Lab Activity 8. Reflux, Introduction to Organic Chemical Reactivity

Part 1. Organic Lab Techniques - Reflux
We spent the first part of Chem 12A learning how to represent organic molecules, e.g., skeletal structures, stereoisomers. We looked at organic acid-base reactions earlier. We will spend the next part of Chem 12A learning about other organic reaction types: substitution, elimination, addition, and radical reactions.

When you perform a chemical reaction, you are doing a synthesis reaction.
Synthesis: Chemical reactions occur when bonds break and form. Energy is involved in every chemical reaction. Thermodynamics tells us how much heat is absorbed or released. Rate tells us how fast the reaction occurs. Most organic reactions are equilibrium reactions. How can you, the experimental scientist, get atoms and molecules to react to form products with a high yield?

Most organic reactions are equilibrium reactions. Recall LeChatelier's principle. You, the experimenter, can control the direction of a chemical reaction by choosing the appropriate reaction conditions, such as temperature, amounts of reactants, pressure, and time.

1. a. (i) If a glass beaker falls 1 inch onto the floor, will it break? Why?
(ii) If a glass beaker falls 5 feet onto the floor, will it break? Why?
b. Atoms and molecules collide with _____ energy for bonds to ____ and ____. Note: this happens when you cook food.
c. When bonds break, energy is _____ (____ thermic).
d. When bonds form, energy is _____ (_____ thermic).
Choices for b, c, and d: absorbed, break, endo, enough, exo, form, released, required, sufficient

2. There are different ways to mix a reaction mixture. Name two different ways.

3. ***Heating Sources***. Your organic lab locker includes a sand bath. You heat up the sand and place a reaction container in the hot sand to heat a reaction mixture.
a. Why do you want to heat a reaction? Hint: why is heat used when you are cooking?
b. What is the effect of higher temperature on molecular motion?
c. What happens when molecules bump into each other?
d. Based on equilibrium concepts (see LeChatelier's principle),
(i) heating a reaction that is exothermic shifts the reaction toward the ____ side and ____ the % yield.
(ii) Heating a reaction that is endothermic shifts the reaction toward the ____ side and ____ the % yield.
e. Other heating sources:
(i) Many organic compounds are flammable so you do not want to use a ____ to heat a reaction mixture.
(ii) What heating source would you use to heat a reaction mixture to 100^{o}C?
(iii) If you want to heat up a reaction mixture to a higher temperature than 100^{o}C, you can use an oil bath. What oil is used? What is the maximum safe operating temperature of an oil bath?
(iv) If you want to heat up a reaction mixture to a higher temperature than an oil bath, you can use a sand bath. Today is a hot day so take a break and walk on the beach. Is the sand hot?
(v) "The microwave oven is the new Bunsen burner of the 21st century." – Ajay Bose, microwave chemistry researcher.
When a substance is exposed to microwave radiation, certain molecules will rotate or spin like a top. Polar solvents, like alcohols and water, can be used in microwave reactions but non-polar solvents, like hexane, do not work well.
A commercial microwave oven has a frequency of 2.45 GHz. This gives a microwave penetration depth of approximately 2 cm.

4. ***Reflux***.
You dissolve reactants in a solvent in a reaction flask and want to heat the reaction mixture at the boiling point of the solvent for an hour.
Problem: solvent evaporates so you need to watch the reaction and add solvent to keep the volume of the reaction mixture constant. How can you keep the solvent from escaping?
Answer: reflux. (You did a macroscale reflux in Chem 1B lab when you made a smelly ester.)
a. In Pot A, you heat 1 cup of water to its boiling point without a lid. In Pot B, you heat 1 cup of water to its boiling point and cover this pot with a lid.
(i) Pot A will evaporate water faster because ____.
(ii) Pot B will boil water faster ____.
(iii) Pot B is like doing a reflux because the ____ works like a condenser when the vapor condenses on the cold ____ and drips back into the pot.

b. Your microscale kit is shown in Figure 1. Or go to chemix.org ("an online editor for drawing science lab diagrams and school experiment apparatus").
(i) What parts would you use to set up a reflux?
(ii) Draw a picture of your reflux set-up. Name and describe the function of each part.
(iii) Show what is happening to the reaction mixture in each part.
(iv) Why shouldn't a stopper be used to keep vapor from escaping?
c. (i) What is the state of matter of reactants in a reflux?
(ii) What is the reason for doing a reflux instead of just heating?
(iii) Why don't you have to add additional solvent during a reflux?
(iv) At what temperature should you set a reflux?
d. How does a reflux help a reaction?
Check the boxes that apply.
(i) Based on equilibrium, refluxing a reaction
makes the reaction occur faster
makes the reaction occur slower
increases % yield of products
decreases % yield of products
(ii) Based on reaction rate, refluxing a reaction
makes the reaction occur faster
makes the reaction occur slower
increases % yield of products
decreases % yield of products

e. You reflux a reaction for 30 minutes. You should start timing the 30 minutes when the reaction mixture starts to boil.
(i) If you starting timing your reflux as soon as you start heating the reaction mixture, the number of collisions between reactant molecules ____ and the % yield of product ____.
(ii) Your group and 9 other groups are doing the same reaction. Each group refluxed the reaction for 30 minutes but the % yield of product varies from 10% to 75% yield. One reason the yield varies so much is the reaction temperature did not stay at the boiling point of the solvent for the entire 30 minutes.
If the reaction mixture is colder in one part of the mixture than another part, what happens to the % yield of product?
How can you make sure the reaction temperature stays constant for the entire reflux time?
When you are refluxing a reaction in Chem 12 lab, monitor the temperature of your reaction mixture with a temperature probe.

5. In Lab 9 (you will watch a video), you will reflux a mixture of NaBr (s), H_2O (l), butanol (l), and concentrated H_2SO_4 (aq). What is the approximate temperature at which this reaction mixture boils? Give reasons.

6. How is a distillation different than a reflux?

References on reflux:
https://www.youtube.com/watch?v=5I1S6evKpe4
http://ochem.jsd.claremont.edu/in-the-lab.html# Click on "Reflux"
http://www.chemistry.mcmaster.ca/~chem2o6/labmanual/microscale/complete.html#reactions
http://academics.wellesley.edu/Chemistry/chem211lab/Orgo_Lab_Manual/Appendix/Techniques/Reflux/reflux_n.html

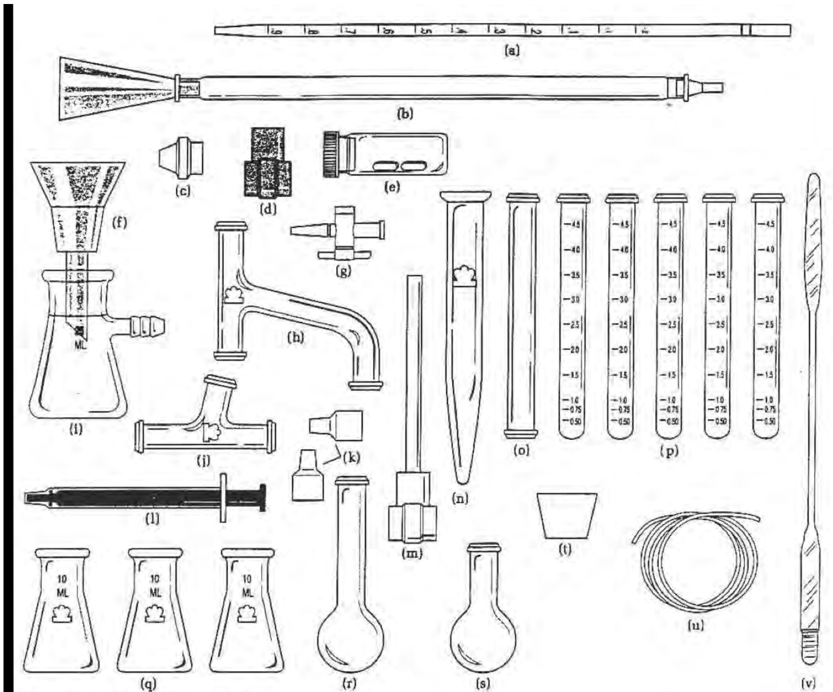


Fig. 1.14 Microscale apparatus kit.

(a) Pipette (1 mL), graduated in 1/100ths.
(b) Chromatography column (glass) with polypropylene funnel and 20-μm polyethylene frit in base, which doubles as a micro Büchner funnel. The column, base, and stopcock are also used as a separatory funnel.
(c) Thermometer adapter (Santoprene).
(d) Connector only (Viton).
(e) Magnetic stirring bars (4 × 12 mm) in distillation receiver vial.
(f) Hirsch funnel (polypropylene) with 20-μm fritted polyethylene disk.
(g) Stopcock for chromatography column and separatory funnel.
(h) Claisen adapter/distillation head with air condenser.
(i) Filter flask, 25 mL.
(j) Distillation head, 105° connecting adapter.
(k) Rubber septa/sleeve stoppers, 8 mm.
(l) Syringe (polypropylene).
(m) Connector (Santoprene) with support rod.
(n) Centrifuge tube (15 mL)/ sublimation receiver, with cap.
(o) Distillation column/air condenser.
(p) Reaction tube, calibrated, 10 × 100 mm.
(q) Erlenmeyer flasks, 10 mL.
(r) Long-necked flask, 5 mL.
(s) Short-necked flask, 5 mL.
(t) Filter adapter (Santoprene) for sublimation apparatus.
(u) Tubing (polyethylene), 1/16-in. diameter.
(v) Spatula (stainless steel) with scoop end.

Figure 1. Microscale organic lab equipment. (Taken from Williamson, K., "Macroscale and Microscale Organic Experiments", 3rd ed., Houghton-Mifflin, 1999.)

Part 2. Introduction to Organic Chemical Reactivity
Objectives
1. Identify structural features (pi bonds, bond polarity, lone pairs) of a compound to determine so you can determine possible reaction types.
2. Determine whether a structural feature is a nucleophile or electrophile so you can determine how the compound can react.
3. Use curved arrows to show the bonds that break and form in a reaction so you can predict the products.

References: 1. D. Klein, "**Organic Chemistry**", 2nd ed., 2014, Ch. 6
2. Chemical Reactivity: http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/react1.htm
3. "Reactivity Principles and Trends" pages from Chem 12A Syllabus

Introduction to Reactivity

With so many organic compounds, there are many organic reactions. Rather than memorizing every reaction, here are a few ideas to remember:

- A chemical reaction occurs when two substances collide with sufficient energy for bonds to break or form. (Think what happens when two cars run into each other. Does speed matter?)
- Two substances that collide must have the right orientation for bonds to break or form. (There are "strong" parts and "weak" parts of molecules.)
- A positive charge, e.g., cation, is attracted to a negative charge, e.g., anion. (What is the name of this law?)
- There are only a **few** different ways organic compounds react: acid-base, substitution, elimination, and addition.

• Certain parts of the structure of the molecule (structural features) tell us where a reaction occurs.

Each functional group undergoes specific reactions. We want to know and be able to predict the reactivity of each group. Organic reactions can be classified as polar (or ionic), radical, or pericyclic reactions.

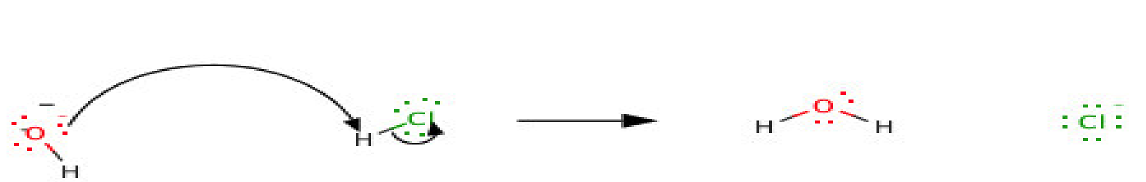
Most organic reactions are polar reactions. In a polar reaction, the **positive** part of a molecule reacts with the **negative** part of another molecule.

Positive part = cation, Lewis acid, electron deficient species, less electronegative atom in a polar bond = **electrophile** = electron sink
Negative part = negative charge, Lewis base, lone pair, π bond = **nucleophile** = electron source

The Table of Nucleophile and Electrophile Classifications in the Course Information Handout ranks nucleophiles and electrophiles in order of strength.
Remember that a single covalent bond involves a pair of electrons. So a polar reaction involves an electron pair to form or break a bond.

Scientists want to figure out how things work, including reactions. Once the products of a reaction are known, chemists want to figure out how the reaction occurred, i.e., the reaction **mechanism**. Looking at the bonds that break and form gives you information about the mechanism. (Why is an understanding of mechanism important?) Organic chemists like to use *curved arrows* (see resonance) to show bonds forming and breaking. **When you used curved arrows, the tail of the arrow starts at the negative part and the head of the arrow ends at the positive part.** We will discuss the use of curved arrows in more detail later this semester when we start looking at organic reactions.

For example, consider the reaction of NaOH with HCl (an acid-base or **proton transfer** reaction). A lone pair on oxygen (nucleophile) in OH^- is attracted to the H (electrophile) in HCl and forms an O-H bond. Since H can't have two bonds to it, the bonding pair between H and Cl breaks and forms a lone pair on Cl. Note that **the curved arrow points from the nucleophile to the electrophile.**



See the Table of Elemental Mechanistic Processes in the Course Information Handout for the common ways nucleophiles react with electrophiles.

In a radical reaction, unpaired electrons form and break bonds. We will look at radical reactions when we look at how plastics are made from alkenes. In a pericyclic reaction, a carbon chain forms a carbon ring.

We'll practice identifying nucleophiles and electrophiles and how to use curved arrows to show bonds breaking and forming.

Materials
molecular model kits

1. Acetic acid, CH_3COOH, reacts with NaOH to form sodium acetate and water.
Go to https://chemagic.org/molecules/amini.html. Under "Load Models", click on the "Draw" button. In the new screen,
a. Draw CH_3COOH. Then, click on the "Load Model" button.
In the new screen, you will see a 3D model of CH_3COOH. Use your mouse to rotate the molecule.
Click on the "Charge" box. Which atom has the most positive charge?
Then, click on the "MEP" box. (MEP = molecular electrostatic potential). The green regions represent neutral, red represents negative (high electron density), blue means positive (low electron density).
Does the acidic H behave like a positive, neutral, or negative?
Are the H's in the methyl group positive, neutral, or negative?
Does the charge on the acidic H match the MEP?
b. Draw the OH^- ion. Click on the "Charge" box. Which atom has the most negative charge?
Rotate the molecule. Which atom in OH^- reacts with the acidic H in acetic acid? Give reasons.
c. This reaction is an ***acid-base reaction***. A proton (H^+) is transferred from the acid to the base. One bond is broken and one bond is formed.
Structural features: acid = H^+ donor (see pK_a table)

Base = H^+ acceptor (see pK_a table)

Write a chemical equation that represents this reaction by drawing the structure of each reactant and product.
Identify the bond that breaks in each reactant and the bond that forms in each product.
d. Draw the acetate ion, CH_3COO^-.
Click on the "Charge" box. Explain why the charge on each O is the same.
Click on the "Length" box. Follow the directions to measure each carbon-oxygen bond. Explain the carbon-oxygen bond length.
Draw the structure of the acetate ion.
e. For each reactant, draw a circle around the "positive" (electrophilic) parts and a box around the "negative" (nucleophilic) parts. Which atom in which reactant is the most electrophilic?
Which atom in which reactant is the most nucleophilic? (HINT: C-H bonds are generally unreactive so skip those bonds.)
Based on the bonds that break and form from part a, draw a curved arrow (that shows the bonds that break and form) from the negative part of one reactant to the positive part of the other reactant.
Make a molecular model of each reactant. Show how the OH^- (nucleophile) reacts at the acidic H (electrophile) in CH_3COOH. Then, show the O-H bond in the acid breaking. This should match your curved arrows.

f. More acid-base reaction practice.
You want to be able to identify which substance is an acid and which is a base in an acid-base reaction. Repeat Steps 1a-e for the following reactions. Make sure you can draw curved arrows to show the bonds that break and form going to reactant to product.
(i) Benzoic acid reacts with HCO_3^-.
(ii) The product of (i) reacts with H_3O^+. (Hint: the product of (i) is a base.)
(iii) tert-butyl phenol reacts with OH^-. (Hint: tert-butyl phenol behaves like an acid in this reaction.)
(iv) The product of (iii) reacts with H_3O^+. (Hint: the product of (iii) is a base.)
(v) C_2H_5OH reacts with H_2SO_4.

2. You did this reaction in Lab 4: 1-bromobutane, $CH_3(CH_2)_2CH_2Br$, reacts with I^- to form $CH_3(CH_2)_3I$ and Br^-.
a. Go to https://chemagic.org/molecules/amini.html. Draw 1-bromobutane.
Click on the "Charge" box. Which atom has the most positive charge?
Then, click on the "MEP" box. Rotate the molecule. Which part of 1-bromobutane is positive? Which part of 1-bromobutane is negative?
b. The iodide ion has a -1 charge. Which part of 1-bromobutane reacts with I^-?
c. This reaction is a ***substitution*** reaction. One atom or group replaces (substitutes) another atom or group (called a ***leaving group***). One bond is broken and one bond is formed.
Structural features: alpha carbon = the carbon bonded to a leaving group.
Leaving group = a base (see pK_a table).
Nucleophile = electron pair donor.

Write a chemical equation that represents this reaction by drawing the structure of each reactant and product.
Identify the bond that breaks in each reactant and the bond that forms in each product.
d. For each reactant, draw a circle around the "electrophilic" parts and a box around the "nucleophilic" parts.
Which atom in which reactant is the most electrophilic?
Which atom in which reactant is the most nucleophilic? (HINT: C-H bonds are generally unreactive so skip those bonds.)
Based on the bonds that break and form from part c, draw a curved arrow from the negative part of one reactant to the positive part of the other reactant.
Then, show the C-Br bond breaking. The Br^- is called the ***leaving group***.
Make a molecular model of each reactant.
Show how the I^- (nucleophile) reacts at the carbon bonded to the Br, which is called the alpha carbon, (electrophile) in $CH_3(CH_2)_2CH_2Br$. Then, show the C-Br bond breaking. This should match your curved arrows.

e. More substitution reactions from Lab 4. Repeat Steps 2a- e for the following reactions:
(i) 2-chlorobutane reacts with NaI. The nucleophile is _____. The electrophile is _____.
Which carbon is the alpha carbon?
What is the charge on this carbon when you click on the "Charge" box?
What color is this carbon when you click on the "MEP" box?
What is the leaving group?
(ii) 1-chloro-2-butene reacts with NaI. The nucleophile is _____. The electrophile is _____.
Which carbon is the alpha carbon?

What is the charge on this carbon when you click on the “Charge” box?
What color is this carbon when you click on the “MEP” box?
What is the leaving group?
(iii) 2-chloro-2-methylpropane reacts with NaI. The nucleophile is _____. The electrophile is _____.
Which carbon is the alpha carbon?
What is the charge on this carbon when you click on the “Charge” box?
What color is this carbon when you click on the “MEP” box?
What is the leaving group?

f. Compare the reaction in Question 2a to the reaction in Question 2e(iii).
The iodide ion reacts at the alpha carbon in 1-bromobutane or 2-chloro-2-methylpropane. Which carbon is easier for the iodide ion to get to? Give reasons.
Your answer will determine the substitution mechanism type (S_N1 or S_N2), which is important when stereochemistry is involved.

3. ***Substitution*** reactions.
(i) 2-chloro-2-methylpropane (also called tert-butyl chloride), $(CH_3)_3C\text{-}Cl$, reacts with $AgNO_3$ to form $(CH_3)_3C^+$ ion and NO_3^- ion and AgCl (s). A precipitate forms. This precipitate is AgCl.
(ii) 1-bromobutane, $CH_3(CH_2)_3Br$, reacts with $AgNO_3$. You should not have seen a precipitate form.
a. Go to https://chemagic.org/molecules/amini.html. Draw $(CH_3)_3C\text{-}Cl$.
Click on the “Charge” box. Which atom has the most positive charge?
Then, click on the “MEP” box. Rotate the molecule. Which part of $(CH_3)_3C\text{-}Cl$ is positive?
Which part of $(CH_3)_3C\text{-}Cl$ is negative?
b. This reaction is a ***substitution*** reaction.
In Reaction (i), the C-Cl bond breaks in 2-chloro-2-methylpropane to form a tertiary (3^o) carbocation. (Recall primary (1^o), secondary (2^o), and tertiary (3^o) carbons from earlier in this course.)
A carbon with a positive charge is called a ***carbocation***.
A carbocation that has 0 or 1 C bonded to it is called a **primary** (1^o) carbocation = **least** stable.
A carbocation that has 2 C bonded to it is called a **secondary** (2^o) carbocation.
A carbocation that has 3 C bonded to it is called a **tertiary** (3^o) carbocation = **most** stable.
The Cl^- is the ***leaving group***.
Use a curved arrow to show how this C-Cl bond breaks to form the 3^o carbocation. 3^o carbocations are stable.
How does AgCl form?

(ii) In Reaction (i), the C-CBr bond breaks in 1-bromobutane to form a primary (1^o) carbocation.
Use a curved arrow to show how this C-Br bond breaks (the Br^- is the ***leaving group***) to form the 1^o carbocation. 1^o carbocations are unstable.
Why does AgBr ***not*** form?

c. 2-chlorobutane or 2-bromobutane reacts with $AgNO_3$.
Did a 2^o carbocation form in this reaction?
What experimental observation tells you the 2^o carbocation formed?

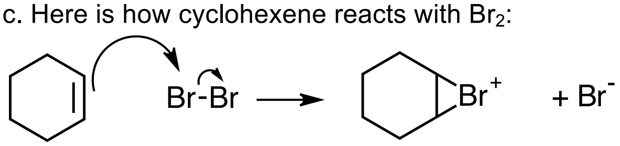
4. In an ***addition*** reaction, one atom or group bonds to each carbon in a carbon-carbon double bond (these carbons are called vinylic carbons). Two bonds break (pi bond in the alkene and usually a sigma bond in the other reactant) and two bonds sigma bonds form.
Structural features: carbon-carbon pi bond.
Electrophile = electron pair acceptor.

Go to https://chemagic.org/molecules/amini.html.
a. Draw ethylene, C_2H_4.
b. Click on the “MEP” box. (MEP = molecular electrostatic potential). The green regions represent neutral, red represents negative (high electron density), blue means positive (low electron density).
Rotate the molecule. Is the pi bond positive, neutral, or negative?
Click on the “Charge” box. What does the number on each atom tell you?
Does a pi bond behave like a nucleophile or electrophile?
c. Draw H_2SO_4. Click on the “MEP” box. Rotate the molecule. Which atom is acidic? Give reasons.
Click on the “Charge” box. What does the number on each atom tell you?
d. Which part of C_2H_4 reacts with H_2SO_4? How do you know?

5. Ethylene, C_2H_4, reacts with HCl to form CH_3-CH_2^+ and Cl^-.
a. This is the first step of an addition reaction. A ***carbocation*** intermediate forms.
Write a chemical equation that represents this reaction by drawing the structure of each reactant and product.
Identify the bond that breaks in each reactant and the bond that forms in each product.
Use curved arrows to show the bonds that break and form.
b. For each reactant, draw a circle around the "electrophiles" parts and a box around the "nucleophiles" parts.
Which atom in which reactant is the most electrophilic?
Which atom in which reactant is the most nucleophilic? (HINT: C-H bonds are generally unreactive so skip those bonds.)
Draw a curved arrow from the negative part of one reactant to the positive part of the other reactant.
Make a molecular model of each reactant. Show how the pi bond (nucleophile) reacts at the H (electrophile) in H-Cl. Then, show the H-Cl bond breaking. This should match your curved arrows.
c. Does CH_3-CH_2^+ have resonance structures? If so, draw the resonance structures. Are the resonance structures equivalent?
d. In the second step of an addition reaction, $CH_3CH_2^+$ reacts with Cl^- to form CH_3CH_2Cl.
Write a chemical equation that represents this reaction by drawing the structure of each reactant and product.
Identify the bond that breaks in each reactant and the bond that forms in each product.
Use curved arrows to show the bonds that break and form.
Which atom or group added to each vinylic carbon?

6. Propylene, C_3H_6, reacts with HCl to form $C_3H_7^+$ and Cl^-.
a. Go to https://chemagic.org/molecules/amini.html.
Draw C_3H_6.
Click on the "Charge" box. Which atom has the most negative charge?
Click on the "MEP" box. Rotate the molecule. Which part of propylene is a nucleophile?
HCl is an acid. The acidic H is an electrophile.
b. This is the first step of an addition reaction. Write a chemical equation represents this reaction by drawing the structure of each reactant and product. Identify the bond that breaks in each reactant and the bond that forms in each product. Use curved arrows to show bonds breaking and forming.
c. There are two isomers of $C_3H_7^+$. Draw the structure of each isomer.
A carbocation that has 0 or 1 C bonded to it is called a **primary** (1^o) carbocation = **least** stable.
A carbocation that has 2 C bonded to it is called a **secondary** (2^o) carbocation.
A carbocation that has 3 C bonded to it is called a **tertiary** (3^o) carbocation = **most** stable.
Classify each $C_3H_5^+$ isomer as 1^o, 2^o, or 3^o carbocation. Which isomer is more stable?
d. In the second step of an addition reaction, $C_3H_7^+$ reacts with Cl^- to form C_3H_7Cl. Write a chemical equation represents this reaction by drawing the structure of each reactant and product.
Identify the bond that breaks in each reactant and the bond that forms in each product.
Which atom or group added to each vinylic carbon?

7. Consider this reaction: cyclohexene + Br_2 --> 1,2-dibromocyclohexane.
a. From Questions 4-6, you now know a pi bond behaves like a _____.
Confirm your answer by drawing cyclohexene in chemagic.com.
Click on the "Charge" box. Which atom has the most negative charge?
Click on the "MEP" box. Rotate the molecule. Which part of cyclohexene is a nucleophile?
b. Draw Br_2 in chemagic.org.
Click on the "MEP" box. Rotate the molecule.
The electron density around each Br is ____ so this tells you Br_2 is _____ (polar or non-polar).
The electron density picture is averaged over time. However, at one instant in time, there will be more electron density around one Br and less electron density around the other Br.
The Br with less electron density around it behaves like an electrophile.
c. Here is how cyclohexene reacts with Br_2:



Confirm the formal charge on Br in the first product.
In the first product, one of the C-Br bonds can break to form a carbocation. Use curved arrows to show how this carbocation forms.

Classify the carbocation as a 1^o, 2^o, or 3^o carbocation.
In the second step of an addition reaction, how does Br^- react with this carbocation?
Use curved arrows to show how this reaction occurs to form 1,2-dibromocyclohexane.

d. Br_2 is a red liquid and behaves like an electrophile.
(i) I ____ expect Br_2 to react with 1-bromobutane because ___ 1-bromobutane is a ____.
Would (blank 1)
Would not (blank 1)
Nucleophile (blank 2)
Electrophile (blank 2)
(ii) Olive oil is an unsaturated fat. I ____ expect Br_2 to react with olive oil because ___ olive oil is a ____.
Would (blank 1)
Would not (blank 1)
Nucleophile (blank 2)
Electrophile (blank 2)
(iii) Lard and butter come from animal fat, which is mostly saturated fats. I ____ expect Br_2 to react with lard because ___ lard is a ____.
Would (blank 1)
Would not (blank 1)
Nucleophile (blank 2)
Electrophile (blank 2)

8. An ***Elimination*** reaction is the reverse of an ***addition*** reaction.
Structural features: H on a beta carbon = the carbon adjacent to the alpha carbon. (Alpha carbon = the carbon bonded to a leaving group.)
Leaving group = a base (see pK_a table).
Nucleophile = electron pair donor.
In an elimination reaction, a nucleophile reacts at the H bonded to the beta carbon. The beta carbon-H bond breaks to form a C=C pi bond. The alpha carbon bond to the leaving group breaks.

CH_3CH_2Cl reacts with OH^- to form C_2H_4, H_2O, and Cl^-.
a. Go to https://chemagic.org/molecules/amini.html.
Draw CH_3CH_2Cl.
Click on the "Charge" box. Which atom has the most positive charge?
Click on the "MEP" box. Rotate the molecule. Is the H bonded to beta carbon positive? The H bonded to the beta carbon should be an electrophile.
b. Draw the OH^- ion. Which atom is the nucleophile?
c. Write a chemical equation that represents this reaction by drawing the structure of each reactant and product.
Identify the bond that breaks in each reactant and the bond that forms in each product.
Use curved arrows to show how bonds break and form.
Make a molecular model of each reactant. Show how the OH^- (nucleophile) reacts at the H bonded to the beta carbon (electrophile) in CH_3CH_2Cl. Then, show the H-C bond breaking to form a pi bond. This should match your curved arrows.

9. C_3H_7Br reacts with CH_3O^- to form C_3H_6, H_2O, and Br^-.
a. Go to https://chemagic.org/molecules/amini.html.
Draw C_3H_7Br.
Click on the "Charge" box. Which atom has the most positive charge?
Click on the "MEP" box. Rotate the molecule. Is the H bonded to beta carbon positive? The H bonded to the beta carbon should be an electrophile.
b. Draw CH_3O^-. Which atom is the nucleophile?
c. Write a chemical equation that represents this reaction by drawing the structure of each reactant and product.
Identify the bond that breaks in each reactant and the bond that forms in each product.
Use curved arrows to show how bonds break and form.
Make a molecular model of each reactant. Show how the CH_3O^- (nucleophile) reacts at the H bonded to the beta carbon (electrophile) in C_3H_7Br. Then, show the H-C bond breaking to form a pi bond. This should match your curved arrows.

10. Compare these reactions. List the "nucleophiles" that reacted and the "electrophiles" parts that reacted. Do you see any patterns?