Understanding Skeletal Formulae

At school, most organic molecules are drawn as structural formulae. Whilst this is a good way of drawing small molecules, it becomes confusing for larger organic molecules which become cluttered when all of the carbon and hydrogen atoms are drawn in. It is often clearer to draw these molecules as skeletal formulae.

In skeletal formulae many of the carbon atoms and many of the hydrogens attached to carbon atoms are not drawn in explicitly. As carbon forms the backbone of organic molecules, the first step towards constructing a skeletal formula can be to redraw the structural formula without writing in the letter C. The position of the atoms stays the same. Some examples of this are shown in **Figure 1**.

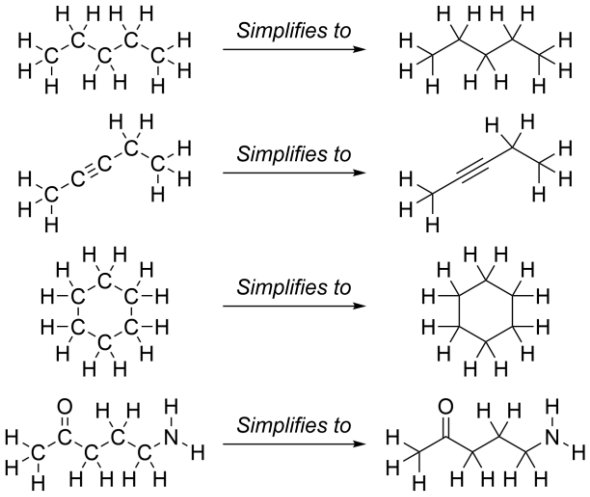

Figure 1

In all of the these examples each carbon atom forms four bonds. This is usual for carbon due to its position in the Periodic Table. To further simplify the drawing of skeletal strucures, hydrogen atoms that are bonded to carbon atoms are not drawn in and the bonds between these carbon and hydrogen atoms are not drawn in either. Simplifying the stuctures in this way gives us our skeletal formulae. Some examples of this are shown in **Figure 2**.

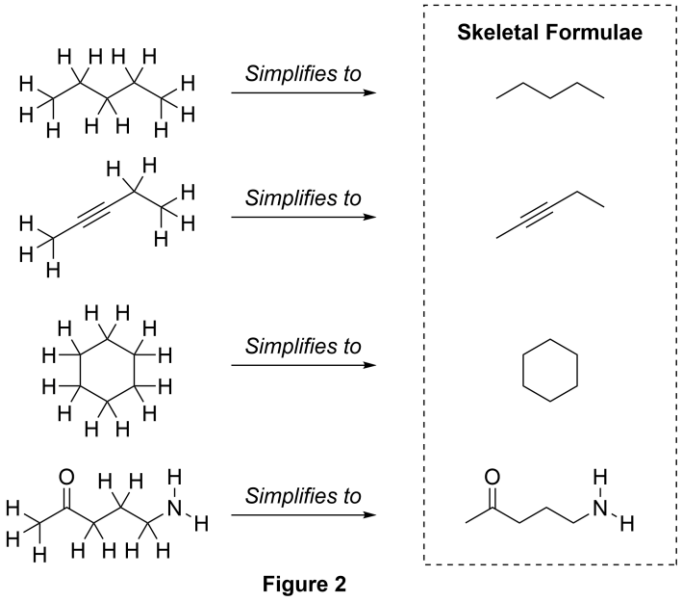

Figure 2

It might be thought that without the hydrogen atoms and the bonds to the hydrogen atoms drawn in that it would be difficult to explicitly identify a structure from its skeletal representation. However, as it is assumed that carbon usually makes four bonds, we can count up the bonds that each carbon makes in the skeletal structure and if this is fewer than four then the remaining bonds must be to hydrogen atoms.

It is important to draw skeletal formulae accurately. The angles in the carbon chain must be clear so that the number of carbon atoms can be readily identified. It is also important to remember that only hydrogen atoms and bonds to hydrogen atoms attached to carbon can be omitted. Hydrogen atoms attached to other elements must be shown. Some common mistakes in drawing skeletal structures are shown in **Figure 3**.

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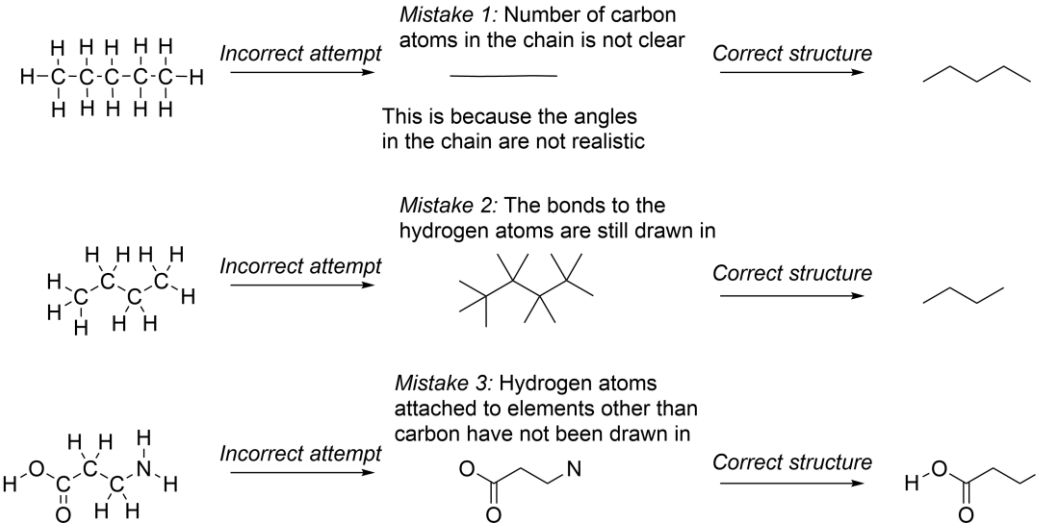


Figure 3

Occasionally certain carbon atoms are still drawn in skeletal formulae. This is optional and sometimes done to highlight a particular functional group. However if you write the letter C, you must show all hydrogens that are bonded to it, otherwise the structure is incorrect (**Figure 4**).

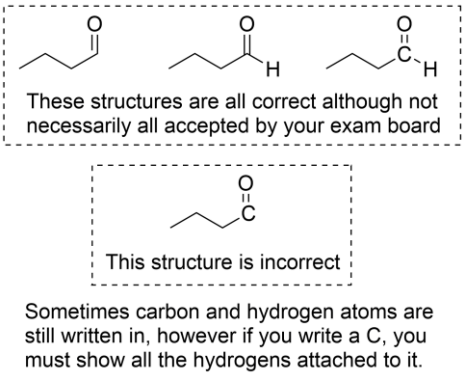


Figure 4

In some cases the hydrogen atoms and the bonds to the hydrogen atoms need to be drawn in. This is necessary when some of the information about the shape of the molecule will be lost if we do not draw in the hydrogens. For example we need to draw in the hydrogens on the carbons at the join between the two rings in **Figure 5** to indicate whether they are on top of the ring (in which case a wedged line is used) or under the ring (in which case a dashed line is used). If we do not draw in the hydrogens here the skeletal formula becomes ambiguous as to which of the two different compounds that we have.

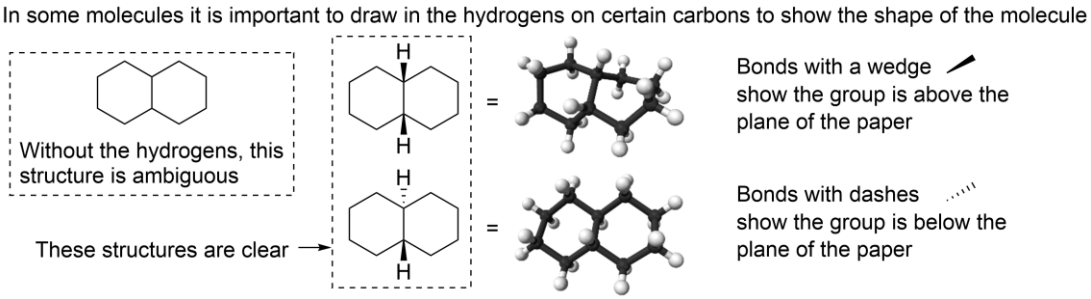
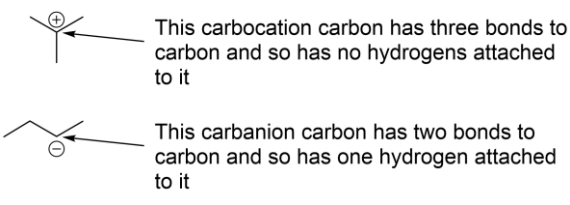


Figure 5

Most but not all carbon atoms form four bonds. However, the carbon of a carbocation or a carbanion only makes three bonds. This can be represented in skeletal formulae. We do not need to draw the carbon C, but we must put a + next to the position of that carbon to indicate that it is a carbocation, or a − to indicate that it is a carbanion. It is assumed in skeletal formulae that carbocations and carbanions make