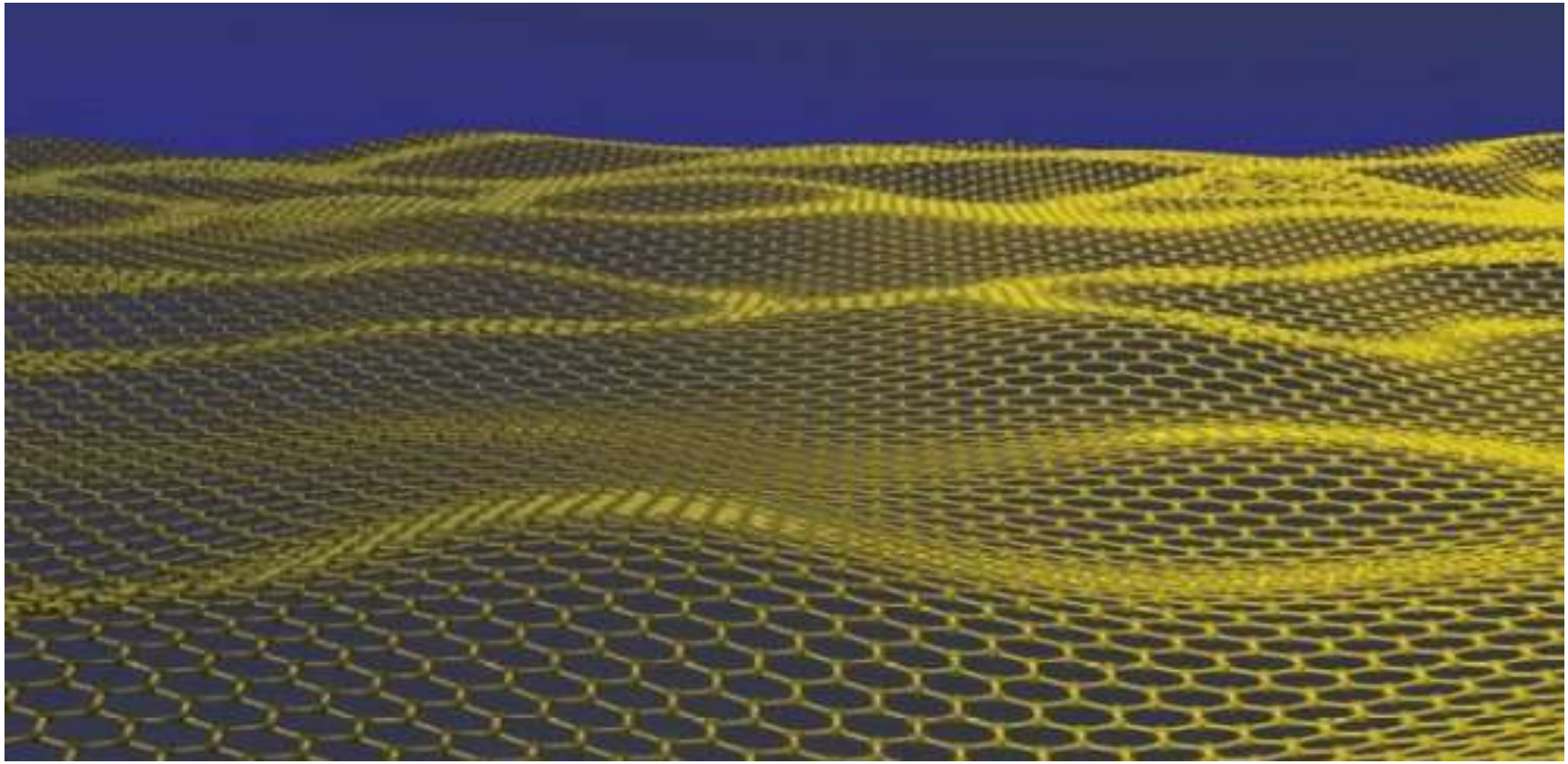
Pre-AP Chemistry

September 4, 2011

15. Covalent Bonding II



Review

How many valence electrons do the following atoms have?

C **O** **H** **N**

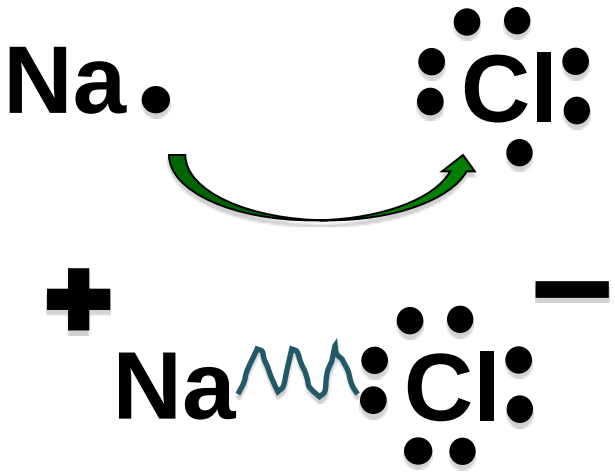
How many electrons do the following atoms need to attain a stable octet?

C **F** **H** **B**

Review

- We have learned three important things so far
  1. How to draw Lewis structures for ions and ionic bonds
  2. How to draw shared electrons in covalent bonds
  3. How to use electronegativity to determine electron sharing in covalent bonds

1.



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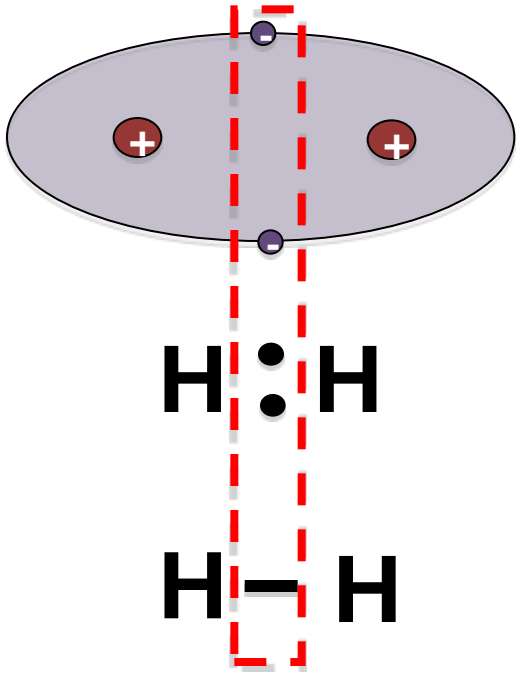

3.

With a few more rules, we can draw a Lewis structure for almost any molecule

Outline

- Molecular Lewis Structures
- Practice

- Molecular Lewis Structures
  - Atom Placement
  - Electron Placement
  - Octet Rule
  - Multiple Bonds
- Practice
- Resonance and Formal Charge

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Atom Placement

- Placing atoms in the correct positions is the first step in drawing any Lewis structure.
- To position atoms correctly in a molecular Lewis structure:
  - Place the least electronegative atom (except for hydrogen) in the center
  - Place up to four other atoms around the central atom
  - (Only place more than four if the central atom has n > 2)
  - Hydrogen and halogen atoms are almost always outermost atoms

CH_3OH

methanol

Which atom is the center atom in methanol?

Atom Placement

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CH_3OH

methanol

Carbon = least electronegative = center atom

C

How do you place the other atoms around C?

Atom Placement

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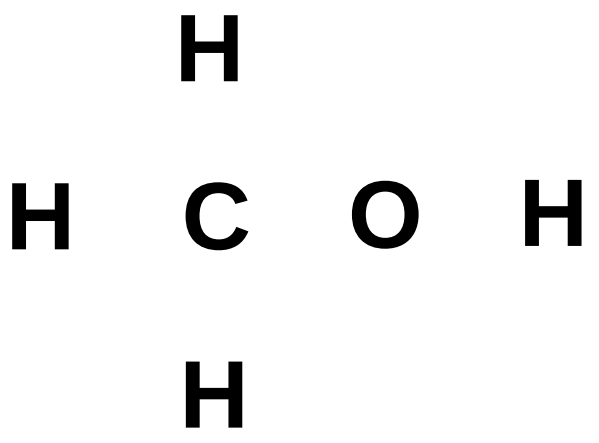
CH_3OH

methanol

Four atoms around C, H's on the outside.



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- Molecular Lewis Structures
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  - Atom Placement
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- Resonance and Formal Charge

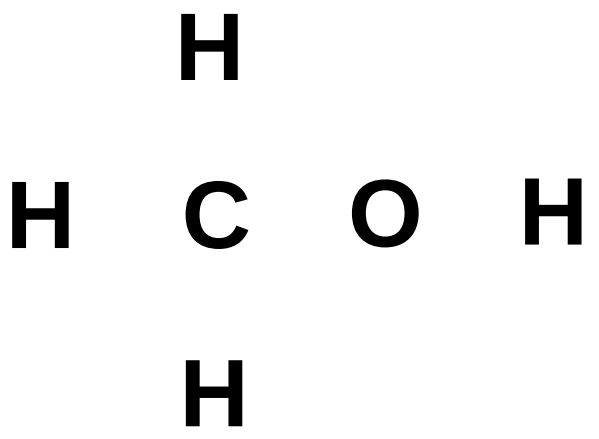
Electron Placement

- Count the total number of valence electrons in the molecule
- Place two electrons between the center atom and each surrounding atom, and between surrounding atoms and outer H's or halogens
- Determine the total number of electrons remaining
- Use remaining electrons to satisfy octet rule on each atom, starting with most electronegative atoms

CH_3OH

methanol

How many total valence electrons are in methanol?



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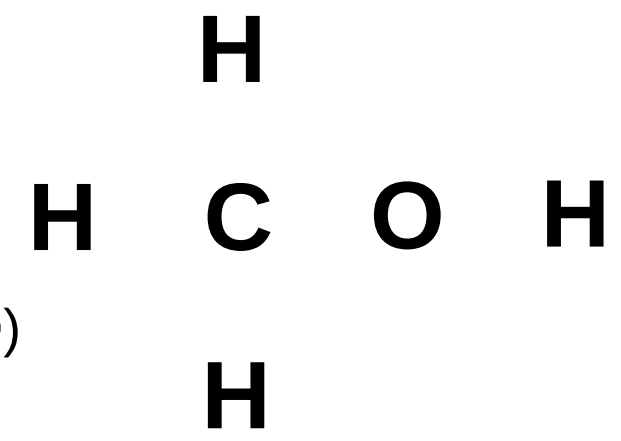
CH_3OH

methanol

Total number of valence electrons = 14

Valence e- (C) = 4
Valence e- (H) = 1
Valence e- (O) = 6

Valence e- (CH_3OH) = 1VE(C) + 4VE(H) + 1VE(O)
Valence e- (CH_3OH) = 1(4) + 4(1) + 1(6)
Valence e- (CH_3OH) =14



Electron Placement

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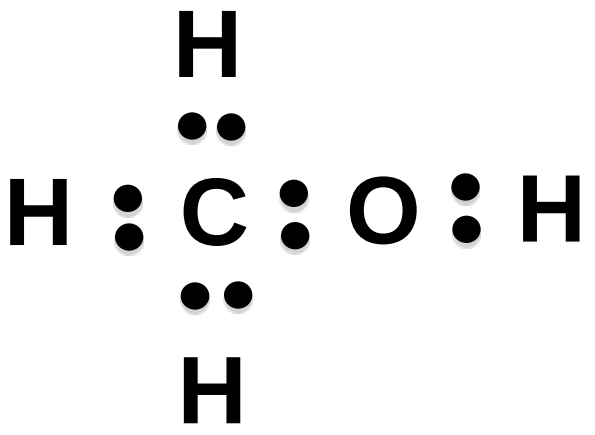
CH_3OH

methanol

Total number of valence electrons = 14



Two electrons shared between two atoms form a _____ bond.

How else can we represent a bond?

Electron Placement

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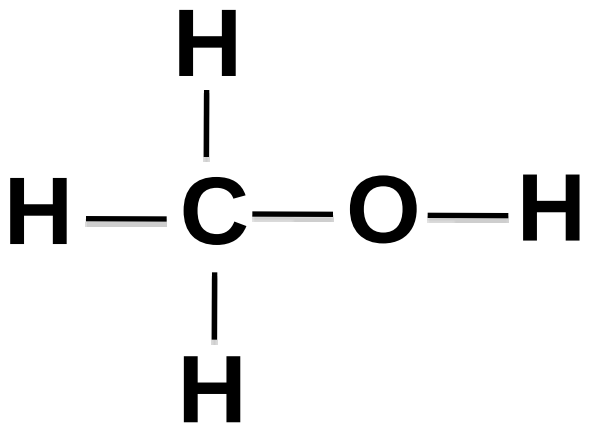
CH_3OH

methanol

Total number of valence electrons = 14

How many valence electrons remain?



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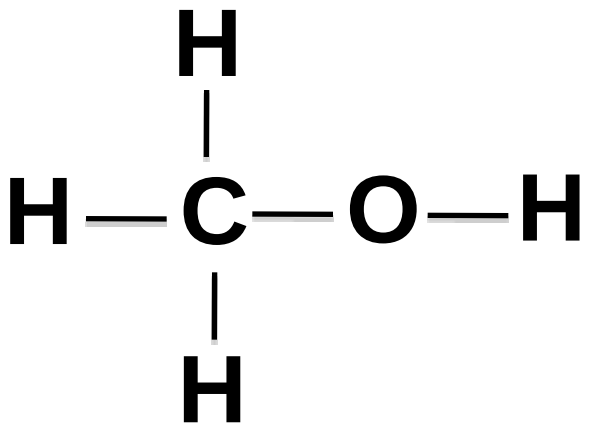
CH_3OH

methanol

Total number of remaining electrons = 4

How many valence electrons remain?

Remaining e- = Total e- – 2(# of bonds)
Remaining e- = 14 – 2(5)
Remaining e- = 14 – 10
Remaining e- = 4



Electron Placement

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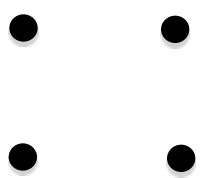
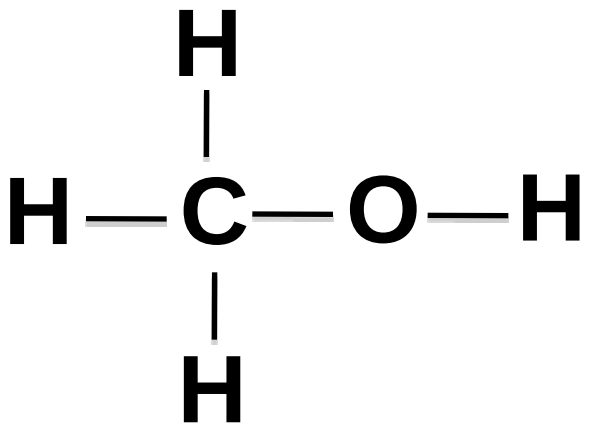
CH_3OH

methanol

Total number of remaining electrons = 4

Where do we place remaining e- ?





Outline

- Molecular Lewis Structures
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Octet Rule

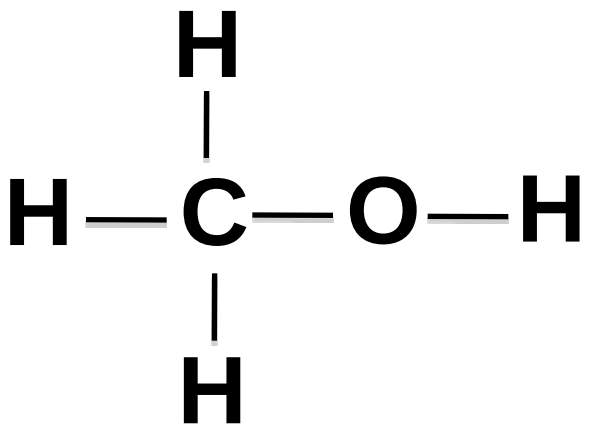
- Atoms in molecules tend to form bonds such that each atom is surrounded by eight valence electrons (i.e., like a noble gas)
- Exceptions:
  - Hydrogen can have no more than 2 valence electrons
  - Boron and Aluminum tend to have 6 valence electrons
  - Atoms with n > 2 (period 3 or higher) can hold more than eight valence electrons

CH_3OH

methanol

First atom to receive remaining e- = most electronegative atom = O

How many more e- does O need to satisfy octet rule?



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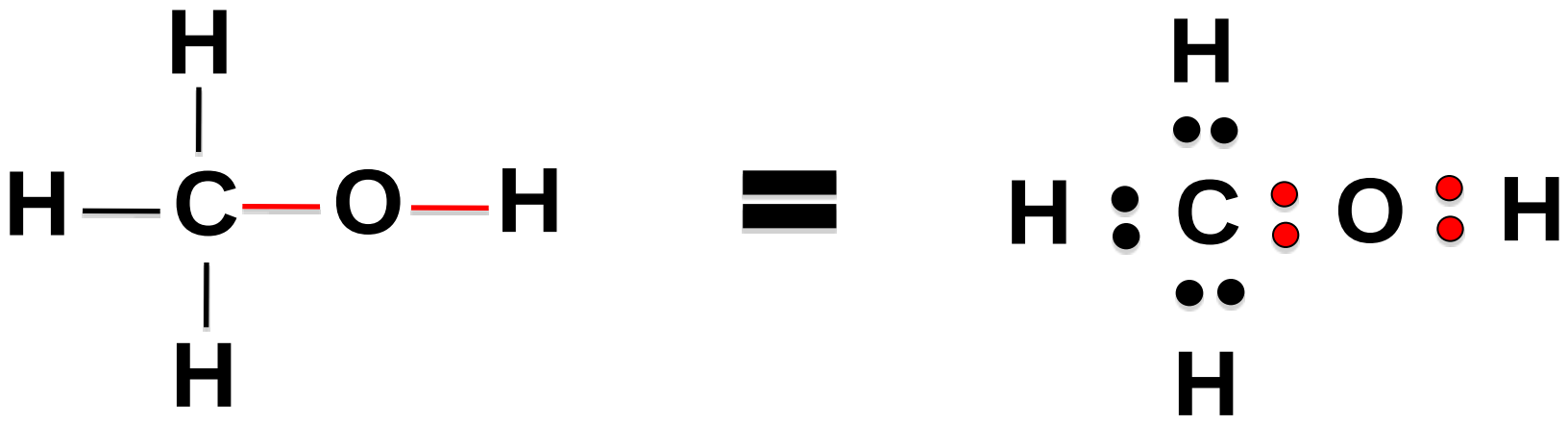

8 – 2(bonds to O) = # e- needed = 8 - # e- in bonds around O

8 – 2(2) = # e- needed = 8 – 4

4 = # e- needed = 4

Octet Rule

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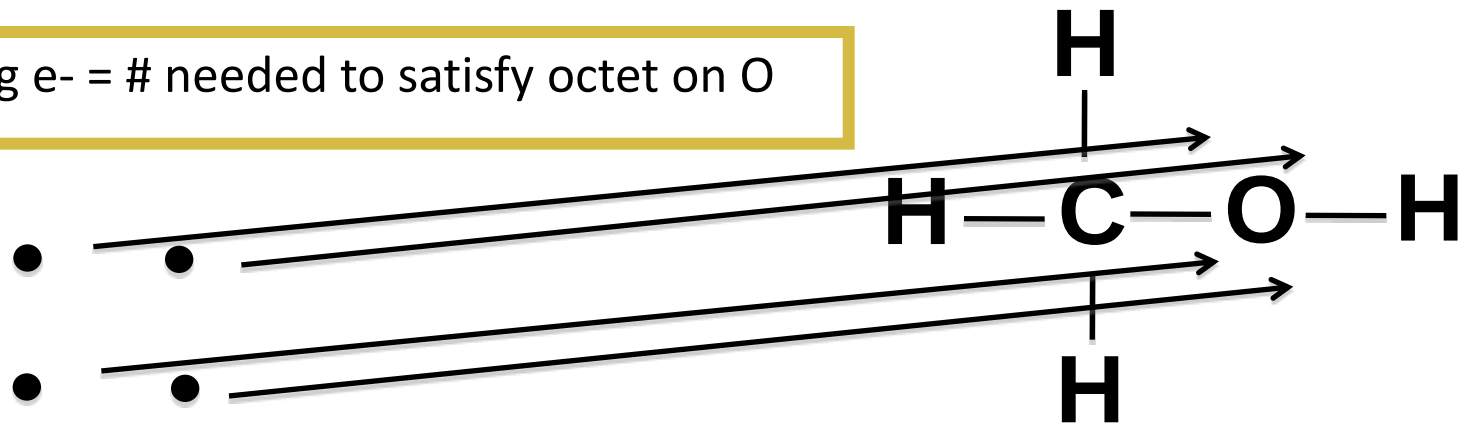
CH_3OH

methanol

Total number of remaining electrons = 4

remaining e- = # needed to satisfy octet on O



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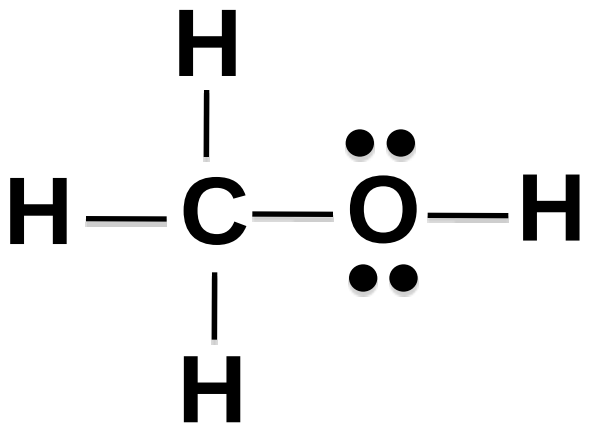
CH_3OH

methanol

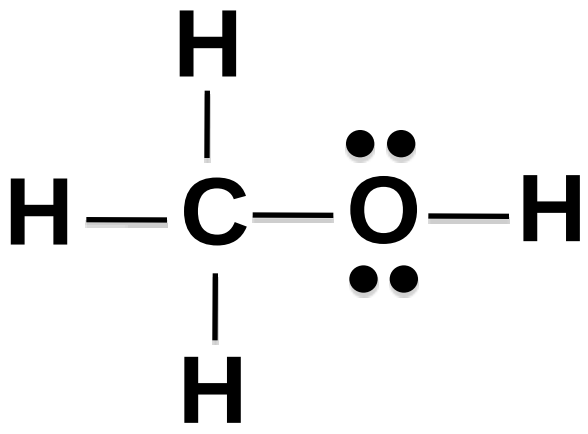
Almost done …

Do any other atoms need more electrons to satisfy octet rule?



Octet Rule

Do any other atoms need to satisfy octet rule?



Octet Rule

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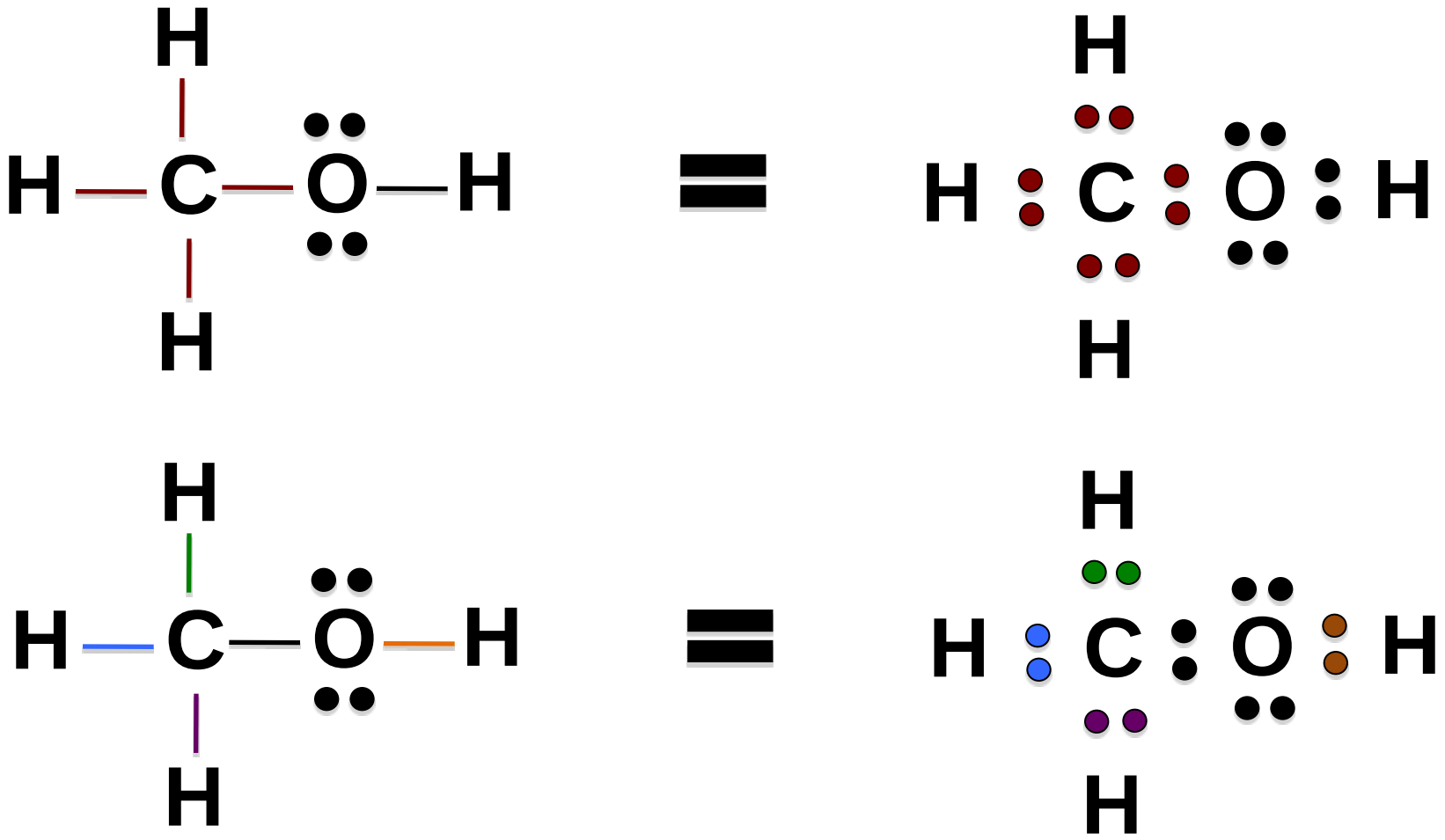

Hydrogen only needs 2 e- to satisfy ‘octet’ rule. Why?

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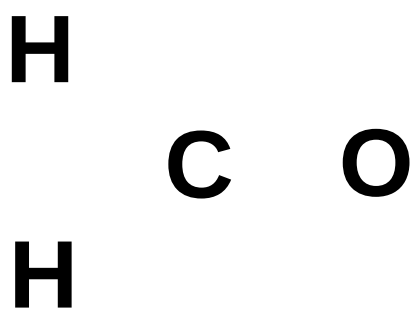
Multiple Bonds

- Let's draw the Lewis Structure for formaldehyde following the steps we just discussed

CH_2O

formaldehyde

Carbon = least electronegative = center atom



Up to four atoms surrounding C

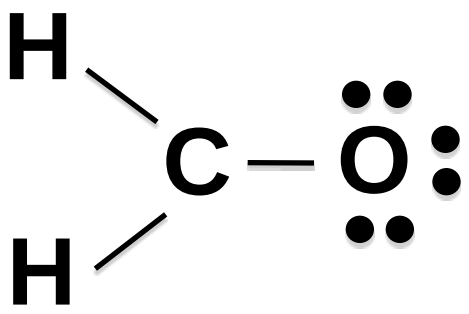
Multiple Bonds

- Let's draw the Lewis Structure for formaldehyde following the steps we just discussed

CH_2O

formaldehyde

Total # e- = 12

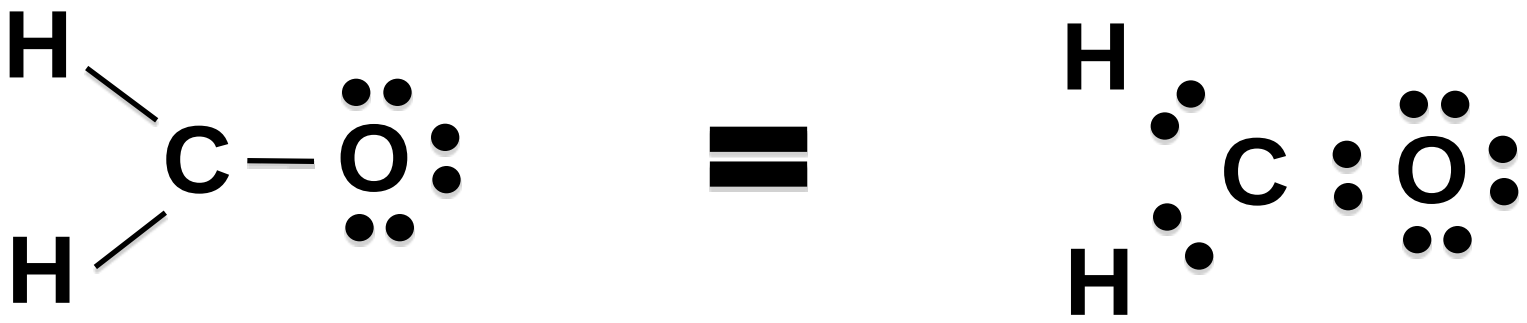


12e- – 6 e- (in bonds) = 6 e- around O

Is octet rule satisfied for all atoms?

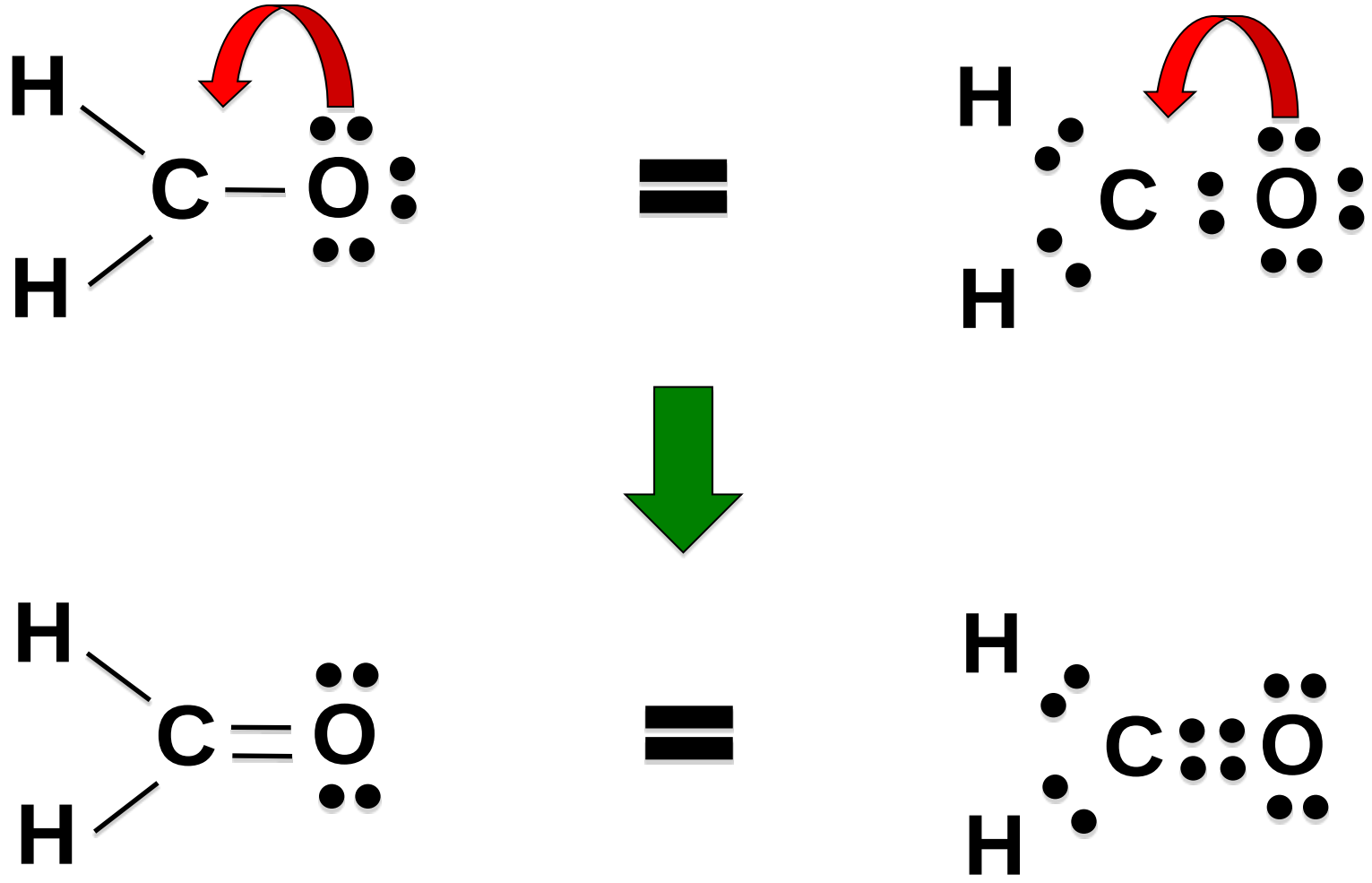
Multiple Bonds

Octet rule not satisfied for C (only has 6 surrounding e-)



Multiple Bonds

Satisfy octet rule by moving 2 e- from O into a double bond with C



Mini Quiz

Draw the Lewis Structure for hydrogen cyanide, HCN.

(Hint: think about triple bonds).

HCN

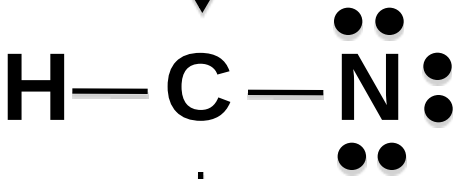
Mini Quiz

Draw the Lewis Structure for hydrogen cyanide, HCN.

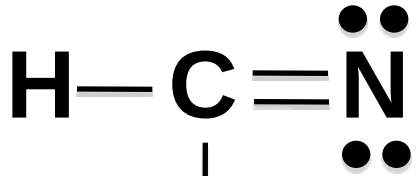
(Hint: think about triple bonds).

HCN

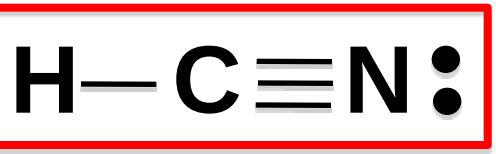
10 total e-, 4 e- in bonds



C only has 4 e-, needs 4 more



C only has 6 e-, needs 2 more



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Practice

Practice drawing Lewis structures for the molecules below:

CF_4 CO SiH_4

NO_3^- NH_4^+ H_2O

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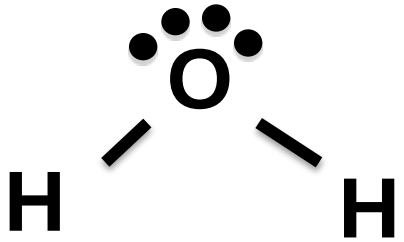
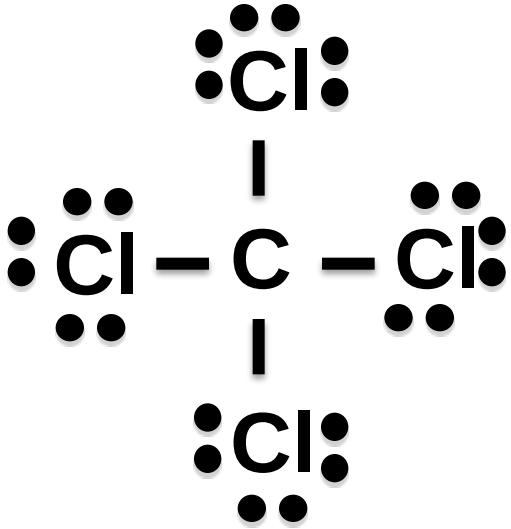
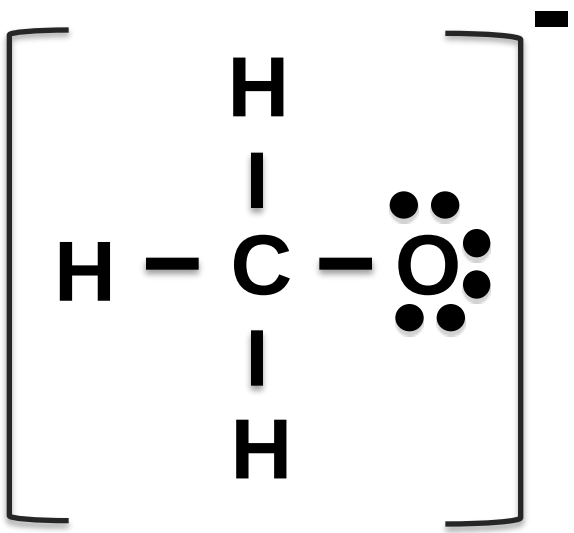
Formal Charge

- Sometimes fulfilling the octet rule on all atoms does not give a unique Lewis structure for a molecule
- Assigning **formal charges** to atoms helps us draw the Lewis structure that most closely models real molecules
- The **sum of the formal charges** on all atoms in a molecule must equal the **overall charge** on the molecule







Formal Charge

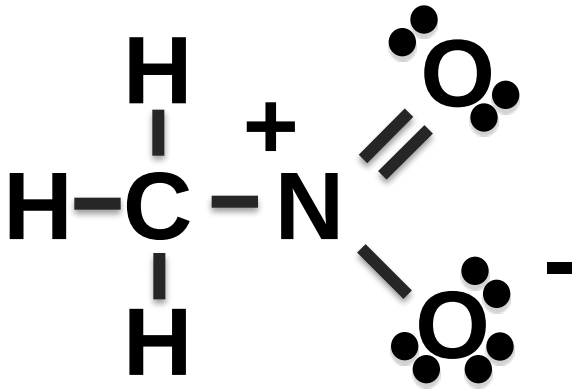
- **Formal charge = valence e^- - [2(# lone pairs) + (# bonds)]**
- Molecules tend to be **more stable** if their atoms **have smaller formal charges**

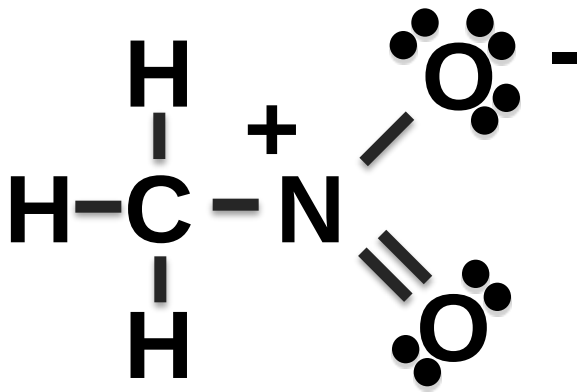
CO **CH_3^+** **CH_3NO_2**

Resonance

- Sometimes, you can draw the double bonds (or triple bonds) in a molecule in more than one way
- We call each different arrangement of multiple bonds a **resonance structure**
- **Resonance structures** must still **obey the octet rule**

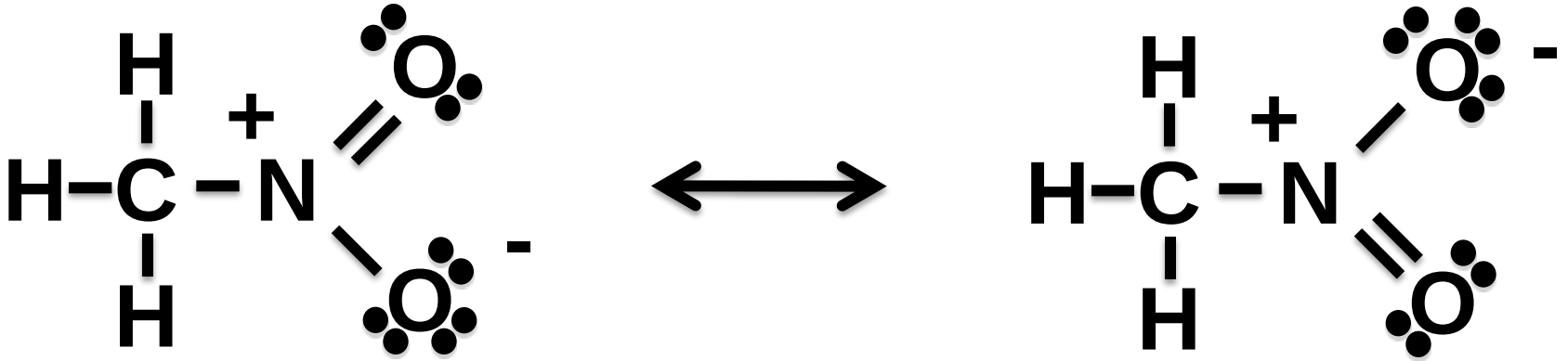
CH_3NO_2

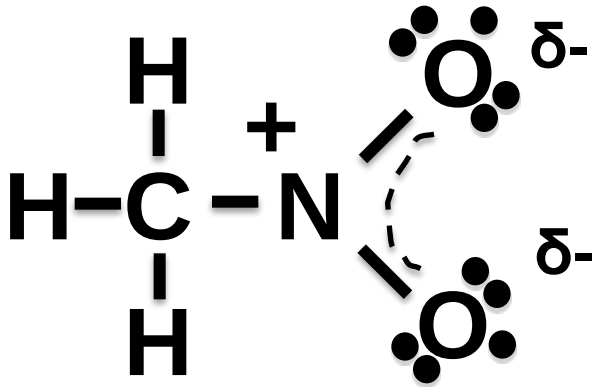




Resonance

- A molecule can exist in any of its resonance structures
- We draw a **double-sided arrow** between resonance structures to indicate that all of them are possible





Mini Quiz

- Draw Lewis structures of the following molecules. Indicate all formal charges and resonance.

HSO_4^- $C_3H_5^+$ $CH_3C(O)NH_2$

Summary

- With a few rules, we can draw Lewis structures for almost any molecule
- We will see how Lewis structures help us predict molecular shapes and reactivity in the next class

Homework

- TBD