Lewis Structures

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YALE UNIVERSITY
CHEMISTRY 161
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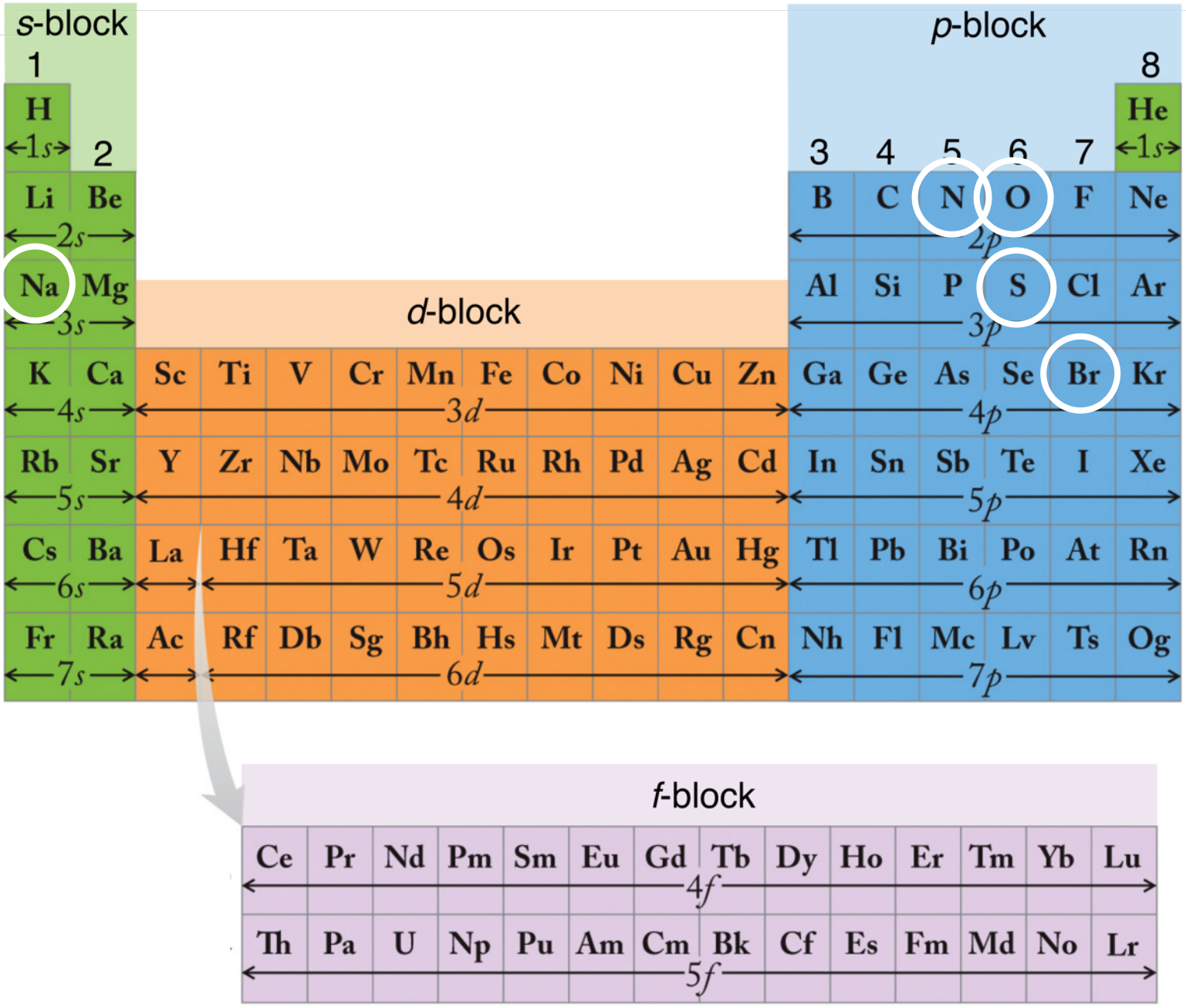


VALENCE ELECTRONS

Electrons in the highest-energy level or the outermost (largest n value) orbitals.

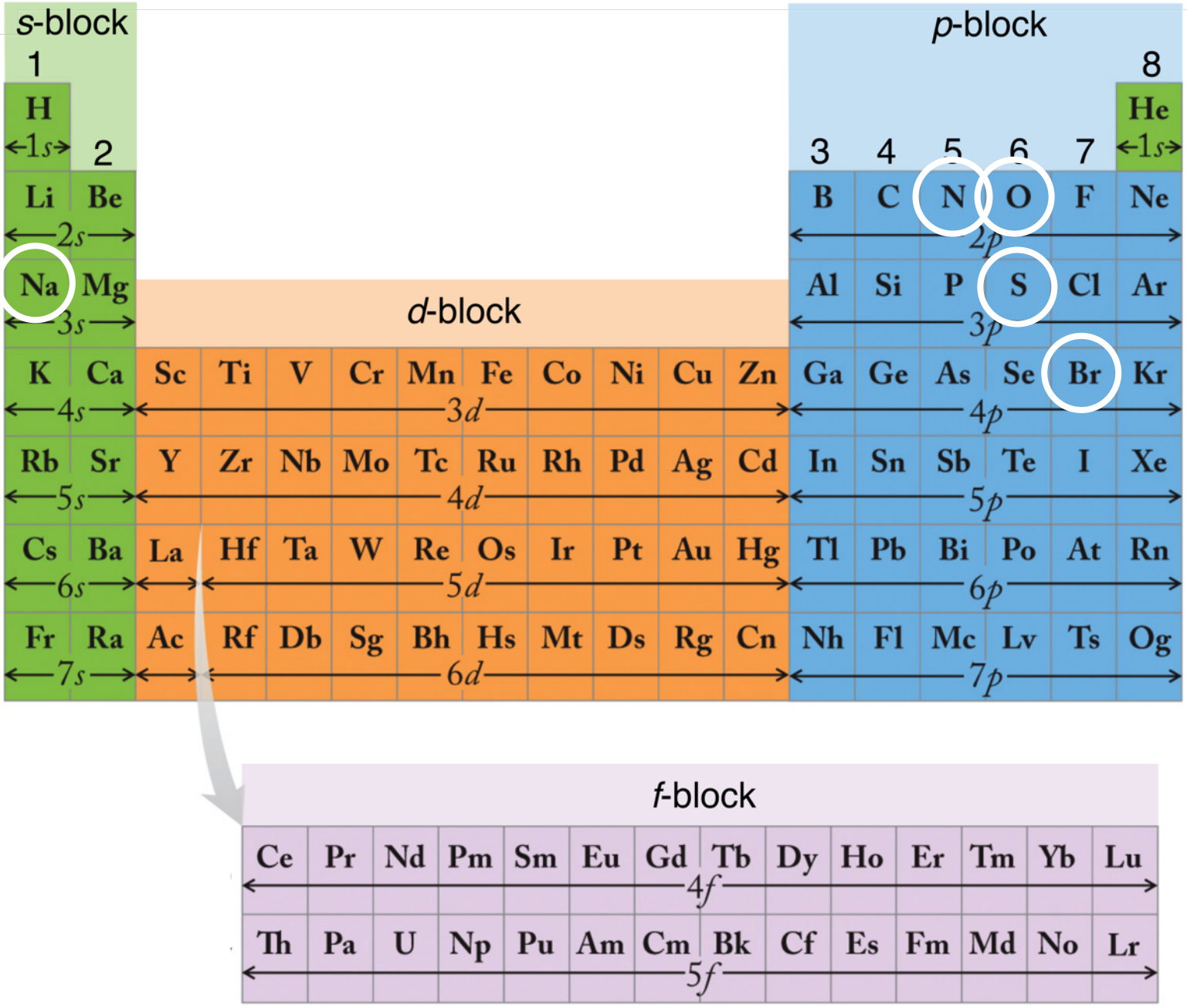
N: (7 electrons, $n = 2$)

O: (8 electrons, $n = 2$)

Na: (11 electrons, $n = 3$)

S: (16 electrons, $n = 3$)

Br^-: (36 electrons, $n = 4$)



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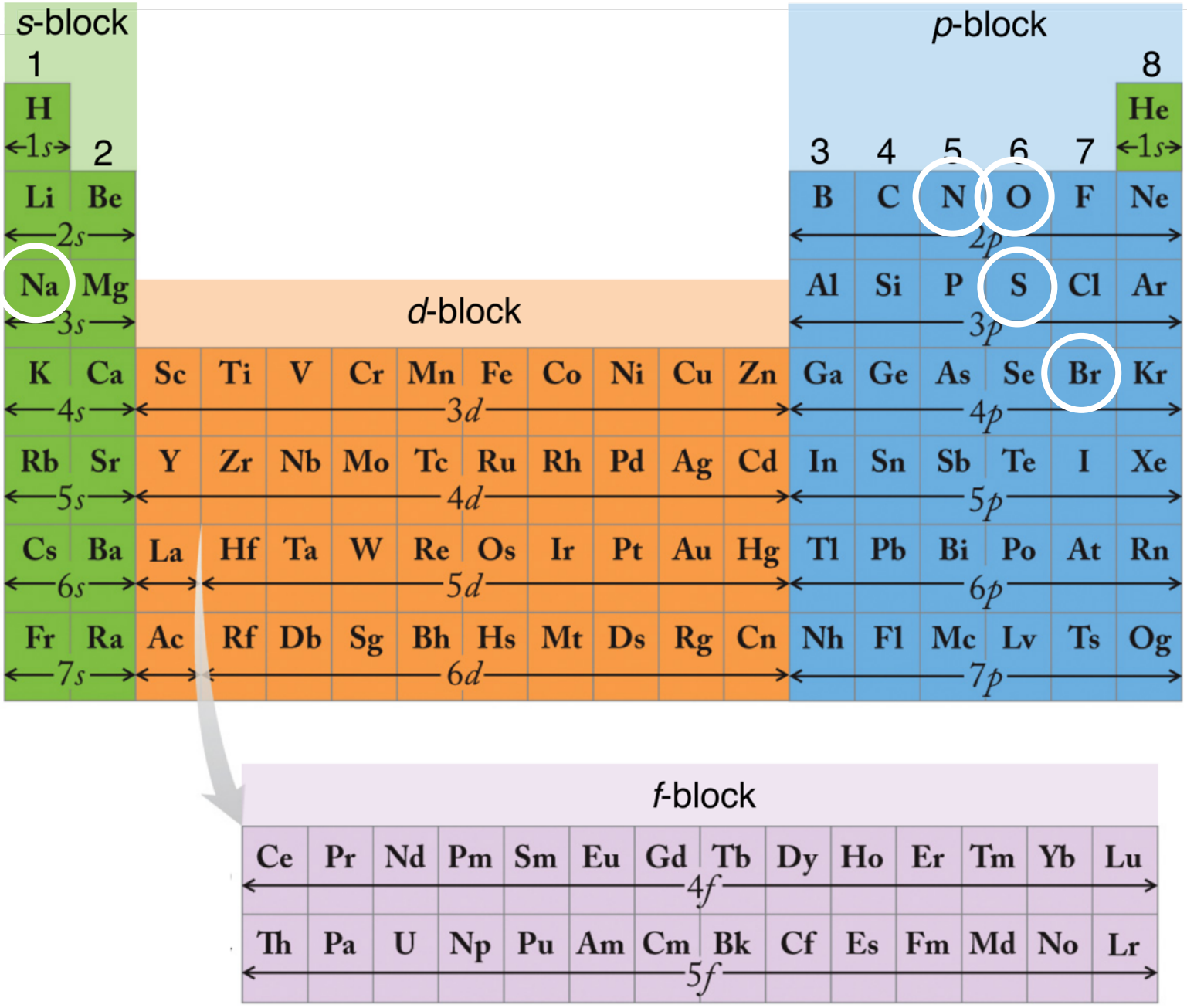

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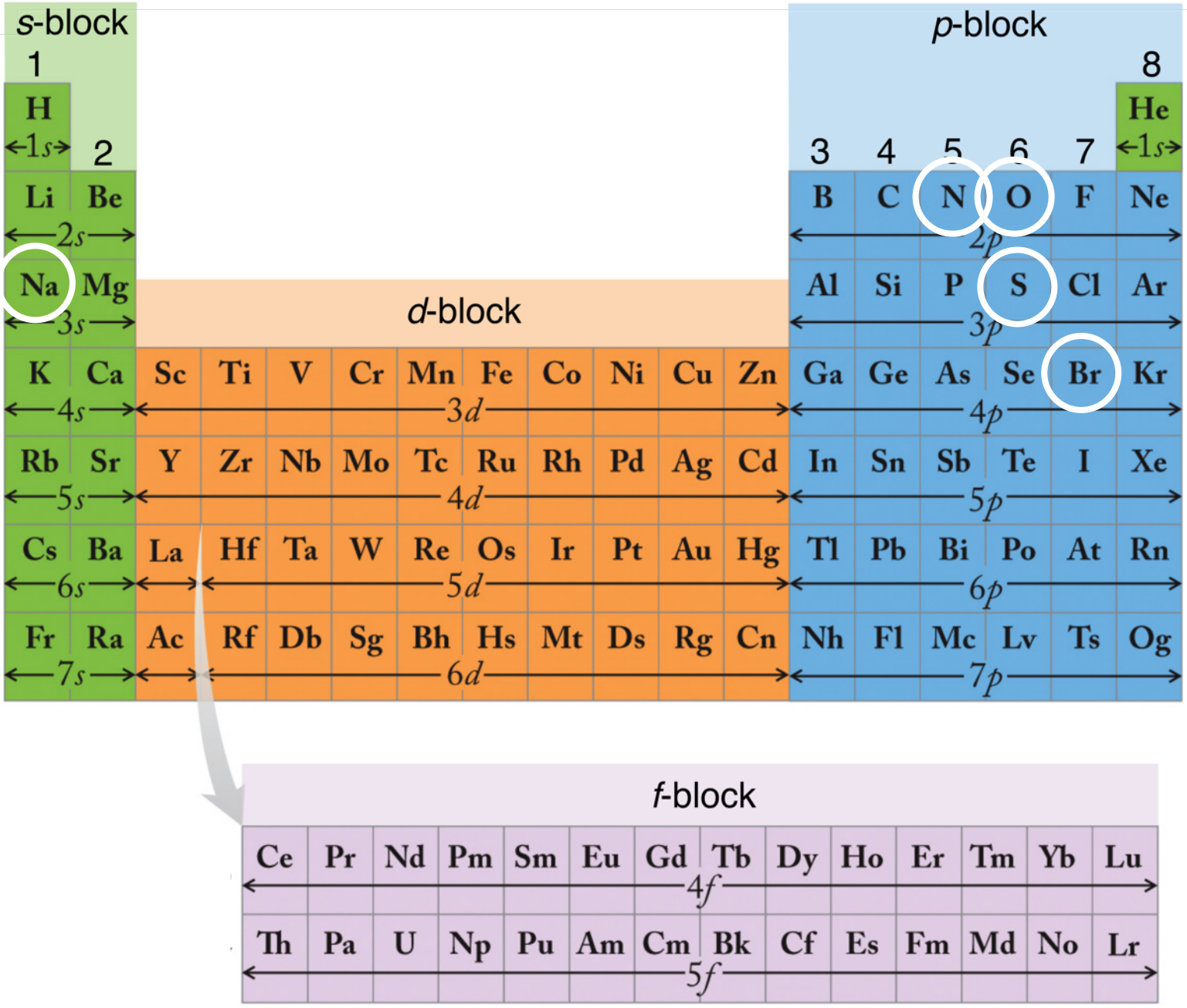

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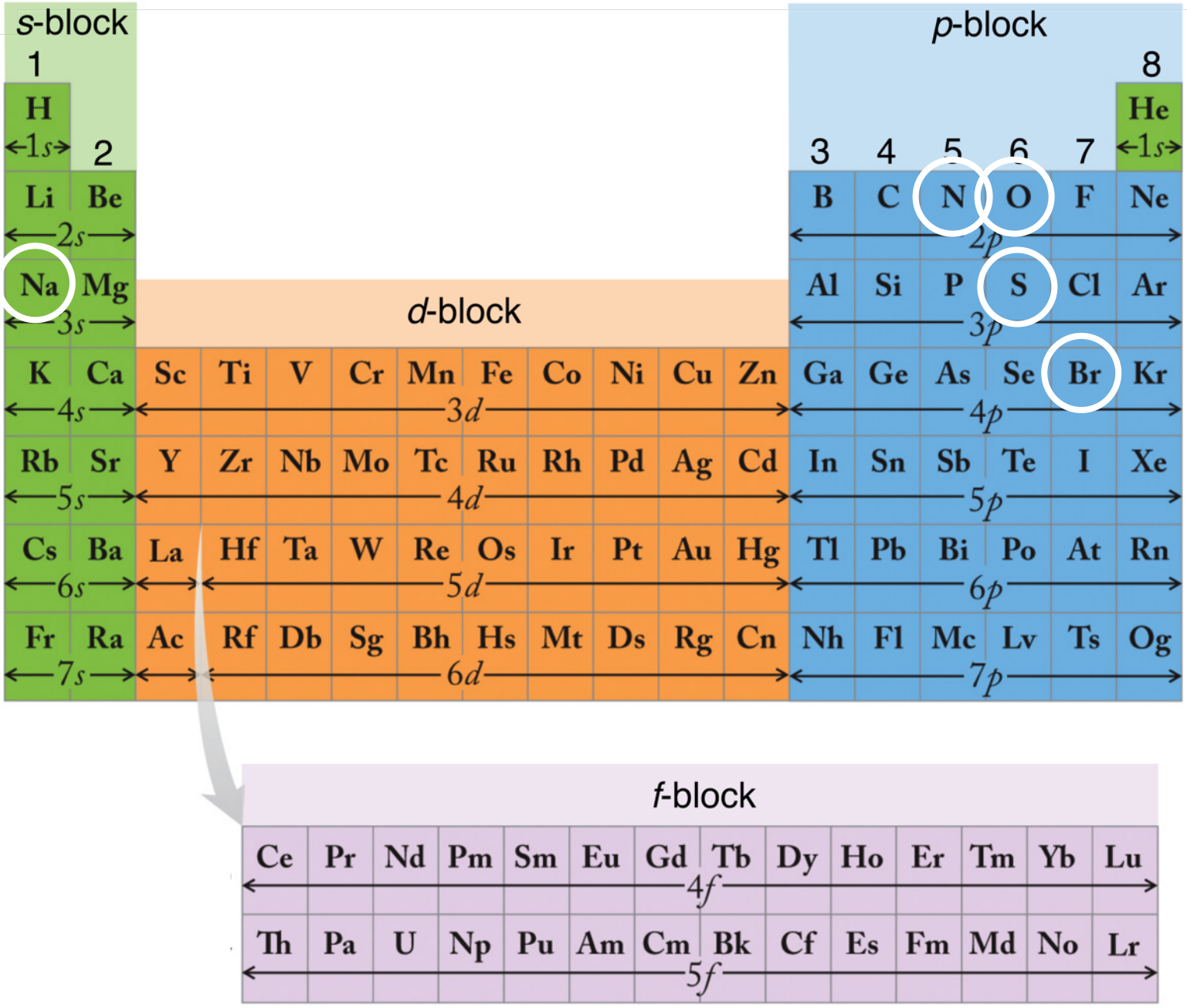

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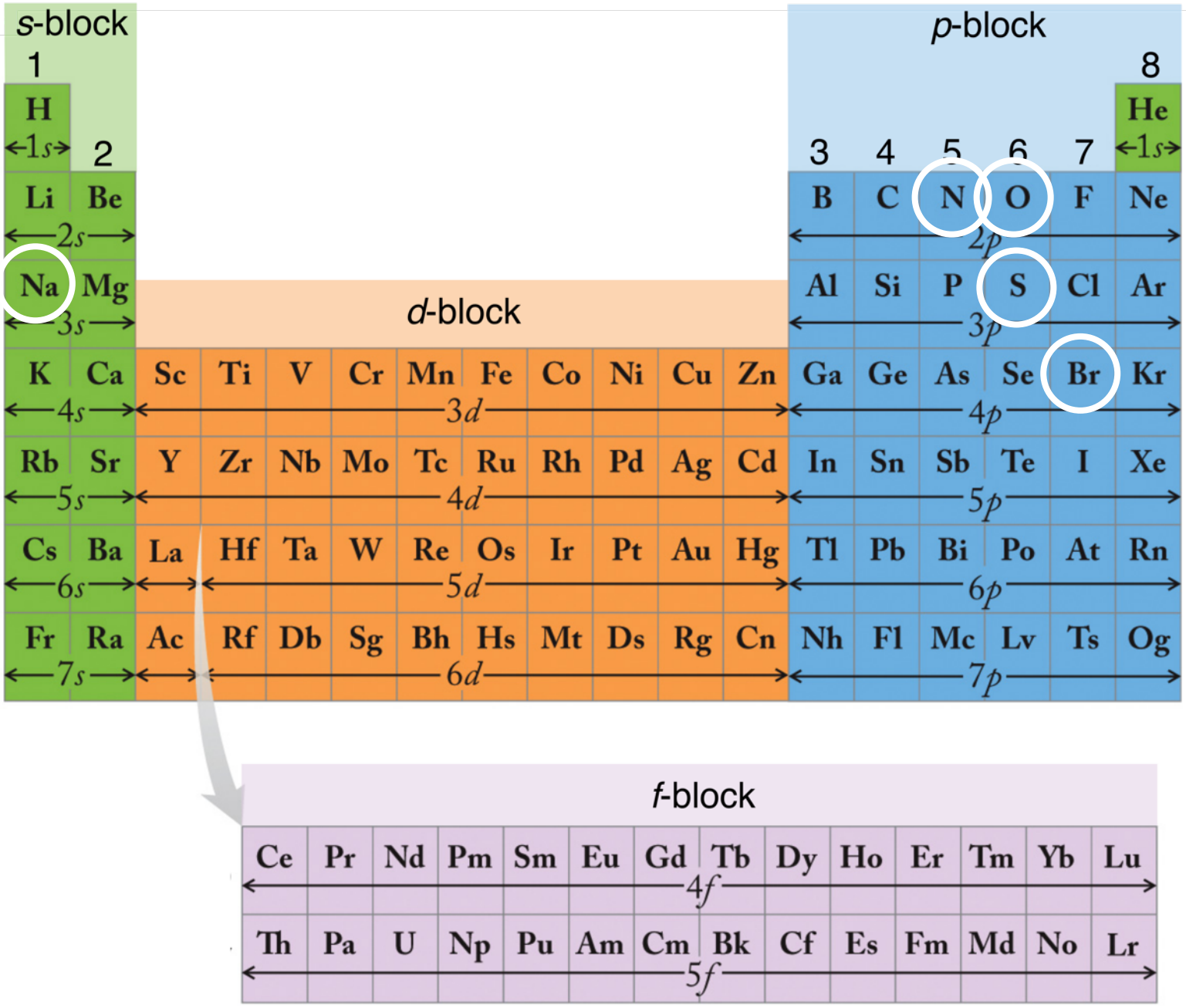

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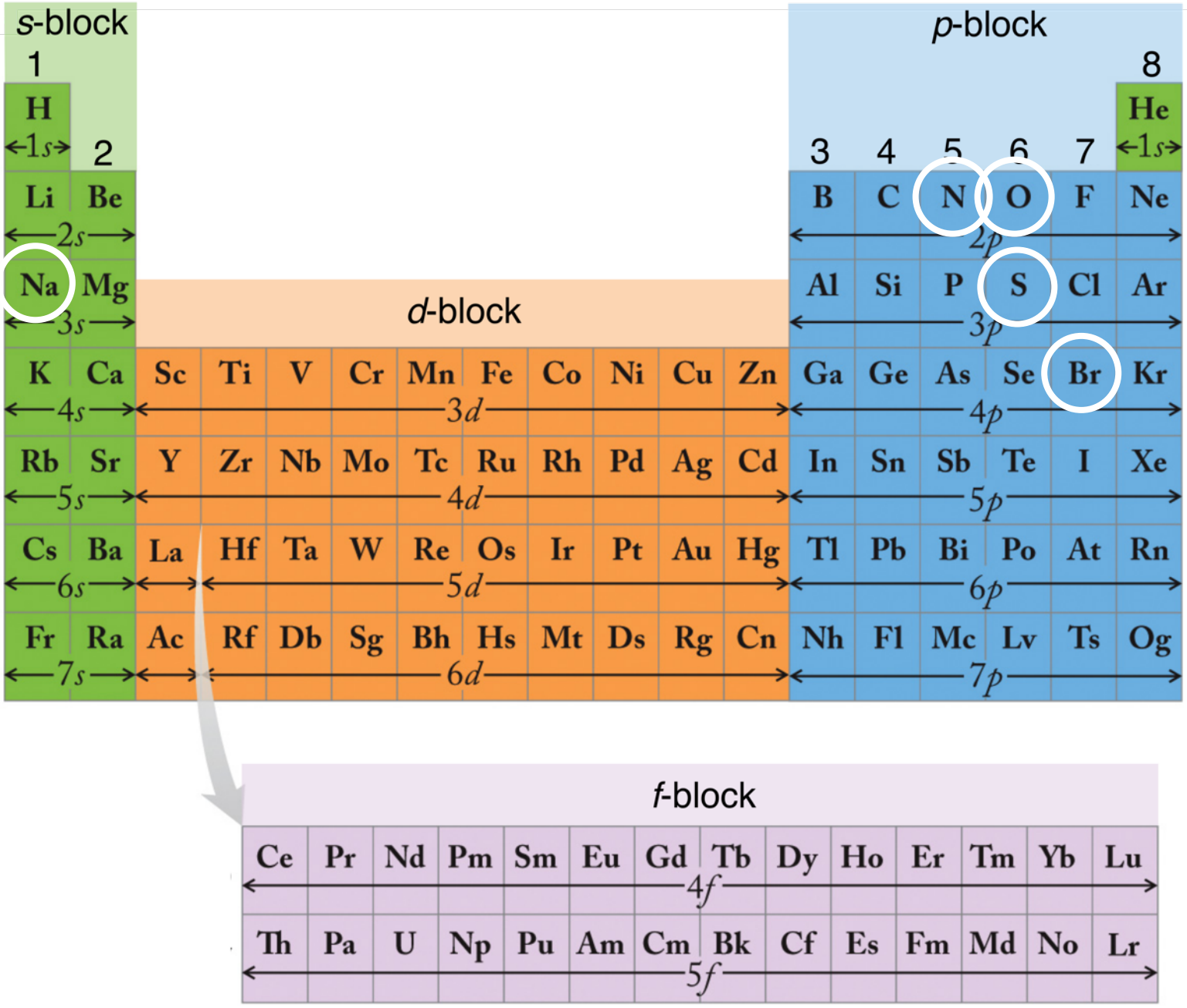

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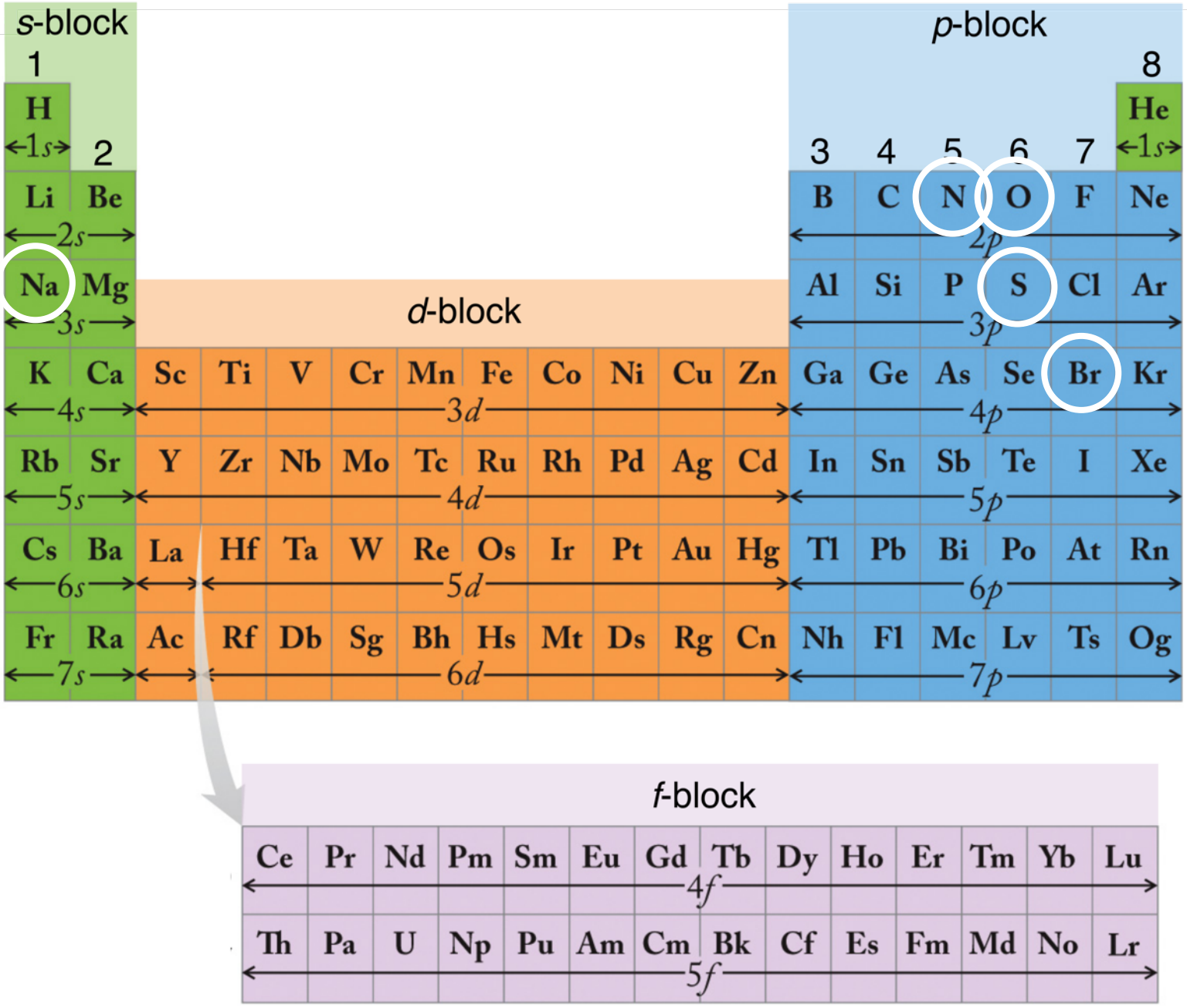

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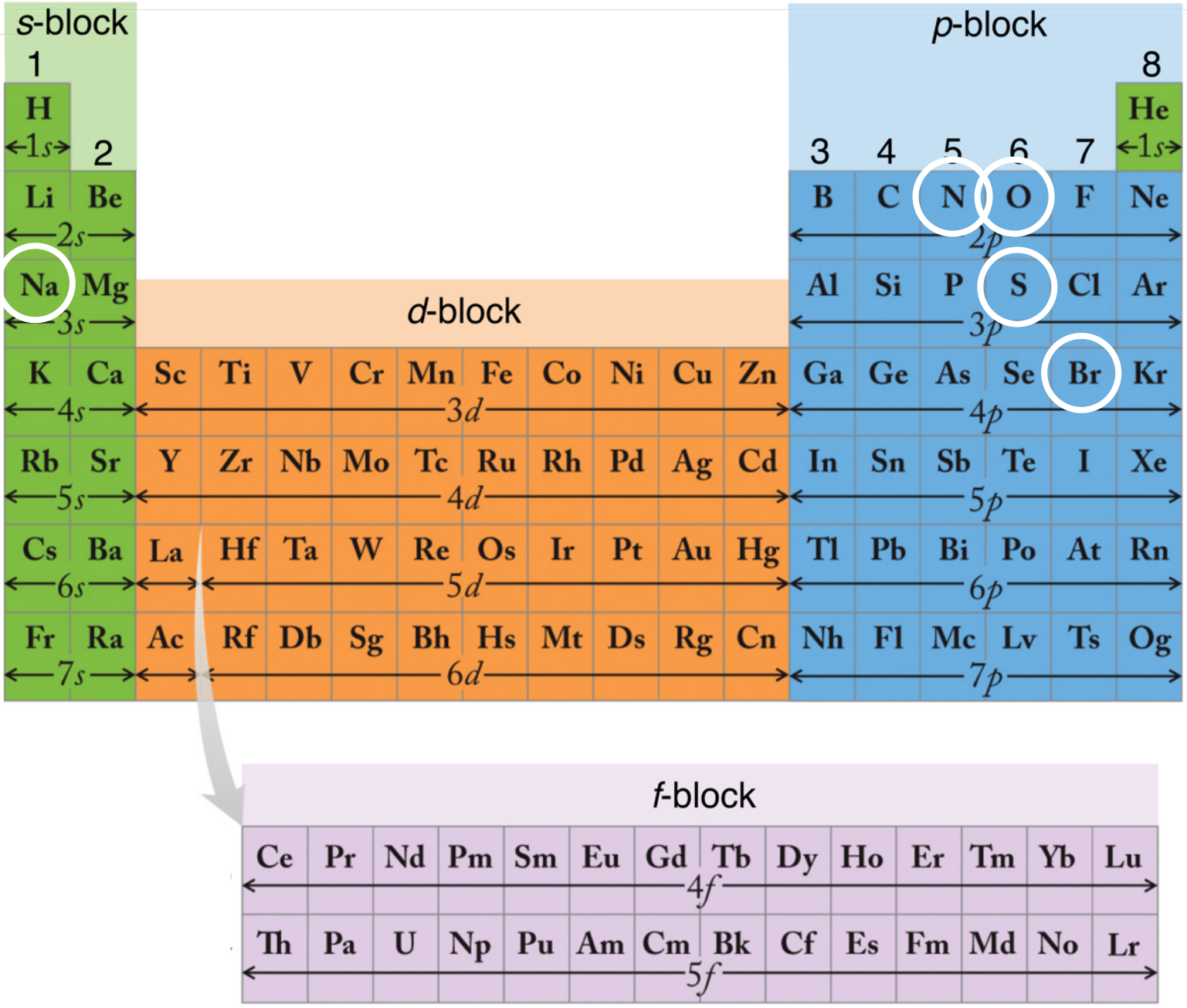

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→ 8 valence e^-

LEWIS STRUCTURES "RULES"

Guided Example

Ammonia (NH_3)

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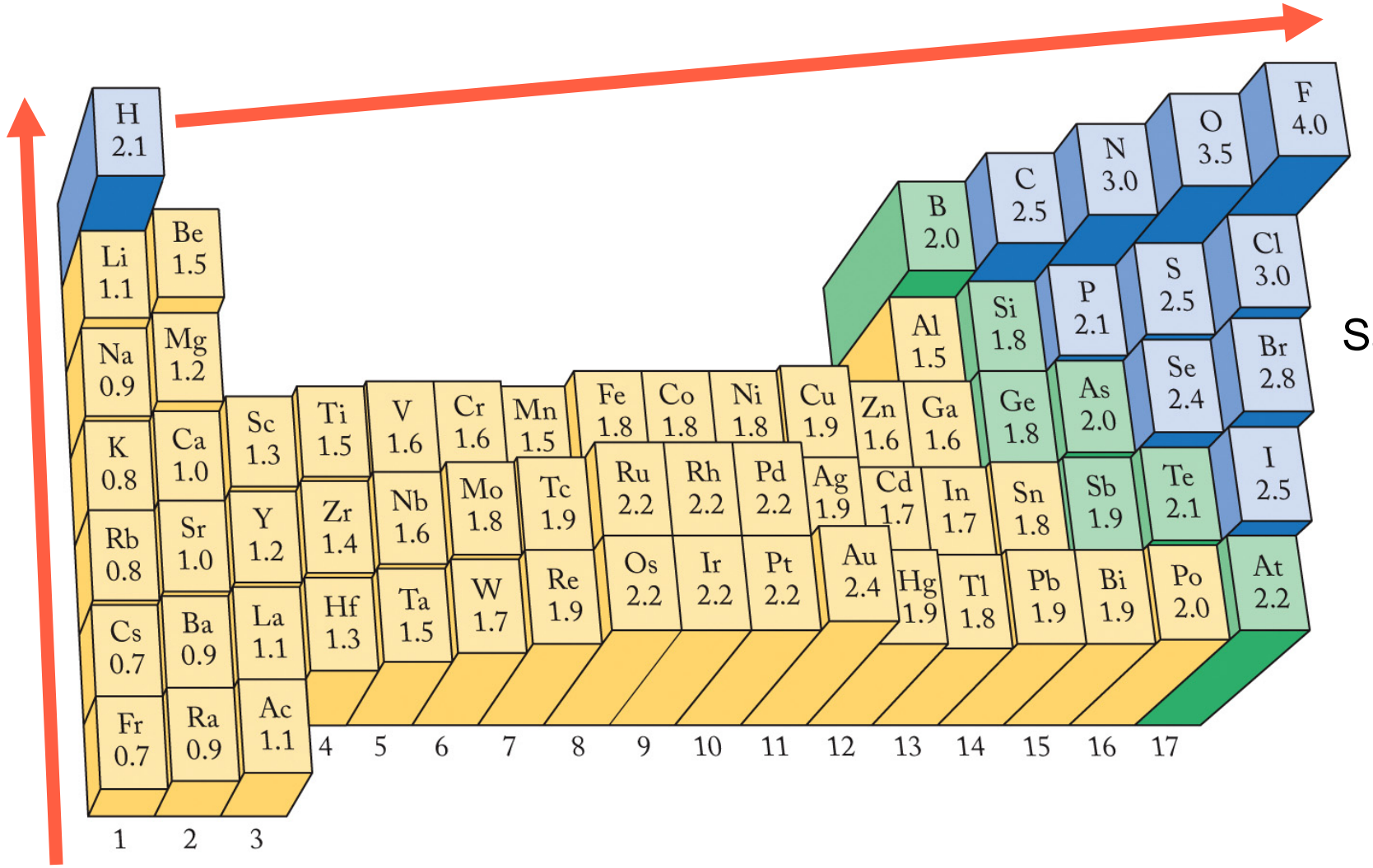
ELECTRONEGATIVITY

The ability for an atom to attract electrons to itself.



Same trend as ionization energy (IE)!

EN decreases down a column.
EN increases across a row.

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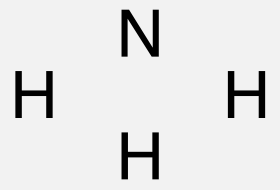

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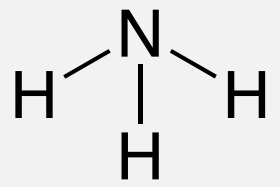

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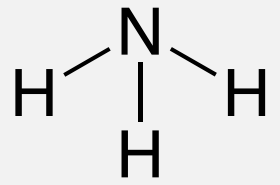

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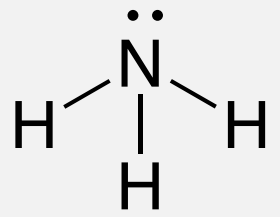

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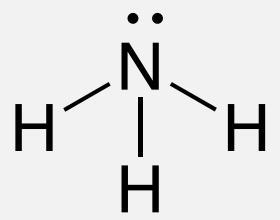

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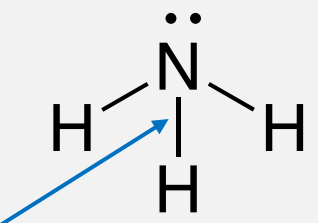

1 single bond = 2 e^-

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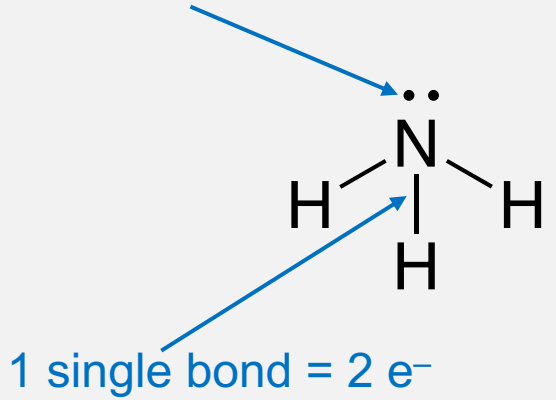

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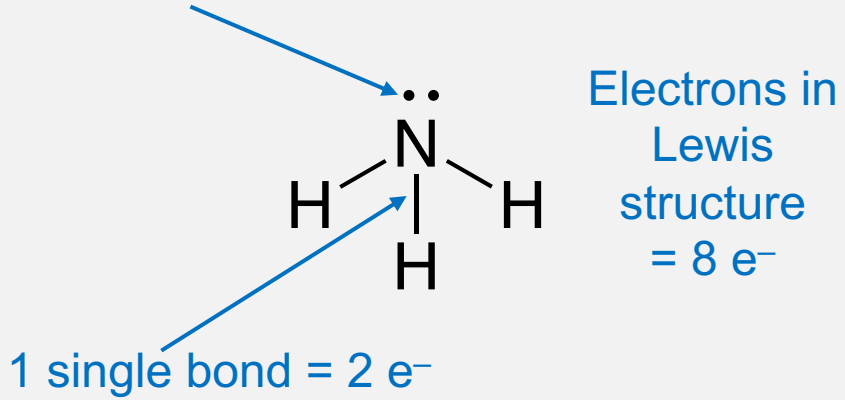

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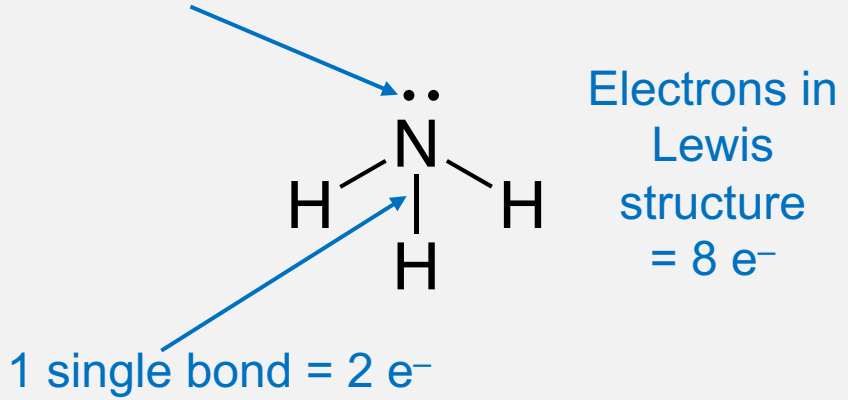

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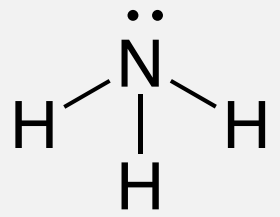

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FC = (valence e^-) – (# bonds) – (# lone e^-)

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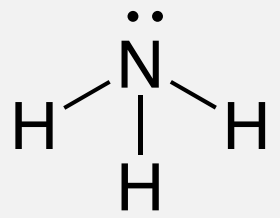
Total	**8 e^-**

FC (N) = (5 e^-) – (3 bonds) – (2 lone e^-) = 0
FC (H) = (1 e^-) – (1 bonds) – (0 lone e^-) = 0



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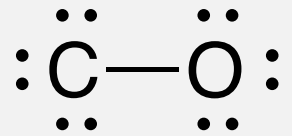

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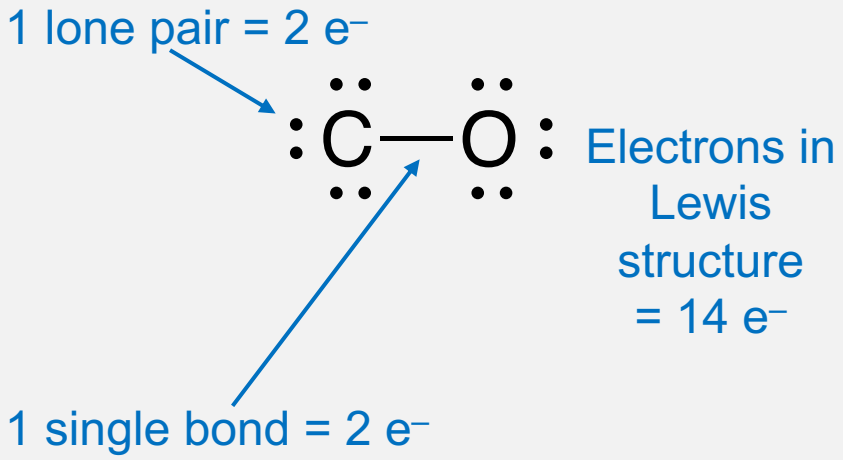

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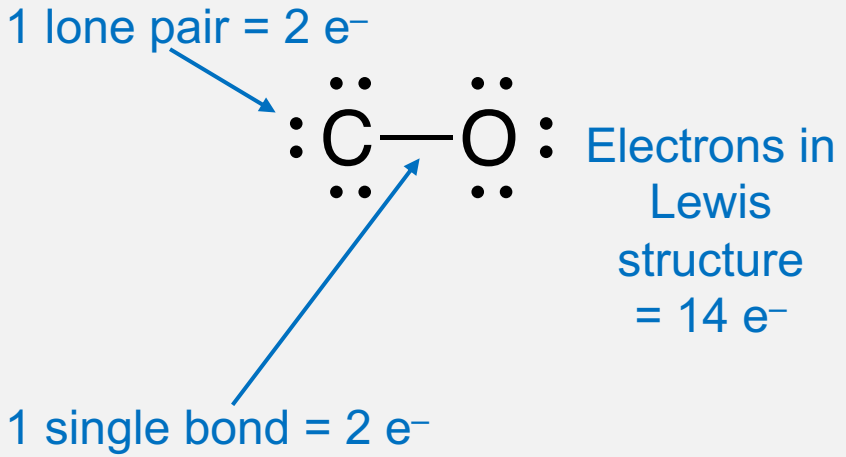

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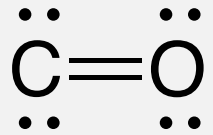
O	6 e^-
Total	**10 e^-**



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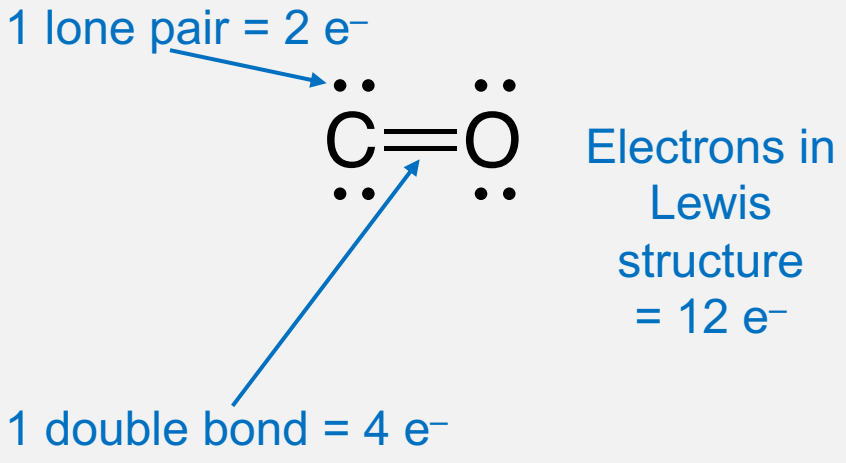

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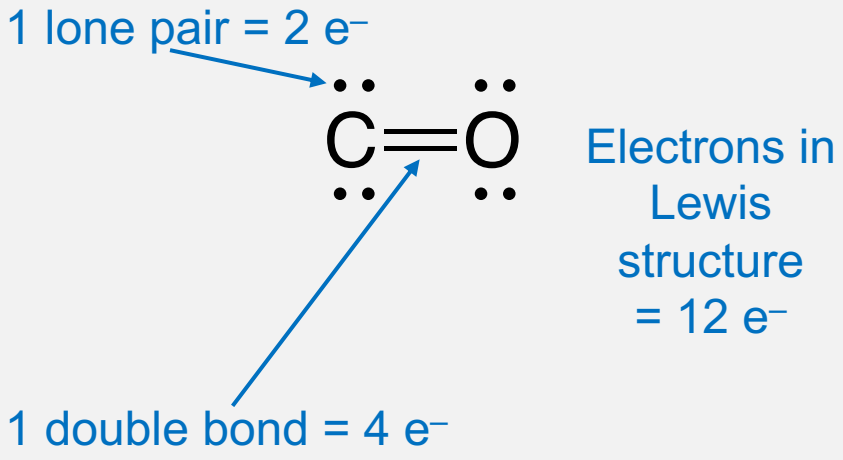

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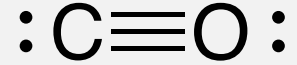

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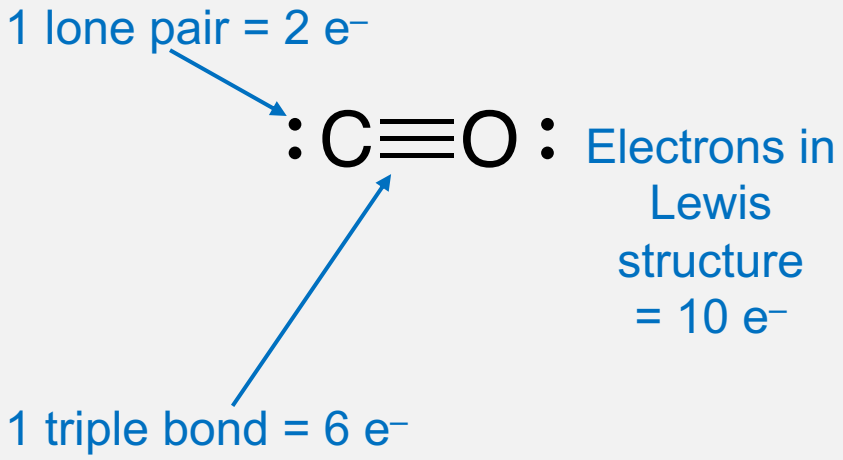

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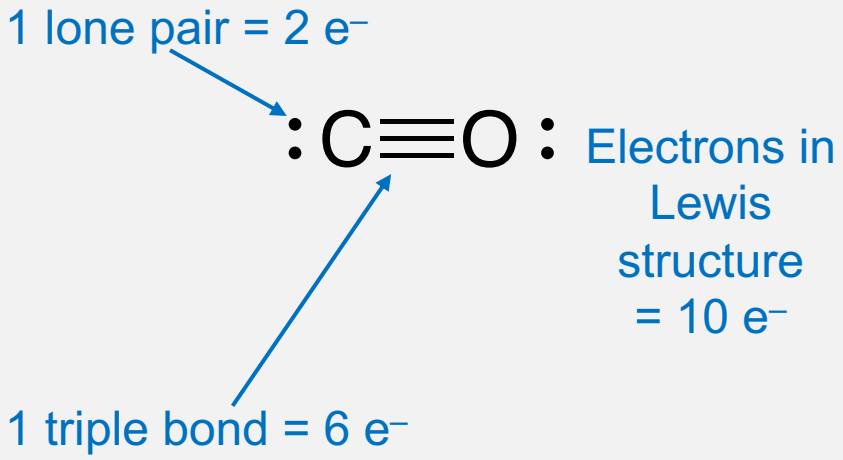

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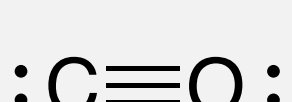

Make sure sum of FC equal total charge.

FC = (valence e^-) – (# bonds) – (# lone e^-)

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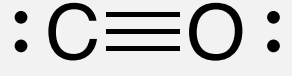
FC (C) = (4 e^-) – (3 bonds) – (2 lone e^-) = –1
FC (O) = (6 e^-) – (3 bonds) – (2 lone e^-) = +1



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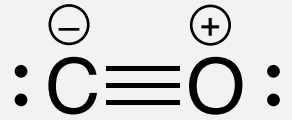

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Sulfur Dioxide (SO_2)

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O—S—O

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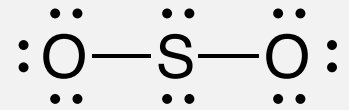

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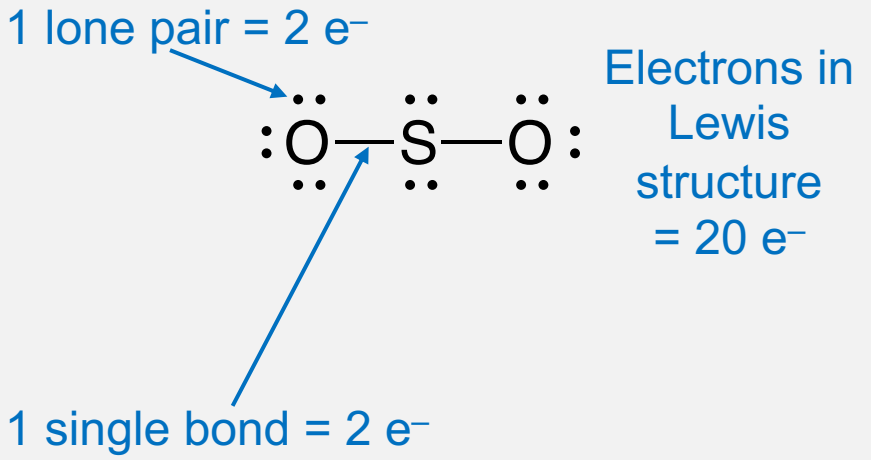

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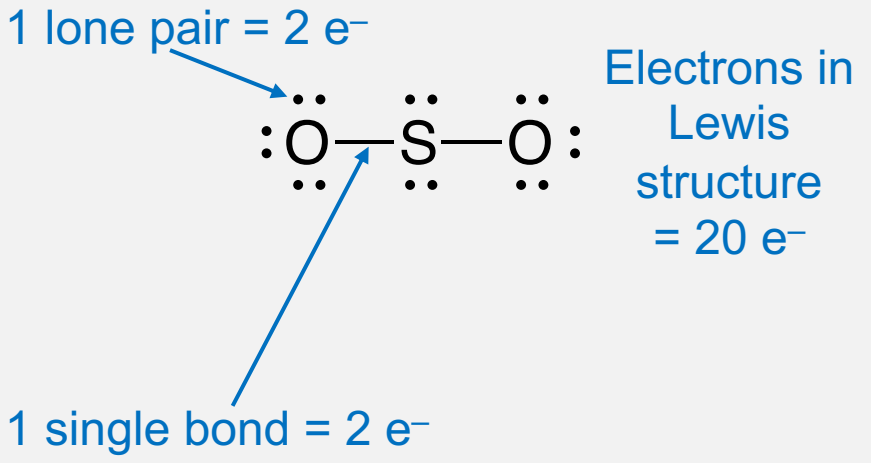

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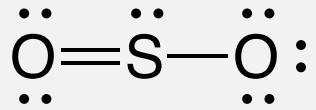

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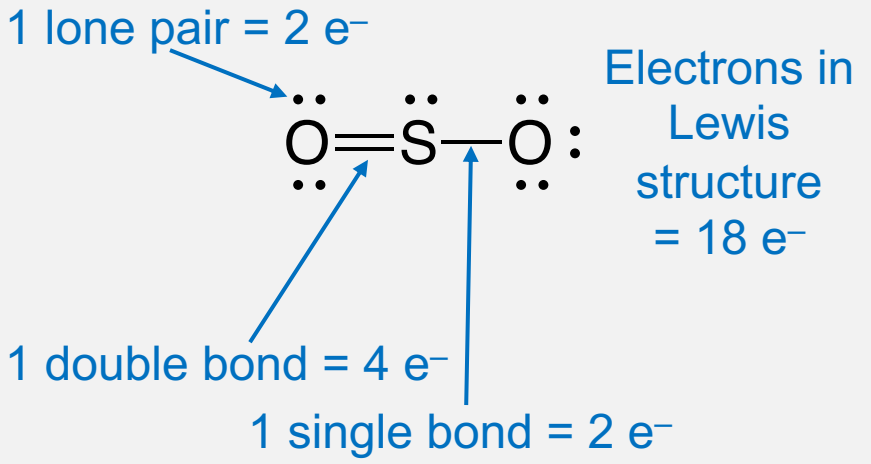

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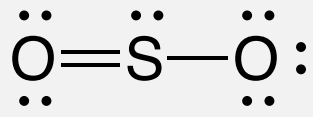

Electrons in Lewis structure = 18 e^-

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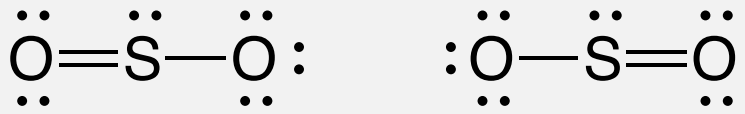

But we arbitrarily chose the left O to be double-bonded…
We could've also chosen the right O.

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RESONANCE: multiple valid Lewis structures

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The real structure is an *average* of the multiple resonance structures.

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FC (S) = (6 e^-) – (3 bonds) – (2 lone e^-) = +1
FC (O) = (6 e^-) – (2 bonds) – (4 lone e^-) = 0
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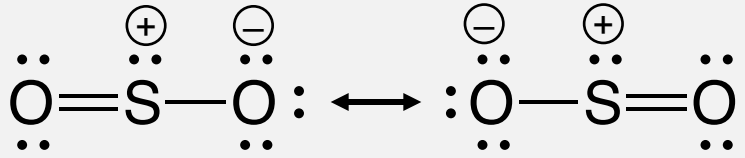

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Cyanide (CN^-)

Atom	Valence
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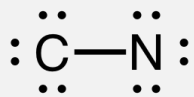

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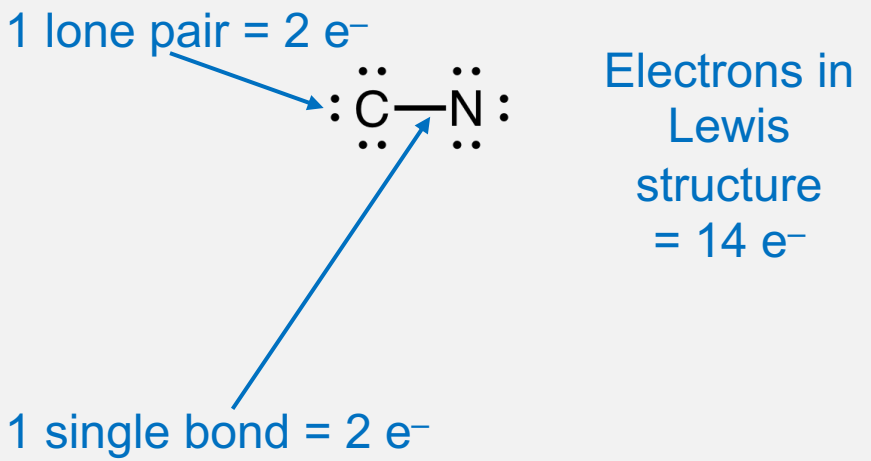

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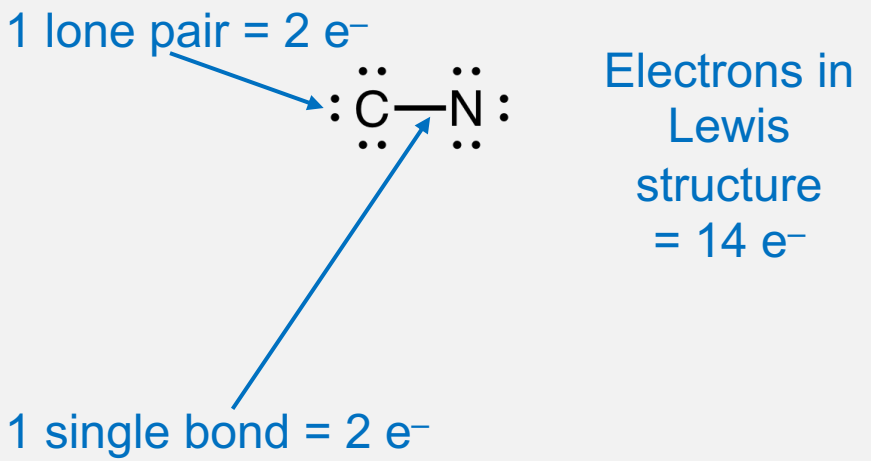

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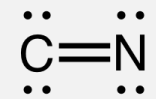

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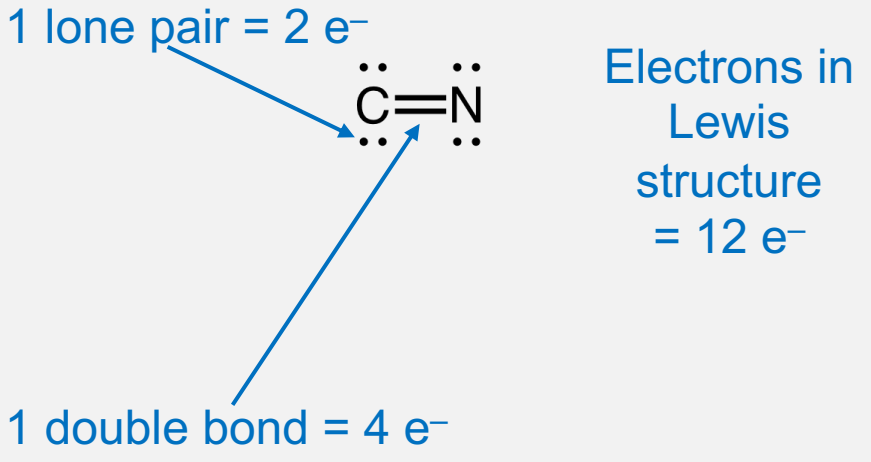

LEWIS STRUCTURES "RULES"

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 do not equal total number of valence electrons, try triple bond.

Guided Example

Cyanide (CN^-)

Atom	Valence
C	4 e^-
N	5 e–
charge	1 e^-
Total	**10 e^-**

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6. If electrons in Lewis structure equal total number of valence electrons, then done.

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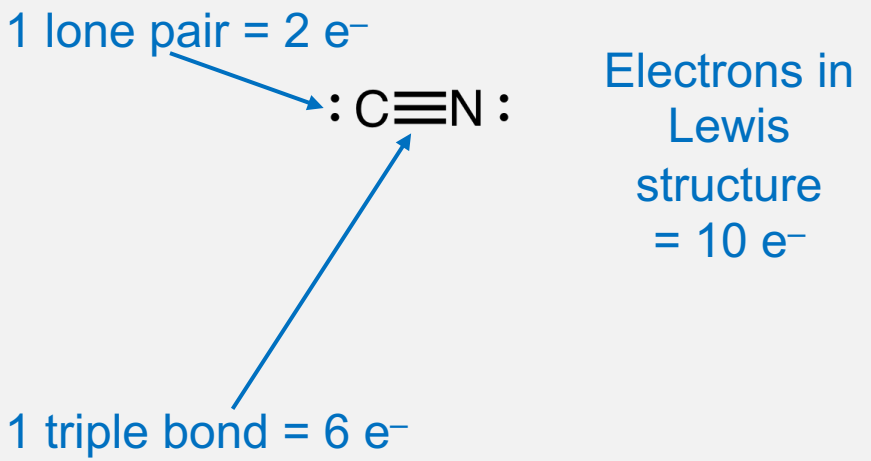

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7. Assign formal charges (FC) on *each* atom.

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Total	**10 e^-**

FC (C) = (4 e^-) – (3 bonds) – (2 lone e^-) = –1
FC (N) = (5 e^-) – (3 bonds) – (2 lone e^-) = 0

Make sure sum of FC equals total charge.

FC = (valence e^-) – (# bonds) – (# lone e^-)

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Generally, it's best to put negative formal charges on more EN atoms and positive formal charges on less EN atoms.

But you can't do that in this example.