E1 REACTIONS
Brief Answers document

Fuller solutions are available in the “Solutions” document.
Step-by-step discussions for each of these answers are available in the “E1 reactions” videos.
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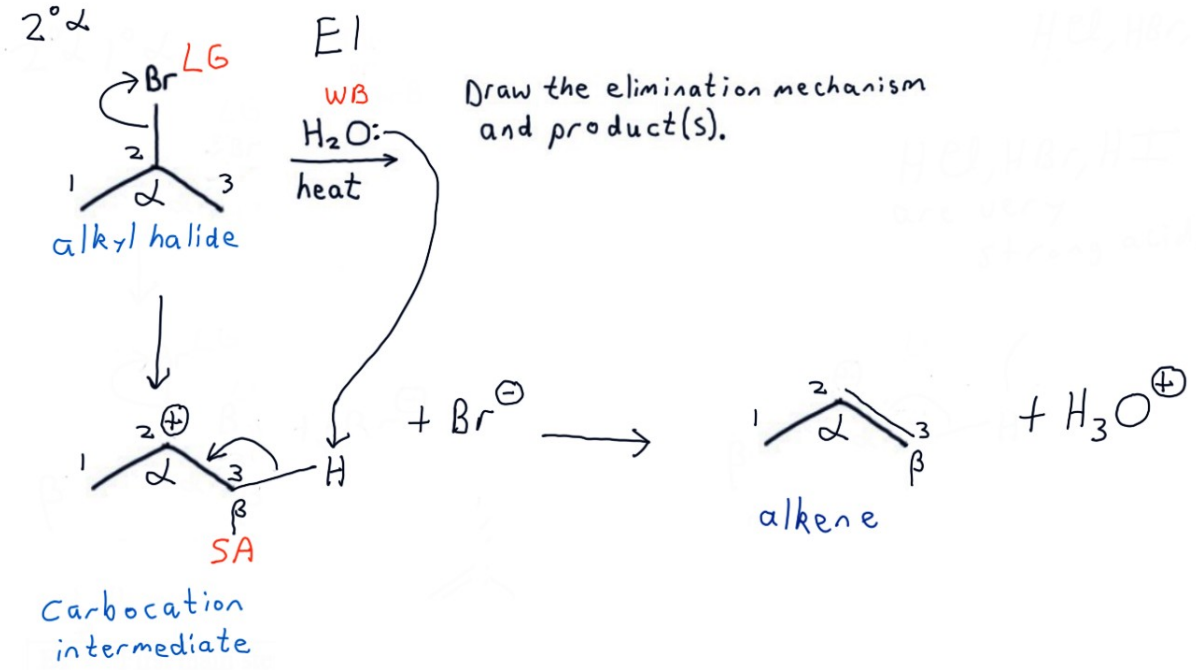
Answers begin on next page.

Video (1)



α carbon: the carbon attached to the leaving group, or
the carbon with a positive formal charge
β carbon: A carbon attached to the α carbon

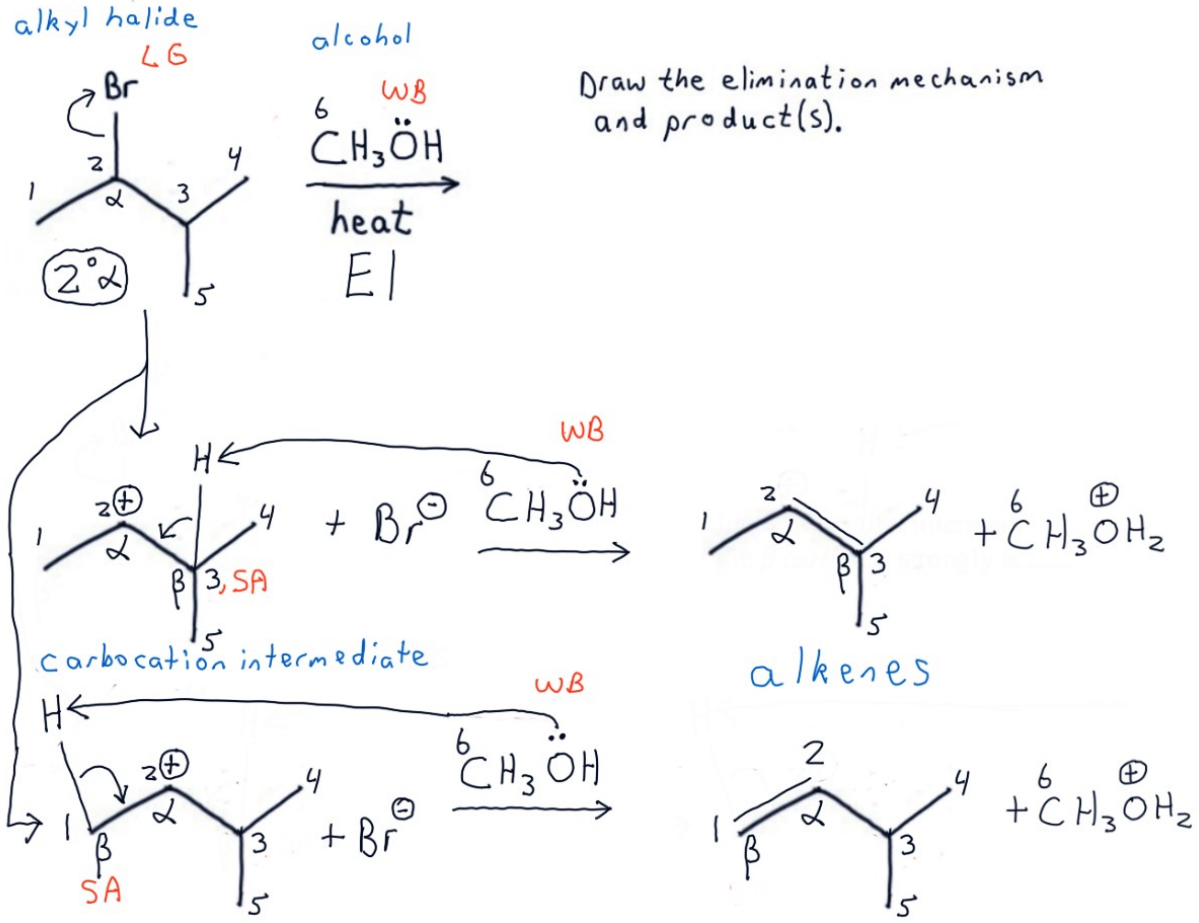
Base: donates electrons to take a H^+ from an acid

alkyl halide: a carbon chain ("alkyl" group) attached to a halogen (usually Cl, Br, or I).
carbocation: A carbon ("carbo") with a positive formal charge ("cation").
intermediate: the product of one mechanism step, and the starting material for the next step
alkene: A carbon-carbon double bond

guidelines for drawing an E1 mechanism

Label the α carbon and the β carbon(s) you will use in the mechanism.
Only a β carbon attached to one or more hydrogens can be used for E1.
If two β carbons have different "connectivity", they result in different E1 products. If two β carbons have the same "connectivity", they result in the same E1 product. Exception: If the E1 product has one or more stereocenters, then two β carbons with the same connectivity *may* result in different E1 products.

Video (2)



Alcohol: An OH group attached to one or more carbon chains.

Elimination mechanism: A mechanism in which one or more groups is eliminated from a molecule, and no groups are added.

E1 is an elimination mechanism. (The “E” in “E1” stands for “elimination.”) For example, in the E1 mechanism above, we eliminated two groups from the alkyl halide: the leaving group, and the β hydrogen. No groups were added to the alkyl halide.

Rules for using electron-pushing arrows to draw the products of a mechanism step

Number *all* the carbons in the starting materials, and in the products you draw. Number the products *consistently* with how you numbered the starting materials.
For each electron-pushing arrow: Erase a bond, or draw a new bond, or both. Break a bond when the tail of the electron-pushing arrow is on a bond. Form a σ bond when the arrow head is pointing to an atom which was not already sharing the electrons at the tail of the arrow. Form a π bond when the arrow head is pointing to a bond.
Change two formal charges. Make the atom that loses electrons at the *start* of the chain of arrows one step less negative—i.e., one step more positive. Make the atom that gains electrons at the *end* of the chain of arrows one step more negative—i.e., one step less positive. Do not change the formal charge for any atom in the *middle* of the series of arrows. THE MOST COMMON MISTAKE is forgetting to change the formal charge on the atom that loses electrons at the *start* of the chain of arrows.

guidelines for drawing an E1 mechanism

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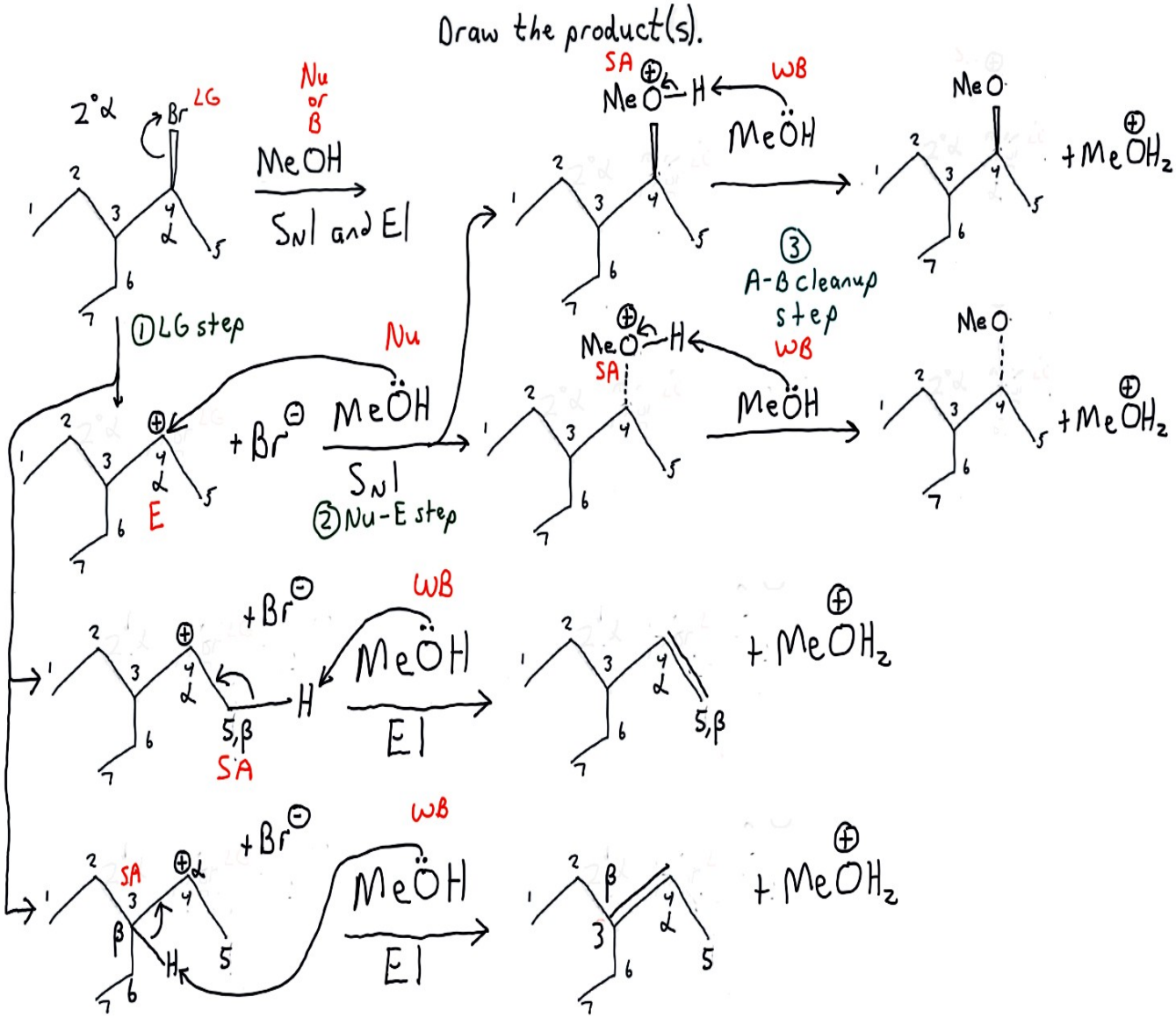
If two β carbons have different "connectivity", they result in different E1 products. If two β carbons have the same "connectivity", they result in the same E1 product. Exception: If the E1 product has one or more stereocenters, then two β carbons with the same connectivity *may* result in different E1 products.

Checklist of things to do for each reaction

Number *all* the carbons in the starting materials, intermediates, and products. Make sure your numbers for the intermediates and products are *consistent* with the numbers you used for the starting materials.
Label which specific atoms will play which roles. Identify the "clues" that tell you which atoms will play which roles.
Label the α-carbon. *Write down* whether the α-carbon is methyl, 1°, 2°, or 3°.
Use the table to determine whether the reaction is S_N2, S_N1, E2, or E1. *Write down* the name of the mechanism.
Don't begin drawing the products for a mechanism step until you have *finished* drawing the electron-pushing arrows for that step
The reaction is usually finished when the "main product" of a mechanism step has no formal charge. When the "main product" of a step has a formal charge, you usually need to continue the mechanism. Exception: the "main product" of an S_N2 reaction can have a formal charge.

Video (3)

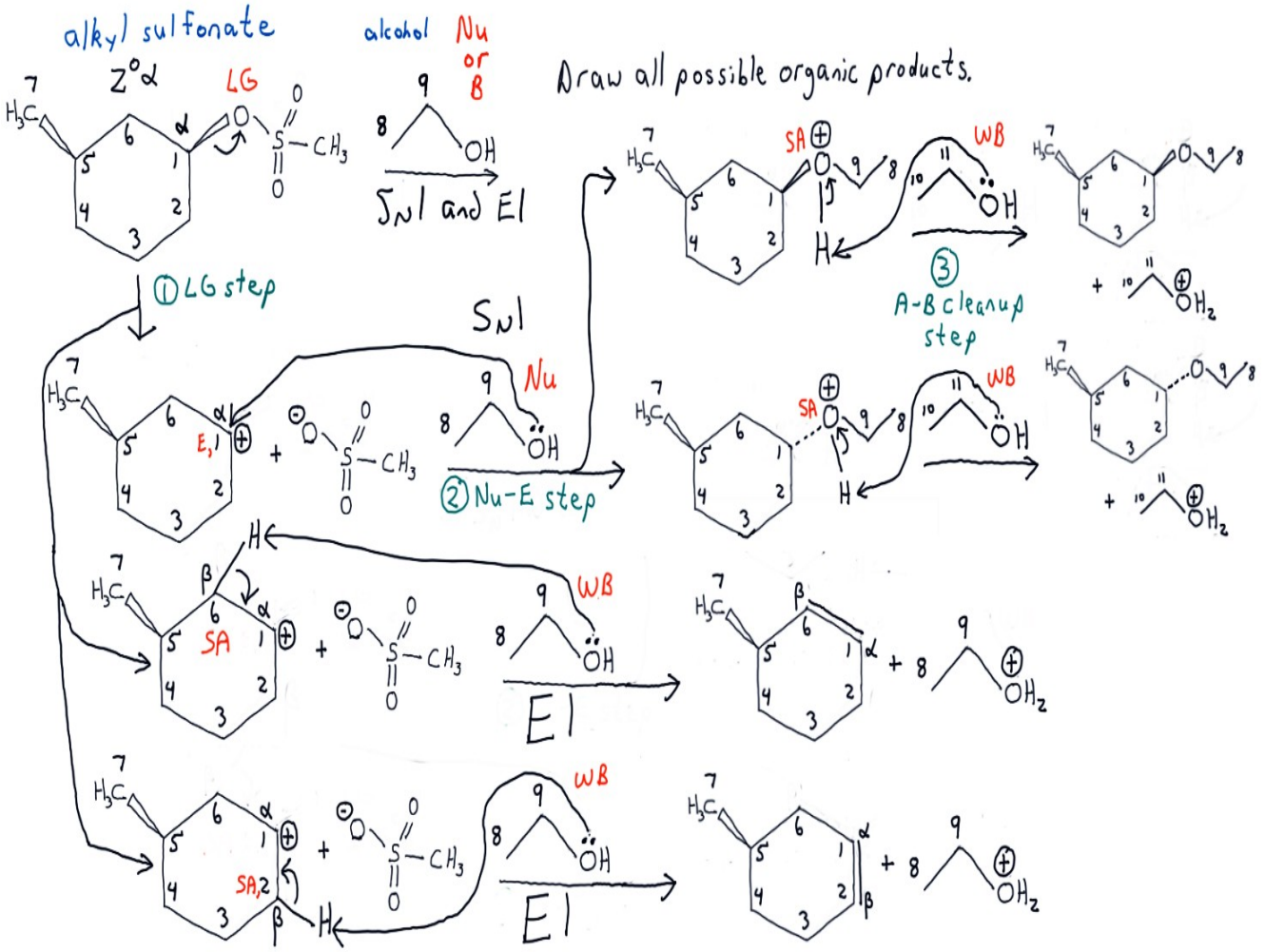


E1 is similar to S_N1 in that they have the same first step: Leaving group leaves the α carbon, forming the carbocation intermediate. Notice that the carbocation intermediate formed for S_N1 is identical to the carbocation intermediate formed for E1. The difference between E1 and S_N1 is that Step Two of S_N1 uses a nucleophile, while Step Two of E1 uses a base.

A base is similar to a nucleophile because both a base and a nucleophile are electron donors. The difference between a base and a nucleophile is that a nucleophile donates electrons *to join another molecule*, while a base donates electrons *to take a proton from another molecule*.

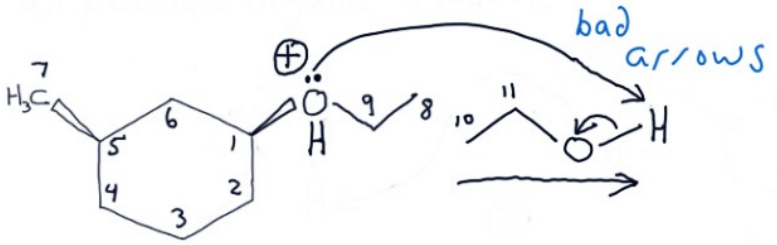
A substitution mechanism is a mechanism in which one or more groups is eliminated from a molecule, and no groups are added. An elimination mechanism is a mechanism in which one or more groups is eliminated from a molecule, and no groups are added. S_N1 is a substitution mechanism (the "S" stands for "substitution); E1 is an elimination mechanism (the "E" stands for "elimination".)

Video (4)



Answer to Bonus question on next page

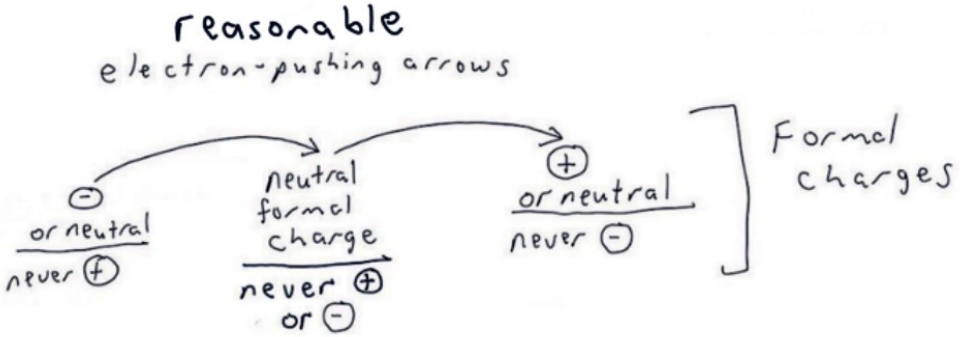
Bonus question for Video (4): Here are alternative arrows that some students might have tried drawing for Step Three of the S_N1 mechanism. Are these reasonable or unreasonable electron-pushing arrows? *Why*?



The electron-pushing arrows above are *unreasonable*, because the series of arrows begins on a positive formal charge. A positive formal charge makes an atom want to receive electrons. But the atom at the beginning of the series of arrows is an atom that the arrows predict will donate electrons. The atom at the end of the series of arrows is the atom that the arrows predict will receive electrons. Therefore, an atom with a positive formal charge should be placed at the end of a series of arrows, to indicate that that atom wants to receive electrons. An atom with a positive formal charge should never be placed at the beginning of a series of arrows, since that is the position for an atom that wants to donate electrons.

You might find it tempting to put the positive oxygen at the beginning of the series of arrows because of its lone pair. You might argue that the lone pair makes positive oxygen want to donate electrons. This logic is false, however, because the importance of the positive formal charge "overrides" the importance of the lone pair.

An atom with a negative formal charge and a lone pair wants to donate electrons, and can be placed at the beginning of a series of arrows. An atom with a neutral formal charge and a lone pair may also want to donate electrons, and may also be placed at the beginning of a series of arrows. But an atom with a positive formal charge and a lone pair wants to receive electrons, and should be placed at the end of the series of the arrows, not at the beginning.



At the beginning of the series of arrows, put a negative or neutral atom, never a positive atom.

At the end of the series of arrows, put a positive or neutral atom, never a negative atom.

In the middle of the series of arrows, put neutral atoms, not positive or negative atoms.[1]

Examine the arrows for the full, correct mechanism, and notice how all the arrows follow the rules above.

The most important factor in organic chemistry is the formal charges, because the formal charges are your tool for drawing reasonable electron-pushing arrows!

1 There are some exceptions to this rule in introductory ochem.