

Lewis Structures: Exceptions

DR. MIOY T. HUYNH
YALE UNIVERSITY
CHEMISTRY 161
FALL 2019

www.mioy.org/chem161

LEWIS STRUCTURES “RULES”

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. Fulfill octet rule for each atom (8 electrons around each) by adding lone pairs (sets of 2 electrons).
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equals total number of valence electrons, then done.
7. Assign formal charges (FC) on *each* atom.

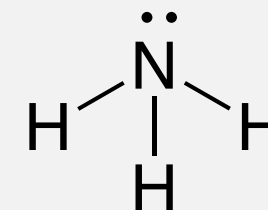
Guided Example

Ammonia (NH₃)

Atom	Valence
N	5 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	8 e⁻

$$\text{FC (N)} = (5 \text{ e}^-) - (3 \text{ bonds}) - (2 \text{ lone e}^-) = 0$$

$$\text{FC (H)} = (1 \text{ e}^-) - (1 \text{ bonds}) - (0 \text{ lone e}^-) = 0$$



*Make sure
sum of FC
equal total
charge.*

$$\text{FC} = (\text{valence e}^-) - (\# \text{ bonds}) - (\# \text{ lone e}^-)$$

LEWIS STRUCTURES “RULES”

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. Fulfill octet rule for each atom (8 electrons around each) by adding lone pairs (sets of 2 electrons).
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equals total number of valence electrons, then done.
7. Assign formal charges (FC) on *each* atom.

THIS DOESN'T ALWAYS WORK THOUGH!

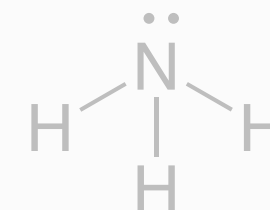
Guided ExampleAmmonia (NH₃)

Atom	Valence
N	5 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	8 e⁻

N 5 e⁻**PERFECTLY**H 1 e⁻H 1 e⁻Total 8 e⁻

$$\text{FC (N)} = (5 \text{ e}^-) - (3 \text{ bonds}) - (2 \text{ lone e}^-) = 0$$

$$\text{FC (H)} = (1 \text{ e}^-) - (1 \text{ bonds}) - (0 \text{ lone e}^-) = 0$$



Make sure
sum of FC
equal total
charge.

$$\text{FC} = (\text{valence e}^-) - (\# \text{ bonds}) - (\# \text{ lone e}^-)$$

EXCEPTION 1: LESS THAN OCTET (B & Be)

Guided Example

Boron Trihydride (BH₃)

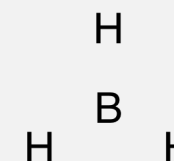
EXCEPTION 1: LESS THAN OCTET (B & Be)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.

Guided Example

Boron Trihydride (BH₃)

<u>Atom</u>	<u>Valence</u>
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻



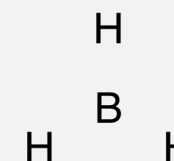
EXCEPTION 1: LESS THAN OCTET (B & Be)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻



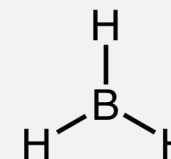
EXCEPTION 1: LESS THAN OCTET (B & Be)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).

Guided Example

Boron Trihydride (BH₃)

<u>Atom</u>	<u>Valence</u>
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻



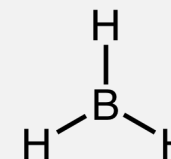
EXCEPTION 1: LESS THAN OCTET (B & Be)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **B only needs 6 electrons instead of an octet.**

Guided Example

Boron Trihydride (BH₃)

<u>Atom</u>	<u>Valence</u>
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻



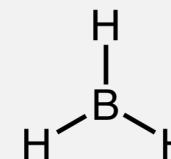
EXCEPTION 1: LESS THAN OCTET (B & Be)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **B only needs 6 electrons instead of an octet.**
5. Count electrons in Lewis structure.

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻



Electrons in Lewis structure = 6 e⁻

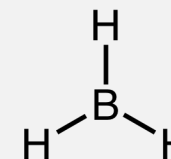
EXCEPTION 1: LESS THAN OCTET (B & Be)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **B only needs 6 electrons instead of an octet.**
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equal total number of valence electrons, then done.

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻



Electrons in Lewis structure = 6 e⁻

EXCEPTION 1: LESS THAN OCTET (B & Be)

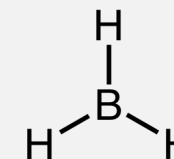
1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **B only needs 6 electrons instead of an octet.**
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equal total number of valence electrons, then done.
7. Assign formal charges (FC) on *each* atom.

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

$$\begin{aligned} \text{FC (B)} &= 0 \\ \text{FC (H)} &= 0 \end{aligned}$$



Electrons in Lewis structure = 6 e⁻

EXCEPTION 1: LESS THAN OCTET (B & Be)

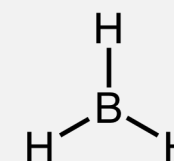
1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.

Guided ExampleBoron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

$$\text{FC (B)} = 0$$

$$\text{FC (H)} = 0$$



Electrons in Lewis structure = 6 e⁻

Beryllium Fluoride (BeF₂)

EXCEPTION 1: LESS THAN OCTET (B & Be)

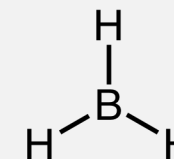
- The total number of electrons in the Lewis structure must equal the total number of valence electrons.

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

$$\begin{aligned} \text{FC (B)} &= 0 \\ \text{FC (H)} &= 0 \end{aligned}$$



Electrons in Lewis structure = 6 e⁻

Beryllium Fluoride (BeF₂)

Atom	Valence
Be	2 e ⁻
F	7 e ⁻
F	7 e ⁻
Total	16 e⁻

EXCEPTION 1: LESS THAN OCTET (B & Be)

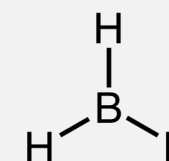
1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

$$\begin{aligned} \text{FC (B)} &= 0 \\ \text{FC (H)} &= 0 \end{aligned}$$



Electrons in Lewis structure = 6 e⁻

Beryllium Fluoride (BeF₂)

Atom	Valence
Be	2 e ⁻
F	7 e ⁻
F	7 e ⁻
Total	16 e⁻



EXCEPTION 1: LESS THAN OCTET (B & Be)

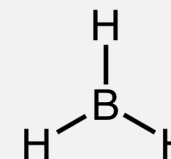
1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

$$\begin{aligned} \text{FC (B)} &= 0 \\ \text{FC (H)} &= 0 \end{aligned}$$



Electrons in Lewis structure = 6 e⁻

Beryllium Fluoride (BeF₂)

Atom	Valence
Be	2 e ⁻
F	7 e ⁻
F	7 e ⁻
Total	16 e⁻



EXCEPTION 1: LESS THAN OCTET (B & Be)

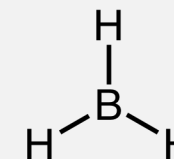
1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **B only needs 6 electrons instead of an octet.**
Be only needs 4 electrons instead of an octet.

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

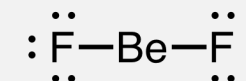
$$\begin{aligned} \text{FC (B)} &= 0 \\ \text{FC (H)} &= 0 \end{aligned}$$



Electrons in Lewis structure = 6 e⁻

Beryllium Fluoride (BeF₂)

Atom	Valence
Be	2 e ⁻
F	7 e ⁻
F	7 e ⁻
Total	16 e⁻



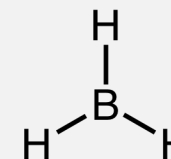
EXCEPTION 1: LESS THAN OCTET (B & Be)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **B only needs 6 electrons instead of an octet.**
Be only needs 4 electrons instead of an octet.
5. Count electrons in Lewis structure.

Guided ExampleBoron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

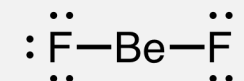
$$\begin{aligned} \text{FC (B)} &= 0 \\ \text{FC (H)} &= 0 \end{aligned}$$



Electrons in Lewis structure = 6 e⁻

Beryllium Fluoride (BeF₂)

Atom	Valence
Be	2 e ⁻
F	7 e ⁻
F	7 e ⁻
Total	16 e⁻



Electrons in Lewis structure = 16 e⁻

EXCEPTION 1: LESS THAN OCTET (B & Be)

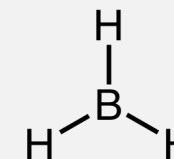
1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **B only needs 6 electrons instead of an octet.**
Be only needs 4 electrons instead of an octet.
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equal total number of valence electrons, then done.

Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

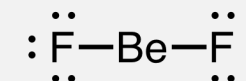
$$\begin{aligned} \text{FC (B)} &= 0 \\ \text{FC (H)} &= 0 \end{aligned}$$



Electrons in Lewis structure = 6 e⁻

Beryllium Fluoride (BeF₂)

Atom	Valence
Be	2 e ⁻
F	7 e ⁻
F	7 e ⁻
Total	16 e⁻



Electrons in Lewis structure = 16 e⁻

EXCEPTION 1: LESS THAN OCTET (B & Be)

- The total number of electrons in the Lewis structure must equal the total number of valence electrons.
- The *least* electronegative atom is usually the central atom (never Hydrogen though).
- Draw single bonds (“skeleton”).
- B only needs 6 electrons instead of an octet.**
Be only needs 4 electrons instead of an octet.
- Count electrons in Lewis structure.
- If electrons in Lewis structure equal total number of valence electrons, then done.
- Assign formal charges (FC) on *each* atom.

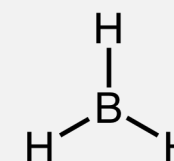
Guided Example

Boron Trihydride (BH₃)

Atom	Valence
B	3 e ⁻
H	1 e ⁻
H	1 e ⁻
H	1 e ⁻
Total	6 e⁻

$$\text{FC (B)} = 0$$

$$\text{FC (H)} = 0$$



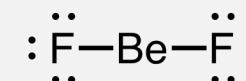
Electrons in Lewis structure = 6 e⁻

Beryllium Fluoride (BeF₂)

Atom	Valence
Be	2 e ⁻
F	7 e ⁻
F	7 e ⁻
Total	16 e⁻

$$\text{FC (Be)} = 0$$

$$\text{FC (F)} = 0$$



Electrons in Lewis structure = 16 e⁻

EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

Guided Example

Sulfur Tetrachloride (SCl_4)

EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.

Guided Example

Sulfur Tetrachloride (SCl_4)

<u>Atom</u>	<u>Valence</u>
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻

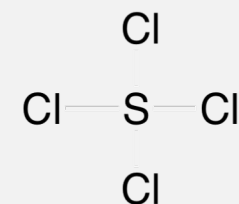
EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).

Guided Example

Sulfur Tetrachloride (SCl_4)

Atom	Valence
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻



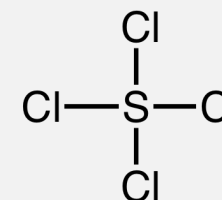
EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).

Guided Example

Sulfur Tetrachloride (SCl_4)

<u>Atom</u>	<u>Valence</u>
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻

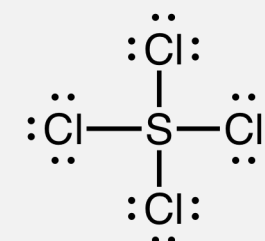


EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. Fulfill octet rule.

Guided ExampleSulfur Tetrachloride (SCl_4)

Atom	Valence
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻



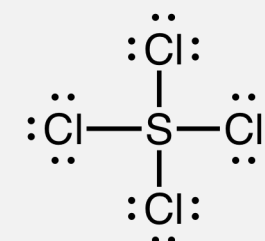
EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. Fulfill octet rule.
5. Count electrons in Lewis structure.

Guided Example

Sulfur Tetrachloride (SCl_4)

Atom	Valence
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻



Electrons in Lewis structure = 32 e⁻

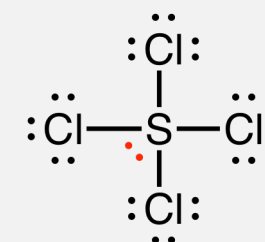
EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. Fulfill octet rule. If central atom is in third row or below ($n \geq 3$), it can have more than 8 electrons.
5. Count electrons in Lewis structure.

Guided Example

Sulfur Tetrachloride (SCl_4)

Atom	Valence
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻

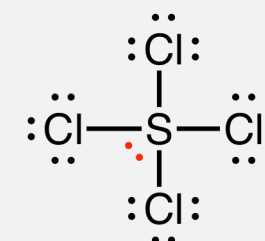


EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. Fulfill octet rule. If central atom is in third row or below ($n \geq 3$), it can have more than 8 electrons.
5. Count electrons in Lewis structure.

Guided ExampleSulfur Tetrachloride (SCl_4)

Atom	Valence
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻



Electrons in Lewis structure = 34 e⁻

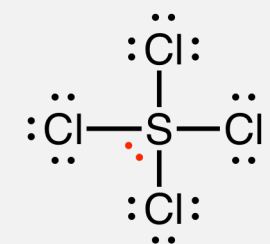
EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **Fulfill octet rule. If central atom is in third row or below ($n \geq 3$), it can have more than 8 electrons.**
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equal total number of valence electrons, then done.

Guided Example

Sulfur Tetrachloride (SCl_4)

Atom	Valence
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻



Electrons in Lewis structure = 34 e⁻

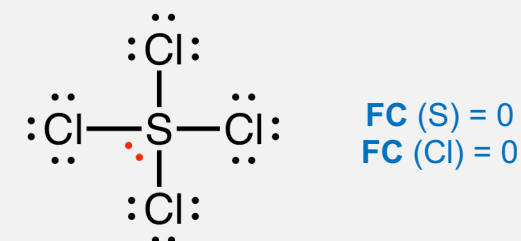
EXCEPTION 2: MORE THAN OCTET ($n \geq 3$)

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **Fulfill octet rule. If central atom is in third row or below ($n \geq 3$), it can have more than 8 electrons.**
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equal total number of valence electrons, then done.
7. Assign formal charges (FC) on *each* atom.

Guided Example

Sulfur Tetrachloride (SCl_4)

Atom	Valence
S	6 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Cl	7 e ⁻
Total	34 e⁻



Electrons in Lewis structure = 34 e⁻

EXCEPTION 3: ODD ELECTRONS

1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. Fulfill the octet for most atoms.
Place odd electrons to minimize formal charges.
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equal total number of valence electrons, then done.
7. Assign formal charges (FC) on *each* atom.

Examples

Nitrogen Monoxide (NO)

Atom	Valence
N	5 e ⁻
O	6 e ⁻
Total	11 e⁻

EXCEPTION 3: ODD ELECTRONS

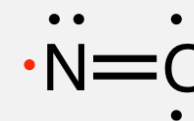
1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. Fulfill the octet for most atoms.
Place odd electrons to minimize formal charges.
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equal total number of valence electrons, then done.
7. Assign formal charges (FC) on *each* atom.

Examples

Nitrogen Monoxide (NO)

Atom	Valence
N	5 e ⁻
O	6 e ⁻
Total	11 e⁻

$$\begin{aligned} \text{FC (N)} &= 0 \\ \text{FC (O)} &= 0 \end{aligned}$$



Electrons in Lewis structure = 11 e⁻

EXCEPTION 3: ODD ELECTRONS

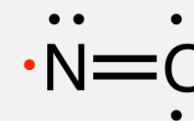
1. The total number of electrons in the Lewis structure must equal the total number of valence electrons.
2. The *least* electronegative atom is usually the central atom (never Hydrogen though).
3. Draw single bonds (“skeleton”).
4. **Fulfill the octet for most atoms.**
Place odd electrons to minimize formal charges.
5. Count electrons in Lewis structure.
6. If electrons in Lewis structure equal total number of valence electrons, then done.
7. Assign formal charges (FC) on *each* atom.

Examples

Nitrogen Monoxide (NO)

Atom	Valence
N	5 e ⁻
O	6 e ⁻
Total	11 e⁻

FC (N) = 0
FC (O) = 0



Electrons in Lewis structure = 11 e⁻

Sulfur Pentafluoride (SF₅)

Atom	Valence
S	6 e ⁻
5 × F	5 × 7 e ⁻
Total	41 e⁻

EXCEPTION 3: ODD ELECTRONS

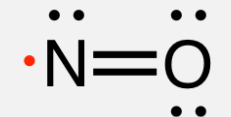
- The total number of electrons in the Lewis structure must equal the total number of valence electrons.
- The *least* electronegative atom is usually the central atom (never Hydrogen though).
- Draw single bonds (“skeleton”).
- Fulfill the octet for most atoms.**
Place odd electrons to minimize formal charges.
- Count electrons in Lewis structure.
- If electrons in Lewis structure equal total number of valence electrons, then done.
- Assign formal charges (FC) on *each* atom.

Examples

Nitrogen Monoxide (NO)

Atom	Valence
N	5 e ⁻
O	6 e ⁻
Total	11 e⁻

FC (N) = 0
FC (O) = 0

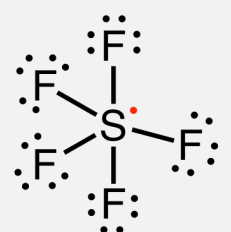


Electrons in Lewis structure = 11 e⁻

Sulfur Pentafluoride (SF₅)

Atom	Valence
S	6 e ⁻
5 × F	5 × 7 e ⁻
Total	41 e⁻

FC (S) = 0
FC (F) = 0



Electrons in Lewis structure = 41 e⁻