2.3 THE TWO COMMANDMENTS

Now we know what curved arrows are, but how do we know when to push them and where to push them? First we need to learn where we cannot push arrows. There are two important rules that you can never violate when pushing arrows. They are the “two commandments” of drawing resonance structures:

1. Thou shall not break a single bond.
2. Thou shall not violate the octet rule.

Let’s focus on one at a time.

1. Never break a single bond when drawing resonance structures. By definition, resonance structures must have all the same atoms connected in the same order. Otherwise, they would be different compounds.

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\[ \text{Never break a single bond} \]
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If you draw a tail of an arrow on a single bond, then you are breaking that single bond and violating the first commandment. So the first commandment is violated when a tail is not drawn in the right place.

2. Never violate the octet rule. Let’s review the octet rule. Atoms in the second row (C, N, O, F) have only four orbitals in their valence shell. Orbitals are used to form bonds and to hold lone pairs. Each bond is using one orbital and each lone pair is using one orbital. So the second-row elements can never have five or six bonds; the most is four. Similarly, they can never have four bonds and a lone pair, because this would also require five orbitals. For the same reason, they can never have three bonds and two lone pairs. Let’s see some examples of arrow pushing that violates the octet rule:

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\[ \text{Bad arrow} \]
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In each of these drawings, the central atom cannot form another bond because it does not have a fifth orbital that can be used. This is impossible. Don’t ever do this.

The examples above are clear, but bond-line drawings are more difficult because we cannot see the hydrogen atoms (and, very often, we cannot see the lone pairs either; for now, we will continue to draw lone pairs to ease you into it). You have to train yourself to see the hydrogen atoms and to recognize when the octet rule is being violated:

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\[ \text{is the same as} \]
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At first it is difficult to see that the arrow on the left structure is violating the octet rule. But when we count the hydrogen atoms, we can see that the arrow above would give a carbon atom with five bonds.

If we draw a head of an arrow that forms a bond on an atom already using all four orbitals, then we are violating the second commandment. So the second commandment is violated when a head is not drawn in the right place.

Thus, the two commandments really do reflect the two parts of the arrow. A bad tail violates the first commandment and a bad head violates the second commandment.