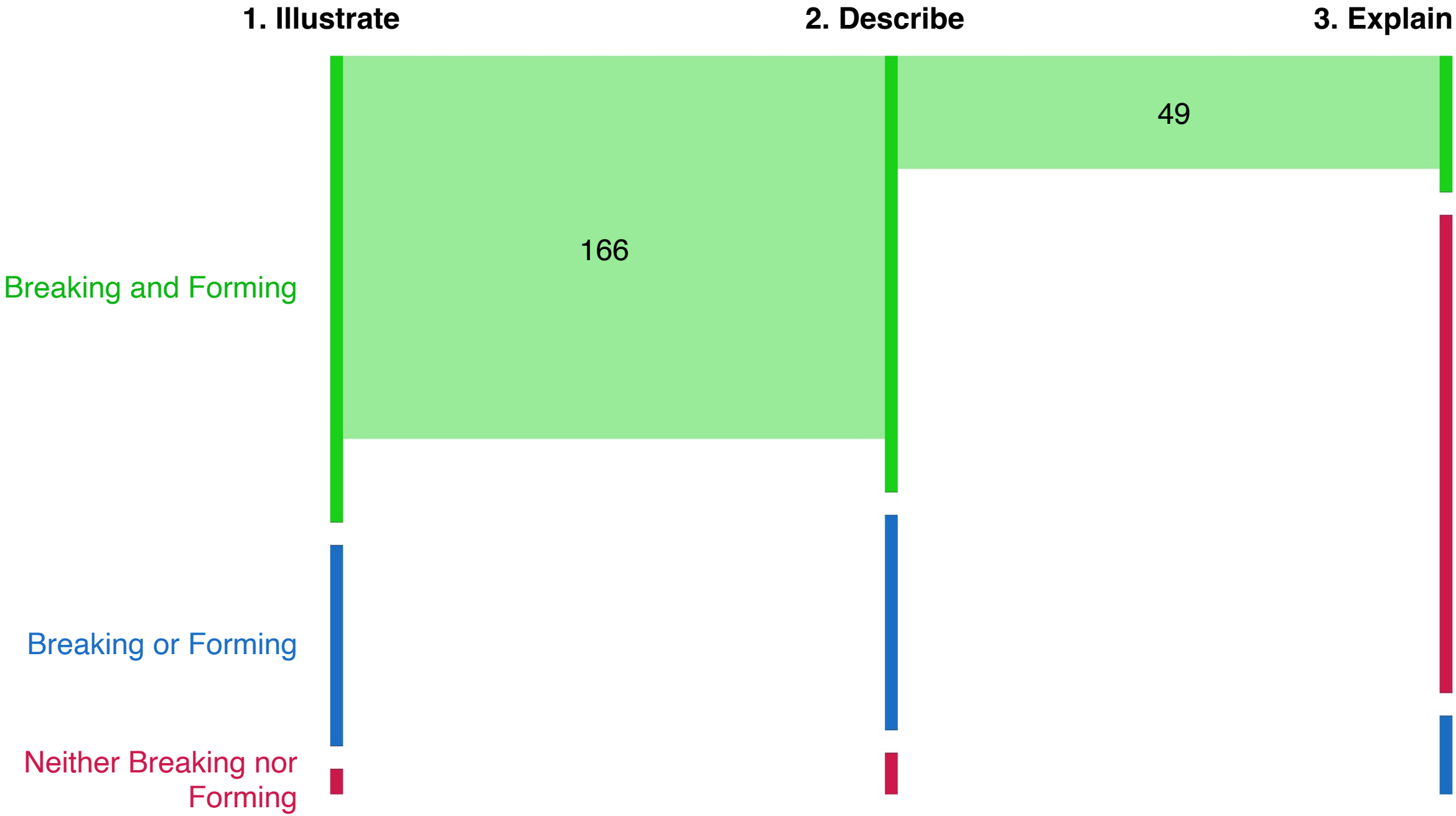
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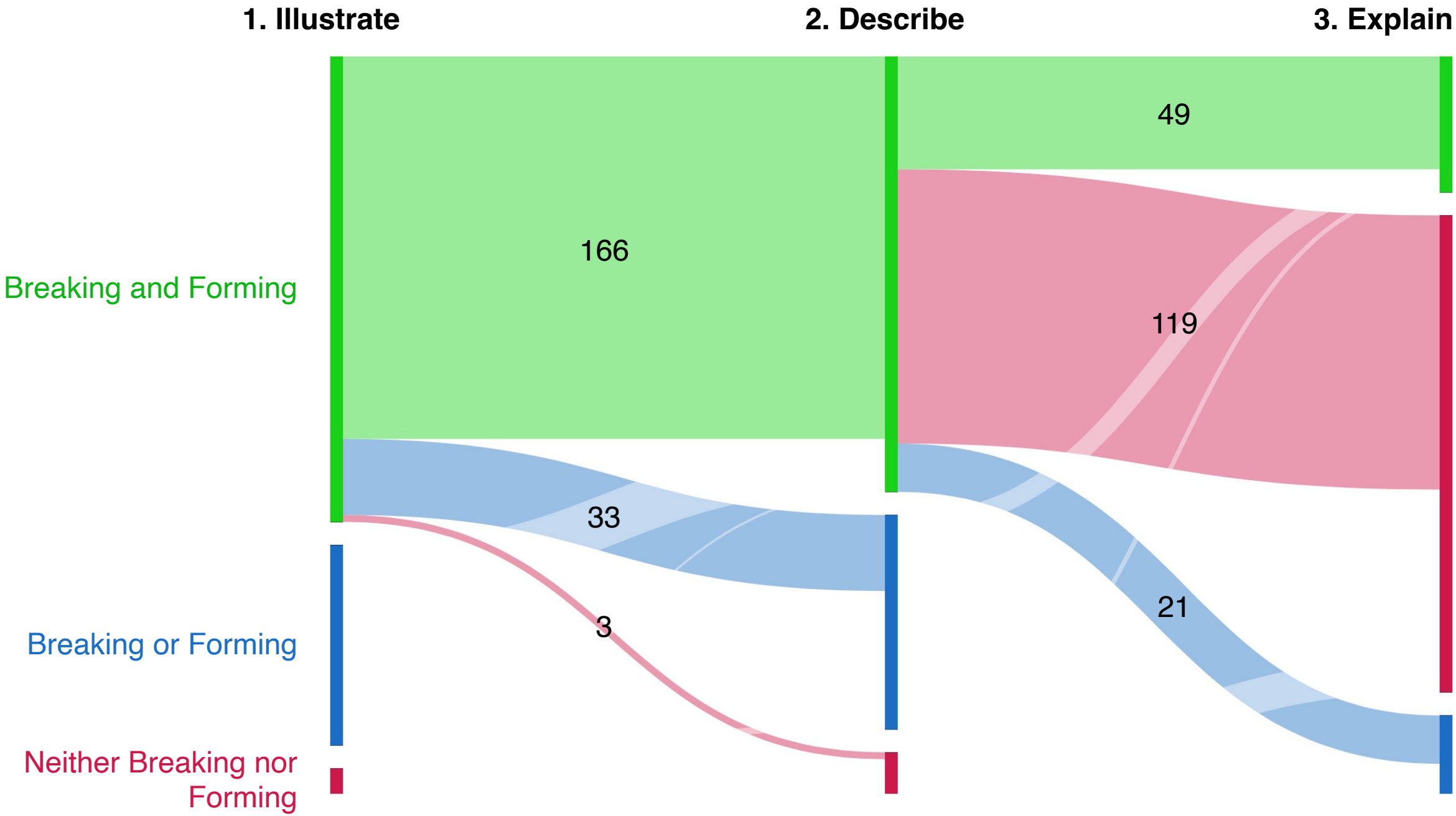
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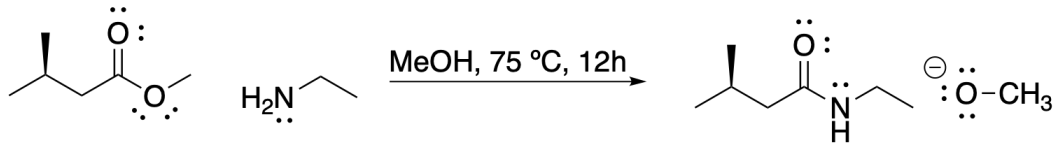
21

Take-Home Messages

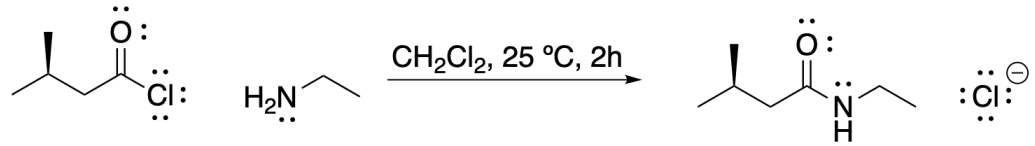
- Don’t assume a “wrong answer” indicates a durable “misconception”
- Embed many opportunities for students to construct causal accounts for phenomena

In search of syntheses for *N*-ethyl-3-methylbutanamide, you come across the two procedures (labeled **A** and **B** below) that both claim to produce good yields of product. You note that procedure **A** requires both higher temperatures and a longer duration than procedure **B**.

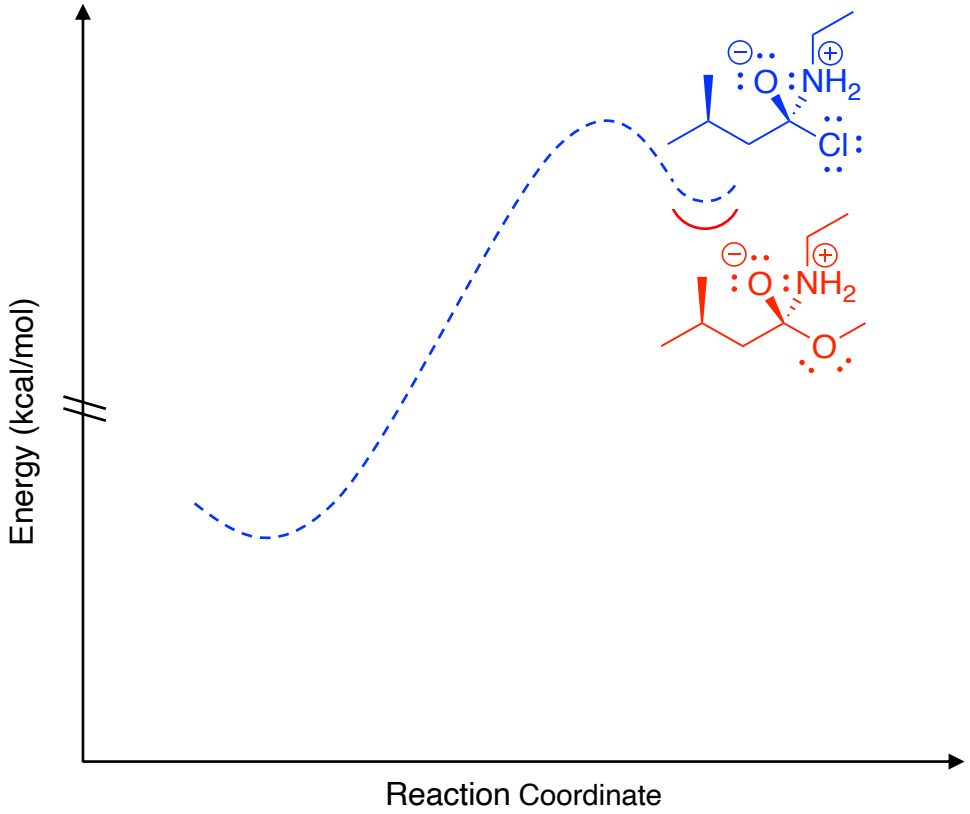
A



B



I. A potential energy surface showing the change in system energy from reactants to a tetrahedral intermediate is drawn to the right for system **B**. On the same axis, draw a potential energy surface showing the change in energy along the path from reactants to the tetrahedral intermediate shown for system **A**.



II. Using the potential energy surface you drew above, explain why procedure **A** requires higher temperature than procedure **B** to produce product. Make sure to connect the relative energies of reactants to reaction rate.

J. Chem. Educ. **2020**, *97*, 2408-2429. DOI: 10.1021/acs.jchemed.0c00757

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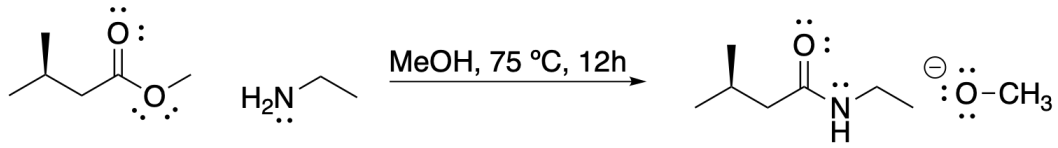

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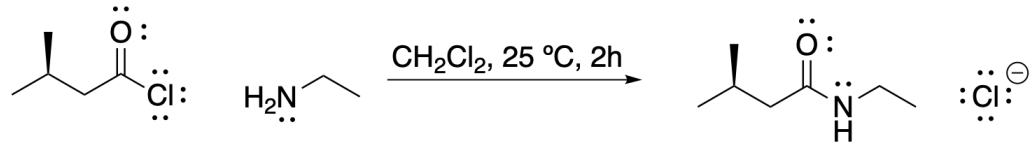

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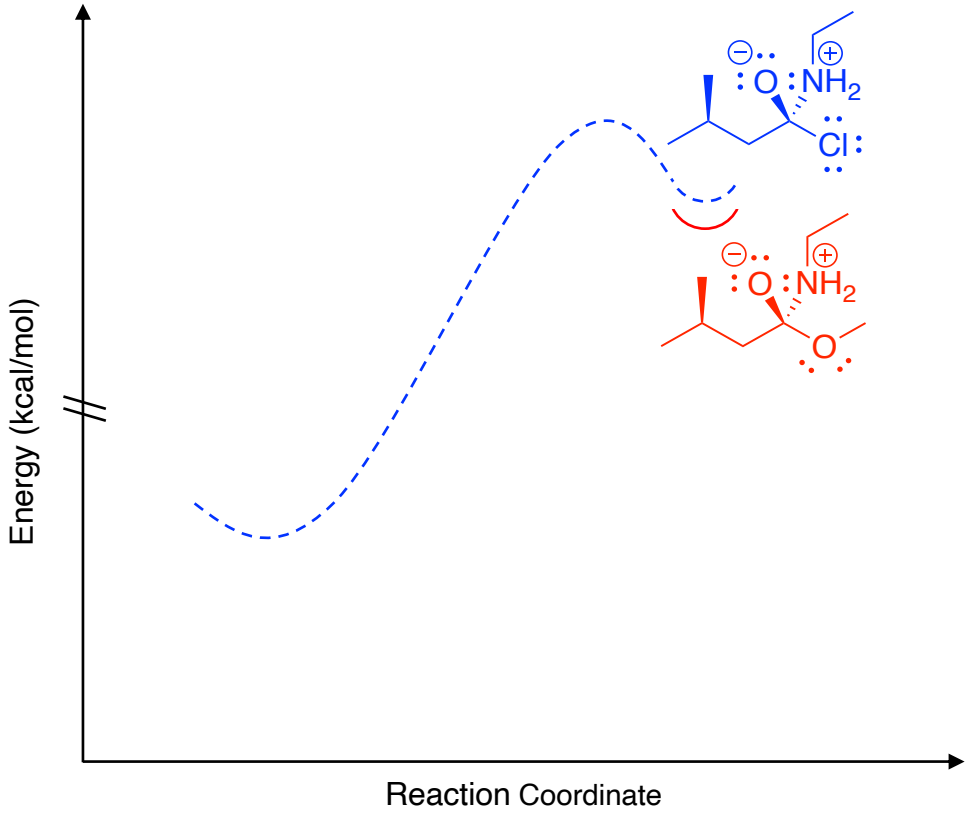

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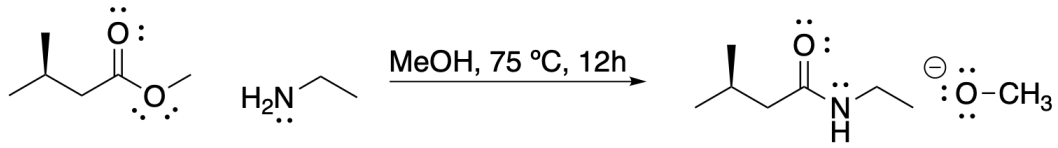

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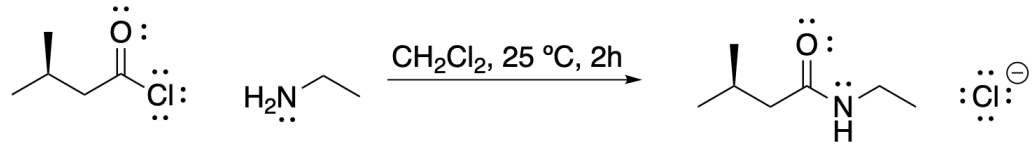

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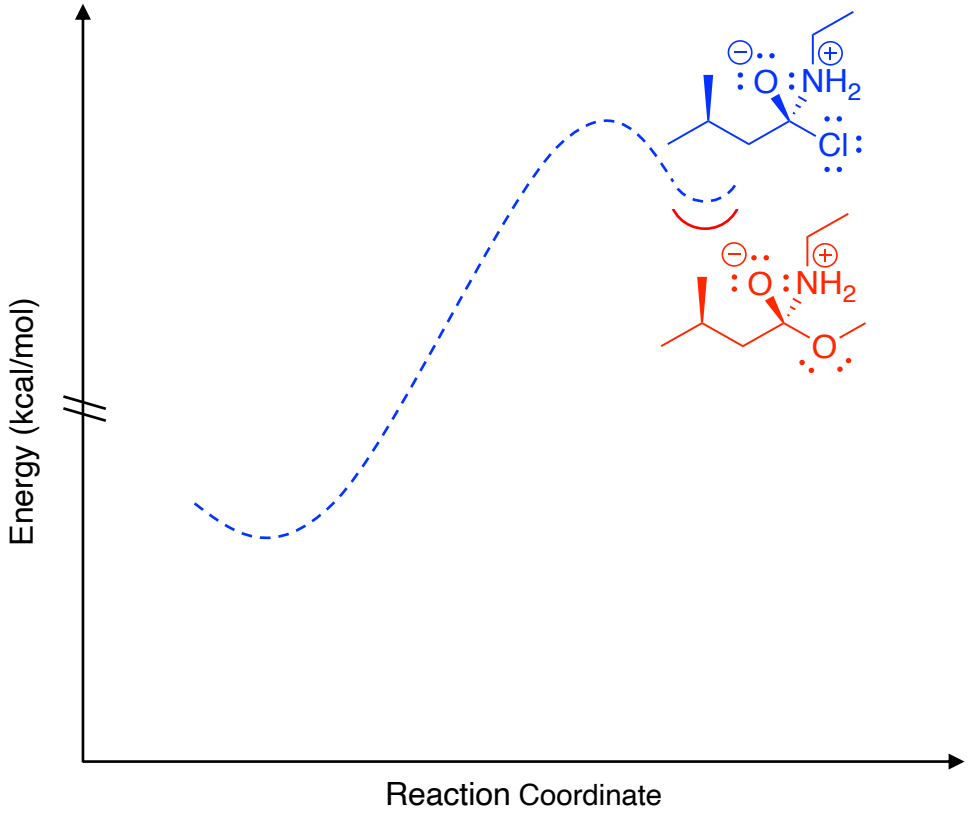

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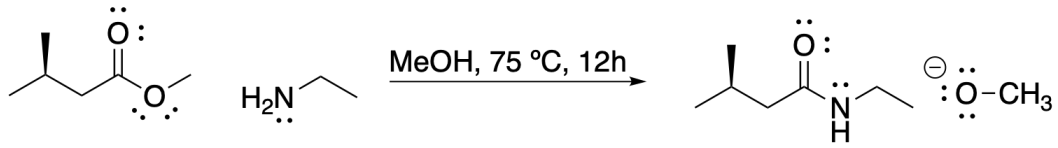

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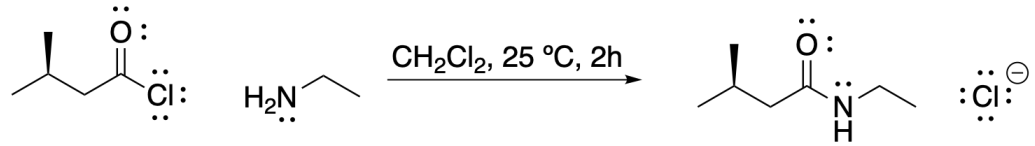

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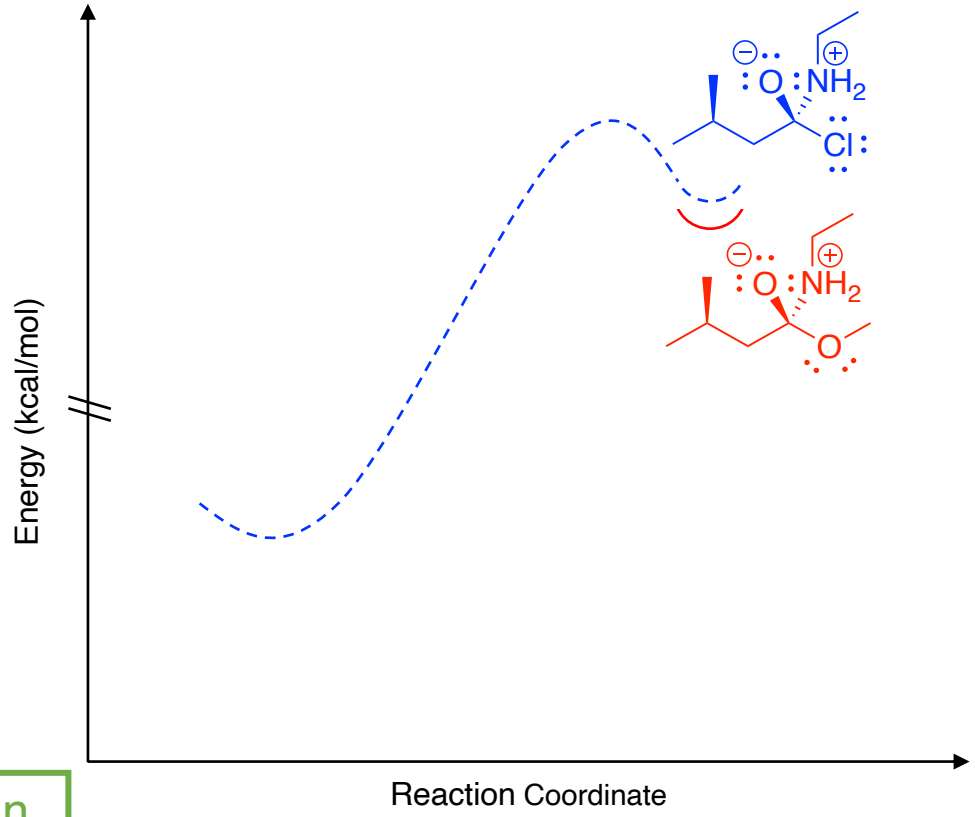

Explain

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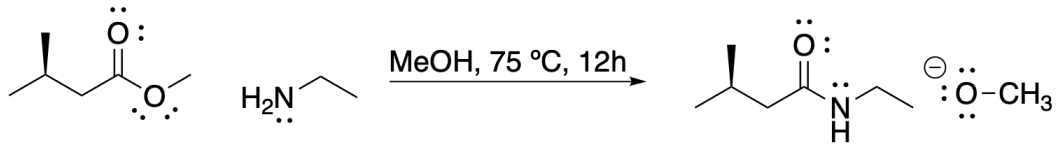

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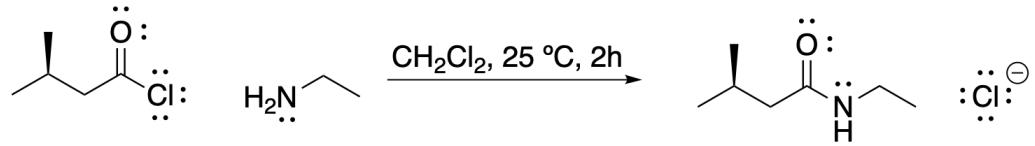

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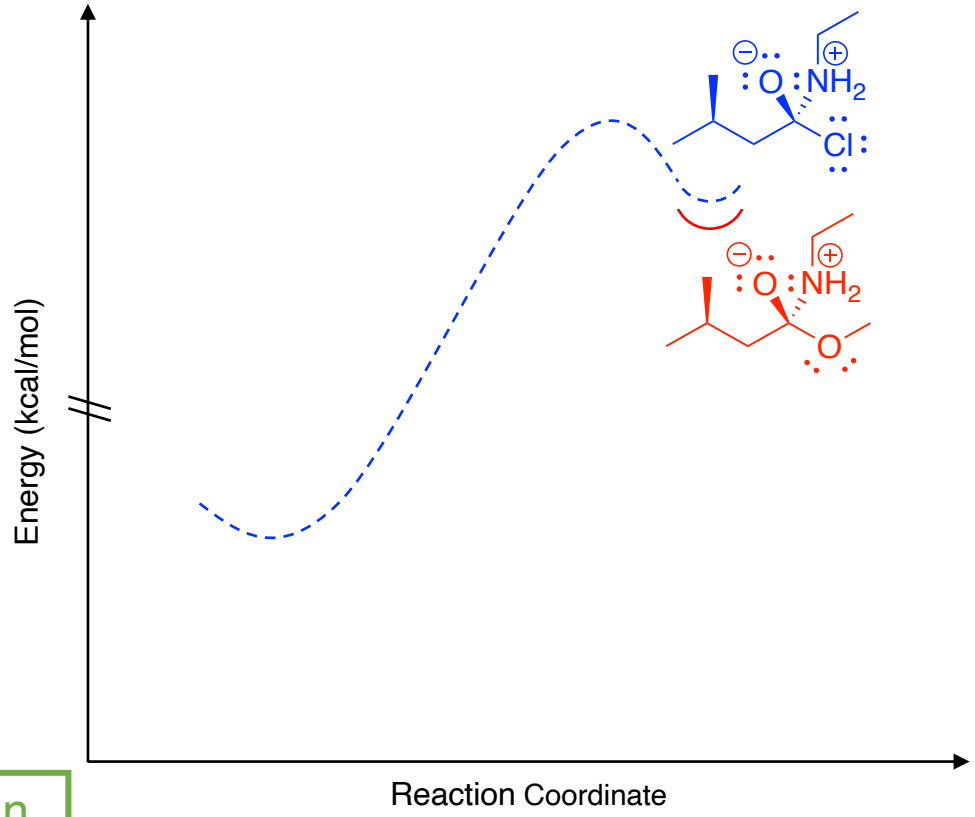

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Provide reasoning

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More information on 3D assessments:

Three-Dimensional Learning Assessment Protocol (3D-LAP)
PLOS ONE **2016**, *11* (9), e0162333. DOI: 10.1371/journal.pone.0162333

Adapting Assessment Tasks to Support 3D Learning
J. Chem. Educ. **2017**, *95* (2), 207-217. DOI: 10.1021/acs.jchemed.7b00645

Arguing from Spectroscopic Evidence
J. Chem. Educ. **2019**, *96* (10), 2072-2085. DOI: 10.1021/acs.jchemed.9b00550

These articles are all open access

Take-Home Messages

- Don’t assume a “wrong answer” indicates a durable “misconception”
- Embed many opportunities for students to construct causal accounts for phenomena
- Use assessment responses to shape future instruction and assessment

Thank you for participating!

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stowe.chem.wisc.edu