Lesson #3 Covalent Bonds

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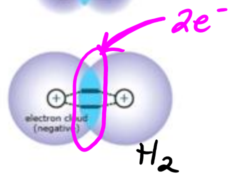
Kinetics (Chem12)

WHY DO ATOMS FORM BONDS?

- Bond formation begins with atoms "colliding"
- For example as two hydrogen atoms approach each other, their kinetic energy ***increases*** as each electron cloud is attracted to the other's approaching ***positive nucleus***. (+ nuclear charge) H_2 attracted H
- Atoms continue moving together until the repulsive forces of the two negative electron clouds and the two positive nuclei slow the atoms and convert their kinetic energy into potential energy (bond energy)

Shared electron pair = covalent bond

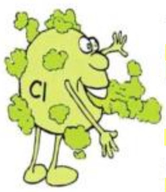


- As the atoms get close to each other, their e^- clouds overlap enough to cause attractive forces to exceed the repulsive ones.
- The two valence electrons will move into the region of space between the atoms nuclei. = BOND ($2e^-$)
- This force of attraction of a pair of valence electrons between two adjacent nuclei constitutes a single covalent bond.

not involved in bonding

The atoms of noble gases have completely full outer shells and so are stable.

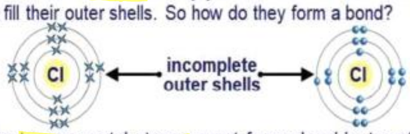
This makes the noble gases very unreactive and so they do not usually form bonds.



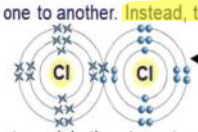
The atoms of other elements have incomplete outer electron shells and so are unstable. => "Octet Rule" 8e⁻

By forming bonds, the atoms of these elements are able to have filled outer shells and become stable.

Non-metal elements usually just need one or two electrons to fill their outer shells. So how do they form a bond?



The two non-metal atoms cannot form a bond by transferring electrons from one to another. Instead, they share electrons.



The shared electrons join the atoms together. This is called a covalent bond.

A COVALENT BOND is formed when two atoms complete their octets by sharing one or more ***pairs of electrons.*** => $2e^-$ shared = single bond; $4e^-$ shared = double bond; $6e^-$ shared = triple bond

- Δ electronegativity results when Δχ < 1.7 (Ionic bond Δχ > 1.7)
- usually involves a non-metal and a non-metal
- both nuclei (+) get to be attracted to more electrons
- both atoms complete their valence shells. (8e⁻)
- Covalent bonds are **VERY** strong

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I. Single (Covalent) Bonds

$2e^-$ (1e- from each atom)

- formed when two atoms share a single pair of electrons.
- simplest examples are the homogeneous diatomic molecules. ⇒ HOFBrINCl elements

Many non-metal elements, such as hydrogen, exist as simple diatomic molecules that contain *covalent bonds.*

2 atoms eg. H_2 or O_2, F_2

How is a covalent bond formed in diatomic molecules?

s-orbital p-orbital

sp-orbitals $8e^-$ "octet"

Example 1 sp H· + ·H → H : H

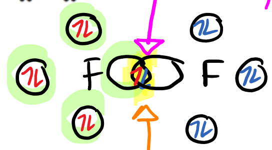
1s 1s

overlapping orbitals shares e- = covalent bond

σ "sigma" bond (single bond) 1 pair e- shared.

Example 2 :F· + ·F: → :F:F:

As they bond the s and p orbitals "blend" to form sp-orbitals ($2e^-$) ⇒ 4 sp-orbitals.



overlap IS the bond.

The number of electrons that an atom can share is usually the same as its valence.

# of unpaired electrons.

Example 3 How many single bonds would you think Carbon could form? Oxygen? Bromine?

valence e-

C : $6e^-$ Total : [He] $2s^2 2p^2$ — 1L (2s) 1 1 _ (2p) ⇒ Bonding 1 1 1 1 — 4 sp-orbitals ∴ 4 bonds possible

O : $8e^-$: [He] $2s^2 2p^4$ — 1L (2s) 1L 1 1 (2p) ⇒ Bonding 1L 1L 1 1 — sp orbital ∴ 2 bonds possible

7 valence e-

Br : $35e^-$: [Ar] $4s^2 3d^{10} 4p^5$ — 1L (4s) 1L 1L 1 (4p) ⇒ 1L 1L 1L 1 — sp-orbital. ∴ 1 bond possible.

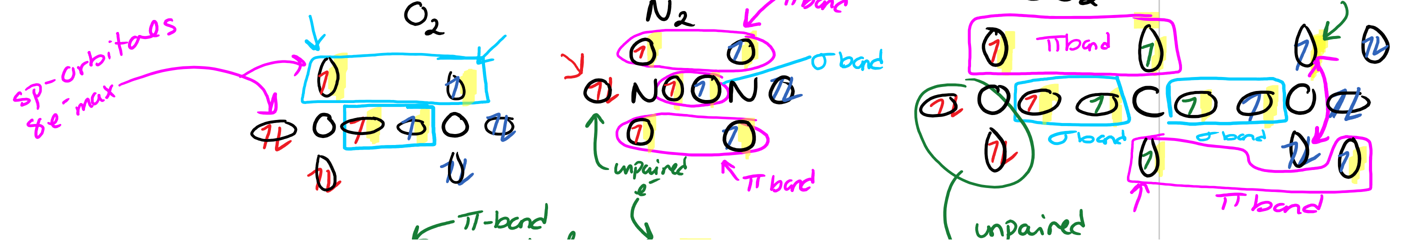
lower energy level ≠ not valence e-

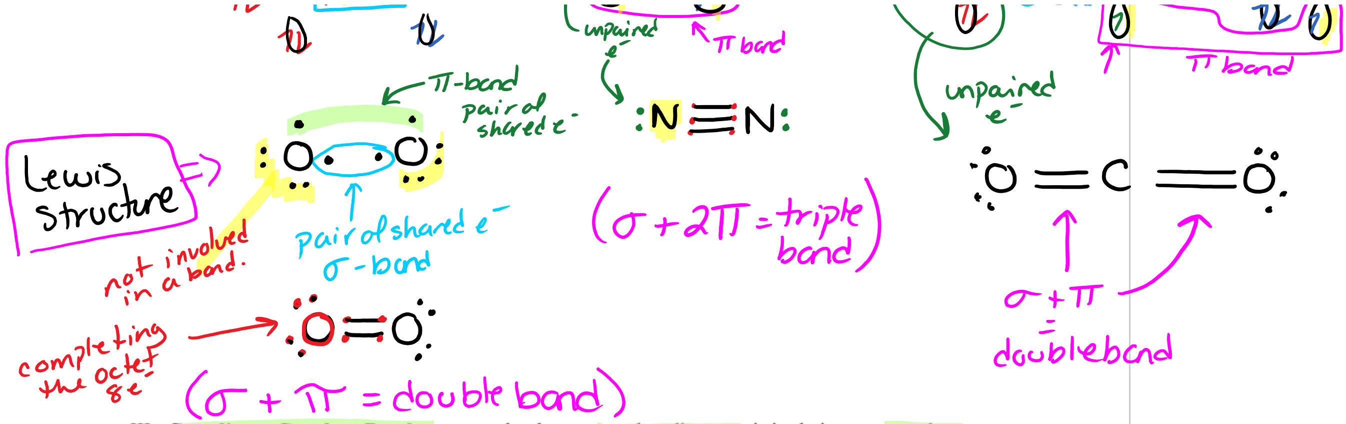
II. Double & Triple (Covalent) Bonds:

Non-metal atoms with less than 7 valence e⁻s are able to share *more* than single pair of e⁻s.

double bond = 2e- pairs = 4e- total
triple bond = 3e- pairs = 6e- total

Examples: Oxygen O_2 Nitrogen N_2 Carbon Dioxide CO_2





III. **Coordinate Covalent Bonds** – atoms that have a non-bonding e⁻ pair in their octet can share to allow an "electron-deficient partner" to complete its octet/duet.

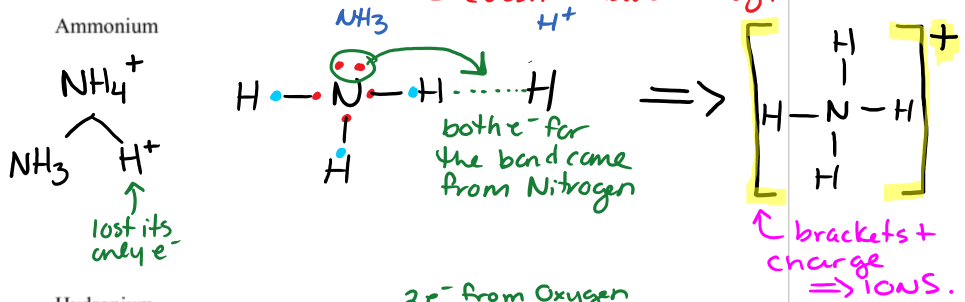
doesn't have enough e⁻ on its own

Examples: Ammonium

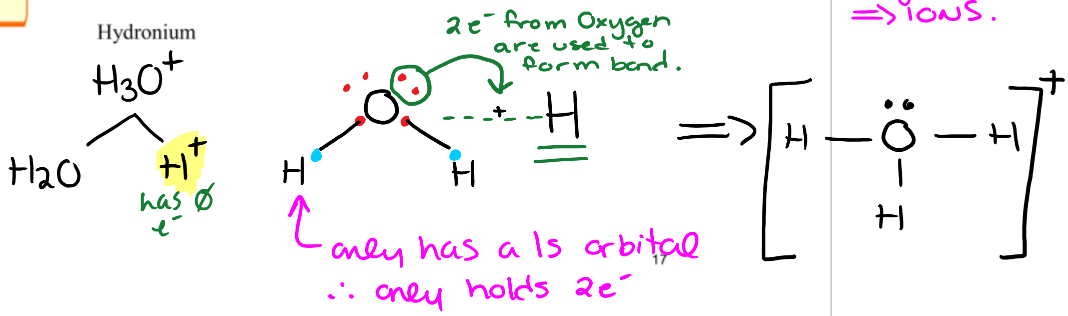
In "normal" covalent bonding, each atom contributes an electron to the bond.

In ***Coordinate covalent bonding*** **both electrons** are donated to the bond from a single atom...

...the other just "shows up"

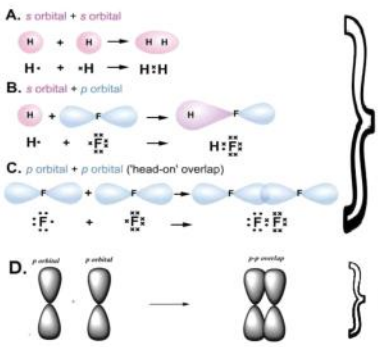


Hydronium



Orbital "blending" during bonding is complex, and certainly extension.
It *can* be helpful in determining the bond type: ie. single, double or triple bond.

extension



σ bond
single

π bond

Bond type	No. of σ bond	No. of π bonds
Single (C-H)	1	0
Double (C=C)	1	1
Triple (C≡C)	1	2

H—Cl:	:O=O:	:N≡N:
One σ bond No π bonds	One σ bond One π bond	One σ bond Two π bonds

How is the ratio of atoms calculated?

To calculate the ratio of atoms in a stable covalent compound:

1. Work out how many electrons are needed by each non-metal element to complete its outer electron shell.
2. Work out the ratio of atoms that will provide enough shared electrons to fill all the outer shells.

EXAMPLE:

How do carbon and hydrogen atoms form covalent bonds in a molecule of methane?

element	C	H
electron configuration		
electrons needed		
ratio of atoms		

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Homework **Assignment #4 Hebden pg. 177 #68-71, 72acegik**
all assignments are to be completed on a separate page with the assignment number & heading

EXERCISE:

68. Which of the following atom pairs would you expect to form covalent bonds when they join?
    (a) S and O (b) Ba and O (c) Fe and Cl (d) N and O (e) H and S (f) C and H

69. (a) When the distance between two covalently–bonded atoms increases, what happens to the electrostatic attraction of their nuclei to the shared electrons in a covalent bond?
    (b) What would you expect to happen to the strength of the covalent bond between two identical halogen atoms when going down the halogen family from F_2 to I_2?

70. What would you expect to happen to the strength of a covalent bond when the number of shared electrons increases?

71. The distance between the nuclei of two atoms involved in a bond is called the **BOND LENGTH.** What should happen to the bond length as the number of shared electrons in the bond increases? Why will this happen?

72. Predict the formula of the compound formed by bonding together the following.
    (a) P and Cl (b) B and O (c) C and S (d) P and O (e) H and Se (f) F and O (g) H and O (h) N and I (i) B and C (j) C and Cl (k) Si and P (l) Si and S