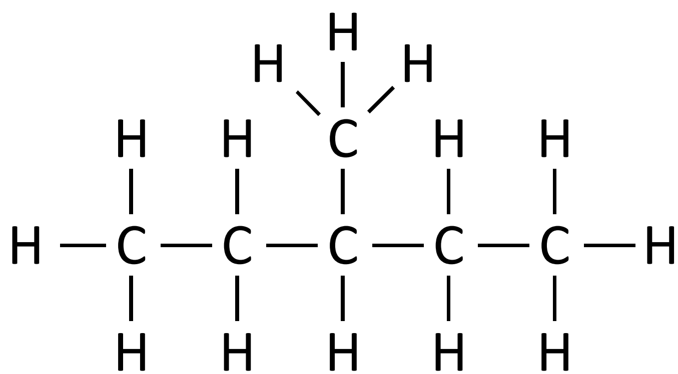
Drawing Skeletal (Zig-Zag) Structures

The quick and easy way to draw organic molecules

Information Overload vs Quick and Easy

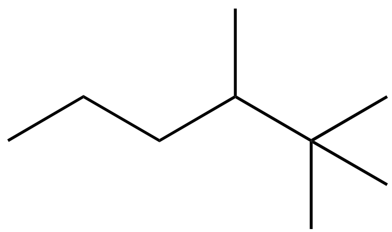
- In a line-bond structure you see EVERYTHING (except for lone pairs, actually).
- All atoms must be drawn into the structure.
- Ex:



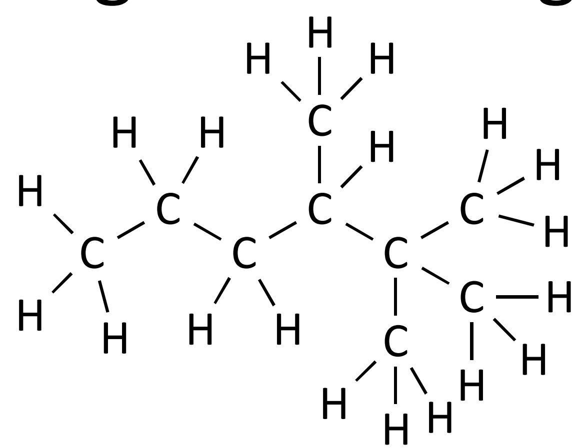
- These can take a long time to draw!

Which is cleaner and more concise?

- Skeletal structures are perhaps a little confusing… Seems like things are missing…



OR

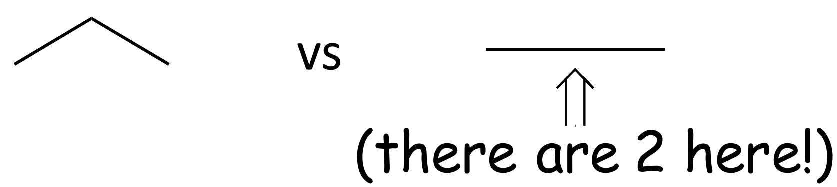


skeletal line-bond

- Once you know the rules, skeletal structures are actually much easier to draw!

Skeletal Structures

- Skeletal structures are those “zig-zag” structures you see quite often.
- “Zig-zag” is required so you can see connectivity… lines that are “straight on” may be confusing:



Skeletal Structures - Rules

- In order to understand **HOW** to draw molecules using these zig-zag lines, you need to follow a certain set of rules, or else none of it makes any sense
- We will start by converting to line-bond structures that show everything.

Skeletal Structures – Rule #1

- Rule #1: never draw a “C” to represent a carbon atom (as in C-H or C-C or C=C…)

- When doing shorthand notation like this, “less” is faster to draw, so ditch those “C”s!

Skeletal Structures – Rule #2

- Rule #2: At the end of any line, you will always assume there is a C, if no other atom is shown.
- Take this single line, the simplest skeletal structure possible:

- How many carbons do you “see”?

Skeletal Structures – Rule #2

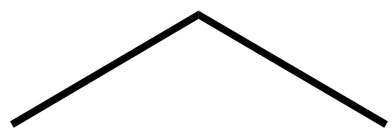
- If the end of a line represents a carbon atom, then you will “see” a carbon at each end of the line:

- That line represents:

C — C

Skeletal Structures – Rule #3

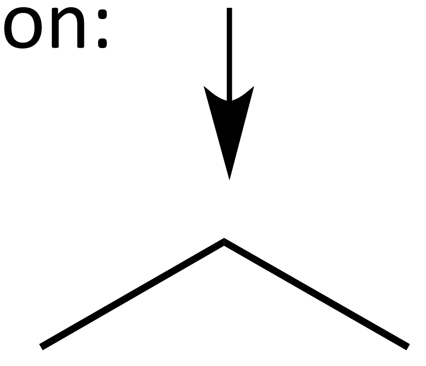
- Rule #3: At the intersection of two or more lines, assume there is a C, if no other atom is shown.
- Now take this skeletal structure:



- How many intersections are there?

Skeletal Structures – Rule #3

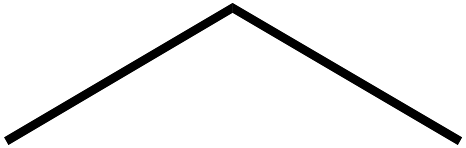
- There are two lines connecting in the center to form one intersection:



- That intersection represents a carbon atom, without having to draw the C’s.
- Up to four lines may connect to intersect.

Skeletal Structures – Rules 2 and 3

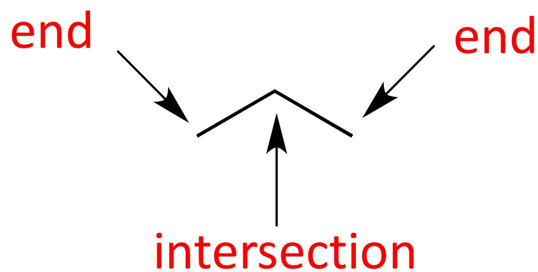
- How many total carbons are in this molecule?



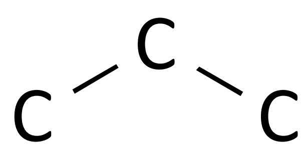
- You have to count all **intersections** and the **ends** of any lines to get the total number of carbons represented.

Skeletal Structures – Rules 2 and 3

- So, how many total carbons are in this molecule?

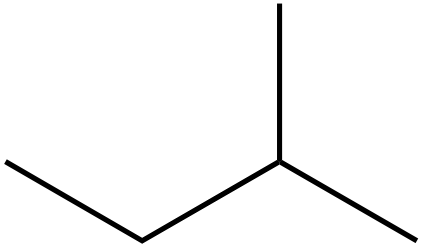


- One intersection plus two ends of lines adds up to three total carbon atoms:



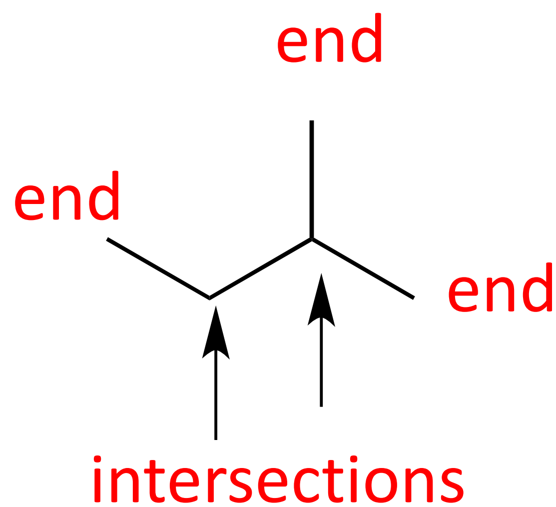
Skeletal Structures – Rules 2 and 3

- How many total carbons are in this molecule?

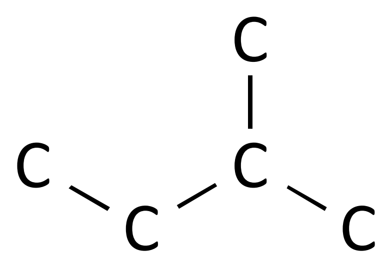


Skeletal Structures – Rules 2 and 3

- How many total carbons are in this molecule?

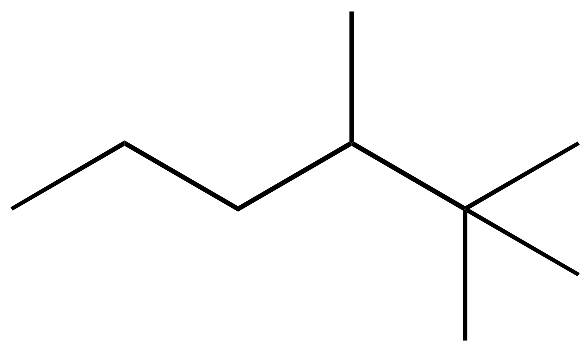


- Five carbons total:



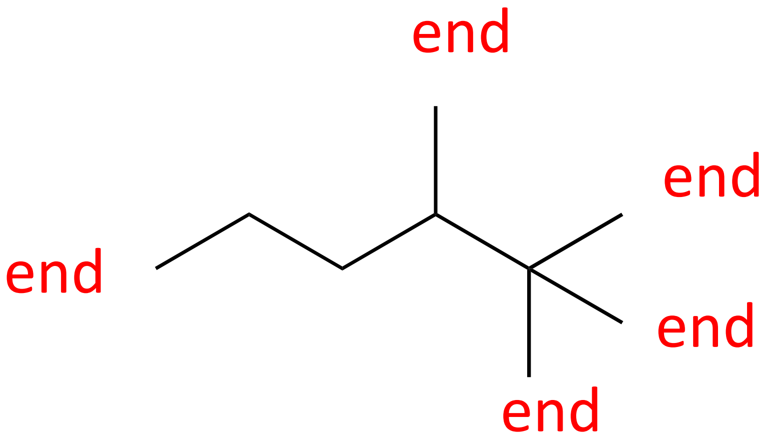
Skeletal Structures – Rules 2 and 3

- One more time, how many total carbons are in this molecule?



Skeletal Structures – Rules 2 and 3

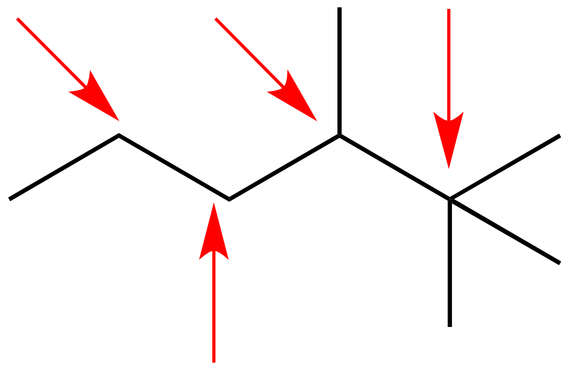
- One more time, how many total carbons are in this molecule?



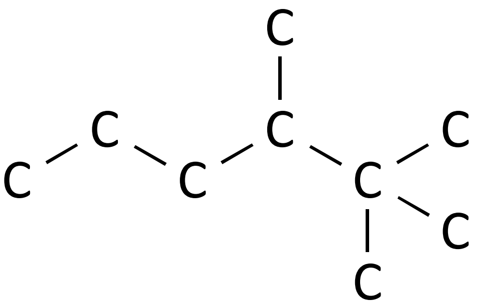
- Five end carbons…

Skeletal Structures – Rules 2 and 3

- …and four intersecting carbons…



- …for a grand total of 9 C’s you didn’t have to draw!



Skeletal Structures – Rule #4

- Rule #4: The "H" of a hydrogen attached to carbon is not drawn.
- Just remember that carbons must have four bonds. Count bonds and subtract from 4 – that will be the number of H's.
- Take this skeletal structure again:

- How many hydrogen atoms are on each carbon?

Skeletal Structures – Rule #4

- Recall that there are C's at the end of each line.

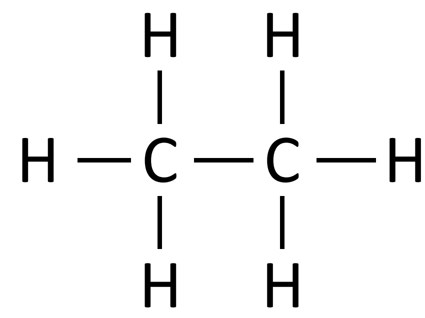
——— equals C — C

- The left-hand C has one bond (to the right-hand C). This means that, by default, it must have 3 hydrogen atoms attached (4 total minus **1 to a C** = **3 H**)
- The right-hand C also has one bond to a C. This means that it too also must have 3 hydrogen atoms attached (4 total minus **1 to a C** = **3 H**)

Skeletal Structures – Rule #4

- Final structure?

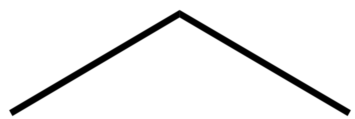
equals C — C equals



- The skeletal structure on the left was WAY easier to draw… With practice, you’ll get used to this process…

Skeletal Structures – Rule #4 again

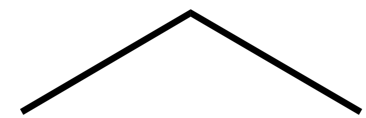
- Take this skeletal structure:



- How many hydrogen atoms are on each carbon?

Skeletal Structures – Rule #4

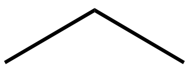
- Left carbon – one line
- Right carbon – one line
- Center carbon – two lines



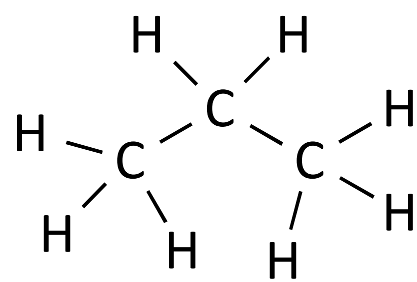
- Left carbon – 4-1 = 3 H
- Right carbon – 4-1 = 3 H
- Center carbon – 4-2 = 2 H

Skeletal Structures – Rule #4

- Equivalent structures

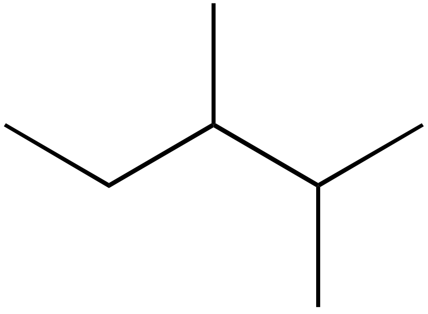


equals



Try another molecule

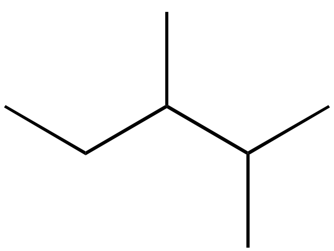
- Convert the following skeletal structure to a line-bond structure:



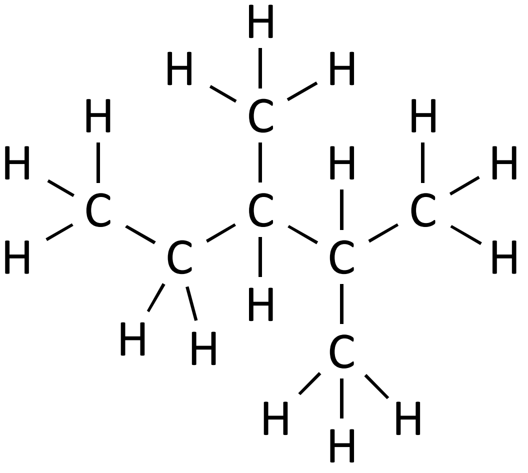
- Add C's to "ends" and "intersections" and then determine how many H's are attached to each. Don't move forward until you've drawn it!

Answer?

- These two are the same molecule:

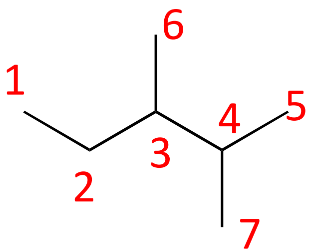


equals

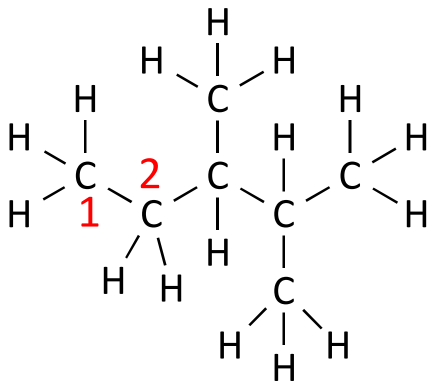


Answer?

- Remember that your answer may look similar but not exactly the same.



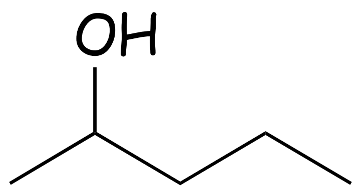
equals

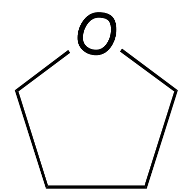


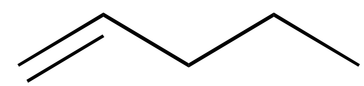
- What counts is that you have the C's labeled correctly and you have the right number of H's on each C. For instance, my C(#1) has to have 3H's, C(#2) has to have 2 H's, C(#3) has to have 1 H, etc…

Skeletal Structures - Rule #5

- Rule #5: Everything besides C-H and C-C must be shown. These other atoms (like O, N, F, Cl, Br, etc) must be shown.



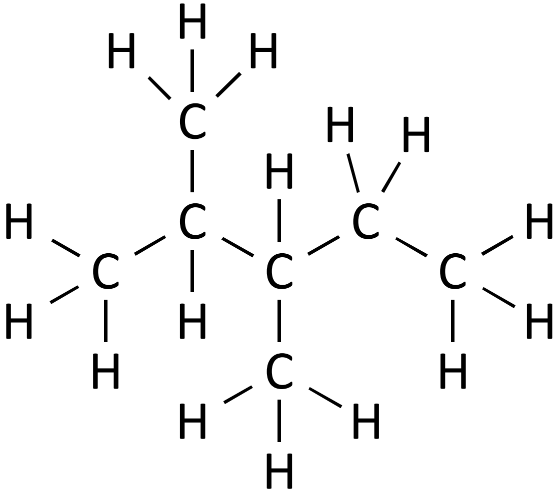




- Note that Hydrogen atoms can and should be shown for these other atoms and even C=C has to be drawn, even when C-C does not.

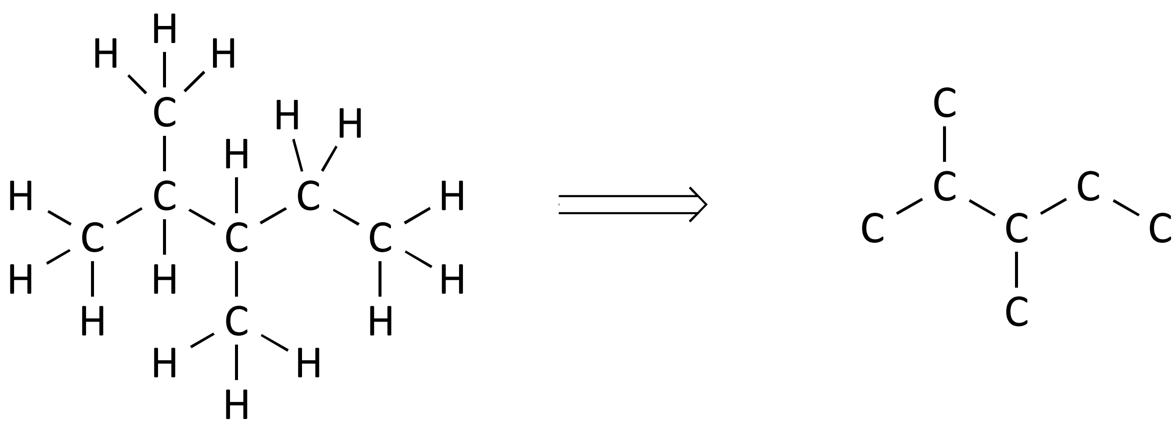
Line-Bond to Skeletal Structure

- Now that you have a sense of what skeletal structures equate to, let's try the other direction…
- A skeletal structure is a line-bond structure without its letters.



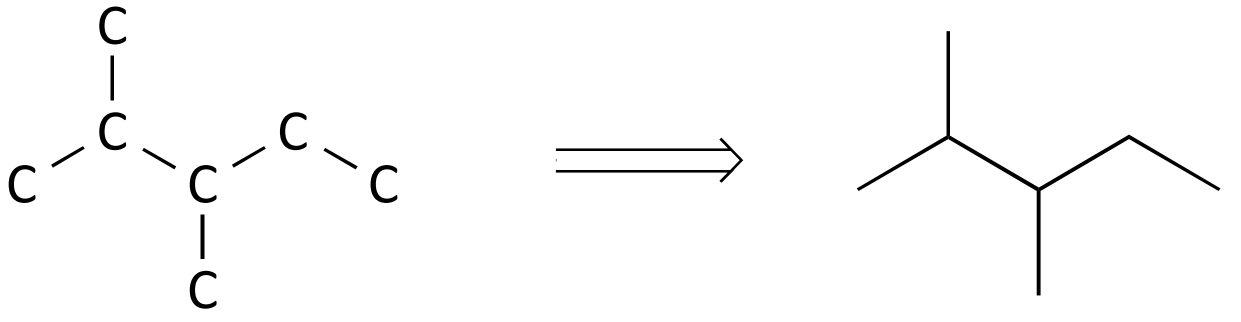
Line-Bond to Skeletal Structure

- So you need to simplify. Start by removing all those H’s on the C’s…



Line-Bond to Skeletal Structure

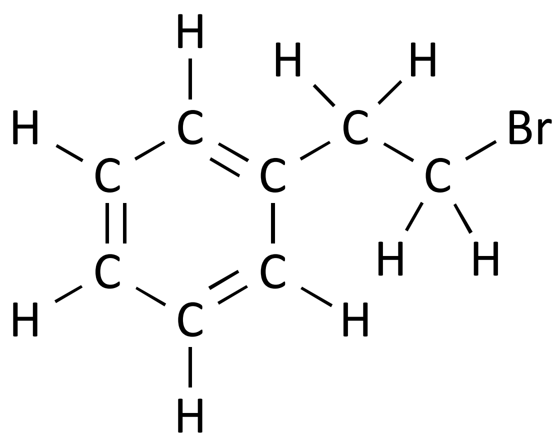
- Then erase all those C's…



- Good job… Try the next one!

Line-Bond to Skeletal Structure

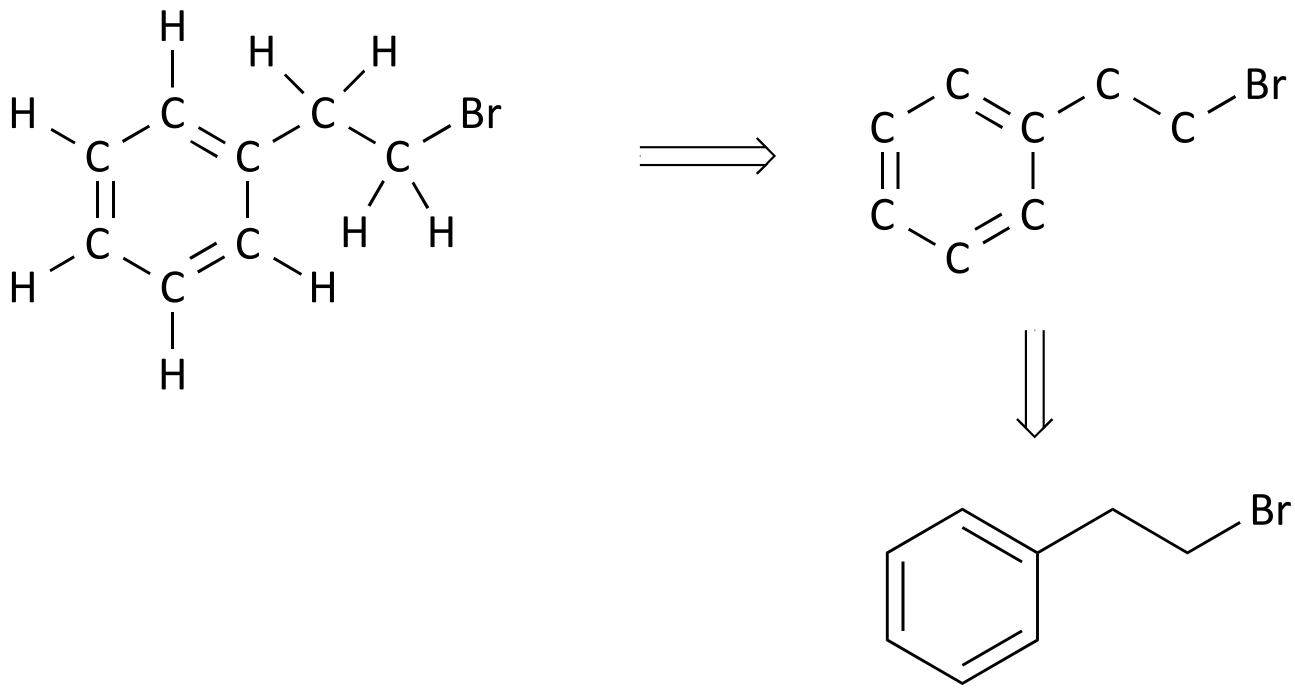
- Convert the following to a skeletal structure:



- Erase the C-H bonds, then the C’s…

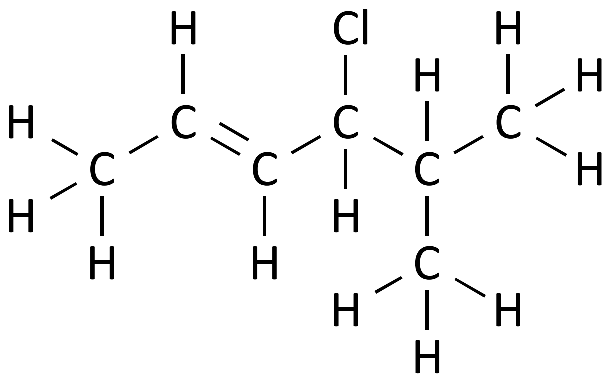
Line-Bond to Skeletal Structure

- Leave the Br though!



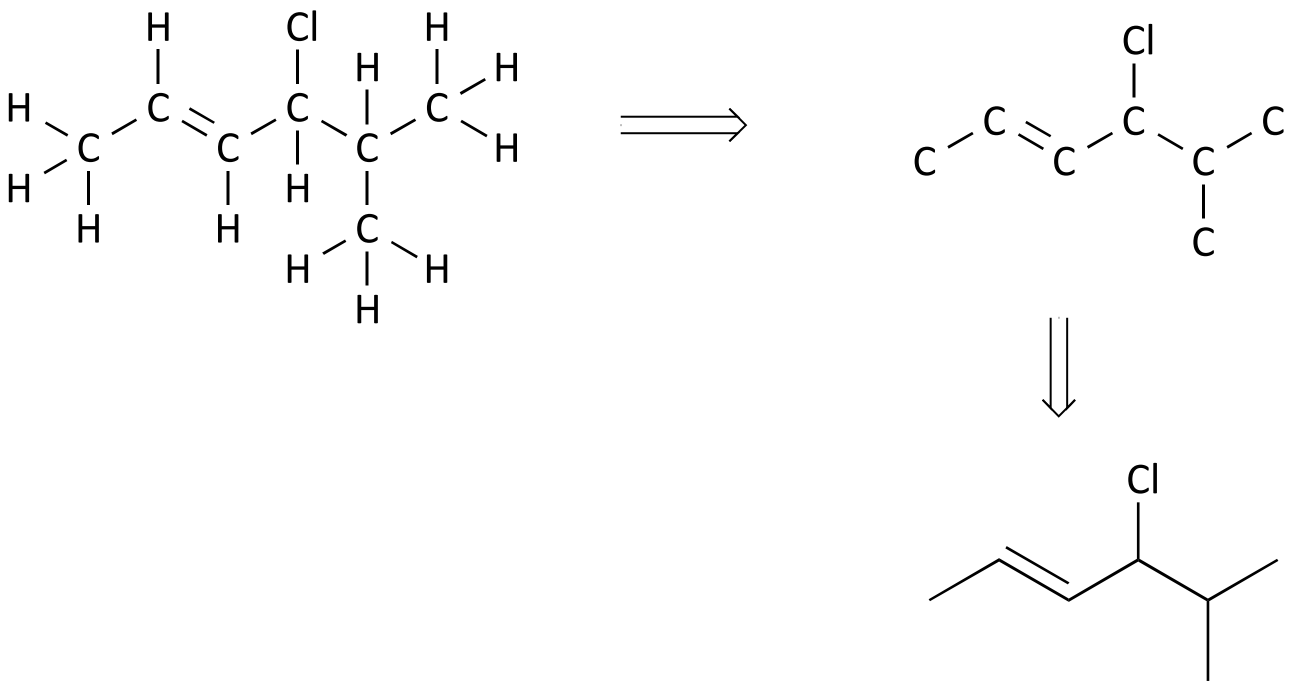
Line-Bond to Skeletal Structure

- Convert the following to a skeletal structure:



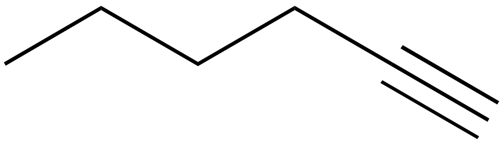
Line-Bond to Skeletal Structure

- Erase the C-H bonds, then the C's… but leave the Cl!



And in the other direction…

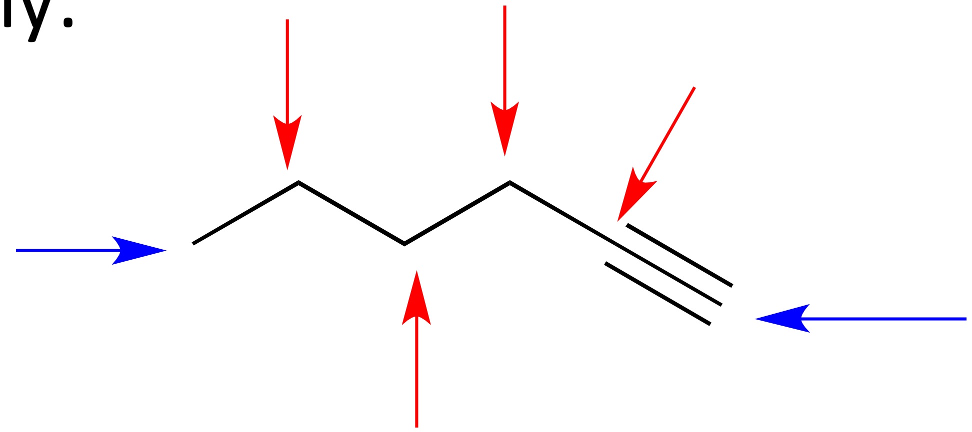
- Obviously, you need to put the letters back into place, alone with the C-H bonds…
- Draw the Line-Bond structure for:



- Find ends and intersections first…

Skeletal to Line-Bond…

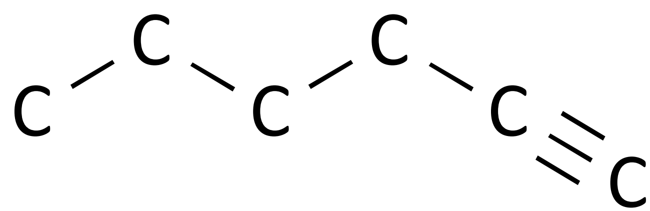
- Ends in blue… intersections in red…
- Triple bonds are a bit confusing at first – the intersection is actually straight, when drawn correctly:



So, put in the C's…

Skeletal to Line-Bond…

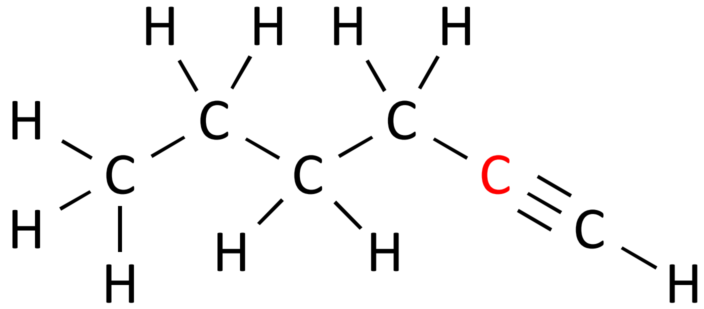
- And now you have:



- Now add in the C-H bonds. Every C must have a total of four lines.

Skeletal to Line-Bond…

- Finished Line-Bond Structure:



- Notice how the one end of the triple bond, the red carbon, already has four bonds so no bonds to H for that carbon!

Skeletal to Line-Bond or V.V

- These take practice… Once you've mastered the basics of the skeletal structure you are ready to make the leap to converting skeletal structures to condensed formulas and back again…
- When you are ready, go check out the next PowerPoint – Skeletal to Condensed and Back Again