California State University SAN MARCOS

Chem 201: Formal Charge Worksheet

FAQs:

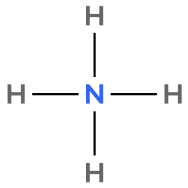
1. **What is formal charge?**
   - There is a fancy definition, but I like to keep things simple. Formal charge is just the charge we give to atoms in a molecule to understand where electrons will tend to hang out within the molecule, generally they will prefer to hang around the most electronegative atom in the molecule.
   - Remember, electrons are constantly moving around a molecule. So, as electrons move, the formal charge of an atom change.
2. **Why do we assign formal charges to certain atoms?**
   - We can assign a formal charge to specific atoms within a molecule, specifically those that have an abnormal bonding pattern.
3. **What constitutes as abnormal bonding pattern?**
   - Atoms in certain groups prefer a specific kind of number of bonds and lone pairs attached to it. For example:
     - Atoms in **Group 4**, such as Carbon, prefer to have **4 bonds** and **no lone pairs**
     - Atoms in **Group 5**, such as Nitrogen, prefer to have **3 bonds** and **1 lone pair**
     - Atoms in **Group 6**, such as Oxygen, prefer to have **2 bonds** and **2 lone pairs**
     - Atoms in **Group 7**, such as Fluorine, prefer to have **1 bond** and **3 lone pairs**
   - If an atom has one more **bond** than it prefers, it's formal charge would be **+1**.
   - If an atom has one more **lone pair** than it prefers, it's formal charge would be **-1**.
   - If an atom in those group exhibit **normal** bonding pattern, they will have a formal charge of **0**.
4. **Don't want to memorize that? You can calculate!**
   - Calculate the formal charge with the following formula:
     - Formal charge = $V - N - \frac{B}{2}$, where
     - V = number of valance electrons (or group of the atom)
     - N = number of non-bonding valence electrons (or number of electrons involved in the number of lone pairs)
     - B = number of bonds to an atom
5. **Why is this important?**
   - Knowing the formal charge of a molecule or atom, helps us determine which model of a molecule is most stable, and hence, most prevalent in equilibria.
   - Remember: A formal charge of zero is the most stable, so that molecule will be more favored in equilibria or contribute more to the resonance structure.
   - A positive or negative formal charge is less stable and will not be as favored.

- Ultimately, understanding formal charge helps us predict where electrons are in the molecule, which helps us predict reaction patterns and products (relevant for your near future in this course).

Let's Practice:

- Remember how I said that you can find the formal charge of an atom in two different ways? Let's try both first to determine which you like more. We'll first try the more theoretical approach.

Let's find the formal charge of the nitrogen (which is the central atom, in this molecule):



1. What group is nitrogen in? ___
2. An atom in this group likes to have ___ bonds and ___ lone pairs.
3. This atom has ___ bonds and ___ lone pairs.
4. Based on that, does this atom exhibit abnormal bonding patterns (Yes or No)? ___
5. What is the formal charge of this nitrogen? ___

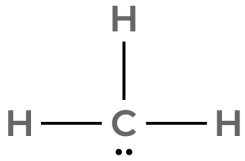
Okay that might have seemed like a lot, but once you do it so many times the thought process can become super quick, and you don't need to memorize yet another formula! (So, if you're like me and forget the formula during your first OCHEM exam, you can still answer this type of question ☺).

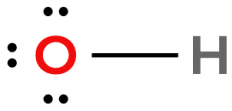
Let's try the mathematical approach!

1. How many valance electrons does nitrogen have? ___
2. How many non-bonding valence electrons are surrounding the nitrogen? ___
3. How many bonds does nitrogen have in this molecule? ___
4. Plug those values in the formula!
5. What is the formal charge of this nitrogen? ___

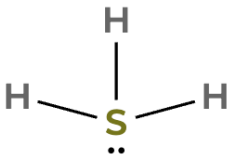
Did you get the same answer? What approach do you like more? Keep that in mind as you go through the rest of this worksheet!

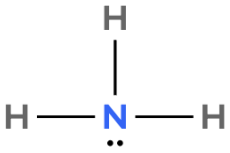
Determine the formal charge of the central atoms in the following molecules:

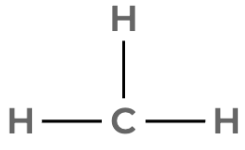
1. 

2. 

3. 

4. 

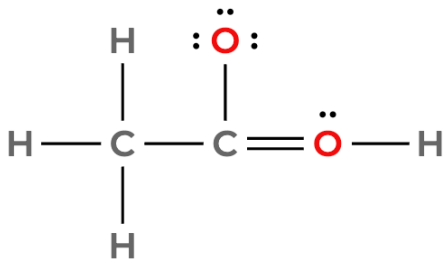
5. 

6. 

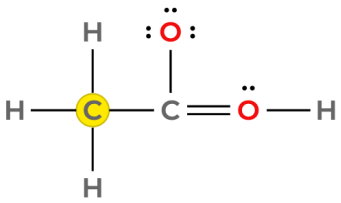
Let's Step it up!

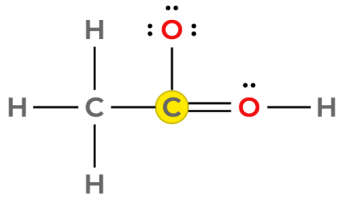
Now that you have a little bit more practice finding the formal charge of a central atom, let's find the overall charge of a molecule (which is just the sum of each atom's formal charges, for the exception of hydrogen).

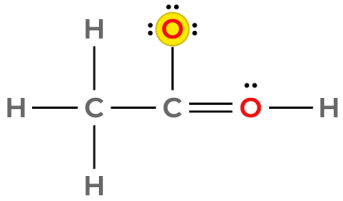
We'll calculate the total charge of acetic acid (main ingredient of vinegar), CH_3COOH by calculating the formal charge of each non-hydrogen atom:

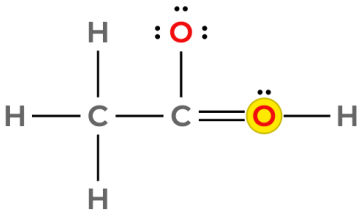


Step One: Determine the charge of each highlighted atom.

a. 

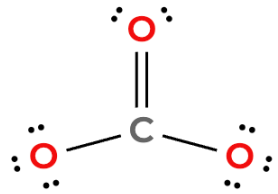
b. 

c. 

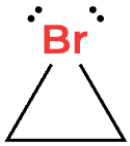
d. 

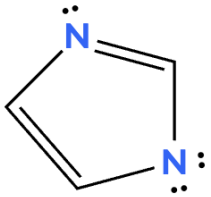
Step Two: To determine the total charge of the molecule, add each formal charge of the atoms you calculated. What is the total charge of acetic acid? ___

Determine the formal charge for the nonhydrogen atoms and the overall charge in the following molecules:

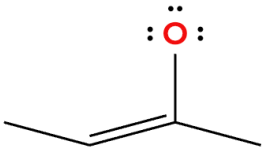
1. 

2. 

3. 

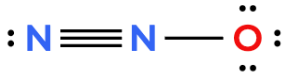
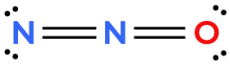
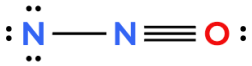
4. 

5. 

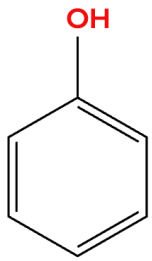
6. 

Based on the formal charges of each nonhydrogen atom in the following molecules, which resonance structure would you expect to contribute most to the resonance hybrid of NO_2? Why?

1. NO_2

A.  B.  C. 

2. C_6H_5OH

A.  B. 