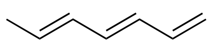
The Game of Resonance™

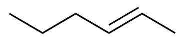
Board game

- Playing board is the Lewis drawing of a structure with a conjugated system
- Only the conjugated system is part of the game; other portions are decorative

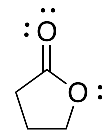
Examples:



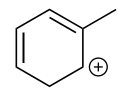
6-atom system



3-atom



3-atom



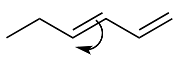
5-atom

Moving pieces

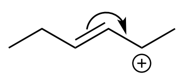
- You may move electrons only
- They must be in the conjugated system
- They must not be σ-bonded

Rules for moving the pieces

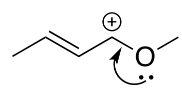
- Electrons can move in pairs or singly
- No move can increase the number of *non-paired* electrons
- Three valid types of move:



Bond-to-atom

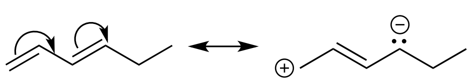


Bond-to-bond



Atom-to-bond

- Multiple moves can happen at once. For example, below, there is a bond-to-bond move and a bond-to-atom move occurring simultaneously.



Notes:

1. The double-headed arrow symbol indicates that the two drawings are part of the game
2. The individual drawings are called "contributors"
3. The final charge of any two contributors must always be the same since electrons are moving but not arriving or leaving the playing board

Strategy

Make moves that have more bonds – these are the most valuable

If there are none then make moves with the same number of bonds

If there are none then make moves with fewer bonds

At the end of the game you want *as many structures as possible* with the *maximum* number of bonds.
If there is only one structure with the maximum number of bonds then you want as many structures as possible with one less bond than the maximum.

For example, if there are four structures with eight bonds and seven others with fewer than eight bonds, then you only want the four with eight bonds. BUT if there is only <u>one</u> structure with eight bonds, two with seven bonds, and six others with fewer than seven bonds, then you want to keep only the three with either eight or seven bonds.

Non-existence of contributors
The basic interpretation of resonance is that NONE of the drawings that you created by following the rules are representation of structures that actually exist in the universe. The following scenario explains what this means.

Imagine that you have a friend who is very playful, laughs a lot, and also loves high-adrenaline adventures.
You might say that your friend has contributors like SpongeBob and Indiana Jones. Neither of those characters actually exist, but they can be used to describe someone real, your friend.

That's what we do with resonance. We determine the important contributors and, from that, determine what really exists. Remember: NO CONTRIBUTOR EXISTS. EVER. NOT EVEN FOR A MOMENT.

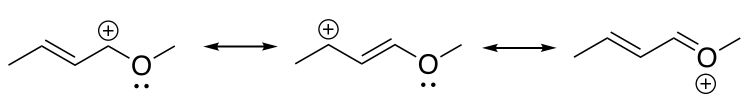
What does exist is the hybrid.

Drawing the hybrid
First, rank the contributors as described in the *Strategy* section above. In addition to the number of bonds, as mentioned in the Strategy section, these factors are used to compare two contributors:

If structure A has a complete octet on every atom and structure B does not	Structure A is more important. Done.
Otherwise, if structure A has both a positive atom and a negative atom in its structure (called separated charge) and structure B does not	Structure B is more important. Done.
Otherwise, if both structures have a negative charge but the negative atoms are not the same	Structure with the more electronegative atom is more important. Done.
Otherwise, if both structures are carbocations	Structure with more stable carbocation is more important. Done.
Otherwise, if both structures have a π bond	C=O π bond is more important than C=C π bond. Done. Otherwise structure with more substituted C=C bond is more important.

Now we can apply these importance factors to drawing the actual structure. Think about the example of a playful, adventurous friend again. Suppose the friend is almost always playful but every now and then likes adventure. Then their SpongeBob contribution is great than their Indiana Jones.

Consider these three contributors:



The third structure is most important because it has the most covalent bonds.
The first and second structures are very similar (no octet on every atom, no separated charge, no negative charge, both carbocations, but we don't know how to rank a carbocation on a carbon attached to an oxygen.) Let's call them a tie.

So the real structure looks a lot like the third, meaning that between the oxygen and its carbon on the left it has a nearly double bond but not quite (shown with a line and a dashed line). That carbon is almost singly bonded to its neighbor but is a little more than that because of the second contributor (shown with a line and dotted line). That neighbor is almost double bonded to its neighbor but not quite. Finally, the positive charge is mostly on the oxygen with little bits on two others carbons.

This structure is more complicated to draw than the contributors but it has the advantage of being the "real" structure. This is what the cation actually looks like!