**Supporting Information**

**Teaching Green Chemistry though Student-Generated Open Educational Resources**

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# **List of Key Reactions from Organic Chemistry II**

**Chapter 12: Alcohol and Phenols**

1 Grignard Reaction (*nucleophilic addition of Grignard Reagents*)

2. Swern oxidation

**Chapter 13: Ethers and epoxides; thiols and sulfides**

3. Williamson Ether synthesis

4. Alkoxymercuration-demercuration ether synthesis

5. Sharpless asymmetric epoxidation

6. Preparation of sulfides from thiols

**Chapter 16: Conjugated pi systems**

7. Diels-Alder reaction

8. [2+2] cycloaddition

**Chapter 17: Aromatic Compounds**

9. Free radical bromination at the benzylic position

10. Catalytic hydrogenation

11. Birch reduction

12. Oxidation of alkyl benzenes

**Chapter 18: Aromatic Substitution Reactions**

13. Bromination of benzene (example of Electrophilic aromatic substitution)

14. Sulfonation of benzene

15. Nitration of benzene

16. Friedel-Crafts alkylation

17. Friedel-Crafts acylation

18. Clemmensen reduction

**Chapter 19: Aldehydes and Ketones**

19. Imine formation from aldehyde or ketone

20. Baeyer–Villiger Oxidation

21. Wolff-Kishner Reduction

22. Formation of the thioacetal followed by desulfurization with Raney nickel

**Chapter 20: Carboxylic Acids and their Derivatives**

23. Hydrolysis of nitriles

24. Carboxylation of Grignard reagents

25. Preparation of acid chlorides via thionyl chloride

26. Gilman reagent reaction

27. Fischer Esterification

28. Saponification of Esters

29. Acid-Catalyzed Hydrolysis of Esters

**Chapter 21: Alpha Carbon Chemistry: Enols and Enolates**

30. Hell–Volhard–Zelinsky Reaction

31. Aldol Addition Reaction

32. Retro-Aldol Reaction

33. Aldol Condensation

34. Claisen condensation

35. Dieckmann cyclization

36. Malonic ester synthesis

37. Michael Reactions

38. Stork Enamine Synthesis

39. Robinson Annulation Reaction

# **Phase 1: Instructions**

***First Draft Due March 7th /Final Paper Due March 14th***

Please choose **one** reaction that you would like to analyze this semester from the list provided and state it as a post on the Discussion Board on Blackboard.

Since each person is to have a different reaction, before posting please check your classmates’ posted responses to ensure that you do not pick the same reaction that they already did.

Then, please use either the **Biovia Draw** (*Windows*) or **MarvinSketch** (*Mac, Windows, Linux*) software to draw the mechanism for your chosen reaction.

*Note: The links for downloading and instructional videos for using Biovia Draw and MarvinSketch are posted in the Course Content tab on Blackboard.*

Please insert the mechanism into the provided *Phase 1 Word document template* and add the citation for the reference that you used in ACS format.

# **Phase 1: Template Document**

***First Draft Due March 7th /Final Paper Due March 14th***

“Insert Drawn Reaction Mechanism.”

**Figure 1.** “REPLACE THIS PART WITH A TITLE FOR YOUR MECHANISM”

 **Description of Image:** This is a mechanism for the “INSERT REACTION NAME”.

**\*Note: The *Description of Image* must be less than 125 characters.**

**References**

“List references in ACS format.”

# **Phase 1: Guidelines for Peer Feedback**

|  |
| --- |
| **Reaction Mechanism: Arrows**1. Curved arrows start from electron source and point to electron sink.2. Curved arrows clearly indicate starting and ending points.3. All arrows are used for correct purpose (*curved, resonance, reaction, equilibrium, etc.*).  |
| **Reaction Mechanism: Mechanistic Steps**1. Only one mechanistic step is illustrated in each step of the mechanism.2. Each mechanistic step is labeled to identify type of mechanistic step. |
| **Reaction Mechanism: Accuracy**1. All structures are drawn correctly.2. Mechanistic steps are drawn correctly.3. All mechanistic steps are labeled correctly. |
| **Reaction Mechanism: Design**1. Mechanism is drawn clearly.2. All structures are sized appropriately in relation to each other.2. Mechanistic steps are organized neatly and can be easily followed. |
| **Reaction Mechanism: Description of Image**1. Description is 125 characters or less.2. Title of reaction is added in the description of image. |
| **Reaction Mechanism: References**1. References are in the ACS format.2. References are cited correctly. |

# **Phase 2: Instructions**

***First Draft Due March 24th /Final Paper Due March 31st***

**Part 1: General Reaction Scheme**

1. Use chemical drawing software to draw the generic reaction scheme.

* Use R for unspecified alkyl groups and X for unspecified halide groups

2. List required reagents above the reaction arrow and the solvent/required conditions below the reaction arrow.

3. Use a contrasting color to indicate the bonds/atoms which will undergo the reaction.

4. Save the file within the chemical drawing software and copy it onto the “Phase 2 Template Page.”

**Part 2: Utility of the Reaction**

1. Write one to two sentences that describe what functional group interconversion this reaction facilitates.

2. Write one to two sentences indicating what types of functional groups would require protecting groups to ensure the reaction proceeds and exhibits regioselectivity and chemoselectivity. For example, Diels-alder reactions work with both alkenes and alkynes.

**Part 3: Description of Reaction Mechanism**

1. Write a short paragraph that describes what happens during each step of the reaction mechanism.

2. Within the paragraph, identify the types of mechanistic steps (*ex. nucleophilic attack, SN1, SN2, loss of leaving group, proton transfer, rearrangement such as methyl shift or hydride shift, homolytic cleavage, addition to pi bond, hydrogen abstraction, halogen abstraction, elimination, and coupling*).

# **Phase 2: Template Document**

***First Draft Due March 24th /Final Paper Due March 31st***

**Part 1: General Reaction Scheme**

“Insert Reaction Scheme Image Here”

**Figure 1.** “REPLACE THIS PART WITH A TITLE FOR YOUR REACTION SCHEME”

 **Description of Image:** General reaction scheme for the “INSERT REACTION NAME”

**\*Note: The *Description of Image* must be less than 125 characters.**

**Reference for Reaction Scheme in ACS Format:**

“Insert Reference in ACS Format Here”

**Part 2: Utility of the Reaction**

“Insert Typed Utility of the Reaction Here”

**References for the Utility of the Reaction in ACS Format:**

“Insert References in ACS Format Here”

**Part 3: Description of Reaction Mechanism**

“Insert Typed Description of the Reaction Mechanism Here”

**Reference for the Description of Reaction Mechanism in ACS Format:**

“Insert Reference in ACS Format Here”

# **Phase 2: Peer Feedback Guidelines**

**Part 1: General Reaction Scheme**

|  |
| --- |
| **Accuracy**1. All structures are drawn correctly.2. All necessary reagents and reaction conditions are shown in appropriate locations around the arrow.3. The appropriate reaction arrow is used. |
| **Design**1. All structures are sized appropriately in relation to each other.2. Reaction scheme illustrates a generic reaction with R groups indicated.3. Contrasting color is used to indicate the bonds/atoms which will undergo the reaction.4. Required reagents are shown **above** the reaction arrow 5. The solvent used and required conditions are shown **below** the reaction arrow.6. Structures of reaction are bottom aligned with arrow center aligned. |
| **Description of Image (Alt text)**1. Description is 125 characters or less.2. Title of reaction is included in the description of image. |

**Part 2: Utility of the Reaction**

|  |
| --- |
| **Accuracy**1. All reactive functional groups are identified. |
| **Mechanics**1. Grammar and punctuation were used correctly.
2. Summary is written clearly with audience of organic chemistry students in mind.
 |

**Part 3: Description of Reaction Mechanism**

|  |
| --- |
| **Accuracy**1. All mechanistic steps are described accurately and in order.2. The type of each mechanistic step is accurately identified.3. Roman numerals are used to indicate the intermediates of the mechanism.4. Mechanism does not use personification.5. Mechanism describes movement of electrons from electron source to electron sink. |
| **Mechanics**1. Grammar and punctuation were used correctly.2. Summary is written clearly with audience of organic chemistry students in mind. |

**References**

|  |
| --- |
| **References**1. References are in the ACS format.2. References are cited correctly. |

# **Phase 3: Instructions**

***First Draft Due April 10th /Final Paper Due April 16th***

**Part 1: Development of the Reaction**

1. Write one sentence that indicates who first reported the reaction and when.

2. What modifications have been made to the reaction? (one to two sentences)

3. Include references for each of these in ACS format.

**Part 2: Example of use with a bio-based molecule**

1. Identify a primary literature article in which your chosen reaction is used with a bio-based/bio-derived molecule as a reactant, product, or catalyst.

2. Draw the reaction scheme where your reaction was used using chemical drawing software.

3. Identify the purpose of the study. (Two to three sentences)

 - What problem was the researchers trying to solve?

- Identify the bio-derived or bio-based molecule was used.

4. Summarize the findings of the study. (Three to five sentences)

5. Cite the reference in ACS format and submit a pdf of the journal article with your assignment.

**Part 3: Connection of chosen literature article to a planetary boundary**

1. Identify which planetary boundary is relevant to the chosen literature article.

 \*\* **Note:** For a description of the planetary boundaries please refer to the following websites:

- <https://planetaryboundaries.kcvs.ca/PlanetaryBoundaries.html>

- [https://www.stockholmresilience.org/research/planetary-boundaries/planetary- boundaries/about-the-research/the-nine-planetary-boundaries.html](https://www.stockholmresilience.org/research/planetary-boundaries/planetary-%20%20boundaries/about-the-research/the-nine-planetary-boundaries.html)

2. Write a short paragraph (three to five sentences*)* describing how it relates to that planetary boundary.

3. Write one to two sentences indicating whether the research in the article will help us from crossing the threshold for that planetary boundary.

# **Phase 3: Template Document**

***First Draft Due April 10th /Final Paper Due April 16th***

**Part 1: Summary of the Development of the Reaction**

“Insert Typed Summary of the Development of the Reaction Here”

**References for Development of the Reaction:**

“Insert Reference in ACS Format Here”

**Part 2: Example of use with a bio-based molecule**

**Reaction Scheme:**

“Insert Reaction Scheme Here”

**Description of Image:** “Insert description here”

**\*Note: The *Description of Image* must be less than 125 characters.**

**Purpose of the Study:**

“Insert Purpose of the Study Here”

**Findings of the Study:**

“Insert Findings of the Study Here”

**Reference for Chosen Literature Article:**

“Insert Reference in ACS Format Here”

**Part 3: Connection of chosen literature article to a planetary boundary**

**Planetary Boundary Identified: \_**“Identify Planetary Boundary here”**\_**

**Description of how research relates to Planetary Boundary:**

“Insert Typed Description Here”

**Impact of the research on the Planetary Boundary**

“Insert Typed Impact Here”

**References for Connection of literature article to planetary boundary:**

“Insert References in ACS Format Here”

# **Phase 3: Peer Feedback Guidelines**

**Part 1: Development of the Reaction**

*1. Write one sentence that indicates who first reported the reaction and when.*

*2. What modifications have been made to the reaction? (one to two sentences)*

*3. Include references for each of these in ACS format.*

|  |
| --- |
| **Development of the Reaction: Origin of the Reaction**1. Authors and date of first report of the reaction are indicated.2. Reference for the first report has in-text citation in ACS format. (*superscripted number corresponding to reference at end of sentence*). |
| **Development of the Reaction: Modifications**1. Modification of the reaction is listed.2. Details of the reactions are listed with sufficient details.3. References for each of the modifications have in-text citations in ACS format. (*superscripted number corresponding to reference at end of sentence*). |
| **Development of the Reaction: Accuracy**1. All reported information is accurate.2. Selected citations correspond to reported information. |
| **Development of the Reaction: References**1. References are in the ACS format.2. References are cited correctly. |

**Part 2: Example of use with a bio-based molecule**

*1. Identify a primary literature article in which your chosen reaction is used with a bio-based/bio-derived molecule as a reactant, product, or catalyst.*

*2. Draw the reaction scheme where your reaction was used using chemical drawing software.*

**a) Example Reaction Scheme**

|  |
| --- |
| **Use with a bio-based molecule: Accuracy of Reaction Scheme**1. All structures are drawn correctly.2. All necessary reagents and reaction conditions are shown in appropriate locations around the arrow.3. The appropriate reaction arrow is used. |
| **Use with a bio-based molecule: Design of Reaction Scheme**1. All structures are sized appropriately in relation to each other.2. Required reagents are shown **above** the reaction arrow 3. The solvent used and required conditions are shown **below** the reaction arrow.4. Structures of reaction are bottom aligned with arrow center aligned.5. Reaction scheme has a title below it. (Figure #. Assigned Figure Title) |
| **Use with a bio-based molecule: Description of Image (Alt text)**1. Description is 125 characters or less.2. Title of reaction is included in the description of image. |

**b) Summary of the Paper**

*3. Identify the purpose of the study. (Two to three sentences)*

 *- What problem was the researchers trying to solve?*

*- Identify the bio-derived or bio-based molecule was used.*

*4. Summarize the findings of the study. (Three to five sentences)*

*5. Cite the reference in ACS format and submit a pdf of the journal article with your assignment.*

|  |
| --- |
| **Use with a bio-based molecule: Purpose of the Study**1. The major problem that researchers are trying to solve is clearly addressed.2. The particular goal of the study is clearly addressed.3. The bio-based or bio-derived molecule used in the study was clearly identified. |
| **Use with a bio-based molecule: Findings of the Study**1. All key findings of the study were reported.2. Summary was written in a concise manner. |
| **Use with a bio-based molecule: Accuracy**1. All reported information is accurate.2. Summary does not paraphrase the abstract. Details from the paper are included.3. Summary was written in past tense. |
| **Use with a bio-based molecule: References**1. References are in the ACS format.2. References are cited correctly. |

**Part 3: Connection of chosen literature article to a planetary boundary**

*1. Identify which planetary boundary is relevant to the chosen literature article.*

*2. Write a short paragraph (three to five sentences) describing how it relates to that planetary boundary.*

*3. Write one to two sentences indicating whether the research in the article will help us from crossing the threshold for that planetary boundary.*

|  |
| --- |
| **Research’s relationship to a Planetary Boundary**1. The chosen planetary boundary is relevant to the research.2. The relationship between the research and planetary boundary is clearly described. |
| **Impact on Planetary Boundary**1. The impact of the research on the planetary boundary has been carefully considered and articulated in their explanation. |
| **Accuracy**1. All reported information is accurate. |
| **References**1. References are in the ACS format.2. References are cited correctly. |

# **Phase 4: Instructions**

***First Draft Due April 21st /Final Paper Due April 28th***

**Part 1: Analysis of Reaction’s Adherence to the 12 Green Chemistry Principles**

1. Pick a specific reaction from the literature article which illustrates the reaction you have chosen.

2. Analyze the reaction’s adherence to each of the applicable green chemistry principles.

**Part 2: Calculate Green Chemistry Metrics for the Reaction Reported in the Paper**

1. For part 2, use the same reaction from the literature article that you chose for part one of this assignment.

2. For that specific reaction, calculate and report the atom economy. Show your calculations using the Equation Editor in Word.

3. For that specific reaction, calculate and report the process mass intensity. Show your calculations using the Equation Editor in Word.

 *- If it is missing quantities of reagents used in the work-up, calculate using available quantities but include a note explaining what it does not account for.*

# **Phase 4: Template Document**

***First Draft Due April 21st /Final Paper Due April 28th***

**Part 1: Analysis of Reaction’s Adherence to the 12 Green Chemistry Principles**

“Insert Analysis Here”

**References for Reactions Adherence to the Green Chemistry Principles:**

“Insert References in ACS Format Here”

**Part 2: Calculate Green Chemistry Metrics for the Reaction**

**Calculation for Atom Economy:**

“Insert Calculation Here. Show your work.”

**Calculation for Process Mass Intensity:**

“Insert Calculation Here. Show your work.”

**Statement for any reagents not included in process mass intensity equation:**

“Insert statement here, if applicable.”

**Any References used in the Calculation of the Green Chemistry Metrics:**

“Insert any References used for the calculations in ACS Format Here”

# **Phase 4: Peer Feedback Guidelines**

**Part 1: Analysis of Reaction’s Adherence to the 12 Green Chemistry Principles**

1. Pick a specific reaction from the literature article which illustrates the reaction you have chosen.

2. Analyze the reaction’s adherence to each of the applicable green chemistry principles.

|  |
| --- |
| **Reaction’s Adherence to the 12 Green Chemistry Principles**1. All applicable green chemistry principles have been applied.2. Green Chemistry principles have been applied correctly.3. Analysis is written in a clear manner.4. Reference for the journal article has in-text citation in ACS format. (*superscripted number corresponding to reference at end of sentence*). |
| **References**1. References are in the ACS format.2. References are cited correctly. |

**Part 2: Calculate Green Chemistry Metrics for the Reaction Reported in the Paper**

1. For part 2, use the same reaction from the literature article that you chose for part one of this assignment.

2. For that specific reaction, calculate and report the atom economy. Show your calculations using the Equation Editor in Word.

3. For that specific reaction, calculate and report the process mass intensity. Show your calculations using the Equation Editor in Word.

 *- If it is missing quantities of reagents used in the work-up, calculate using available quantities but include a note explaining what it does not account for.*

|  |
| --- |
| **Atom Economy**1. Atom economy was correctly calculated.2. Calculation was clearly shown using the Equation Editor. |
| **Process Mass Intensity**1. Process Mass Intensity was correctly calculated.2. Calculation was clearly shown using the Equation Editor. |
| **References**1. References are in the ACS format.2. References are cited correctly. |

# **Phase 5: Instructions for Uploading Phases to Libretext**

Please refer to this document for instructions on uploading your information onto each of your Libretext pages. Please use the provided headings included below (without phase and part numbers) for each section on the page. Headings need to be formatted using the *Heading 1* option on Libretext. For instructions on uploading images and equations, please refer to the Libretext’s Training, Tutorials, and References webpage available through your sandbox. Additionally, here is a direct URL: <https://chem.libretexts.org/Sandboxes/00%3A_Training_Tutorials_and_References>.

**Page 1. Information about the Reaction**

General Reaction Scheme **[Phase 2*, Part 1*]**

1. Use chemical drawing software to draw the generic reaction scheme.

* Use R for unspecified alkyl groups and X for unspecified halide groups

2. List required reagents above the reaction arrow and the solvent/required conditions below the reaction arrow.

3. Use a contrasting color to indicate the bonds/atoms which will undergo the reaction.

4. Save the file within the chemical drawing software and copy it onto the “Phase 2 Template Page.”

Summary of the Development of the Reaction **[Phase 3*, Part 1*]**

1. Write one sentence that indicates who first reported the reaction and when.

2. What modifications have been made to the reaction? (one to two sentences)

3. Include references for each of these in ACS format.

Utility of the Reaction **[Phase 2*, Part 2*]**

1. Write one to two sentences that describe what functional group interconversion this reaction facilitates.

2. Write one to two sentences indicating what types of functional groups would require protecting groups to ensure the reaction proceeds and exhibits regioselectivity and chemoselectivity. For example, Diels-alder reactions work with both alkenes and alkynes.

**Page 2. Reaction Mechanism**

Reaction Mechanism **[Phase 1]**

Description of Reaction Mechanism **[Phase 2, *Part 3*]**

1. Write a short paragraph that describes what happens during each step of the reaction mechanism.

2. Within the paragraph, identify the types of mechanistic steps (*ex. nucleophilic attack, SN1, SN2, loss of leaving group, proton transfer, rearrangement such as methyl shift or hydride shift, homolytic cleavage, addition to pi bond, hydrogen abstraction, halogen abstraction, elimination, and coupling*).

**Page 3. Use of reaction with bio-based/bio-derived molecule**

Example of use with a bio-based molecule **[Phase 3, *Part 2*]**

1. Identify a primary literature article in which your chosen reaction is used with a bio-based/bio-derived molecule as a reactant, product, or catalyst.

2. Draw the reaction scheme where your reaction was used using chemical drawing software.

3. Identify the purpose of the study. (Two to three sentences)

 - What problem was the researchers trying to solve?

- Identify the bio-derived or bio-based molecule was used.

4. Summarize the findings of the study. (Three to five sentences)

5. Cite the reference in ACS format and submit a pdf of the journal article with your assignment.

**Page 4. Analysis of reaction’s adherence to the Green Chemistry Principles**

Analysis of Reaction’s Adherence to the 12 Green Chemistry Principles **[Phase 4, *Part 1*]**

1. Pick a specific reaction from the literature article which illustrates the reaction you have chosen.

2. Analyze the reaction’s adherence to each of the applicable green chemistry principles.

Calculate Green Chemistry Metrics for the Reaction Reported in the Paper **[Phase 4, *Part 2*]**

1. For part 2, use the same reaction from the literature article that you chose for part one of this assignment.

2. For that specific reaction, calculate and report the atom economy. Show your calculations using the Equation Editor in Word.

3. For that specific reaction, calculate and report the process mass intensity. Show your calculations using the Equation Editor in Word.

 *- If it is missing quantities of reagents used in the work-up, calculate using available quantities but include a note explaining what it does not account for.*

**Page 5. Connection to Planetary Boundaries**

Connection of chosen literature article to a planetary boundary **[Phase 3, *Part 3*]**

1. Identify which planetary boundary is relevant to the chosen literature article.

 \*\* **Note:** For a description of the planetary boundaries please refer to the following websites:

- <https://planetaryboundaries.kcvs.ca/PlanetaryBoundaries.html>

- [https://www.stockholmresilience.org/research/planetary-boundaries/planetary- boundaries/about-the-research/the-nine-planetary-boundaries.html](https://www.stockholmresilience.org/research/planetary-boundaries/planetary-%20%20boundaries/about-the-research/the-nine-planetary-boundaries.html)

2. Write a short paragraph (three to five sentences*)* describing how it relates to that planetary boundary.

3. Write one to two sentences indicating whether the research in the article will help us from crossing the threshold for that planetary boundary.

# **Phase 5: Feedback Guidelines for Libretext Pages**

**Page 1 Feedback Guidelines**

**General Reaction Scheme**

|  |
| --- |
| **Accuracy**1. All structures are drawn correctly.2. All necessary reagents and reaction conditions are shown in appropriate locations around the arrow.3. The appropriate reaction arrow is used. |
| **Design**1. All structures are sized appropriately in relation to each other.2. Reaction scheme illustrates a generic reaction with R groups indicated.3. Contrasting color is used to indicate the bonds/atoms which will undergo the reaction.4. Required reagents are shown **above** the reaction arrow 5. The solvent used and required conditions are shown **below** the reaction arrow.6. Structures of reaction are bottom aligned with arrow center aligned. |
| **Description of Image (Alt text)**1. Description is 125 characters or less.2. Title of reaction is included in the description of image. |

**Development of the Reaction**

|  |
| --- |
| **Development of the Reaction: Origin of the Reaction**1. Authors and date of first report of the reaction are indicated.2. Reference for the first report has in-text citation in ACS format. (*superscripted number corresponding to reference at end of sentence*). |
| **Development of the Reaction: Modifications**1. Modification of the reaction is listed.2. Details of the reactions are listed with sufficient details.3. References for each of the modifications have in-text citations in ACS format. (*superscripted number corresponding to reference at end of sentence*). |
| **Development of the Reaction: Accuracy**1. All reported information is accurate.2. Selected citations correspond to reported information. |
| **Development of the Reaction: References**1. References are in the ACS format.2. References are cited correctly. |

**Utility of the Reaction**

|  |
| --- |
| **Accuracy**1. All reactive functional groups are identified. |
| **Mechanics**1. Grammar and punctuation were used correctly.
2. Summary is written clearly with audience of organic chemistry students in mind.
 |

**Page 2 Feedback Guidelines**

**Reaction Mechanism Image**

|  |
| --- |
| **Reaction Mechanism: Arrows**1. Curved arrows start from electron source and point to electron sink.2. Curved arrows clearly indicate starting and ending points.3. All arrows are used for correct purpose (*curved, resonance, reaction, equilibrium, etc.*).  |
| **Reaction Mechanism: Mechanistic Steps**1. Only one mechanistic step is illustrated in each step of the mechanism.2. Each mechanistic step is labeled to identify type of mechanistic step. |
| **Reaction Mechanism: Accuracy**1. All structures are drawn correctly.2. Mechanistic steps are drawn correctly.3. All mechanistic steps are labeled correctly. |
| **Reaction Mechanism: Design**1. Mechanism is drawn clearly.2. All structures are sized appropriately in relation to each other.2. Mechanistic steps are organized neatly and can be easily followed. |
| **Reaction Mechanism: Description of Image**1. Description is 125 characters or less.2. Title of reaction is added in the description of image. |
| **Reaction Mechanism: References**1. References are in the ACS format.2. References are cited correctly. |

**Description of Reaction Mechanism**

|  |
| --- |
| **Accuracy**1. All mechanistic steps are described accurately and in order.2. The type of each mechanistic step is accurately identified.3. Roman numerals are used to indicate the intermediates of the mechanism.4. Mechanism does not use personification.5. Mechanism describes movement of electrons from electron source to electron sink. |
| **Mechanics**1. Grammar and punctuation were used correctly.2. Summary is written clearly with audience of organic chemistry students in mind. |

**Page 3 Feedback Guidelines**

**Example Reaction Scheme**

|  |
| --- |
| **Use with a bio-based molecule: Accuracy of Reaction Scheme**1. All structures are drawn correctly.2. All necessary reagents and reaction conditions are shown in appropriate locations around the arrow.3. The appropriate reaction arrow is used. |
| **Use with a bio-based molecule: Design of Reaction Scheme**1. All structures are sized appropriately in relation to each other.2. Required reagents are shown **above** the reaction arrow 3. The solvent used and required conditions are shown **below** the reaction arrow.4. Structures of reaction are bottom aligned with arrow center aligned.5. Reaction scheme has a title below it. (Figure #. Assigned Figure Title) |
| **Use with a bio-based molecule: Description of Image (Alt text)**1. Description is 125 characters or less.2. Title of reaction is included in the description of image. |

**Summary of the Paper**

|  |
| --- |
| **Use with a bio-based molecule: Purpose of the Study**1. The major problem that researchers are trying to solve is clearly addressed.2. The particular goal of the study is clearly addressed.3. The bio-based or bio-derived molecule used in the study was clearly identified. |
| **Use with a bio-based molecule: Findings of the Study**1. All key findings of the study were reported.2. Summary was written in a concise manner. |
| **Use with a bio-based molecule: Accuracy**1. All reported information is accurate.2. Summary does not paraphrase the abstract. Details from the paper are included.3. Summary was written in past tense. |
| **Use with a bio-based molecule: References**1. References are in the ACS format.2. References are cited correctly. |

**Page 4 Feedback Guidelines**

**Analysis of Reaction’s Adherence to the 12 Green Chemistry Principles**

|  |
| --- |
| **Reaction’s Adherence to the 12 Green Chemistry Principles**1. All applicable green chemistry principles have been applied.2. Green Chemistry principles have been applied correctly.3. Analysis is written in a clear manner.4. Reference for the journal article has in-text citation in ACS format. (*superscripted number corresponding to reference at end of sentence*). |
| **References**1. References are in the ACS format.2. References are cited correctly. |

**Green Chemistry Metrics for the Reaction Reported in the Paper**

|  |
| --- |
| **Atom Economy**1. Atom economy was correctly calculated.2. Calculation was clearly shown using the Equation Editor. |
| **Process Mass Intensity**1. Process Mass Intensity was correctly calculated.2. Calculation was clearly shown using the Equation Editor. |
| **References**1. References are in the ACS format.2. References are cited correctly. |

**Page 5 Feedback Guidelines**

**Connection of chosen literature article to a planetary boundary**

|  |
| --- |
| **Research’s relationship to a Planetary Boundary**1. The chosen planetary boundary is relevant to the research.2. The relationship between the research and planetary boundary is clearly described. |
| **Impact on Planetary Boundary**1. The impact of the research on the planetary boundary has been carefully considered and articulated in their explanation. |
| **Accuracy**1. All reported information is accurate. |
| **References**1. References are in the ACS format.2. References are cited correctly. |

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# **Analysis of Student Perception of Project’s Impact on Professional Development Skills**

