Drawing Lewis Structures

A Tutorial on Writing Lewis Dot Structure

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Lewis Structure by Bond Determination

1. **Know how to determine the valence electron for all elements.**
2. **(Connectivity) From the Chemical Formula, determine the atom connectivity for the structure.**
   i. Given a chemical formula, AB_n, A is the central atom and B flanks the A atom. i.e., NH_3, NCl_3, NO_2. In these examples, N is central in the structure.
   ii. H and F are never central atoms.
2. **(# of Bond) Determine the number of bonds in the compound, by calculating the theoretical Octet electrons (Oe) minus the total valence electrons (TVe). O-e is the theoretical number of electrons necessary for each atom in the structure to obtain a Noble Gas electron configuration, while TVe is the actual number of total valence electron for each atom in the structure.**
3. **(Remaining e-) Calculate the number of remaining electrons in the compound by taking the total valence electron (TVe) minus the number of electrons that was used to form bonds.**

Complete Lewis structure by drawing atomic connectivity. Write bonds in the structure and the place remaining electrons to selected atoms in the structure to give each atom an octet. Keep in mind that the H-atom is satisfied with 2 electrons.

Valence electrons for Elements

Recall how to determine the valence electron for the elements based on the elements position on the periodic table.

Lewis Dot Symbol

IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
H ·							
Li ·	·Be·	·B·	·C·	:N·	:O·	:F·	:Ne:
Na·	·Mg·	·Al·	·Si·	:P·	:S·	:Cl·	:Ar:
K ·	·Ca·						

Valence electrons and number of bonds

Recall the number of bonds at atom prefers depending on the number of valence electrons

Family	→	# Covalent Bonds*
Halogens F, Br, Cl, I	:X·	→ 1 bond often
Calcogens O, S	·O·	→ 2 bond often
Nitrogen N, P	·N·	→ 3 bond often
Carbon C, Si	·C·	→ 4 bond always

In general, these are the number of bonds formed by these atoms.

Lewis Structure, Octet Rule Guidelines

When compounds are formed they tend to follow the Octet Rule.

Octet Rule: Atoms will share e^- until it is surrounded by eight valence electrons.

Rules of the game-

i) O.R. works mostly for second period elements.

Many exceptions especially with 3rd period elements (d-orbitals)

ii) H prefers 2 e^- (electron deficient)

iii)

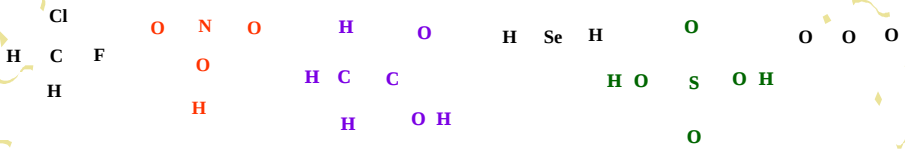
:C:	·N:	:O:	:F:	
4 u.p	3u.p	2u.p.	1u.p.	up = unpaired e-
4 bonds	3 bonds	2 bonds	1 bond	
O=C=O	N≡ N	O = O	F - F	

iv) H & F are terminal in the structural formula (Never central)

Atomic Connectivity

The atomic arrangement for a molecule is usually given.

CH_2ClF HNO_3 CH_3COOH H_2Se H_2SO_4 O_3



In general when there is a single central atom in the molecule, CH_2ClF, $SeCl_2$, O_3 (CO_2, NH_3, PO_4^{3-}), the central atom is the first atom in the chemical formula.

Except when the first atom in the chemical formula is Hydrogen (H) or fluorine (F). In which case the central atom is the second atom in the chemical formula.

Find the central atom for the following:

1) H_2O	a) H	b) O	2) PCl_3	a) P	b) Cl
3) SO_3	a) S	b) O	4) CO_3^{2-}	a) C	b) O
5) BeH_2	a) Be	b) H	6) IO^{3-}	a) I	b) O

Setting up Bond Table

Setting up the bond table requires the chemical formula, and determining the number of electrons around each atom.

A) Chemical Formula I.e., **HNO_3**

B) Oe - Octet Electrons (This is always either 8 (or 2 for H)

C) Tve - Total Valence Electron.

ChemFormula **HNO_3**	Octet e- **Oe**	Tot Val e- **Tve**
H	**1 x 2 = 2**	**1 x 1 = 1**
N	**1 x 8 = 8**	**1 x 5 = 5**
O	**3 x 8 = 24**	**3 x 6 = 18**
	34	**24**

Note this receipt works only if the chemical specie obeys the octet rule. For chemical specie which violates the octet rule, this method must be modified.

Calculating the Number of Bonds and the Remaining electrons

After setting up the bond table, calculate the **number of bonds** in the chemical specie and the number of electrons.

The **remaining electrons** are place around the atoms in the chemical specie such that each atom obeys the octet rule

HNO_3	**Oe**		**Tve**		**# Bonding e⁻**
Bond Table	**34**	-	**24**	=	**10**
# of Bonds				10 / 2 =	**5**
Remaining e⁻	Tve(24) - electrons in Bond (10) = **14**				

Putting it Together

1) Chemical formula: HNO_3

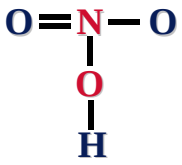
2) Atomic sequence:

O N O
O
H

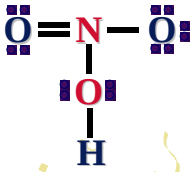
3) Number of bonds = 5

4) Remaining electrons = 14

5) Lewis Structure with 5 bonds:



6) Complete Lewis Structure with **14** remaining electrons



Lewis Dot Structure of CO_2 by Bonds Table

A. Calculate Octet electrons (Oe-) and Total Valence electrons to determine number of bonds

CO_2	Oe	TVe
1 C	1•(8)= 8	1•(4) = 4
2 O	2•(8)=16	2•(6)=12
Chg		
	24	16

B. Calculate the number of bonds in compound structure.

$$\text{\# bonds} = \frac{(Oe - TVe)}{2}$$

$$= \frac{(24 - 16)}{2} = \frac{8}{2} = 4 \text{ bonds}$$

C. Calculate the remaining electrons to add to structure to complete Lewis dot structure.

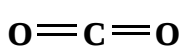
Remaining e- = TVe - e- used in bonding.
= 16 - 8 = 8 e- Remaining

Writing Lewis Structure:

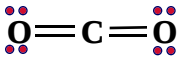
First determine atom connectivity keeping in mind that H and F can never be central atoms. Generally when given the formula, ABn, A is the central atom in the structure (but not always), and B atoms flank the central atom. Next use information from the above calculations. Total of 16e- in CO_2, of which 8 electrons are used to form 4 bonds and 8 remaining electrons are used to complete Lewis structure.

O C O

1,2. Write atom connectivity for CO_2.



3,4,5. Draw the four bonds in the structure.



6. Place the remaining 8 electrons in the structure to complete the Lewis Structure

Lewis Dot Structure of ClO_4^- by Bonds Table

A. Calculate (Oe-) and (TVe)

ClO_4^-	Oe	TVe
1 Cl	1•(8)= 8	1•(7) = 7
4 O	4•(8)= 32	4•(6)= 24
Chg		1
	40	32

B. Number of Bonds.

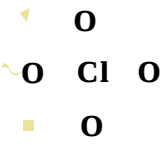
bonds = $\frac{(40-32)}{2} = \frac{8}{2}$ = **4 bonds**

C. Remaining electrons.

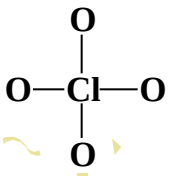
Remaining e- = 32 - 8 = **24 e- Remaining**

Writing Lewis Structure:

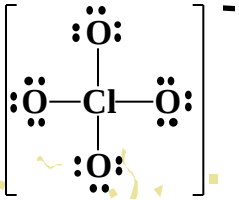
1,2. Write atom connectivity for ClO_4^-



3.4.5. Draw the four bonds in the structure.



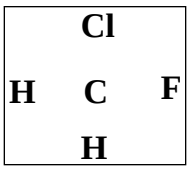
6. Place the remaining 24 electrons in the structure such that each atom has an octet to complete the Lewis Structure



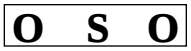
Lewis Structures: Examples

Example

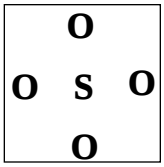
a) CH_2ClF



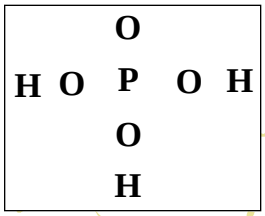
b) SO_2



c) SO_4^{2-}



d) H_3PO_4



Summary

Lewis Structure Determination:

- Molecular Formula
- Atomic Sequence (H and F are terminal)
- Determine the # of bonds

  Oe^- and TVe^-

  # of Bonds = $(Oe - TVe^-) / 2$
- Determine remaining electrons

  Re = (TVe^-) - (# e^- in bonding)
- Make sure all atoms satisfy octet rule (Except H which is satisfied with 2 electrons)