Name: _____ Date:_____ Score: _____/ 20

Lab 2/ Writing Formal Charges *Organic Chemistry*

Please read the material below (came from your textbook), and answer what you can at home. Then bring to class to work on as a group.

Lab 2 - Writing Formal Charges

1.9 Assigning Electrons to Atoms in Molecules: Formal Charge and Oxidation State

In an *isolated* atom or atomic ion, charge is determined by the difference between the atom's group number and the actual number of valence electrons it possesses. A carbon atom, for example, has zero charge if it possesses four valence electrons—its group number is 4. It carries a charge of −1 if it has five valence electrons and it carries a charge of +1 if it has only three valence electrons.

YOUR TURN 1.8

Fill in the table below for a carbon atom.

Number of Valence Electrons	Total Number of Electrons	Number of Protons	Charge
3			
4			
5			

In a molecule or polyatomic ion, we can also assign a charge to an individual atom by computing the difference between the atom's group number and the number of valence electrons it possesses. But how do we assign electrons to atoms involved in covalent bonds, where electrons are being *shared*?

Two methods are used: **formal charge** and **oxidation state**. In both methods, lone pairs are assigned to the atom on which they appear in the Lewis structure. The methods differ, however, in how they treat covalent bonds.

Formal Charge

In a given covalent bond, half the electrons are assigned to each atom involved in the bond.

Oxidation State

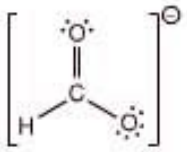
In a given covalent bond, all electrons are assigned to the more electronegative atom. If the two atoms are identical, the electrons are split evenly.

Because the methods of assigning formal charge and oxidation state differ simply by the way in which they assign valence electrons to atoms within a molecule or ion,

the methods are essentially different ways of distributing the net charge of the species. Therefore,

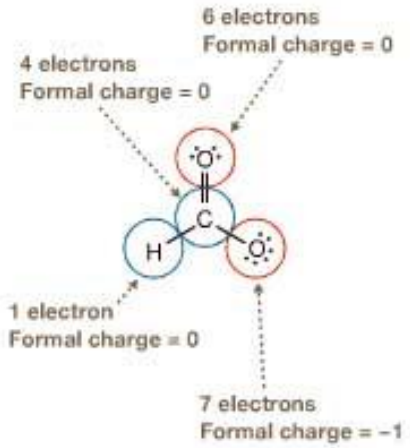
- The formal charges of all atoms must sum to the total charge of the species.
- The oxidation states of all atoms must sum to the total charge of the species.

SOLVED problem 1.16 Determine the formal charge and the oxidation state on every atom in the methanoate anion (formate anion, HCO_2^-).

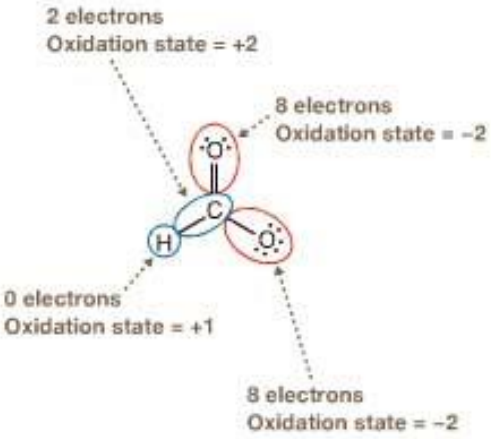


Think How are lone pairs assigned? In determining how to assign bonding pairs of electrons, when is electronegativity relevant and when is it not?

Solve The figure below on the left shows how valence electrons are assigned according to the formal charge method. Notice that each pair of electrons in a covalent bond is split evenly. The H atom, the C atom, and the top O atom are assigned formal charges of 0 because they have the same number of valence electrons as their corresponding group numbers. The O on the right is assigned seven valence electrons, which is one more than its group number of 6. It is therefore assigned a formal charge of −1.



Formal charges



Oxidation states

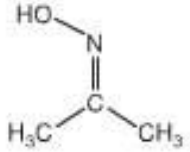
The oxidation state method for assigning valence electrons is shown on the right. In this case, the electrons in each covalent bond are assigned to the more electronegative atom. H (EN = 2.20) is assigned zero electrons, one less valence electron than its group number, for an oxidation state of +1. C (EN = 2.55) is assigned two electrons, two fewer electrons than its group number, giving it an oxidation state of +2. Each O atom (EN = 3.44) is assigned eight electrons, two more electrons than its group number, giving each an oxidation state of −2.

1.9 YOUR TURN

Sum the formal charges and oxidation states assigned in Solved Problem 1.16. What do you notice?

Formal charges _____ Oxidation states _____

problem 1.17 Determine the formal charge and oxidation state of each atom in the molecule below. (*Note:* You may assume each atom has a filled valence shell.)

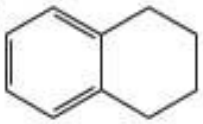


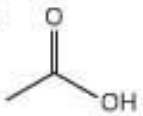
The two methods for assigning covalently bonded electrons represent extremes. The formal charge method, for example, assumes perfect covalency, where the electrons are shared equally. The oxidation state method, on the other hand, assumes perfect ionic character, where the electrons belong entirely to the more electronegative atom. Neither is exactly correct; the true behavior of the electrons is somewhere in between.

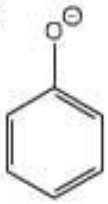
Despite the fact that neither method is exactly correct, *formal charges are used much more often than oxidation states* because, in most cases, formal charge provides more insight into a species' reactivity. Therefore,

> Unless otherwise stated, you may assume that any charges that appear in a Lewis structure are formal charges.

1.53 Determine the oxidation states for all atoms other than hydrogen in each of the following species.

(a) 

(b) 

(c) 

(d) 

1.54 Identify the formal charge and oxidation state on each atom in the following species. Assume that all valence electrons are shown.