Multiple Covalent Bonds

✓ Sometimes the only way that bonding atoms can attain a stable octet is by sharing more than one pair of electrons

✓ The ONLY elements that can form multiple covalent bonds with itself or each other are: $\boxed{C, N, O, S, P}$

DOUBLE BONDS – formed when 2 atoms share 2 pairs of electrons

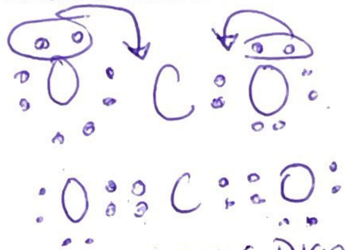
Example 1: CO_2

$C: 4\bar{e}$

$O: 6\bar{e} \times 2 = 12\bar{e}$

$16\bar{e}$

-4 / $12\bar{e} - 12\bar{e} = \emptyset$



Lewis Diagram

$O=C=O$ [Linear]

Lewis structure

Example 2: O_2

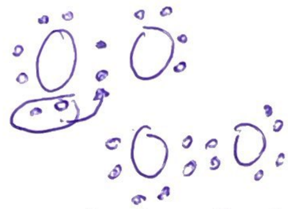
$O: 6\bar{e} \times 2 = 12\bar{e}$

-2

$10\bar{e}$

$-10\bar{e}$

$\emptyset$



$O=O$ [Linear]

Lewis Structure

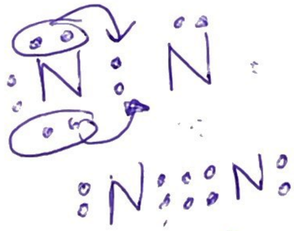
TRIPLE BONDS – formed when 2 atoms share 3 pairs of electrons

Example 1: N_2

$N: 5\bar{e} \times 2 = 10\bar{e}$

-2

$8\bar{e}$



Lewis Diagram

$N \equiv N$ [Linear]

Lewis Structure

Example 2: C_2H_2

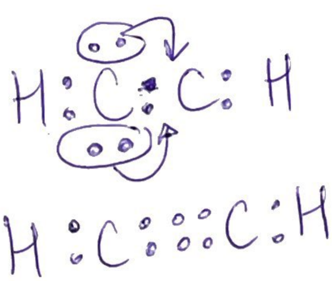
$C: 4\bar{e} \times 2 = 8\bar{e}$

$H: 1\bar{e} \times 2 = 2\bar{e}$

$10\bar{e}$

-6

$4\bar{e}$



Lewis Diagram

$H-C \equiv C-H$

Lewis Structure (linear)

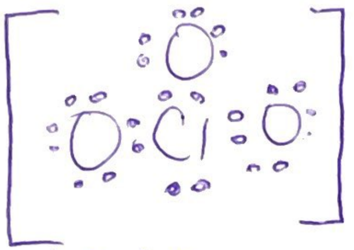
Lewis Diagrams and Structures of Polyatomic Ions

Ex. PO_4^{3-} SO_4^{2-} OH^{1-} ClO_4^{1-}

- ✓ Recall: a polyatomic ion is an ion that contains a group of atoms covalently bonded together but has an overall negative (or positive) charge.
- ✓ E.g. nitrate NO_3^{-1}, sulphate SO_4^{-2}

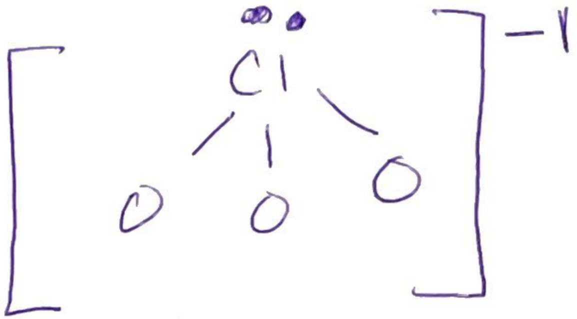
Example 1: chlorate, ClO_3^{-1} (note – in the ion, Chlorine is the central atom)

Cl: 7e
O: 6e x 3
(-1): 1e
26e
-6e
20e
-18e
2e



Lewis Diagram

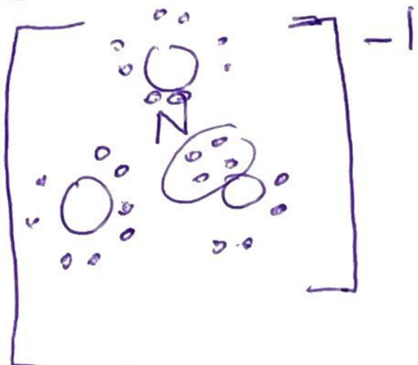
must have brackets & charge



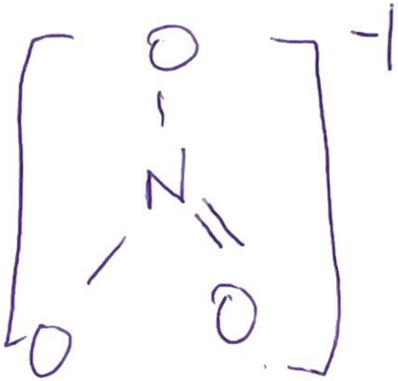
Lewis Structure

Example 2: nitrate, NO_3^{-1}

N: 5e
O: 6e x 3
(-1): 1e
24e
-6
18e
-18e
∅



Lewis D



Lewis structure

Coordinate covalent

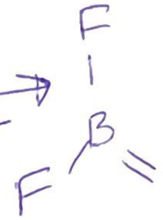
Molecules with atoms that do not obey the OCTET RULE

Example 1: BF_3 (boron will have less than 8 electrons in its valence shell)

B: $3\bar{e}$
F: $7\bar{e} \times 3$

$24e$
-6
$18\bar{e}$
$-18e$
$\emptyset$

Note NOT →



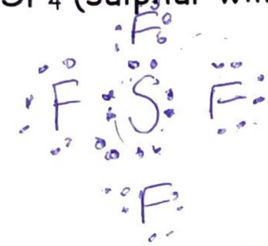
Boron does not make double bonds.

Note: Boron has $6\bar{e}$ but you have no more electrons in the bank.

Example 2: SF_4 (sulphur will have more than 8 electrons in its valence shell)

S: $6\bar{e}$
F: $7\bar{e} \times 4$

$34e$
-8
$26\bar{e}$
24
$2\bar{e}$



There are $10\ \bar{e}$ around the S!

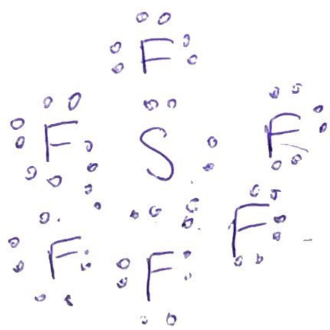
Lewis structure (shape is not important)

- ✓ Why can sulfur EXPAND its octet?
  - We need to look at the electron orbital configuration for sulphur
  - Sulphur [Ne]$3s^2 3p^4$ ⇅ ↑ ↑
  - It only needs 2 more electrons to fill its valence shell
- ✓ BUT, when n=3, this energy level contains 3s, 3p AND 3d sublevels (18 electrons total)
- ✓ Sulphur can use its EMPTY 3d orbitals to hold EXTRA electrons
  - A similar explanation can be used for Phosphorus (e.g. PCl_5) / Xenon

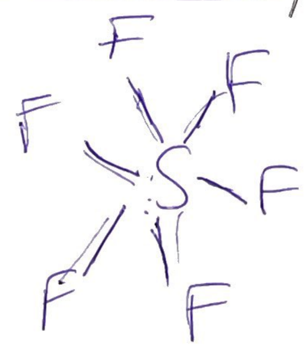
Example 3: SF_6

S: $6\bar{e}$
F: $7\bar{e} \times 6$

$48\bar{e}$
-12
$36e$
$-36e$
$\emptyset$



Lewis Diagram



Lewis Structure

Note: There are $12\bar{e}$ around the sulphur atom.