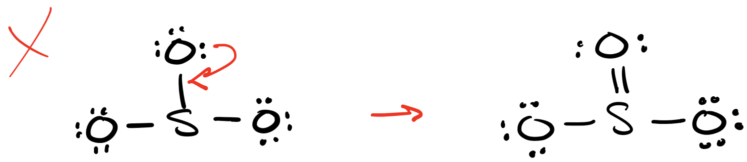
Lewis Structure

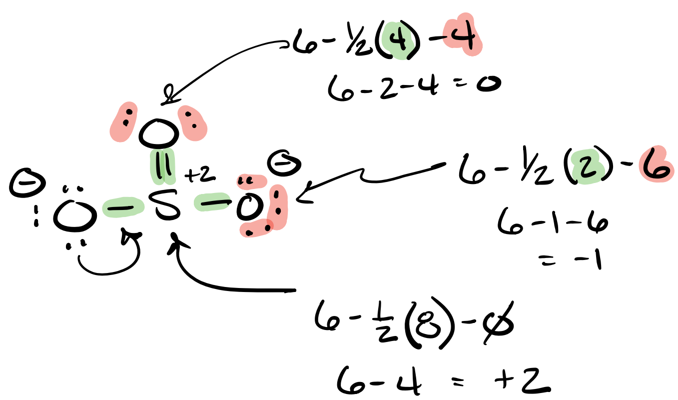
SO_3

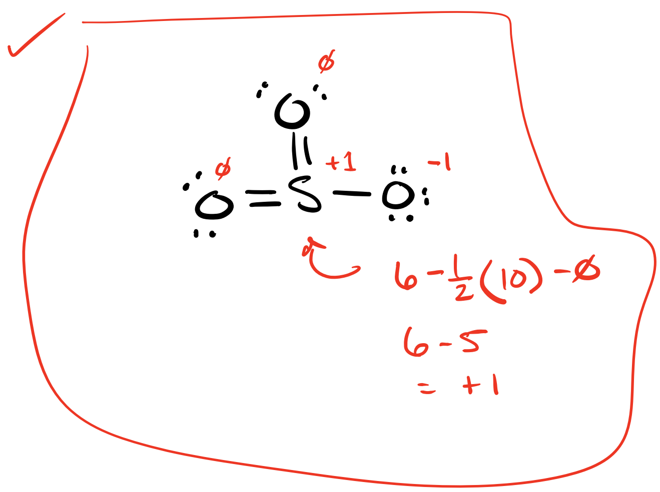
VIA	S	1×6 =	6
VIA	O	3×6 =	18
			24 e⁻

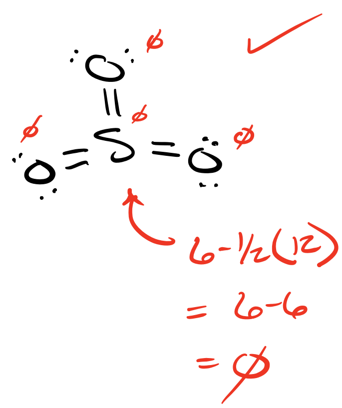


octets ✓
Formal Charge

Formal Charge = Valence e⁻ − ½ bonding − nonbonding







Lewis Structures – 2D structure, Atom Connectivity
Model System

- 3 main Systems for writing Lewis Structures

  - Traditional System
  - Common Bonding Patterns
  - Valence e^- method

Traditional Method

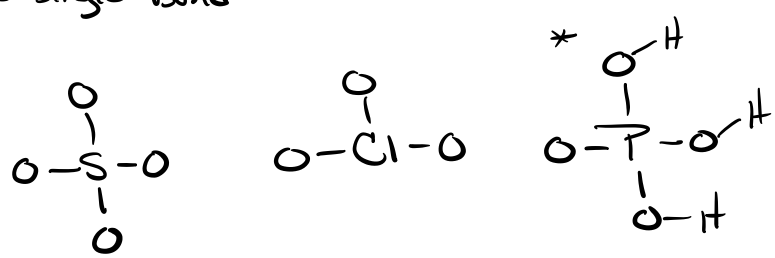
Steps

① Calculate total # valence e^- in System
  - Add e^- for negative charges SO_4^{2-} → add $2e^-$
  - Subtract e^- for positives H_3O^+ → sub $1e^-$

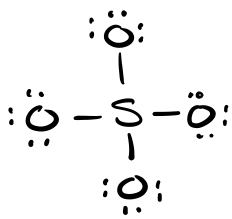
② Identify central element
  - often the underlined element $\underline{C}H_2O$ $\underline{C}H_3\underline{C}HO$ multiple centrals
  - often the Least EN element

SO_4^{2-} ClO_3^- * H_3PO_4

Connect the Substituent elements to the Central with a Single bond

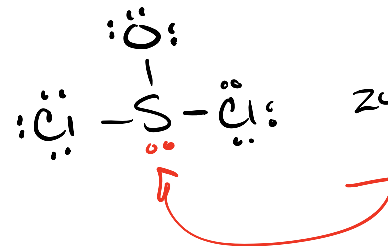


③ Add e^- pairs (••) to outter most, most EN elements, to give them an octet. If extra e^- pairs remain they go on the larger central atom.



$SOCl_2$

S 1×6 = 6
O 1×6 = 6
Cl 2×7 = 14
26 e^-

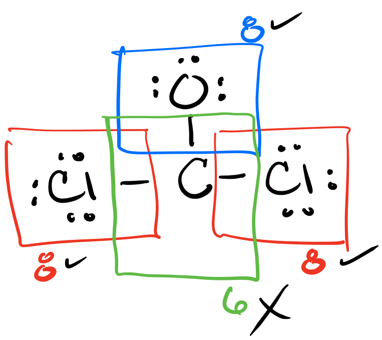


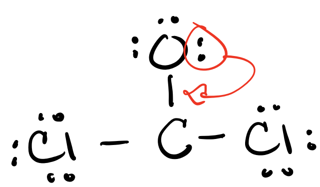
24 e^- used
2 e^- unused
26 e^- ✓

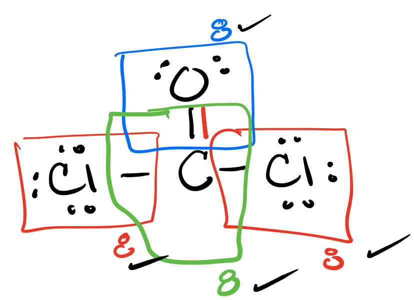
④ Check octets, check total e^- used

- If an atom (central) does not have an octet, then make double or tripple bonds by using the e^- pairs of the most EN element to make an octet on central.

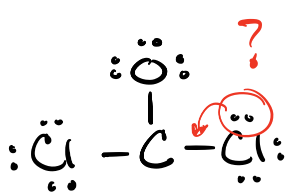
$COCl_2$

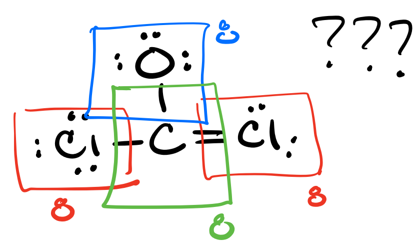






O > Cl
more EN





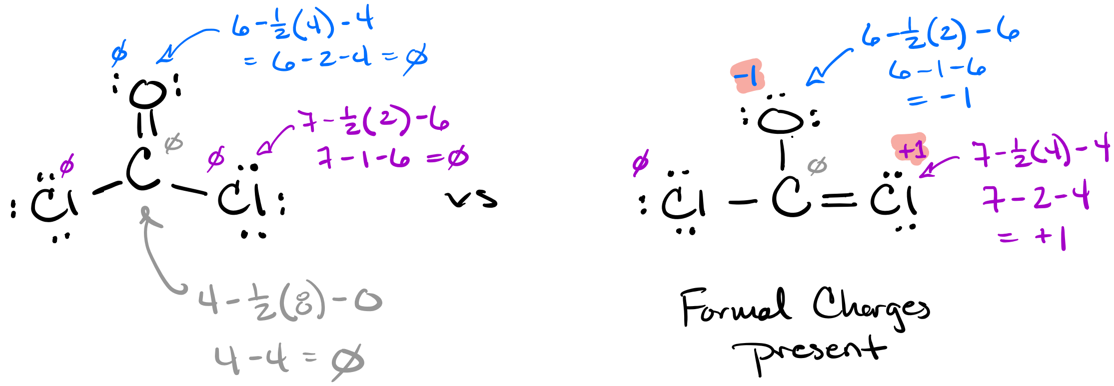
⑤ Run Checks

Check octets ✓

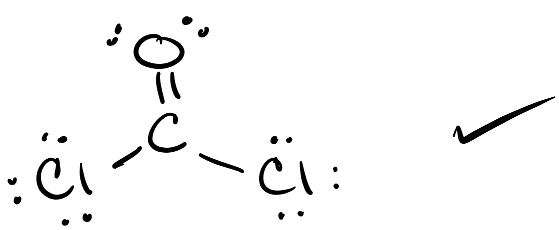
Check valence e^- used ✓

*Check formal charge ?

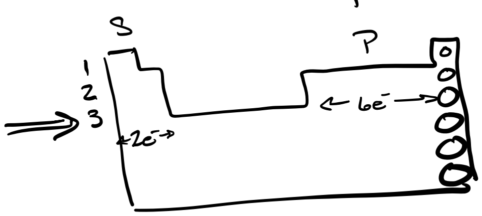
Formal Charge = valence e^- − ½ bonding e^- − nonbonding e^-



The best structure is the one with <u>Less</u> formal charges. (or ideally <u>no</u> formal charges)

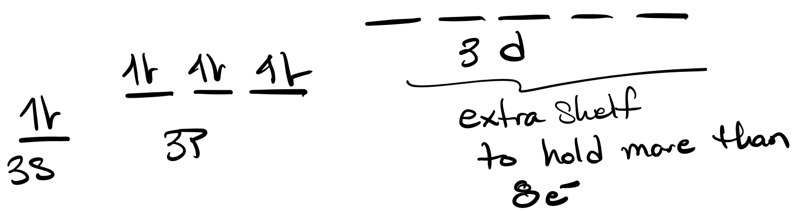


⑥ Elements in period 3 & below in Periodic Table



1 s
2 s+p = $8e^-$
3 s+p+d
$2+6+10 = 18e^-$

$2+6 = 8e^-$
= octet Rule not Law



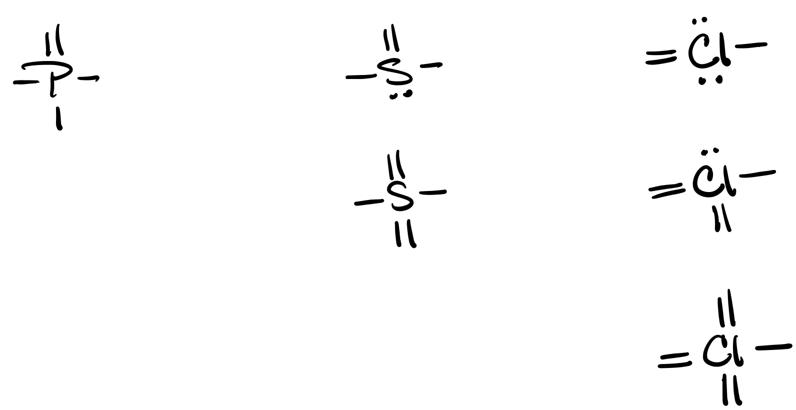
* These elements can have octet exceptions

2	N	O	F
3 ⟹	P	S	Cl

$10e^-$

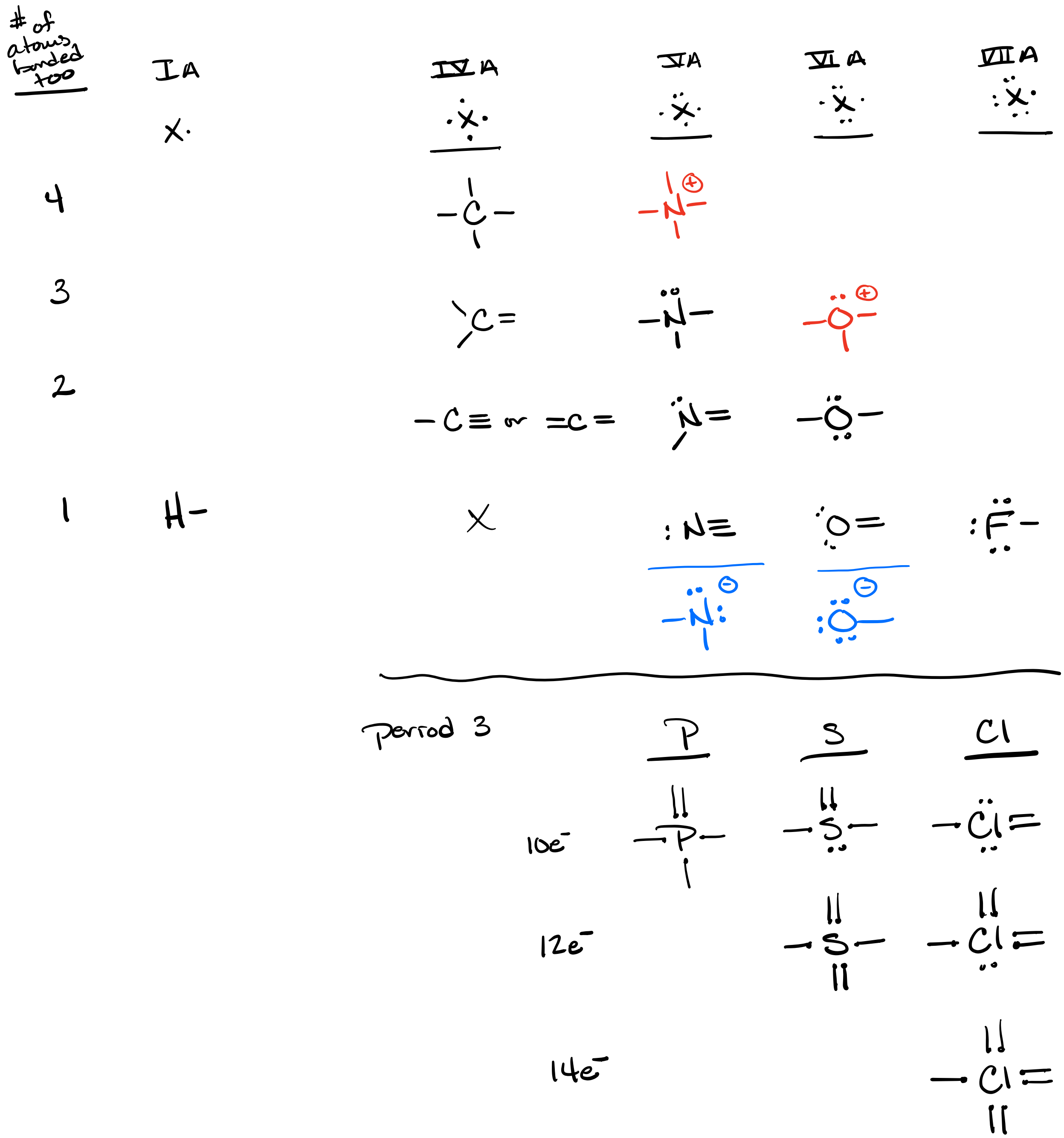
$12e^-$

$14e^-$



Large & have d-orbitals
$> 8e^-$ okay for these guys.

2nd System Common Bonding Patterns



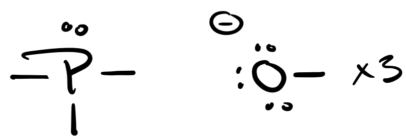
Common Bonding Pattern examples

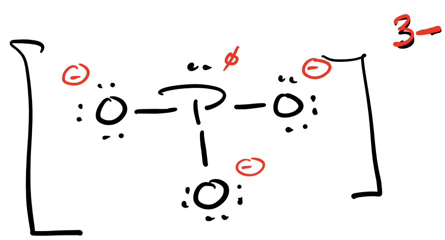
PO_3^{3-} ← 3- charges

each O is bound to 1

P is bound to 3 atoms

P 1×5 = 5
O 3×6 = 18
23
+ 3
26e⁻



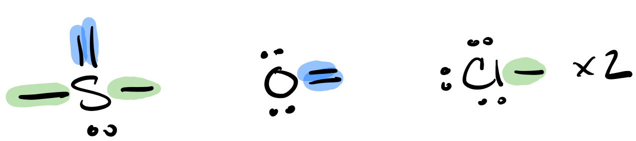


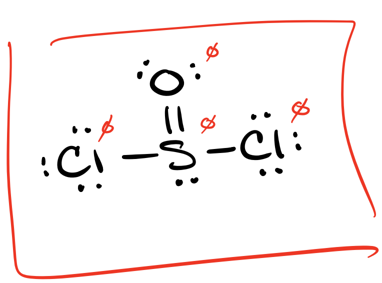
26e⁻ ✓
octets ✓
FC ✓

$SOCl_2$

3 atoms

S 1×6 = 6
O 1×6 = 6
Cl 2×7 = 14
26e⁻





26e⁻ ✓
octets ✓ 10e⁻ on S ✓
FC ✓

Name______________________________

Section____________ Date_______

Lewis Dot Structure Worksheet

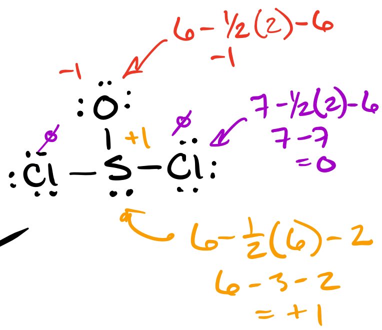
Write the Lewis electron dot structures for the following molecules and ions. The bonding sequence is given where needed.

1. $\underline{N}F_3$

2. $\underline{S}Cl_2$

* 3. $\underline{S}OCl_2$ (central S)

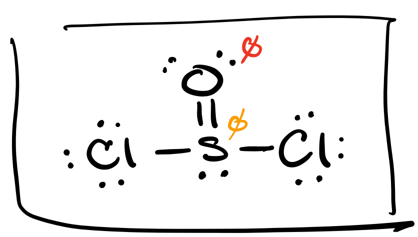
S 1×6 = 6
O 1×6 = 6
Cl 2×7 = 14
26e⁻ ✓



26e⁻ used ✓
octets ✓
Formal Charge x ?

4. $\underline{C}S_2$

5. $\underline{C}Cl_2F_2$ (central C)



Run Checks
26e⁻ ✓
octets x S 10e⁻ okay
Formal Charge ✓

6. C_2H_6O (C-C-O sequence)

7. C_2H_6O (C-O-C sequence)

"Sequence" means more than <u>1</u> central atom

C_2H_6O (Sequence C–C–O)

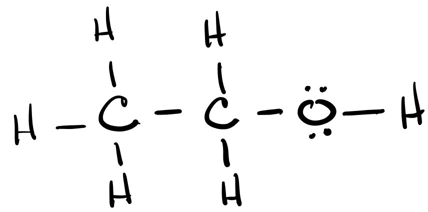
backbone

C $2 \times 4 = 8$

H $6 \times 1 = 6$

O $1 \times 6 = 6$

$20e^-$



Checks

- $20e^-$ ✓
- octet ✓
- FC ✓

8. $\underline{N}H_2Cl$ (central nitrogen)

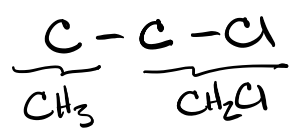
9. $H\underline{Cl}O_2$ (central chlorine, hydrogen attached to oxygen)

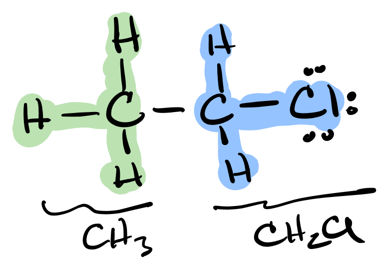
10. ClO^- $ClO^{\ominus}$

11. $\underline{P}H_4^+$ $PH_4^{\oplus}$

12. CH_3-CH_2Cl (C-C-Cl sequence)

$CH_3 - CH_2Cl$





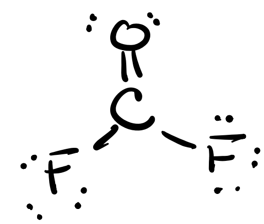
13. CN-CO-CN (C-C-C sequence)

14. CCl_3-CHO (C-C sequence)

Use the VSEPR theory to predict the shapes of the following. 1.Draw Lewis dot structures for each case. 2. Describe the shape about each underlined central atom in terms of an expression of the form AX_nE_m and in words (e.g., "linear"). Some structures have more than one indicated central atom. 3. Sketch the shape of each molecule or ion.

15. $\underline{C}OF_2$

Sketch



16. $\underline{C}F_4$

17. $\underline{P}Br_3$

18. $\underline{C}OS$

19. $\underline{S}O_2$

20. $\underline{Se}Br_2$

21. $\underline{C}H_3\text{-}\underline{C}O\text{-}CH_3$ (C-C-C sequence; give shape for two centers)

22. $\underline{C}H_3\text{-}\underline{S}H$ (give shape for two centers)

23. $Cl\underline{C}H_2\text{-}\underline{C}N$ (C-C sequence; give shape for two centers)

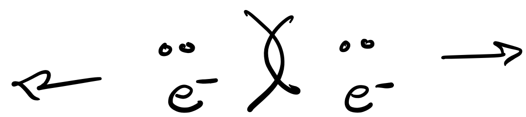
24. $\underline{As}H_4^+$

25. $\underline{Cl}O_2^-$

26. $O\text{-}\underline{P}\text{-}\underline{O}\text{-}P\text{-}O$ (i.e., P_2O_3; give shape for two centers)

Valence Shell Electron Pair Repulsion Theory
(VSEPR)

Electron pairs in the Valence Shell (outter most e^-) Repel one another.



Helps to model expected 3D structure

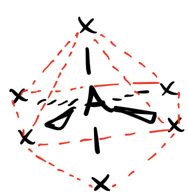
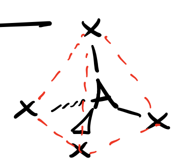
2D Lewis $\xrightarrow{\text{VSEPR}}$ 3D Structure

A = Central Atom

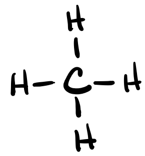
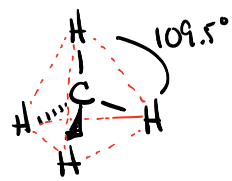
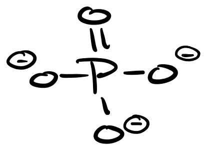
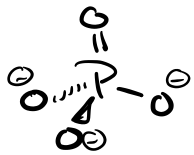
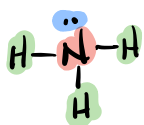
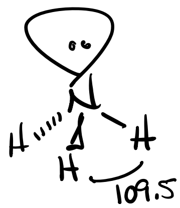
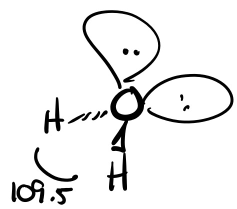
X = Substituent Atom or group

E = lone pair ••

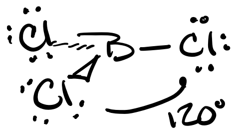
Chem 1A

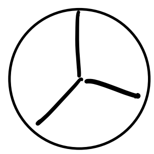
		Parent	Individual names
AX_6		octahedron 8 sided object	AX_6, AX_5E, AX_4E_2 AX_3E_3 AX_2E_4
AX_5			
AX_4		Tetrahedral	AX_4, AX_3E, AX_2E_2
AX_3		Trigonal planar	AX_3, AX_2E
AX_2	X — A — X	Linear	AX_2

Tetrahedral Family

			"Family" Electronic Geometry	Molecular Geometry	Bond Angle
	AX_4		Tetrahedral	AX_4 Tetrahedral	109.5
	AX_4				
	AX_3E (4)		Tetrahedral	AX_3E Trigonal Pyramidal	109.5
	AX_2E_2		Tetrahedral	AX_2E_2 Bent-109.5	109.5

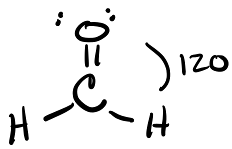
Trigonal planar family

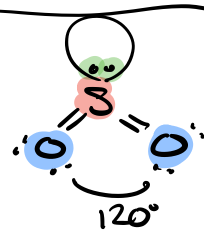
			Electronic Geometry		Molecular Geometry	Bond Angle
BCl_3	AX_3		Trigonal Planar	AX_3	Trigonal Planar	120°



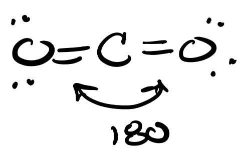
$\frac{360°}{3} = 120°$

COH_2



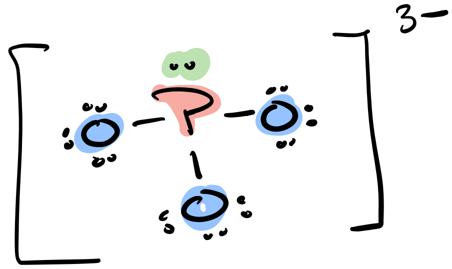
SO_2	AX_2E		Trigonal Planar	AX_2E	Bent-120°	120°

Linear Family

			Electronic Geometry		Molecular Geometry	Bond Angle
CO_2	AX_2		Linear	AX_2	Linear	180°

Ex

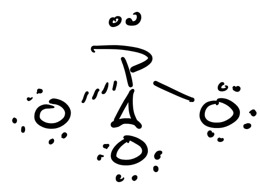
PO_3^{3-}



AX_3E

4 ← tetrahedral family

Trigonal Pyramidal



109.5°

Ex

≤ Centers