Multi-Step Module Overview - Organic Chemistry

Hide All Answers

Format and Introduction

The Multi-Step Module is used in two problem types: synthesis and mechanism.

For a **synthesis** question, you'll be asked to draw or modify structures to complete a multi-step synthesis.

For a **mechanism** question, you'll be asked to draw curved arrows (and structures in many cases) to illustrate the flow of electrons in a reaction mechanism.

In both synthesis and mechanism questions, the Multi-Step Module is constructed of sequences of Molecule Drawing Module (MDM) windows, or "boxes." Thus, the same icons and templates that you see in regular MDM problems (e.g. Bonds tool, Cyclohexane tool) will also appear in Multi-Step problems. Remember that there are two important settings: Terminal Carbons ON/OFF and Lone Pairs ON/OFF. In **synthesis** problems, various combinations of these settings may be used. For example, if Terminal Carbons are ON and Lone Pairs are OFF, then hydrogens attached to heteroatoms are automatically drawn for you, and you do not need to draw nonbonding electrons in your structures. For **mechanism** problems, Terminal Carbons are OFF and Lone Pairs are ON, so you will need to explicitly draw hydrogen atoms on heteroatoms and draw all nonbonding electrons in all structures. Recall that you can always draw in explicit hydrogens as long as you do not exceed the correct number of hydrogens for a particular atom.

When you are working on a multi-step problem, you can always submit one step at a time to get feedback. However, it is recommended that you do this *only if your instructor does not limit multiple attempts and does not deduct points for multiple attempts, because otherwise you could lose points*. If you are unsure about this, check with your instructor.

A Multi-Step problem will begin with a general set of instructions at the top. Each box will then also have its own instructions. The instructions for each box are more specific about what you need to draw in that box. In the screenshot shown below, these "box-specific" instructions are outlined in pink. Also notice that above these instructions and the drawing window, there are three smaller boxes at the top of the screen. These boxes show the entire problem. The border around the first box is darker than the others, meaning that this is the box you are currently working in (i.e., this is the box displayed in the drawing window). To work on a different box, simply click on the new box you want to work on and its contents will appear in the drawing window, allowing you to work on it and displaying the specific instructions for that box.

Notice that the third box, outlined in dark blue, has a "lock" symbol in its upper left corner. This means that the box is locked and the structure in it cannot be modified. In other words, you will not be able to draw in that box.
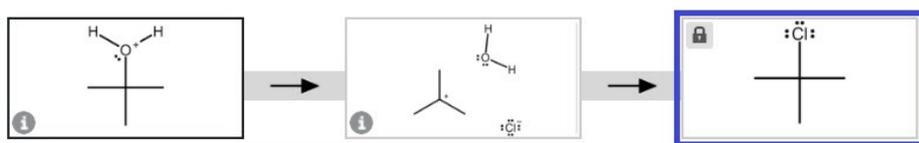
Draw the missing curved arrow notation

Once you've submitted a problem, feedback can take two forms. There will be specific feedback for the common errors encountered in each box, as demonstrated in the example shown in this screenshot. Each box has its own specific feedback:

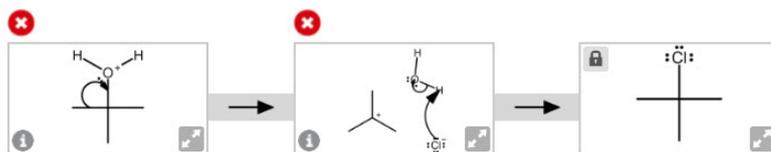**Feedback**

2nd attempt — ❌ Incorrect — 📖 See page 468

How should this arrow be changed to show the formation of a lone pair?

Does this arrow show the correct nucleophile attacking to form the final product?

↻ TRY AGAIN

However, generic feedback can also be displayed when a student has made multiple or uncommon errors. The generic feedback usually encourages you to review your work to double check things that are easy to overlook, like including lone pairs, adding formal charges, or ensuring arrows go in the correct direction:

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Copy Feature

Often in a Multi-Step problem (whether it's a synthesis or a mechanism problem), you will need to draw structures in empty boxes. In that situation, once you click on the empty box to begin working in it you will receive a message asking you if you want to copy the contents of the previous box, as shown in this screenshot:

Draw the carbocation formed when the compound in the first box ionizes.

Note again that the second box above the drawing window has a darker border, meaning it is the box currently displayed in the drawing window. Within the window, you have the option to copy the contents of the previous box (YES, COPY) or draw the structure yourself (START NEW). Click one of these two options to start your work in the box. (You can click on your desired option either in the main drawing window or in the smaller box above it.) Copying structures from previous boxes can save you time and avoid the common errors of accidentally omitting or gaining atoms. You simply modify the copied structure so that it conforms to what is expected for the current box.

You only get one opportunity to copy the contents of the previous box; the prompt is only available the first time you click on an empty box. If you copy the previous box, begin modifying the structure, and then decide you want to start over, resetting the drawing window means you'll then need to draw the structure yourself.

Here is a video showing the process of using the copy feature:

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Adding Curved Arrows

Multi-step mechanism problems require you to show how a reaction occurs by drawing curved arrows on structures. (In some problems you will also need to draw the structures themselves.) To draw curved arrows, you'll use the Electron Flow tool found in the left toolbar. Clicking on the white bottom right corner of the button reveals a dropdown menu with two options:
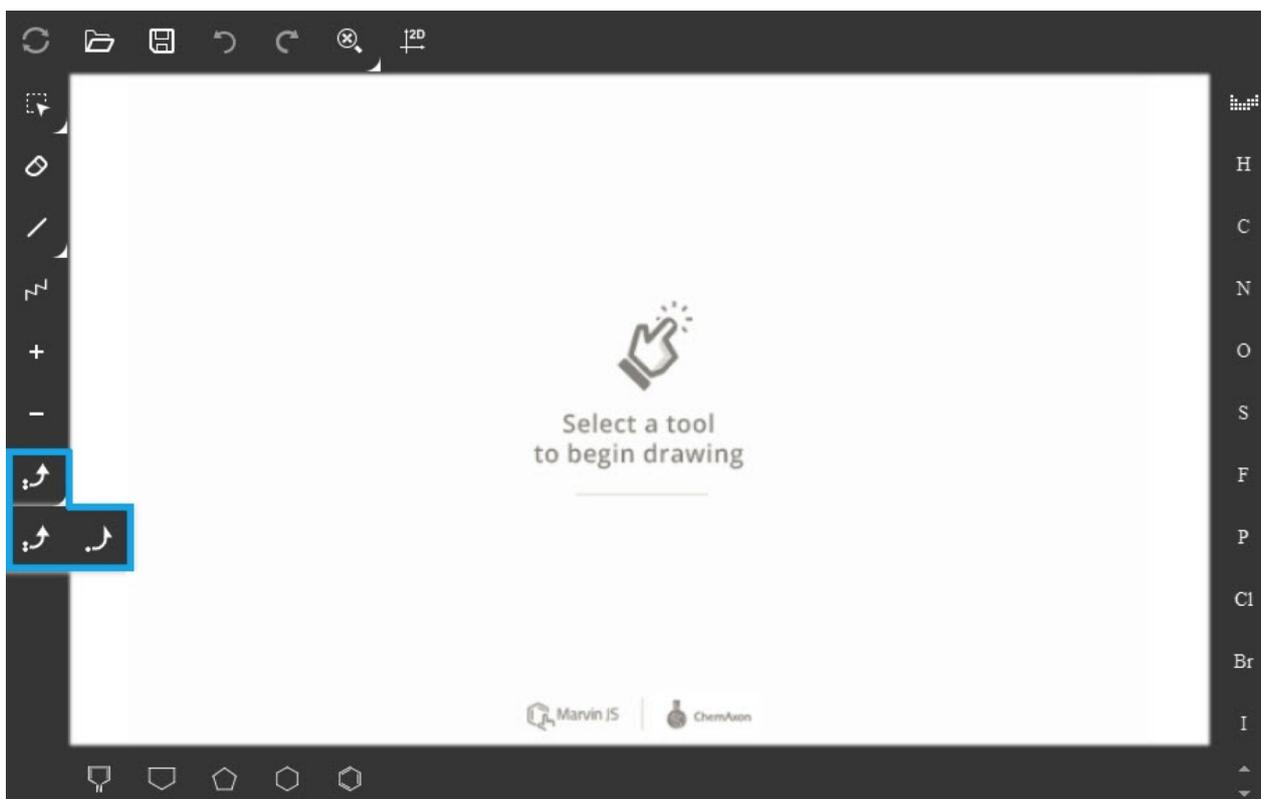
Electron Flow Tool Dropdown Menu Options	Tool Name	Tool Function
	Electron Flow Double Arrow	Draws a double-headed arrow to show the movement of a pair of electrons.
	Electron Flow Single Arrow	Draws a single-headed arrow ("fishhook") to show the movement of a single electron.

The majority of Smartwork Multi-Step mechanism problems involve the double-headed arrow type; the single-headed arrows are used only very rarely for specific topics. Since both arrow types (double-headed and single-headed) show the movement of electrons, they must always originate either at a bond or at nonbonding electrons (lone pair or radical). Arrows will always point either to a bond or to an atom.

Arrows always start at a bond, lone pair, or radical. Arrows always terminate either at a bond or at an atom.

Drawing an arrow of either type requires you to

1) **click on the origin bond or nonbonding electrons on an atom,**

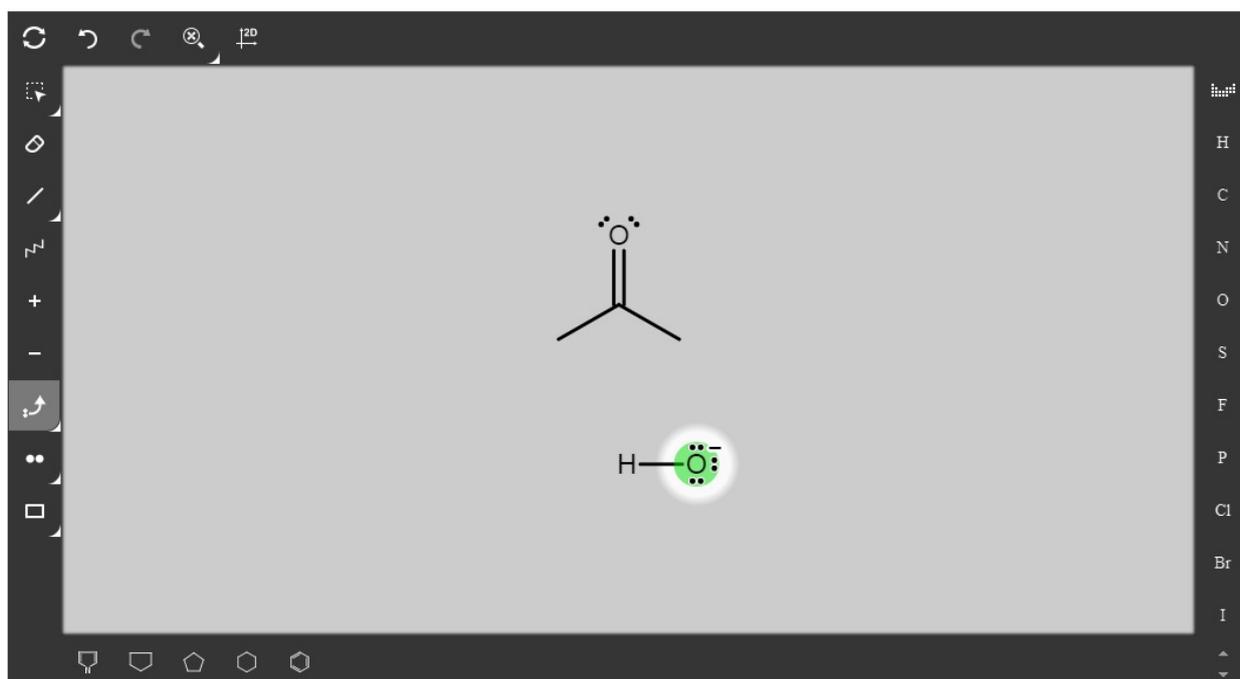2) **drag the cursor to the destination bond or atom while holding down the mouse button,**

and

3) release the mouse button when the destination bond or atom becomes highlighted.

Let's go through each of the steps. First, select the Electron Flow tool and choose which type of arrow you wish to draw. If you are starting the arrow at a lone pair or radical on an atom, move the cursor over that atom until it highlights as shown in this screenshot. *Be sure that the tip of your cursor arrow is pointing at an electron, not at the atom symbol itself:*
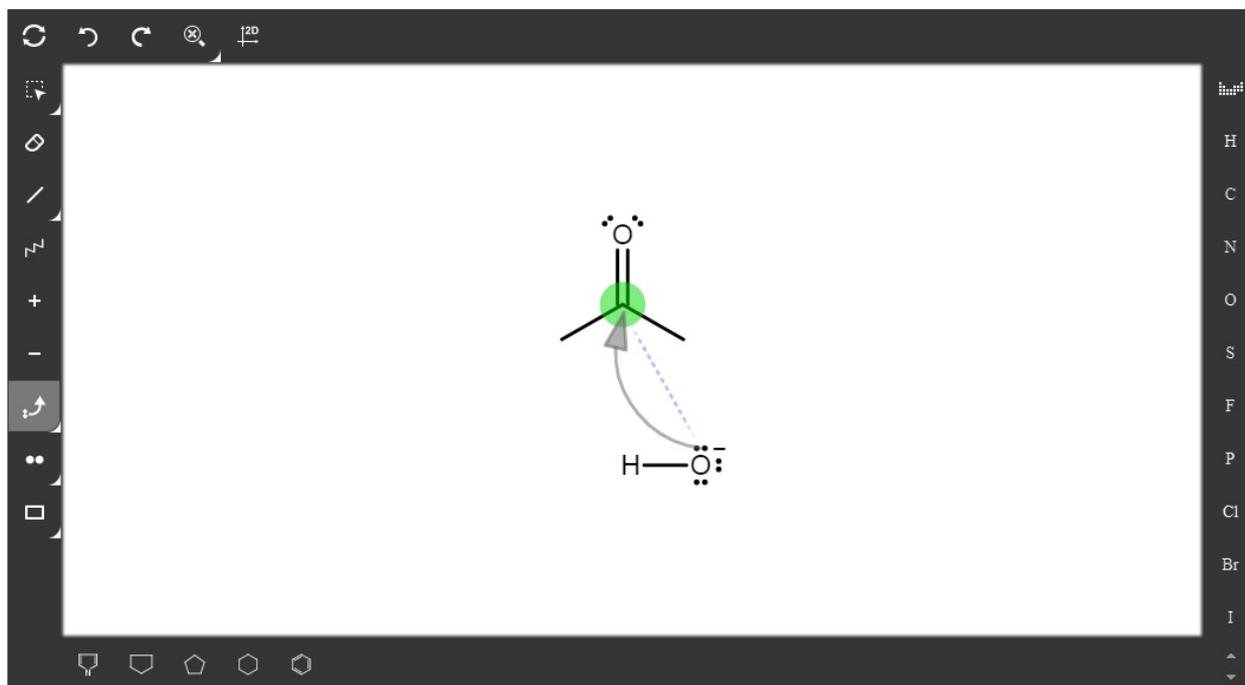

Draw curved arrows to show how the hydroxide ion and acetone react to form the structure in the next box.

When the atom is highlighted, click and drag the cursor to the destination (atom or bond), which will then become highlighted:
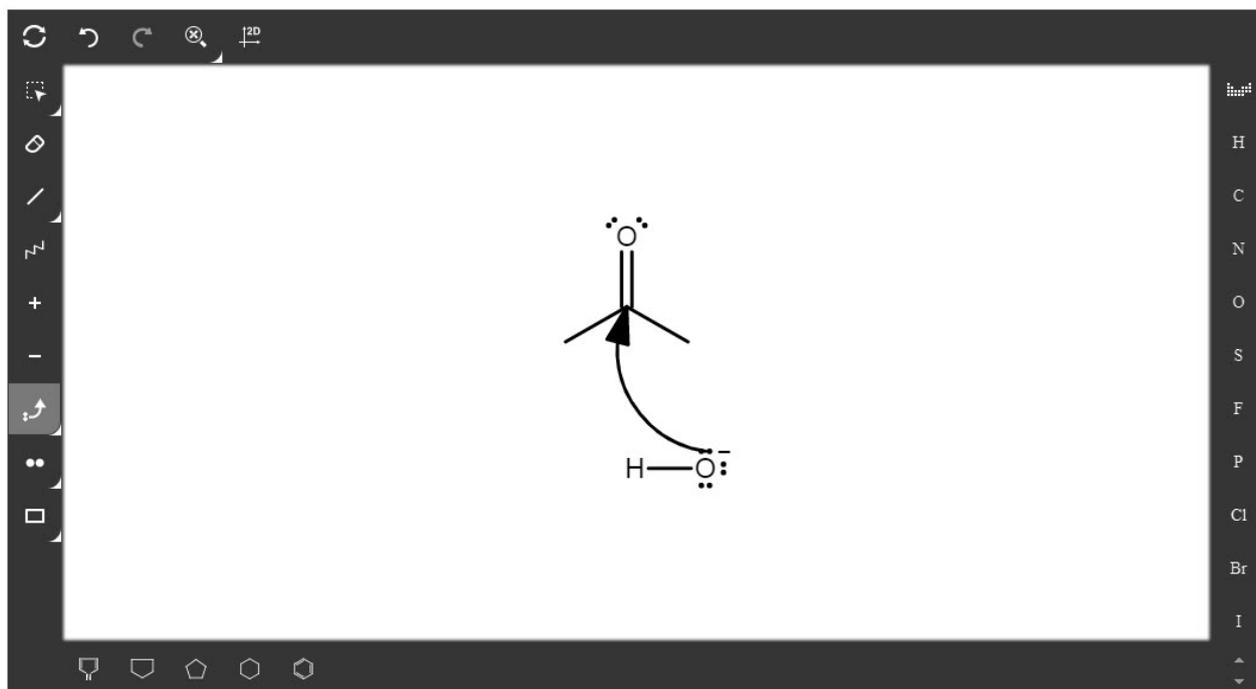
Draw curved arrows to show how the hydroxide ion and acetone react to form the structure in the next box.

The screenshot above shows arrow drawing (bond forming) in progress. The arrow is pale gray, meaning it is in the process of being drawn; once it is completed, it will appear black. The faint purple dashed line is related to how Smartwork is programmed and indicates the two atoms involved in the process. The green highlighted carbon is the destination for the electrons—the termination point of the arrow. Once the destination atom or bond is highlighted, release the mouse button and the completed arrow will appear. Notice in the following screenshot that the arrow started at the electron pair. Also notice that the smaller box in the upper left corner reflects the work you have done in the drawing window:
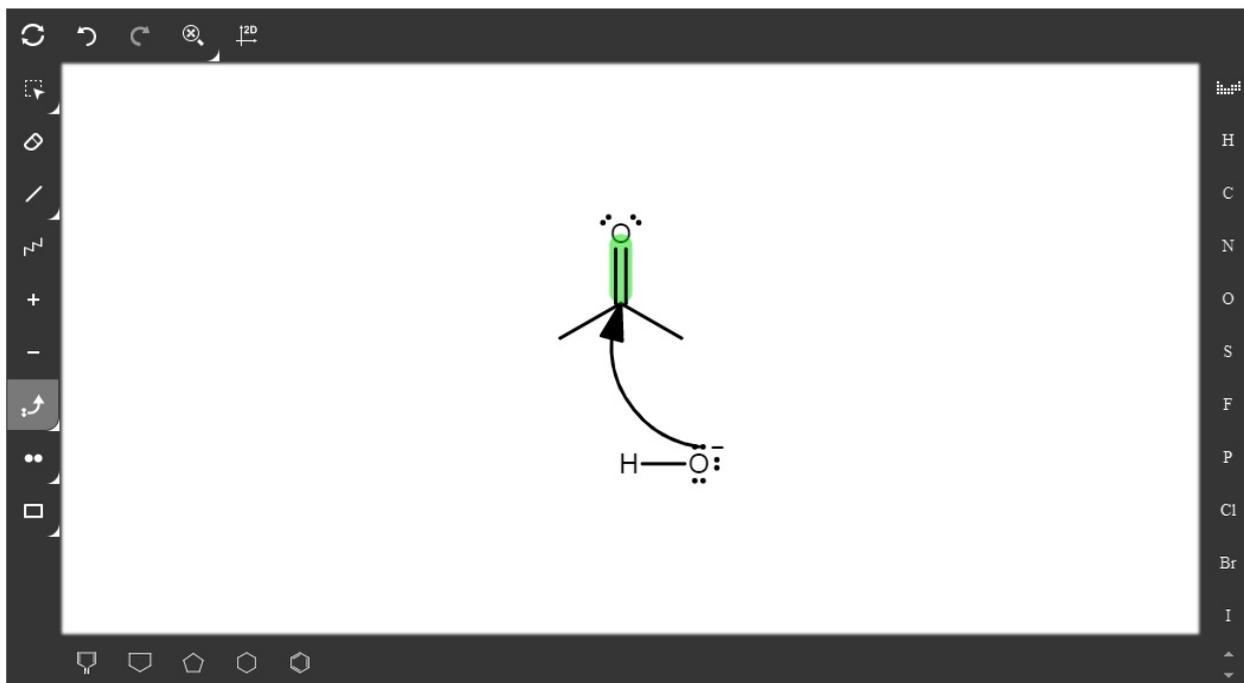
Draw curved arrows to show how the hydroxide ion and acetone react to form the structure in the next box.

To draw an arrow originating at a bond, follow the same process. Be sure the Electron Flow tool is selected and that you have chosen the appropriate arrow type. Move the cursor over the bond from which you want to start the arrow. It will become highlighted:
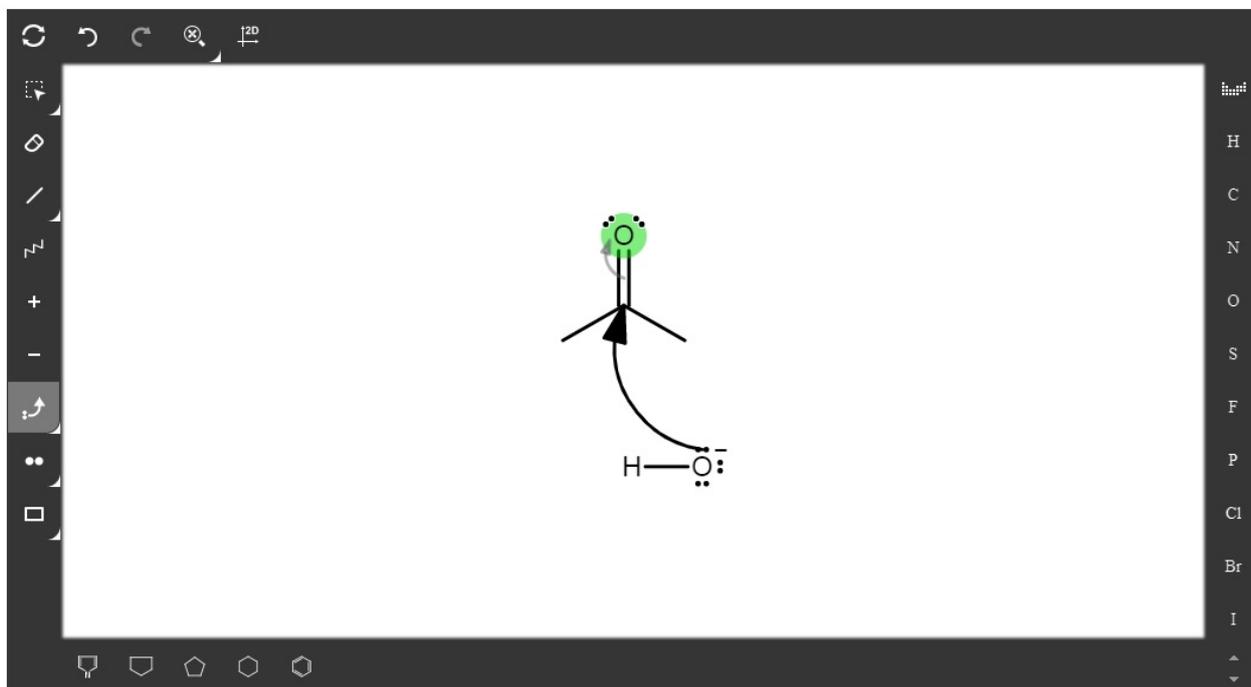
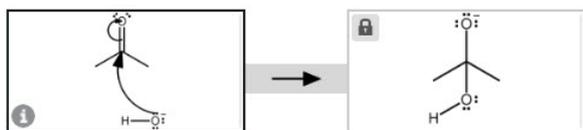Draw curved arrows to show how the hydroxide ion and acetone react to form the structure in the next box.

Click and drag to the arrow's termination point. In this example, the arrow ends at the oxygen atom. Note that in the screenshot below, the oxygen atom is highlighted and the arrow is pale gray because you are in the process of drawing it:
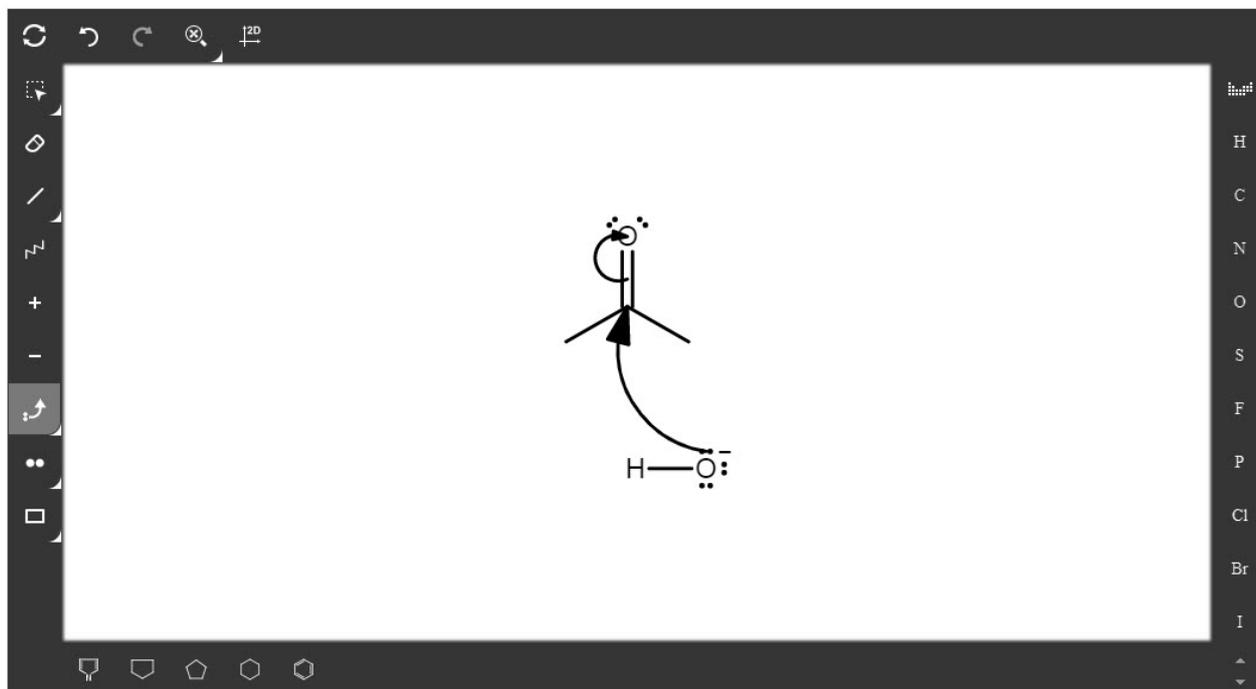
ⓘ Draw curved arrows to show how the hydroxide ion and acetone react to form the structure in the next box.

Once the destination is highlighted, release the mouse and the arrow will appear:

Draw curved arrows to show how the hydroxide ion and acetone react to form the structure in the next box.

Writing a Mechanism

Writing a mechanism in Smartwork involves drawing curved arrows and, frequently, structures. In mechanism problems, the Lone Pair tool will be present in the left toolbar, meaning that you need to draw nonbonding electrons on all atoms that have them. If you've overlooked drawing these electrons, Smartwork's feedback will remind you when you submit the problem.

It's important to carefully read the specific instructions for each box so that you know what is expected. You should also be attentive to including nonzero formal charges. These oversights will result in incorrect answers. All the structures you draw must be chemically correct, and using the "Copy Previous Box" feature described above will help you to avoid the common errors of drawing too few or too many atoms when you try to reproduce a structure.

Smartwork does allow you to submit one step at a time to check your work as you go. However, you should only do this if your instructor does not penalize or limit attempts, because otherwise you could lose points.

Your browser does not support HTML5 video.